Immersive Soundscapes to Elicit Anxiety in Exposure Therapy: Physical Desensitization & Mental Catharsis

Jessica Evelyn Argo

BA (Hons), MDes

Submitted in fulfilment of the requirements for the

Degree of Doctor of Philosophy

School of Simulation and Visualisation

Glasgow School of Art

February 2017

Abstract

There is a wide range of sensory therapies using sound, music and visual stimuli. Some of these established therapies focus on soothing or distracting stimuli as an analgesic (such as natural sounds or classical music), while other approaches emphasize active performance methods of producing music as therapeutic. Instead, this thesis proposes immersive soundscape exposure therapy, inviting people suffering from anxiety disorders to react to densely detailed ambisonic composition. In this work, soundscapes are composed to include the users' own idiosyncratic anxiety triggers to facilitate habituation, and to provoke psychological catharsis, as a non-verbal, visceral and enveloping exposure. In this research, the participants' vital signs are recorded during exposure, to accurately pinpoint the most effective sounds that alter the participant's resting state, which informs an optimal construction of future soundscapes. Across psychology and neuroscience literature, it is widely agreed that sound is a major trigger of anxiety, and auditory hypersensitivity is an extremely problematic symptom. In this project, it is hypothesized that these dense, anxiety-eliciting soundscapes will progress future immersive therapies for various psychological conditions. Results from this study indicate that exposure to stress-inducing sounds can free anxiety sufferers from entrenched avoidance behaviors, teaching physiological coping strategies whilst simultaneously encouraging resolution of the repressed psychological issues agitated by the sound.

List of Tables

All tables by author, unless stated otherwise.

List of Figures

All figures by author, unless stated otherwise.

Acknowledgement

This research was supported by the Global Excellence Initiative Fund, granted from the Scottish Government and the Scottish Funding Council. I am profoundly grateful for this opportunity to answer research questions in far greater depth than would have been possible as an independent artist.

The dedication of the supervisory team is sincerely appreciated. Firstly, from Professor Minhua Eunice Ma, who acted as primary supervisor from the project's conception and for the first several months. Her heartfelt encouragement for me to join the PhD programme, publish and present at conferences, as well as her suggestions to tighten the focus of the research catalysed the project and set the momentum for the years following her departure. Professor Christoph Kayser, from the University of Glasgow, acted as a constant presence as external supervisor throughout the entirety of the project, offering invaluable insights from the realm of neuroscience and psychology, meaning that this project could truly bridge art with science. Dr. Daniel Livingstone, as a primary supervisor contributed his immense knowledge and advice as to the logistics of the experimental procedure, the implementation of wearable technology, as well as the statistical analysis. Ronan Breslin, also a supervisor, offered ingenious expertise regarding the theory and practice of soundscape composition as well as the spatialisation of the sound (for which Dr. Iain Laird from Arup Acoustics is also sincerely thanked for his assistance). Ronan also played an incremental role in the recruitment of participants, and encouraged the exhibition of soundscapes, following the experiment. The supervision team were tirelessly involved in all aspects of the study: reviewing the soundscapes, as well as several drafts of conference papers and the thesis, shaping the final outcome presented here. I also greatly appreciate their everyday boosts of morale, and their genuine enthusiasm for the research.

Thanks are also given to Alison Hay, the research developer at Glasgow School of Art, who helped to ensure that this potentially provocative research was entirely ethically sound. In turn, the diligence of the participants who contributed their time and their energy (both physical and emotional) to the pilot and the experiment is very much appreciated. Finally, the unfaltering support and curiosity from my family and friends ensured that I never lost motivation, even during the inevitable ups and downs of the doctoral research. Thank you.

1 Introduction

Immersive Soundscapes to elicit Anxiety in Exposure Therapy is an interdisciplinary research project based in an optimal audio-visual production suite, the Arup Ambisonic Soundlab at Glasgow School of Art's School of Simulation and Visualisation, with guidance from the Centre for Cognitive Imaging, at the University of Glasgow's Institute of Neuroscience. I, the principal researcher, approach this work from the perspective of a 3D sound designer and audio-visual installation artist who has previously exhibited in diverse socio-cultural contexts from white cube galleries to nightclubs, as well as site-specific performances in acoustically fascinating locations. I work in collaboration with a serious games specialist, a neuroscientist, and an established TV, film and theatre composer/sound engineer. The primary discipline in this research is outlined in the first two words of the title – the design of *immersive soundscapes.* The construction of these soundscapes was informed by years of research of the innovative sonic practices within experimental art, minimal music, sound design for horror cinema, and acoustic ecologists. The content of the soundscapes largely references the anxiety-triggering sounds recounted in arts and exposure therapy literature and neuroscientific experiments, as well as the musical structures that can induce strong sensations. The secondary discipline is experimental psychology, as these immersive soundscapes are presented to participants as a therapeutic intervention: the participant is asked to meticulously plot their timeline of emotional and physical affect, through both conscious evaluations in questionnaires and indeed the recording of their unconscious psychophysical signals. Thus, the original contribution to knowledge is two fold: primarily a suite of five archetypal anxiety-eliciting soundscapes have been created and panned in an immersive ambisonics loudspeaker array; secondly, a proof of concept for a new form of psychotherapeutic soundscape exposure, which uses these soundscapes as temporary anxiety stimuli. The aim is to synthetically induce anxious sensations in the user, to physically desensitize and encourage a psychological catharsis. (According to the Medical Research Council's new guidance for complex interventions (Craig et al. 2006), the experimental research serves as a feasibility study.)

Sufferers of mood disorders are quite often riddled with unpleasant physical sensations: this is essentially due to a dysfunction of their autonomic nervous system, quite often triggered by an unresolved fear or grief, or perhaps a standalone chemical imbalance in the brain. Figure 1 lays out the two quite distinct branches of common mood disorders: anxiety is broken down on the left, whilst depression is shown on the right. In anxiety, there is usually an unresolved fear, which results in hypertension, and hypersensitivity to everyday stimuli. Post-Traumatic Stress Disorder is an acute branch of anxiety, with an unresolved trauma at the root of it, characterised by intrusive horror memories and a fragmented memory of the traumatizing event. PTSD sufferers can either be hypersensitive to even seemingly innocuous sonic or visual stimuli (if the stimuli were present at the time of the trauma) or they can feel defensively numbed. At times PTSD sufferers find it difficult to focus or organise their thoughts, and can have indescribable feelings, as they are often unable to find an outlet for their anger, or allow themselves to feel pleasure (Grillon et al., 2013). Whilst anxiety is caused by an excess of fear and results in hypersensitivity to stimuli, depression is a co-morbid but almost opposite mood disorder, as it is caused by and felt as a stimulation deficiency, characterised by excessive negative ruminations, a lack of energy and motivation and at times a distorted, muted sensory perception. At the root of depression there is often an unresolved grief. Although the underlying cause and indeed symptoms manifest as a disrupted nervous system - the “fight or flight” mode is activated too easily - of course there are myriad intrapersonal factors and circumstances which may condition these mood states to a particular sonic or visual stimulus (and if they are left unresolved, this becomes Post-Traumatic Stress Disorder). A dual solution is required to alleviate the intensity of symptoms from these mood disorders: both a mental catharsis to resolve the repressed trauma or grief, and a physical desensitization to the dysfunctional nervous overreactions induced by anxiety-triggering stimuli are crucial, for the anxiety sufferer to overcome what can be a debilitating affliction.

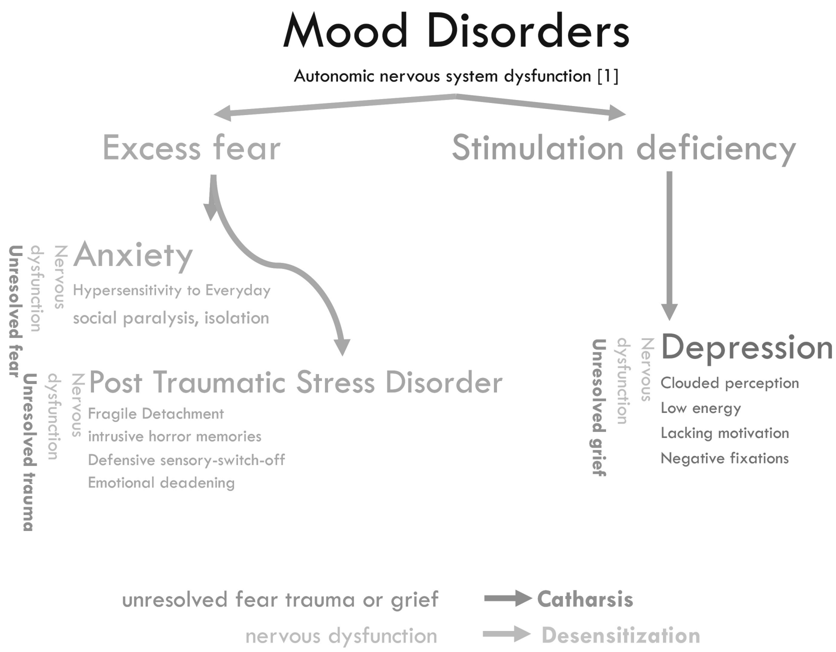


Figure 1: The psychological and physical manifestations of common mood disorders

Sound is a major trigger of anxiety, and auditory hypersensitivity is an extremely problematic symptom. Exposure to stress-inducing sounds can free anxiety sufferers from entrenched avoidance behaviours, teaching physiological coping strategies and encouraging resolution of the psychological issues agitated by the sound. Exposure therapy is an established psycho-therapeutic technique designed to diminish the intensity of anxiety symptoms, by gradually exposing the user to their fear triggers, either directly (*in vivo*) or through simulation (such as Virtual Reality visualization) (Roy et al, 2010). However, out of all the senses, humans have evolved to have the deepest immediate fear response to sound (Panksepp and Bernatzky, 2001) - so exposure therapy would undoubtedly be more powerful if therapists implement sonic anxiety triggers instead of only visual stimuli.

Acoustic features can reliably elicit physical sensations: sudden loud sounds can startle the listener (Hoffman 1995) or abrasive high frequencies send a shiver down the spine (Grewe et al. 2010, cited in Altenmuller, Kopiez, and Grewe, 2013). A soundscape can evoke memory, as indicative sound sources can locate the listener in a past situation (Liljjedahl 2007), and melody can induce emotions (Juslin and Vastfjall 2008). In soundscape exposure therapy as devised in this research, individual anxiety trigger sounds are repeated to habituate the listener - to remind them that it is just a noise, and encourage them to focus on how it sounds rather than what it means (as outlined in Wegerer et al’s 2013 description of counter-conditioning). Soundscape exposure fuses physical desensitisation with emotional catharsis, as the user develops practical coping strategies whilst simultaneously confronting repressed traumatic memories.

In Chapter Two, an assessment of the current sensory rehabilitation context is necessary, to identify the gaps in psychotherapeutic knowledge that can be filled by insights from this research study, which has the advantage of being conducted from the perspective of a creative practitioner. In Chapter Three, there is an explanation of the complex soundscape production techniques used in this research, and a detailed outline of this project’s methodology. Chapter Four describes and justifies every element of the experimental procedure used in the small pilot study, which provided indicative results that shaped the format of the larger scale experiment. The results of the experiment are then split into primary and secondary findings. Chapter Five comprises the primary experiment results, which are designed to familiarise the reader with the multiple modes of data analysis, offering a broad overview of both the short-term and long-term impact of soundscape exposure on the participants' overall physical wellbeing and state of mind. Chapter Six then descends into close detailed data analysis of the secondary results, revealing more specialised insights into the nature of the sounds that reliably trigger anxiety, and the nature of anxious sensations that can be synthetically induced by an immersive soundscape. There are many hypotheses and objectives for the primary results, some of which are expanded upon for the secondary results. In addition, there some more specific hypotheses for the secondary results, which take into account the detailed analytical techniques used there. These primary hypotheses are outlined at the start of the primary results (Chapter Five), and reviewed at the end of the primary results, as is the case for the secondary hypotheses. Chapter Seven comprises of the conclusions from the results, and there is a comprehensive discussion of the successes and limitations of this research project that follows, including some practical implications for healthcare practitioners and anxiety sufferers, who might benefit from a form of soundscape exposure used as therapy.

1.1 Research questions

There are two areas of questioning in this research, the first based in the primary discipline, immersive soundscape design, and the second based in the secondary discipline, experimental psychology. One area of questioning identifies the nature of sounds which frequently trigger strong sensations (whether physical or emotional, recorded through conscious reports or by increases in physiological signal activity). The other area of questioning evaluates the nature of the soundscape exposure experience, identifying whether the long-term impact on the participant's emotional wellbeing was positive or negative (it was predicted that the short-term impact would be negative). The pinpointing of sounds that trigger strong sensations, and the instructive outline of the ambisonic workflow serves creative practitioners, whereas the evaluation of the participant's experience is informative for healthcare practitioners. The psychological effect of the ambisonic panning is assessed, as we ask participants whether hyperreal, exaggerated spatialisation of sounds is more anxiety eliciting than realistic or minimal spatialisation.

Crucially, the physiological signals from participants at different stages in the experiment are compared to discover if participants habituate to the abrasive sounds over time. Differences in perception of the exposure experience is also evaluated between the participants with higher levels of pre-exposure anxiety and those with the lower pre-exposure anxiety – again sensations scores from questionnaires as well as the physiological signals are used as measures.

The highly specific sub-questions regarding the effective construction of the soundscapes are to identify the individual sounds responsible for eliciting strong sensations most frequently, and clarifying whether these sounds are liked or disliked. There are also highly specific sub-questions regarding the nature of the soundscape exposure experience: the sensations most frequently elicited are identified, as are the body parts most frequently affected. The tricky question of whether off-the-shelf soundscapes with non-relevant sounds can elicit strong sensations very frequently (or if matching participants' pre-existing anxieties enhances the sensation triggering in any way) is also investigated.

The central research question is, can immersive soundscapes reliably elicit strong sensations in participants. If they do, it is important to discern the type of sounds responsible in terms of their acoustic properties (e.g. high frequency/low frequency, loud/quiet, erratic/rhythmic), or whether it is the way these sounds are arranged (in terms of their spatialisation and manipulation).

2 Literature Review

2.1 Introduction

There are myriad non-pharmaceutical interventions using sound or music designed to alleviate the symptoms of mood disorders, and indeed to tackle the underlying psychological issues of anxiety sufferers. Elements from music therapy and exposure therapy are acknowledged and expanded upon in this study. Firstly, accounts are given from the many musicologists and psychologists in recent years who have specialised in quantifying the profound benefits of music listening, from the unconscious automatic nervous system responses such as goosebumps and chills, to music's power to manipulate emotions. Secondly, the fundamentals of established exposure therapy techniques (such as imaginal, in vivo, interoceptive or Virtual Reality virtualisations) are reviewed which presents the crux of this research study. The use of sound as an exposure stimulus seems to be widely neglected in current exposure therapy practice, so the relevance of using sound stimuli is argued throughout this research study. In this study, high-quality, innovative soundscapes have been composed, and listening tests are carried out with psychophysical monitoring to quantify the emotional and visceral affect elicited. The compositions feature sounds commonly reported as personal anxiety triggers, which have been identified through surveying the reports of many anxiety, depression and trauma sufferers available in psychotherapy literature, academic studies and online forums. This subverts a typical use of music therapy as a tool to bring momentary joy, or the therapeutic implementation of music familiar to the participant, or indeed soothing natural sounds as an analgesic. A notable variable specific to this research study, is the enhancement of anxiety-elicitation that spatial immersion in an ambisonic soundscape can bring, one that is densely packed with numerous sounds. This differs from standard practice for scientific listening tests such as the existing psychophysical studies which focus on the arousal caused by one or two specific isolated timbres or naturally occurring sounds, which tend to be played in two-channel stereo sound, often through headphones.

This literature review also proved influential on the creative process of designing the immersive soundscapes specifically for use in an anxiety exposure therapy situation. A deep engagement in sound studies and cultural theory informed the design process, as key compositional techniques have been discovered which can reliably manipulate the listener's physical and psychological state. For example, repetitive loops can generate states of irritation, or fear of a menacing onslaught, and eventually trancelike hypnosis. Equalization, which is essentially the ducking or boosting of high or low frequencies of a sound, can simulate the sensory distortion that can be induced by panic. Excessive reverb or indeed a lack thereof, can simulate a large agoraphobic space or recreate an inner-subjective auditory hallucination. Whilst inaudible frequencies were found to subliminally alter listener's brainwaves (Goodman, 2010; Oohashi et al, 2010), this was omitted from the literature review, instead focusing on the effects on physiology and psychology enabled by causal identification of sounds, or reduced listening to audible acoustic attributes.

In short, this literature review delves into the core principles and working practices of music therapy and exposure therapy. The relevant cultural history which paved the way for creation of non-musical soundscapes is also appraised in addition to a little about the sound technology used to render these immersive, anxiety-eliciting soundscapes used in this research experiment.

2.2 Established Modes of Sensory Therapy

2.2.1 Music Therapy

2.2.1.1 Passive Listening versus Active Participation

Music and arts therapies often prefer an active approach, encouraging clients to play instruments or sing to express their own emotions. Yet, the benefits of passive listening to the prescribed mood induction within existing music are also widely acknowledged (Cohen, 2001; Greenman, Meulenberg and White, 2008). In fact, superficially, music listening was found to reduce stress and anger the most, depression the least and anxiety moderately, compared to instrument playing or singing (which decreases anxiety and depression the most) (Hwang and Oh, 2013). However, to tackle chronic anxiety, it is crucial to go beyond a mere short-term stress reduction: more significant in facilitating recovery from anxiety afflictions is the triggering of a cognitive re-evaluation of trauma-memories and a physical training of coping strategies. An optimal compromise between passive listening exposure and expressive performance-based therapy could be to offer the participant-receiver a degree of input. Previously, input has been as minimal as a patient asking for diverse, empathetic song requests from musicians performing cathartic hospital recovery services, from the elegiac to flamboyant pop-rock (Greenman, Meulenberg and White, 2008). True Aristotelian catharsis ("the cleansing of the soul through an emotional experience" (Have, 2008)) was also observed in terminal AIDS sufferers, through their addictive listening to Arvo Part's *Tabula Rasa* (Ross, 2007). Furthermore, participant input could become as incremental as a compositional decision for a soundscape: the participant can include their own anxiety triggers or sounds associated with pleasant memories; or they can choose between rousing and soothing tempo, or major and minor chords (Austin, 2006).

In established arts therapies either sound, movement or visualization can provide the patient with an external, non-verbal catalyst for catharsis. The sensation and emotions stimulated during arts therapies can provoke unexpected feelings - this is a powerful discussion stimulus, as listeners primarily reflect on the intensely emotional session itself and then verbalise their more underlying emotions stirred. Hospital patients "sharing innermost feelings" bring myriad benefits: a patient-clinician dialogue aids a more personalised treatment; nausea can be reduced and musically triggered endorphins boost the immune system (Greenman, Meulenberg and White, 2008). Music, as an external stimulus, is seen as an explorative playground which offers the patient concrete handles of musical motifs or discursive metaphorical frameworks (a descending scale = a downward spiral) to use as psyche allegory: the listener at once recognises musical structure, but it also simultaneously propels the imagination into a dream realm (Winnicott, 1968). Neurologically, music also fosters a bi-lateral link between the sensorial and rational sides of the brain, encompassing elements of both emotional expression and a musical language (Ready, 2011).

2.2.1.2 The neural and physiological mechanisms of music listening: therapeutic applications

Music is known for its' powerful mood-inductive ability, which Juslin and Vastfjall (2008) categorise into six distinct manipulations, which broadly separate into the more immediate, involuntary reaction provocations and then the complex, slow to unfold reactions which the listener can induce willingly (as seen in Table 1).

Table 1: Juslin and Vastfjall's *Mood Manipulation Mechanisms*

Immediate, involuntarily induced	Slow to unfold, voluntarily induced
Brain stem reflex	Musical expectancy
Evaluative conditioning	Episodic memory
Emotional contagion	Visual imagery

The seminal psychologist, Silvan S. Tomkins' "quasi-Darwinian" conceptualisation of affect evaluates vestigial reflexes to sound, instilled throughout humans' evolution. Tomkins categorises affect according to the different physiological responses generated by the brain's perceptions of stimuli, placed across a spectrum of intensity of neural firing: from "enjoyment-joy → interest-excitement → surprise-startle → anger-rage → distress-anguish → fear-terror → shame-humiliation → [to] disgust, and dis-smell" (Biddle and Thompson, 2013). The "surprise-startle" affect is elicited in by a sudden surge of neural firing (in response to a loud, unexpected sound bursting out of a quiet background), whereas a more gradual rise in neural activity is perceived as "fear-terror", perhaps triggered by an ominous, creaking floorboard in a quiet house previously believed to be empty. In this research study, an immersive soundscape can be reliably engineered to guide the listener along a path of Tomkins' affects: first, "interest-excitement" would be encouraged by the listener's immersion within a multiple speaker array, and the anticipation of the unknown sounds to follow; then, "enjoyment-joy" would be felt on correct identification sounds that resonate with a positive past experience; then, out of nowhere a blaring bell will elicit a "surprise-startle; "anger-rage" will bubble upon repetitive loops of grinding metallic industrial sounds; blood-curdling screams spinning round the array excites a "fear-terror"; "distress-anguish" is triggered by an overheard baby's cry; "disgust and dis-smell" are simulated by bubbling mud or visceral flesh squishing; and finally, even a tinge of "shame-humiliation" may be triggered upon recognition of sounds resonating with repressed negative past experiences, idiosyncratic to each listener. It is advisable that the finishing state should be a positive one, such as "enjoyment-joy" or "interest-excitement", to appease the user.

Back to the already established therapeutic implementations of the arts, music is commonly used for mood regulation. A widely referenced database of questionnaire responses which analyses participants' uses of music for mood regulation, has been compiled by Saarikallio et al (2008). Saarikallio categorises music mood regulation behaviours into seven distinct strategies as seen in Table 2.

Table 2: Saarikallio et al's Music for Mood Regulation Behaviours

Entertainment	amusing or decorative use of music
Revival	awakening when doing monotonous tasks, energizing from fast tempo or lively melodic leaps
Strong Sensation	vivid emotions, musical pleasure
Diversion	distraction, temporary obliteration of intrusive thoughts or feelings
Discharge	catharsis, purging through facilitation of a re-experience of unpleasant sensations (disgust or pain) and emotions (anger or fear).
Mental Work	thought-provoking self-examination for evaluation and resolution of past events or present cognitive worries
Solace	seeking reassurance from soothing music, or music which accurately mimics the emotional disturbance of current mental turmoil

Music can also provoke renewal ecstasies during *Strong Experiences in Music* (Gabrielsson, 2001). When listening to traditional music with melodic structures such as pop, classical and rock, moments of frisson tend to be viscerally felt at the onset of an instantaneous climax. Frisson can also be experienced as rushing over the body multiple waves, induced by a build of timbral texture or musical complexity. Gabrielsson establishes that there is often a biological mimicry to musical features: as an accelerando sets a pulse racing, shivers can be induced in response to a deviation of anticipated harmony, and emotionally expressive melodies cause tears (Gabrielsson, 2001). Percussiveness is even correlated with peaks in Galvanic Skin Response readings (van der Zwaag, Westerink and van den Broek, 2011), perhaps due to the violent striking nature inherent to the sound's production, which naturally elicits a fear response. The overstated 'heart-rending and ghost-ridden' shock chord in Mahler's Tenth Symphony (where the whole orchestra suddenly roars in dissonant minor thirds) commonly triggered a strong emotional experience among several respondents in Gabrielson's study (2001).

A concept extremely pertinent in the pursuit of fear extinction is that chills can be caused by both fear and pleasure: whether the experience is deemed as a positive or negative one is due to cognitive evaluation. Whilst pleasurable auditory input (such as music) can sometimes cause chills, aversive sounds (such as the high frequency scrape of metal on glass) were proven to induce chills consistently (Grewe et al., 2010, cited in Altenmuller, Kopiez, and Grewe, 2013). A cognitive re-evaluation of valence association (whether a sound is deemed to be positive or negative) can work to diminish the cyclical "fear of fear" that perpetuates anxiety. It is essentially a form of psychoeducation, to illustrate to the user that humans are genetically engineered to experience piloerection in response to physically adverse or emotional situations. That is, our hairs stand on end, usually as a reflex reaction to being cold as an attempt to warm the body, but piloerection is also associated with the reaction to a call of social loss in the wild (such as a mother bird desperately trying to find her offspring). Thus, humans have evolved with innate physical responses which are activated upon hearing the cry-mimicking wails of pain within music (Panksepp, 1995). For instance, power-ballads often emulate the physical pain induced by a relationship's break-up.

When a human undergoes physical or psychological pain, the brain automatically attempts to bring the body back to homeostasis by secreting opioid neurochemicals, as a natural analgesic. The paradoxical pleasure perceived when listening to sad music (an external representation of pain) is caused by the same instinctual opioid secretion, synthetically stimulated: this is perceived as an extra boost, as the body is soothed even though it was not actually in pain to begin with. Usually when listening to sad music the body is not physically in pain, so it is not really in need of an analgesic - so this additional opioid stream is surplus to the previously balanced neurochemistry (Stein et al., 2007). Sad music is thought to catalyse the release of prolactin, a neurochemical whose primary function is to bring the body back to homeostasis through comfort in times of psychic pain; some music listeners are said to find sad music pleasurable, due to the release of the analgesic and hedonic effects of these endorphins which are released in a state without physical or psychic pain, thus their state has a surplus comfort (Huron, 2006). Moreover, listeners of sad music seem to be able to experience arousal of negative emotions without displeasure, in an aesthetic context through triggering what is referred to a "dissociation node" (Wilhelm et al., 2013). So, listeners can experience the sad emotions through symbolic reference, but these emotions can at times be clearly distinguished from their own psyche. However, when using sad music as exposure therapy (in this research), music induced-sadness is likely experienced in addition to real psychic pain, elicited by memory-triggering real world sounds. The pacing and navigation of the simulated sad framework within the music would be artificially engineered, so any naturally occurring sadness can be heightened - thus the sad soundscapes may catalyze prolactin secretion in excess of what would normally be induced during real-life sadness.

Thus, it has been discovered that music can provoke powerful sensations on even emotionally stable listeners; however, the subjective experience of sound for those with neurological disorders can be remarkably heightened. Anxiety sufferers can experience hypersensitivity to any sonic intrusion, but especially to sounds imbued with connotative reminders of a traumatizing experience. Musical frisson, a sensation commonly perceived as pleasurable, can initially disturb a sensory therapy participant with anorexia, as it enforces a strong physiological reaction – clients are reminded they “have a body” (Austin, 2006). Conversely, an alternative symptom of repression of a traumatic experience can be a defensive sensory switch-off, or emotional deadening. Detachment is problematic, rendering the traumatized sufferer’s stability extremely fragile, as attempts to avoid conscious emotional realization will eventually be overwhelmed. If emotionally and sensorially repressed trauma sufferers are locked in a behaviour where their “spontaneous impulses become short-circuited by secondary inhibitive ones” (Austin, 2006), perhaps embodied music cognition may encourage a break from their sensory-emotional avoidance. A pulsating rhythm that strongly invokes finger-tapping may surprise listeners into physical movement, as the non-verbal musical stimuli can bypass cognitive, linguistic modes of perception, felt solely through kinaesthetic perception or bodily sensation.

Listening to instrumental, performed music which involves obvious, coded bodily movements (such as the undulating bows of a cello, or the caressing of piano keys) is said to trigger mirror neurons, primarily in the frontoparietal motor-related regions: that is, the listening brain imagines the body movements even when the listener is completely still, as premotor regions (Broca’s area on the right, the inferior parietal lobule bilaterally and cerebellar areas on the left) show excitability, especially upon hearing keyboard music the participants were trained to play (Lahav, Saltzman and Schlaug, 2007). The premotor regions are particularly sensitive to previously experienced or learned actions. Transcranial magnetic stimulation in static participants revealed brain activity which is usually present when moving the hands (left-hemispheric motor corticospinal activation, especially linked to the hands) (Aziz-Zadeh et al., 2004), when the participants heard simplistic action sounds such as knocking, or finger clicking. Thus, it is probable that when we hear viscerally aversive body horror sounds (bones breaking, for instance), part of the revulsion is that we imagine our own bones being broken. Humans are neurologically hardwired to physiologically empathise, projecting our own imagined pain onto external suffering sounds.

Another strong reaction induced by playing violent sound effects (as opposed to merely instrumental music) through directionally pointed sound arrays, is that listeners may also instinctively “move out of the way” of an incoming virtual disembodied sound object "perceived to be in close proximity," as the unconscious fear response-and-action of *fight or flight* is triggered (Leadley 2011, p.130). This effect may be enhanced further through use of a blindfold, or playing the sounds in darkness, so the cause of the sound is ambiguous, the barrier between real and virtual is blurred, or hard to grasp (a technique that is heavily utilized in the post-apocalyptic videogame, *Silent Hill* (Cheng, 2014; Eckman, 2012)). Human bodies have several instinctive physical reactions to sound and music which do not require cognitive awareness: even coma patients exposed to music in an Intensive Care Unit have shown a consequential reduction in blood pressure - the music can filter through their sympathetic nervous system, although they may not be cognitively interpreting it (Greenman, Meulenberg and White, 2008).

The mental disturbance caused by poorly recorded or considered audio for use in rehabilitation, is often overlooked. So, the sound composer should sensitively produce high quality audio and carefully consider the sonic events to feature in the soundscape. High quality audio is typically recorded in high resolution file formats such as .wav, .aiff, or .flac, with higher sampling rates and bit-depths than found on a CD. Audio on CDs has a sampling rate of 44.1 kHz, and a 16 bit depth, whereas sampling rates of 48kHz or above with a 24-bit depth have greater resolution and a greater dynamic range. For high quality audio, a respectable recorder should be used, with either built-in microphones - the Zoom H4n and Tascam DR-40 are favourites among the handheld portable recorders - or microphones appropriate to the nature of the sound source being recorded. For example, a shotgun microphone is ideal for recording intelligible speech, tightly focusing on the voice whilst minimising extraneous ambient sounds. Patients in physical pain and mental distress can be soothed by natural organic, ordered smoothness, but this experience can be interrupted by periods of digital distortion (Fassbender and Martyn Jones 2014).

Soothing music and natural soundscapes are known to reduce stress and anxiety in post-operation patients, pregnant women and palliative care patients. Furthermore, a virtual sensorial opposite offers a distracting analgesic for a burns victim who was immersed in a "snow-world scene" (Hoffman et al., 2011). However, an analgesic stress reduction soundscape will doubtless need to be more delicate and soothing than sounds for the soundscape exposure therapy proposed in this research, which must become more abrasive and challenging over time. Whilst both soothing nature sounds such as "murmuring water" and low energy music with a positive valence music is known to rapidly reduce blood pressure and aid relaxation along the lines of Zen meditation (Tsunetsugu et al., 2007), positive relaxation music can be seen as incongruent to anxious or repressed traumatized mental states. Not only is pleasant, soothing music incongruent to an anxious or depressed listener, but it merely temporarily spoon-feeds rapid feel-good sensations, thus fuelling reliance on emotional avoidance, rather than confronting the unpleasant sensation to offer the user a chance at emotional resolution of repressed trauma. Emotional denial eventually results in cognitive dissonance: an unstable, fragile state, perhaps even more harmful than engaging in and accepting the original anxious state. Many depressed or anxious individuals attempt to regulate sad moods through short-term musical pleasure if they believe their mood can be regulated, if they think they can be temporarily brainwashed, influenced by pleasant melodies (Manucia, Baumann and Cialdini, 1984), especially those with unresolved sad events which are too difficult to fully process (Tahlier, Miron and Rauscher, 2012).

Mood regulation through empathetic listening to music can be more beneficial, as a more honest matching with the psyche can accelerate the venting of anger. Negative valence, high energy music “inflates” anger, increasing blood pressure and heart rate, thus driving bottled up anger out (van der Zwaag et al., 2011): the loud thrashing guitars of heavy metal such as Disturbed, or mechanical construction noises or the high frequencies of crying children provoked much higher levels of the stress hormone, cortisol, than listening to Bach’s predictably soothing Orchestral Suite No.3 in D major (Trappe, 2012). A laboratory study investigating the neuroendocrine responses to techno music, with its synthetic, unnatural timbres and high energy rhythms, showed increases levels of a significant number of hormones including stress-induced cortisol, adrenocorticotropic hormone, and norepinephrine; prolactin, catalysed by sadness; among the analgesic pain-induced beta-endorphin, a growth hormone, thus it induces a complex bittersweet enhancement of healthy physiology (Gerra et al., 1998). In Gerra et al.’s study, participants appeared both stressed and distressed but also high on the stimulated soothing effect of the endorphins. (It must be clarified that participants in Gerra et al’s laboratory study are experiencing the music in isolation on headphones, outwith the standard social-cultural context of the nightclub, where the social dynamics and the intense volume at which the music is played back actually have myriad influences on physiological response.) Techno combines the two strands of stress caused by musical arousal: *eustress,* associated with simultaneous enjoyment and arousal (catalysing adrenaline release); and *distress*, the fusion of dislike and arousal (causing spikes in cortisol) (Frankenhaeuser, 1980, cited in Vickhoff et al., 2012). Seemingly paradoxically, the boosting of cortisol concentrations in the user may enhance fear extinction, as a synthetic pill has been administered in several trials (Soravia et al., 2006): small rises in cortisol is said to crystallise memory, and anxiolytic drugs which inhibit cortisol are said to impede long-term learning in exposure therapy (Otto, McHugh and Kantak, 2010). Thus, stress has been found to cement fear extinction.

Children were also shown to favour playing eerie synthesized sounds to share underlying concerns about the nature of fear, during *Wiimprovisation* therapy for children with behavioral difficulties, when presented with an array of instrumental and synthesized timbres at their fingertips through a Wii controller interface (Benveniste et al., 2009). When using public environmental soundscape recordings, the composer can maintain a balance (as in musical harmony) to avoid "schizophonic" soundscape experiences with a cacophony of clashing, unpredictable or naggingly persistent, dissonant sound events (Davies et al., 2013). The tone of a composition of sound events can change dramatically from vibrant and positive hubbub to gradually morph into unpleasant overcrowded mishmash of sounds. In fact, the most infuriating deviation from classical or pop musical norms is said to be ineptitude of a performer (Hegarty, 2013), and lack of an overarching structure to “hold on to” (Landy, 2007) – so some forms of noise can be culturally appreciated, if skilfully executed.

Another innovative use of auditory stimulation is found in EASe (Electronic Auditory Stimulation effect) Listening Therapy CDs (Mueller, 1995), designed to habituate children with hypersensitivity disorders by means of sophisticated manipulation of sound frequencies (the Berard AIT modulation system). A low-pass filter is imposed on passages of music, with the high frequencies only emerging in 0.3-second intense volume-boosted bursts. The bursts are constructed to be too short to trigger the flight-or-flight response, so the child becomes familiar with the stimulation but is not frightened. This encourages a tolerance of the sensory cacophony in the real-world.

To summarise, there are many therapeutic applications of musical and non-musical sound. Users of music therapy are often encouraged to express their emotions through an external framework of musical sounds or use their own voice to reconnect with their repressed physical sensations. Even mainstream music listening is used as a mood regulation tool, and strong emotional experiences with music are often triggered in live concert situations. Music can affect both our cognitive psychology (by encouraging complex emotional journeys and triggering re-experiences of past sensations and emotions) and our unconscious nervous responses, eliciting physical sensations or secreting hedonic neurochemicals. Whilst pleasant music or relaxing natural sound is often used as an analgesic in established music therapies to soothe or distract patients, it is rare that desensitization and catharsis is the goal, sought by using aversive, unpleasant sounds. These established therapeutic applications of musical and non-musical sound are profoundly influential to the design of the soundscapes used in this research experiment, as well as the shaping of the research project's methodology. Also crucial in shaping this research study, is an extensive survey of existing psychotherapies, such as cognitive behavioural therapy and exposure therapy, which now follows.

2.2.2 Exposure Therapy: Visual Virtual Reality versus Immersive Soundscapes

Using immersive soundscapes to reconstruct the frightening sensations of neurological disorder in a safe environment should encourage trauma and anxiety sufferers to stop their life-restricting reliance on safety behaviours, through training them to endure, acknowledge and feel more at ease during stimulation. After all, the most distressingly debilitating element of anxiety and depression is physiologically caused by the dysfunctional autonomic nervous system (Ellis, Koenig and Thayer, 2012), so a synthetic anxiety stimulation can train the sufferer to fight back against the painful symptoms and engage in a more outgoing life. Current exposure therapies mostly rely on visual stimuli, such as the replication of fearful situations in virtual reality, sometimes with accompanying sound - but rarely with sound as the focus. However, using sound alone has fantastic potential to engage both the mind and the body, by using non-verbal and non-literal sound-imagery, that could be used to enhance or complement exposure therapies. It has been found that to enhance a subjective sense of presence within a mediated environment, spatial surround sound is not the key sonic augmentation - it is in fact the addition of Low Frequency Enhancement (bass) and a rise in volume (Freeman and Lessiter, 2001). However immersive sound does raise enjoyment, therefore engagement, thus also increasing the likelihood for the user to consistently attend a program of exposure therapy.

Further, using spatially pointed sonic cues can negate the need for a visual overload of information (Schnall, Hedge and Weaver, 2012); using sound alone can even encourage the user to close their eyes to block out external distractions to induce a greater sense of immersion and suspension of disbelief. Visual-less games such as *Beowulf,* and *Papa Sangre* show an innovative shift of focus onto the auditory imagination rather than dominating, prescriptive visuals, as the creators argue that prominent spatial cues in the game-soundscape can stimulate a richer, individualized internal mental imagery in the gamer (Liljjedahl, 2011). Roy et al. showed that signs of fear response in the amygdala became diminished, as war veterans used visual Virtual Reality Exposure Therapy (VRET), where they re-enacted combat situations through a gaming environment (Roy et al, 2010).

However, soundscapes which go beyond the constraints of reality can provoke otherworldly, spiritual catharsis – established mood-inductive emotional triggering from musical structures will fuse with real world sounds, and the unnatural timbres of digital synthesis. Perception of sound is a far more personalized, memory-triggering mode of reception than watching a visual Virtual Reality: sound feels more directly applicable to our own memories and real-life encounters - no matter how realistic or universal a visual image is, it is unlikely it will match our memories and experiences as precisely as replicable sound events do (Liljjedahl, 2011). Intriguingly, in a study exploring the link between crying and catharsis, a participant's teary evaluation of a self-contained autonomous problem which can realistically be improved is much more likely to result in catharsis. Conversely, although participants cried when witnessing the suffering of others, catharsis was less frequent in this instance, as the event was perceived to be outwith the viewer's control, a situation they are powerless to resolve, only able to empathize with but not fully comprehend or change (Bylsma, Vingerhoets and Rottenberg 2008). Thus, it is vital to implement the most personalized subject matter available, and indeed use the medium which is most capable of aligning with personal memories. Moreover, using aversive sound stimuli is crucial in desensitization, since auditory hypersensitivity is the most common sensory-perceptual abnormality, more prevalent than visual and tactile hypersensitivity. In fact, hypersensitivity to sound is a direct cause of several sensory-specific anxieties under several names: hyperacausis; phonophobia (physiological alarm in response to sound); misophonia (a psychological, conditioned emotional association with a sound) (Stiegler and Davis, 2010). Panksepp and Bernatzky (2002) even deemed sound to have a more direct neurological affect (primarily in the subcortical emotional systems) than visuals.

The opiate receptors play a crucial role in the elicitation of emotions and physical sensations such as bliss and shock when listening to music, the most influential neurochemical secretion being the release of dopamine linked to a momentary musical climax. Altenmuller and Schlaug (2013) note that when participants were monitored during listenings to both pleasant and unpleasant music, that serotonin levels rose substantially when they found the music pleasing. *Immersive Soundscapes to elicit Anxiety in Exposure Therapy* will investigate the psychosomatic affects induced by a more continuous catharsis, by developing a complex anticipatory system within the densely constructed soundscapes; a reaction akin to that triggered by abstract electroacoustic music and found-sounds of Shaefferian *musique concrète*. A further hypothesis (the proving of which is beyond the scope of this project) is that unpleasant music may regulate the opioid secretion patterns: an unpleasant but complex, sculpted soundscape could be intellectually intriguing, thus elicit a long-term reward rather than a fleeting pleasurable sensation. A gradual fade to a pleasing sound might even generate a more stable, healthy neurochemical response than a manic low-to-high jump. An inhibition of dopamine (by serotonin) is actually thought to reduce anxiety, as OCD and social phobic symptoms are partially caused by an excessive secretion in dopamine in the brain areas manifesting the anxiety – essentially, the addictive compulsive behaviours are endorsed by a maladaptive dopamine secretion (Hofmann, Gutner and Asnaani, A., 2012). A soundscape with multiple sonic peaks inducing shocks, bliss and shivers can replicate the physiological compulsive symptoms and neurochemical sensation of excessive dopamine; or a calmer soothing soundscape can induce serotonin, which can regulate the listener’s mood.

The accurate personalisation of Virtual Reality visualisation exposure therapy for individual perspectives is expensive and time consuming, but it has been shown that even one simulated element of a larger situation (such as the 9/11 terrorist attack) can be effective for numerous survivors. Goncalves et al. (2012) found that only some of the stimuli depicted in the virtual environment are required to produce enough anxiety to activate the traumatic memory. The use of a partial sensory exposure which focuses on one isolated mode of stimulus (in this *Immersive Soundscapes* research, that mode is sound) can be adequate to stimulate anxiety. The isolation of one visual element, symbolic of a larger anxiety-inducing situation, was previously demonstrated in an experiment where the participant enacted a public speaking scenario to a VR simulated audience of disembodied eyes (Herbelin et al., 2002). The isolation of one specific stimulus in exposure therapy (rather than attempts at a comprehensive reconstruction of reality) may even prove more helpful in achieving fear extinction, as the user will realise that it is not necessarily the whole situation that is feared, but a panic attack can actually be induced solely by one seemingly insignificant sensory hypersensitivity.

Whilst it is ideal to tailor soundscapes to include personalized sonic triggers, the known power of abrasive sounds to induce universally predictable psychophysical affects means that one soundscape will provide a rich, diverse array of sounds applicable to many unique sufferers. Indeed, the ambiguity of *reduced listening* (Schaeffer, 1966) to sonic stimuli may even lend itself more readily to a wider range of disorders and circumstances than the traditional prescriptive, situational narrative exposure. Pierre Schaeffer and Jerome Peignot originally devised the term acousmatic sound, as one that is heard without visual apprehension of its source (1966), which in turn encourages a reduced listening mode of attention. Michel Chion (1994) distinguishes three listening modes: *reduced listening* is when the listener focuses on the acoustic qualities of the sound itself, in a deliberate attempt to avoid *causal listening* (where an identification of the source of the sound is sought), or *semantic listenting* (where the listener derives meaning from linguistic cues). As well as removing the sound from visual confirmations of its source, *reduced listening* is also enabled by cutting short extracts of an original sound event and repeating them until the meaning is lost (which dually encourages habituation to the source of the sound). For this reason, the immersive exposure soundscape proposed in this research is consciously designed as acousmatic sound, to be received in the *reduced listening* mode. Additionally, humans' inherently selective perceptual processes (such as the *Cocktail Party Effect*, which enables us focus on one voice in a chatter-saturated environment) mean that each participant will also internally amplify those sounds with most relevant resonance in their own memories.

Post-Traumatic Stress Disorder (PTSD) sufferers are not merely sad, but they also have fragmented memory of the traumatic event and can even struggle to process new memories. They are often hypersensitive to stimuli, unable to focus, and can have indescribable feelings, particularly unable to find an outlet for their anger or allow themselves to feel pleasure (Grillon et al., 2013). Primarily, these are symptoms of a larger dislocation of the past-traumatized body from the present-self, as hallucinatory horror-memories intrude upon their daily life. Hence, engaging trauma sufferers in a composition that seizes their attention, and lets them over-react could be a useful emotional outlet to enable them to overcome their daily struggle to fully experience emotion. The *Attention Training Technique* (Wells, 2007 cited in Graham, 2010), is a metacognitive therapy to force concentration on external stimuli, which encourages a reduction in internal rumination, teaching an ability to consciously switch between internal or external focusing: a mindful modification of entrenched depressive behaviour. *ATT* consists of a verbally guided direction to sonic events in the environment or in a recorded soundscape, often including everyday positive or neutral valence sounds such as church bells, water gurgling, birdsong, and urban traffic noise. It has been used in treatment of hypochondriacs, major depression, auditory hallucination and anxiety sufferers. During these taught practice sessions a proactive strategy is instilled for the participant to independently prevent habitual worry internal-monologues, or introspective behaviour. The verbal direction could be replaced by a more sophisticated integration of directional sonic indicators, augmented through spatial sound arrays which naturally attract the listener's attention through unusual panning.

Moreover, integrating real world sounds in a musical framework (that is not too simple but not too complex) can encourage the listener to achieve a perceptual state of *flow,* an attentional experience where the listener becomes optimally challenged - not to the point of frustration, but rather *absorption*. The listener is reassured that their mind can feel organized as they consciously follow and attend to organised patterns sounds: Csikszentmihalyi believes that true engagement with music "reduces psychic entropy, or the disorder we experience when random information interferes with goals" (1990, p.109). Thus, the brain can be preoccupied from excessive mental rumination, by attending to a dense layering of instrumental tracks, from a multitude of directions leaving no perceptual faculty able to process an internally generated negative voice – which is often an overwhelming anxiety symptom. Karen Callaghan, a movement therapist experienced in working with torture survivors, notes a frustration of conflicting emotions, as victims stifle their anger by deliberate seclusion or self-harm "for fear of being over-whelmed or destroying others with their rage" (1997). Stimulating, aversive compositions could trigger this overwhelmed sensation within a safe environment, increasing user confidence that they can survive the painful symptoms and that repeated experience can train them to become more resilient

In everyday life, anxious states can be triggered either by external cues or internally generated worry: external triggers are easier to include within a constructed soundscape, such as simulated locations, situations, objects, and sensory cues (olfactory, sonic, tastes, gustatory, temperature, tactile); whereas internal manifestations (strong fear or disgust emotions, racing heart as signs of physiological arousal, or morbid catastrophic assumptions of cardiac arrest or going insane) can be focused on through interoceptive exposure (Falsetti, Resnick, and Davis 2005). Interoceptive exposure therapy uses physiological stimuli to generate the symptoms of a panic attack within a therapeutic environment: the pure physiological symptoms of panic, devoid of external cognitive stimuli, and out-with the feared social situations. Evans believes that "bodily symptoms of arousal may constitute conditioned stimuli which in turn elicit phobic anxiety," and that the sufferers were conditioned to the vicious cycle, "the fear of fear" (Evans, 1972, cited in Gerlach and Neudeck 2012, p. 185). Interoceptive exposure is used to stop the self-perpetuating nature of the syndrome, the paralysing "fear of fear". The participant deliberately limits their breathing (through voluntary hyperventilation, or breathing through a straw) to overload on carbon dioxide, or spins to make themselves dizzy, or even watches a head-mounted display of a shaky video to induce nausea. These symptoms are provoked within a controlled safe environment with the guidance of a therapist, so the participant is reassured of their safety and gains confidence in their ability to withstand unpleasant physical sensations associated with panic, "mastering their ability to experience a full range of emotional responses, fully and without defense" (Eifert and Forsyth, 2005, p.202 cited in Gerlach and Neudeck 2012, p. 189). Whilst interoceptive exposure induces anxious symptoms through physical exercises, the motive at the heart of the technique is replicated in this research study, proposed as a soundscape exposure. Instead of paper bags or straws, breathing patterns can be manipulated or interrupted by loud, intrusive shock sounds which obscure all thought (Ihde 2007).

Immersion into a rich audiovisual arena is known to induce depersonalization, a symptom of a panic attack where sufferers can doubt that they are real, feeling oddly disconnected to their physicality, losing faith in their physiological stability. This effect can be simulated by intensely focusing on an overbearing auditory or visual stimulus, such as disorientating 3D visualizations or loud, assaulting soundscapes. Mckay and Moretz (2008) used 3D glasses in the natural environment to induce depersonalization on three anxiety sufferers who suffered acute depersonalization during panic attacks (cited in Gerlach and Neudeck 2012, p. 192). Gerlach and Neudeck (2012) listed other methods, such as focusing on a single mark on the wall, or immersion in booming, unsettling Schoenbergian music in no discernible key, in a dark room to enable a focus on the sound stimulus in isolation. Thus, exposure therapy practitioners have reported instances that the patient can experience an isolated symptom of anxiety, synthetically, and they can model a rational response to this frightening sensation, guided by the therapist.

In this research study, the proposed *Immersive Soundscapes to Elicit Anxiety in Exposure Therapy* fuse together the core aims, principles and practical techniques from music therapy, both active performance and passive listening, (Fig. 2, top left, from images from Memory, 2012 and Kzenon, 2014) and those from exposure therapy. In particular, Virtual Reality visualization exposure therapy is used as a model technique (Fig. 2, bottom left, from Breton-Lopez et al, 2010), but instead of a Virtual Reality goggles, the listener is ideally in an ambisonic array of loudspeakers, and visual exposure stimuli is replaced by a medium much more appropriate to anxiety treatment: complex, multi-layered, spatial soundscapes.

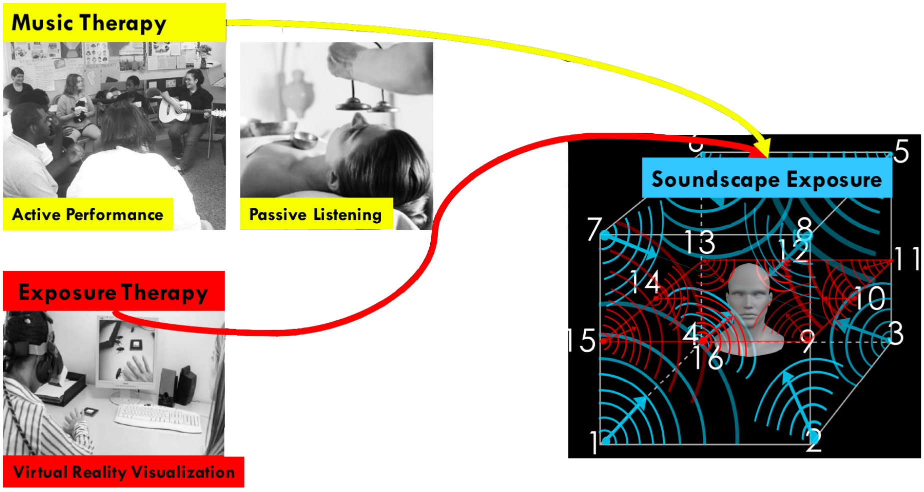


Figure 2: Fusion of techniques from Music Therapy and Exposure Therapy: Soundscape Exposure Therapy. Diagram by author, using images from Memory, 2012 (top left) and Kzenon, 2014 (top middle) and Breton-Lopez et al, 2010 (bottom left).

2.3 Sound Production Techniques to Physiologically Optimize Exposure

There are several fundamental techniques at a sound designer's disposal for them to carefully engineer a soundscape to elicit a timeline of emotional and physical affects. The toolkit of digital plugins included with Digital Audio Workstations, such as Avid ProTools, allows the composer to manipulate sounds to heighten or dampen certain frequencies either to make audible alterations or induce physiological affect through inaudible frequencies outwith the spectrum of human hearing, as well as construct exaggeratedly reverberant sound fields (Avid, 2017). The composer is also free to cut and loop the most minute extracts of sounds, chopping a real world recording or sound effect into a less recognisable reconstruction. Moreover, it is even possible to choreograph these transformed sounds to move around complex spatial paths, either immersing or bombarding the listener. These sound-editing and mixing techniques are enhanced further by interweaving of discoveries from the realm of exposure therapy, cognitive behavioural therapy and neuro-rehabilitation, such as the deliberate inclusion of widespread or personalised anxiety trigger sounds, and even their pairing alongside pleasant sounds for counter-conditioning. The fusion of sound design techniques and therapeutic frameworks is inherent in the formulation of the experimental stimuli for this study.

2.3.1 Idiosyncratic sonic triggers

An illustrative example of a particularly problematic anxiety trigger sound can be seen in a torture survivor's report:

> "Reemtsma… became the victim of a hostage situation and realized afterward that his intrusive memories were triggered by hearing footsteps or a knocking sound... he had heard footsteps approaching the cellar before the kidnappers knocked at the door during his captivity." (Wegerer et al., 2013, p.1)

So Reemtsma has a strong, visceral aversion to the sound of footsteps, due to the fear-conditioned response learned throughout his captivity. This account exemplifies the necessity for catharsis and desensitization to the sonic trigger: it is an extremely problematic aversion, as Reemtsma would frequently encounter footsteps in everyday situations - to stick to a strategy of avoidance, he would have to live alone locked in a soundproof domicile, socially paralyzed. A soundscape designed for Reemtsma's exposure therapy could include footsteps which fade in and out of focus, gradually foregrounding the composition, and transforming through a variety of filters and reverberation to fully explore the acoustic qualities of the sound, dislocating the sound of footsteps from its' learned causal association. Footsteps can work as a universal anxiety trigger even in less extremely conditioned circumstances, due to the ominous threat associated with an angry gait rushing towards the listener, in a directionally pointed sound array (the psychological impact of hyperreal or realistic spatialisation of footsteps is evaluated in Section 5.4).

Indeed, there is a multitude of clichéd short-hand to provoke fear in the listener, universally used in film (especially startle-inducing stingers, short, stabbing, anthropomorphized sforzando instrumentation most recognized in the shrieking violins of Hitchcock's *Psycho* (1960)) and video games (like gunfire and explosions in first-person shooter games such *Call of Duty*) (Jonsson, Breslin, and Ma, 2013). These shorthands are sometimes created through inventive instrumentation - indeed, film music theorist Kevin Donnelly hypothesises that ethereal shrieking film scores are directly mimicking and amplifying physiological sounds such as the "high buzz of the nervous system and the deep throb of the bloodstream and heart" (2005, p.105) to provoke an empathetic fictional fear in the audience. However, many of the shorthands are alarming sound effects which act as a threat to the on-screen protaganist (and thus the empathetic listener), including barking dogs, squeaking doors, cats screaming, ravens cawing, and lightning strikes. The *International Affective Digitized Sounds: Affective Ratings of Sounds* (Bradley and Lang, 2007) provides an expansive standardised library of instantaneous subjective responses to a broad array of sound event stimuli, rated across three axes, valence, arousal and dominance. Cox conducted an extensive online survey collecting over 1.5 million ratings of over thirty sounds from tens of thousands of people, to discover the "worst sounds in the world" (2008). The worst sounds were deemed to be vomiting (a natural disgust reaction), followed by microphone feedback, multiple babies crying, scraping squeaking train wheels, a squeaking seesaw, a violin, a whoopee cushion, a baby crying, a soap opera argument and mains hum. Functional Magnetic Resonance Imaging (FMRI scanning) of human brains show visible responses upon exposure to aversive sounds: first sounds are identified and categorised in the auditory cortex and then affectively assessed in fear-regulating amygdala. Specifically, sounds with audibly high spectral frequencies and low temporal modulation (such as a fork on a bottle, or chalk on a black board) are perceived to be highly unpleasant and frightening (Kumar et al., 2013).

Whilst these sounds listed above are acoustic symbols widely known to induce fear, disgust or sensory irritation, the hypersensitivity of anxiety actually renders a wide array of causally inoffensive sounds frequenting everyday environments just as traumatic, if not more due to their chronic, on-going nature. Initial searching for "sound triggers for anxiety" in online forums such as psychcentral.com revealed a plethora of individual sensitivities, which can then be categorized into several common sources: domestic, environmental, social and visceral (noises triggering anxiety in users on Psychcentral.com (2010) are seen in Table 3). The domestic triggers seem to recur frequently, perhaps due to the invasive nature of the unwanted sound - the sounds of inconsiderate neighbours pervade what should be the anxiety sufferer's safe zone. Then, categorizing by Shaefferian *reduced listening* (that is distinguishing the acoustic property of the sound, in Table 4) provides further creative potential, as the acoustic property can be used as a template to record or create different nuanced sound messages based on the aversive properties. The anxiety inducing acoustic qualities are largely either mechanical, loud abrasive frequency, vocal, repulsive visceral, or rhythmic irritation (either irregular or repetitive rhythms).

Table 3: Sonic triggers for anxiety shared by users on psychcentral.com

Domestic	Environment	Social	Visceral
vacuum cleaners “loud bass drum noise when a neighbor has a party” “floor shaking when air conditioner is running” “the shower & toilet above me” abruptly opening doors squeaky hinges on a door doors slamming “too much sensory input going on	cars splashing water, coming & going, idling dogs barking lawnmowers leaf blowers power tools high-pitched drill hammering revving motorbikes airplanes siren birds singing “constant mechanical noise of printer wheels” hand-dryer	toddlers running & screaming people talking “people that talk loud by nature” people hollering whistling footsteps “especially women in high heels” crackling sounds of wrappers or chip bags tapping “low repetitive beat of the big drum in a live band”	cracking bones (fingers, ankles, knees) nail-picking “it makes me feel utterly sick to my stomach” tinnitus loud clapping snoring eating sounds “like Chomp, chomp, slurp, sip, squish”

Table 4. Categorization of sonic triggers by quality using *reduced listening*

Mechanical	Loud, abrasive frequency	Vocal	Repulsive Visceral	Rhythmic irritation: Irregular - Repetitive
vacuum cleaners “floor shaking when air conditioner or washing machine is running” lawnmowers leaf blowers power tools high-pitched drill airplanes siren mechanical noise of printer wheels hand-dryer	cars splashing water “the shower & toilet above me” crackling sounds of wrappers or chip bags cars coming & going revving motorbikes squeaky hinges on a door	toddlers running & screaming people talking “people that talk loud by nature” people hollering whistling too much sensory input going on (TV, talking, radio, computer) football crowds	cracking bones (fingers, ankles, knees) nail-picking, “it makes me feel utterly sick to my stomach” tinnitus loud clapping snoring eating sounds “like Chomp, chomp, slurp, sip, squish”	cars idling outside doors slamming abruptly opening doors loud TV ads “loud bass drum when neighbour has party” birds singing dogs barking “low repetitive beat of big drum in live band” hammering footsteps “especially women in high heels”

Inviting users to include their own custom template of sonic triggers or indeed synthesized timbres means that they can create an exposure stimulus that is more aligned with their identity, using their preferred musical vernacular (Magee et al., 2011). The Digital Audio Workstations available now enable even a musical novice to engage in compositional therapy, as there are vast libraries of instrumental loops and synthesizers that can be layered together, without previous music theory knowledge. Apple Logic Pro has a bank of musical loops to draw from, so it was ideal for the children's workshop in Magee et. al's study.

A key benefit of a simulation soundscape, is that the user is presented with a concrete, replicable stimulus timeline and is guided by realistic triggers to respond to, rather than the uncontrollable real-world in vivo exposure or imaginal exposure, in which immersion can be limited by a strained ability to accurately recall memories (Gamito et al., 2010). The exposure stimulus is tailored to empower the user, so it becomes an otherworldly, heightened environment with choice isolated elements. Even if visual Virtual Reality is not photorealistic, the provided imagery and sounds are meaningful external stimuli to respond to, as opposed to pure reliance on imagination, including salient sounds users may have forgotten or suppressed (Rizzo et al., 2006). There also are reports that exposure therapy is perceived as less stigmatized than counselling, as it's delivery is more akin to sensory entertainment such as gaming or cinema.

Ambiguous sound encourages the listener to actively seek meaning, so they become engaged and inquisitive rather than just passively receiving the sounds, complacently aware of their origin (Eckman 2012). Uncertain sounds in First Person Shooter or quest games train the user to be attentive to their surroundings and find causal meanings embedded within sound events; offering a space for imaginative interpretation encourages a more active emotional and visceral involvement. Minimalist sound design (seen in games such as *Eternal Darkness* and *Silent Hill 2*) can prevent user habituation: a prime example of this is felt when playing *Doom 3* - a few well timed loud sounds cause a greater shock than bombarding the player with a constant barrage of loud sounds, due to the self-protective aural reflex which perceptually diminishes sustained loud volume over time by an automatic clamming up of the auditory receptors (Toprac and Abdel-Meguid 2011). Indeed, use of mid volume ambient noise, such as ominous hissing of gas vents or electrical hum seems to provoke suspense and thus, a more nuanced anxiety by means of immersion in a generally perilous environment (Cheng, 2014). Aesthetically, the semantic origin of "noise" derives from the latin, *nausea* meaning disgust and visceral disturbance from external sources (such as motion), and several western languages correlate noise with unwanted fear, states of alarm or conflict, triggered by aggressive sonic indicators of danger such as weather anomalies: the physical body and the psyche are at odds with the intrusive sound (Sangild, 2002). In acoustic science, noise is broadly defined as a fluctuating, busy signal, packed with multiple frequencies across the audible spectrum blasting in chorus, varying from *white noise* (containing all frequencies) to more selective low portions of the spectrum in *purple noise* (Sanglid, 2004)

Mysterious acousmatic sounds, such as a disembodied baby's cry will generate anxiety and inquisitiveness, as well as paranoia and self-doubt that player has missed a visual cue (Cheng, 2014). These games can be seen as exaggerated, heightened simulations of perceptual experience - in comparison the everyday real world will seem more placid as the user is trained to cope with a game's exhausting surround sounds and indeed utilizes them to detect events or to enjoy the buzz of virtual fear, a heightened stimulation. A controlled virtual provocation of fear enables user habituation and adaptation to real world problem solving, aiding the user to be able to discern between a real threat and a virtual threat. Moreover, these virtual threats can even symbolise the psychological intrusion of unhelpful automatic thoughts, an allusive mechanism employed by a Serious Game for Cognitive Behavioural modification in children called *Treasure Hunt,* which features annoying flying fish bursting into view unexpectedly (Brezinka and Hovestadt, 2007).

2.3.2 Digital Sound Manipulation.

A solid base with which to begin composing a soundscape, is to collect recordings from real world sites known for their striking acoustic properties, as the type of sound that would be made in the space can be sought, predicted in advance (Schafer, 1994) (see examples in Section 3.2.2). These sounds can be edited using a reduced listening technique to extract intriguing, sudden, or tonal sounds. This process provides hundreds of short clips, which can be stitched together in looping musical sequences. Whilst it is ideal to personally record sounds for soundscape compositions, it is invaluable to draw upon the extensive sound effects libraries available to practitioners. Realistically, there are limitations to how many sounds can be recorded by one researcher in a short time span, so more obscure sound effects are sourced from the Sound Ideas Effects Library, in addition to online libraries such as freesound.org and SoundSnap.

The repetition of a single sound can transform the listening mode: from one of initial identification, to one of confusion at its unnatural repetition, to the eventual dissolution of the sound as signifier, freeing the sound of its connotations somewhat forcing the listener to scrutinise merely its acoustic properties, and also begin to see the repeated sound as a musical motif. There is a sense of fusion of beginning and ending, the sound has become a Möbius strip of pitch contours and attacks and decays (see a visualisation of this seemingly infinite sonic Möbius strip in Figure 3) (Dack, 2013).

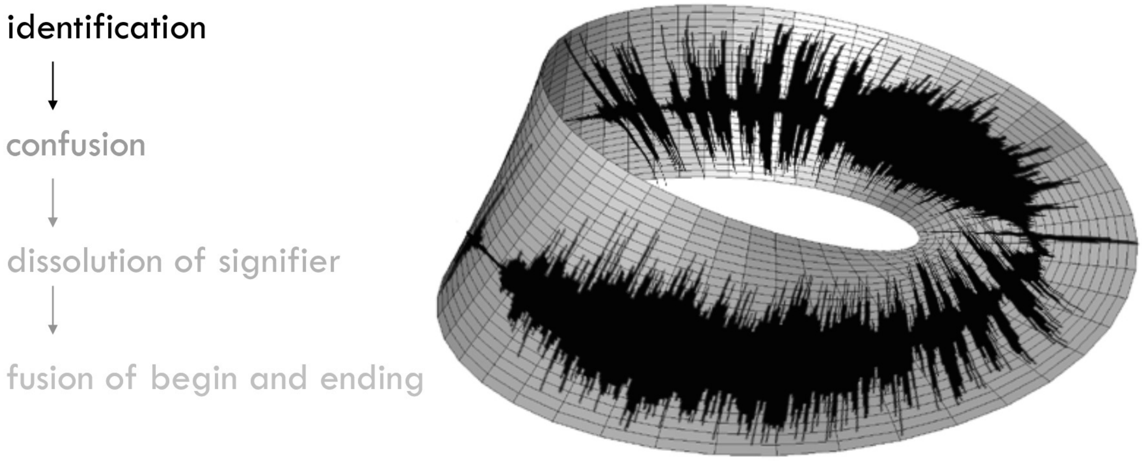


Figure 3: The repetition of a single sound can transform the listening mode: the sound becomes a Möbius strip of pitch contours and attacks and decays. Diagram by author (using Möbius wireframe image from Bourke 1996)

As perceived when listening to Steve Reich's tape loop work, *Its Gonna Rain* (1965) and Pierre Henry's study of squeaking doors, *Variations for a Door and A Sigh (1968)*, the single short sound evolves to a much more menacing onslaught when extended temporally through repetition, or the emotion in a voice can be "magnified" (Ross, 2007). The four principle fluctuations in mood induced by sonic repetition are visualised in Figure 4. However, repetition can become profoundly irritating, akin to the frustration of canned "hold music," which often features faux-ambient saccharine tunes, or degrades popular classical works, rarely playing the movements in their entirety – ironically, the jarring looping of a short segment somehow exacerbates the boredom, frustration and anger of being placed on hold, extending the ordeal (Ashton, 2010). The incessant repetition of a found sound can provoke an uneasy sense of the *uncanny*, a Freudian term denoting the unpleasantness of perceiving objects that are lifelike but slightly wrong looking or sounding, or resemble the ghostly reviving of the undead. If sounds were originally made by real people or material situations, but they are played and re-played as if stuck, like a broken record or pop up ad, this can seem uncanny (Freud, 1919). *11'09"01*, Alejandro Gonzalez Inarrutu's hotly contested film "tribute" to the sufferers of the terrorist attacks on the World Trade Center, features an overwhelming compression of hundreds of found sounds and media reports, abstracting the words from many languages, into tonic prosody, a speech noise which emits voices across the frequency spectrum, overloaded to the point of unintelligibility and bombardment. The “accelerated repetition” is said to resemble the sensory perception at the point of trauma, symbolising the inability for the traumatized process memories along a rational timeline (Young, 2007).

Conversely, repetition can lilt from the excessively grating, towards a hypnotic soothing of cyclical sounds, reminiscent of those played on the Ethiopian lyre *bagana*, which often consist of a short melody of 8 to 30 seconds repeated over at least 10 minutes – these spiritual songs are known to induce religious meditation, ecstatic trance states and emotional catharsis (also due to the employment of anhemitonic *tezeta* scale, literally meaning “nostalgic”, and the “sentimental” *anchihoye* scale) (Weisser, 2011). Indeed, repetitious music has long been ingrained within Ayurvedic spiritual meditation, from mantra-chanting to socially-cohesive drumming circles (Hanser, 2009).

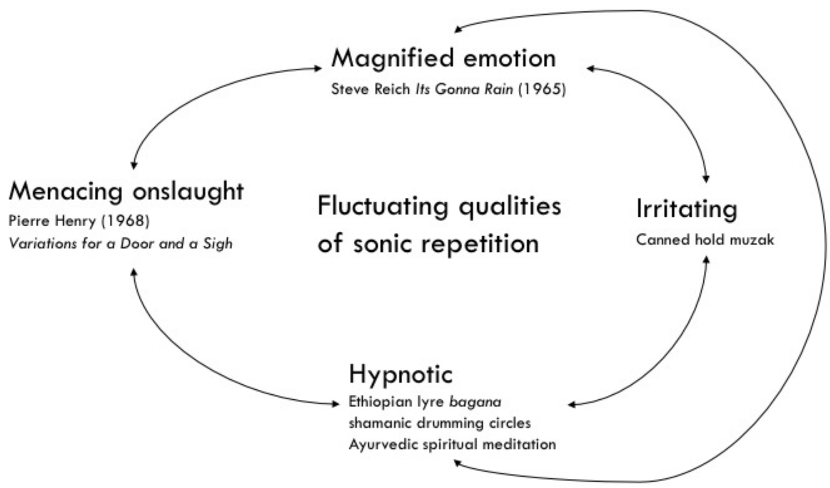


Figure 4: Repetition of a sound can induce four mood inductions: menacing onslaught, irritation, magnified emotion, or hypnotic trance states

Practically, base elements of field recordings, foley, sound effects and instrumentation and vocalisations are combined to play along multiple tracks simultaneously, either organised into coherent musical arrangements or renderings of real world scenarios (see the list on the left of Figure 5). Each of these sounds can then be creatively skewed to reproduce the unsettling phenomenological distortion perceived during moments of panic, anxiety or depression, using digital filters, time stretching, delays or even altered equalization to sweep up from a natural sound to a distorted high frequency, or to strip a voice of its clarifying harmonics to abstract words or make it sound monstrous. These initial composition techniques are further enhanced by the astonishing capabilities of surround-sound panning, used frequently in mass entertainment (mainly to aid suspension of disbelief and heighten immersion in cinema, or to provoke fear in theme parks).

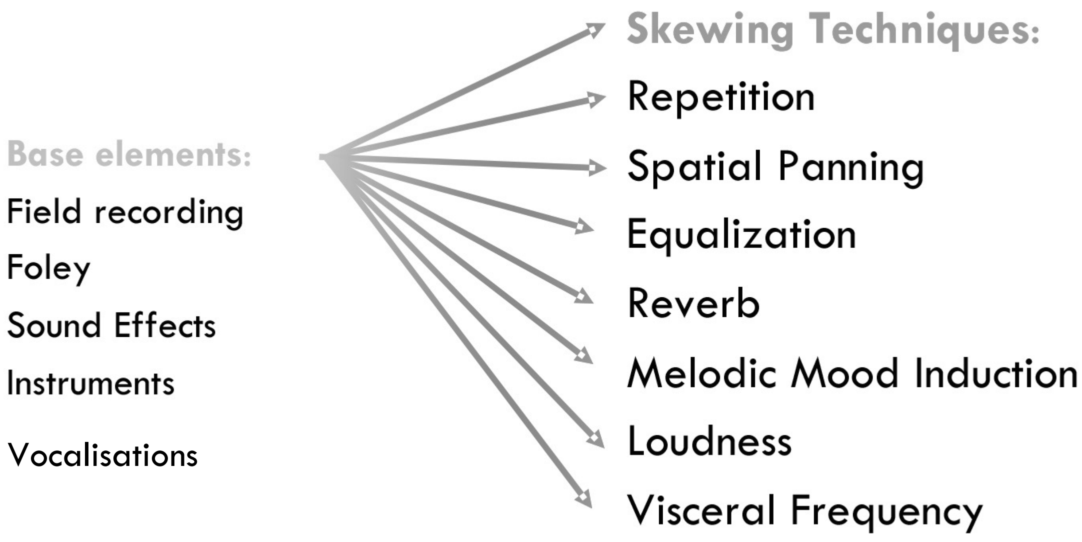


Figure 5: Base element sounds and skewing manipulation techniques

The psychological aims of fear extinction and exposure therapy also provide creative frameworks, as techniques used can be translated into concrete sonic ideas. Fear extinction aims to desensitize the patient (that is, reduce the activation of the brain's fear center, the amygdala) through repetition of aversive stimuli, or through counter-conditioning, to "establish a new stimulus–outcome association where the trauma reminder no longer signals danger" (Wegerer et al., 2013, p.2). A form of counter-conditioning could be pairing an aversive auditory stimulus with a pleasant visual stimulus (see Figure 6 for an example of purple skies shot from the window of an airplane, which might offset the sound of a pneumatic drill played alongside it), so the user can visualise a happy place whilst listening to horror sounds.

Figure 6: Counter-conditioning can alternatively be induced playing an aversive sound alongside a pleasant visual

Counter-conditioning can even emerge from a singular sonic stimulus: four basic sonic counter-conditioning methods are illustrated in Figure 7. First, the impact of a shock is diminished by repeating the shock sound, so the shock essentially fades in intensity each time the sound is heard. Second, a grating timbre could gradually transform to a pleasant timbre, through semantic means (a baby crying gradually transforming to laughing) or purely through sonic structure (a high frequency could be digitally stepped down to more comforting lower frequency), or a loud sound becomes quiet (a baby crying at close range moves further away, drifting into a indistinct echo).

Figure 7: Counter-conditioning: implemented in a soundscape by transforming a sound stimulus over time

Even classical music uses transformation to express and provoke psychological resolution, when distressed jerky bows of a violin in a Minor mode modulate to gentle calm strokes in a Major mode. Counter-conditioning through a journey to a Major resolution from an established Minor mode underlies the concept of the choral-orchestral, funereal requiem, an astounding example being Fauré's *Requiem in D minor, Op. 48* (1887-1890). Fauré himself expressed a positive outlook on death, writing that the work evoked "a very human feeling of faith in eternal rest" (Fauré, 1921, cited in Steinberg, 2005). This is heard in the unusual conclusion of the last movement, *In Paradisium*, an extremely delicate, reassuring haze of broken triads in the orchestra (reminiscent of a gently rippling pool of water) with a constantly ascending, angelic melody from the choir – importantly this movement is entirely in D Major, lifted out of the previously funereal D minor. This is said to give "finality and closure to the work" (McKendrick 2007).

Reverberation is the naturally occurring reflection of sound waves after an initial source, idiosyncratic to each architectural space - a longer decay time indicates a larger room, and a glass-walled room produces a longer decay time than a foam-walled studio due to the reflective properties of hard rigid surfaces. Reverberation provides a sense of depth, enhances a mood, or reconstructs a natural or overemphasized decay time, with ability to sample real-world acoustics using an impulse response recorded on location. It can be used either to realistically match sounds to a visually depicted environment, or to create a hallucinatory inner-subjective viewpoint if there is no reverberation, to show the sound is not occurring in a real space but is merely imagined.

Equalization is the name of the process of either boosting or removing the low, middle or high frequencies from a natural sound (often a complex blend of several harmonics) or music, either to emphasize verbal clarity or to distort the voice beyond the point of recognition. Each sound quality has distinct connotations (McGeoch, 2013), often unconsciously associated, as shown across the frequency spectrum in Table 5.

Table 5: Psychoacoustic connotations of various frequencies boosted using equalization (McGeoch, 2013).

Frequency (Hz)	Low 20 Hz →		High 20kHz
Excess	boomy muddy	honky nasal	harsh sibilant
Connotative Association	power rumble ominous dizzied perception	natural unthreatening	definition loud edgy bright sparkly presence
Deficiency	Thin anaemic wimpy	dull too realistic	distant

2.3.3 Mood-induction sampling

Samples from film scores, created with a specific manipulation of mood, can attach false emotions to an abstract image or film. In *Ghosts*[1] (2013), a soundscape panned across 5.1, the most prominent example is *Virtua Mima (Voice Version)* from Satoshi Kon's *Perfect Blue* (1997). This haunting, a-cappella theme features layered chromatic chanting, with stop-starts and demonic throaty sounds. The "mm-mm" taunts run in two tracks each floating past in opposite directions; a solitary choral voice is centered; one of the last "aaaas" floats from front to back. The voices are panned to burst through from the front and float away to the back as they end. The disembodied voices are activated to frighten the viewer and test the limits of the *exit sign effect*, usually an undesirable result of overzealous Dolby Surround Style mixing in cinema (Kerins, 2011), where sounds

[1] Argo, J. (2013) *Ghosts*. https://youtu.be/JZlRQGpaowo

randomly emerge from the rear surrounds prompting the spectator to turn around believing the source to be from the cinema space itself: hence shattering the illusion of the narrative. However, deliberately sending sounds from behind the listener in non-narrative artworks make the viewer question their listening space, and rudely awakens them from the lull of the pleasant. As the listener is forced to listen to bombing sound effects with a visual absence of the cause, or haunting disembodied chanting vocals, their listening mode is changed, converting causal or semantic listening into a pure reduced appreciation of noise. One of the soundscapes used in this research features original instrumental score, combining an ominous-harmonious piano underlay with a supra-expressive cello voice, as well as a disturbingly high pitched (seemingly castrati) vocal excerpts from a Japanese Butoh dancer.

2.3.4 Spatial panning

Spatial surround sound is most commonly employed in mass entertainment venues such as cinema and theme parks to immerse the viewer in simulations of real world or fantasy scenarios: this immersion, in turn aids a suspension of disbelief. However, a small number of music producers are beginning to employ spatial techniques, using digital panning to create surreal extensions of space – a soundscape that can surpass the reality of sound physics (Moorefield, 2005 cited in Michelsen, 2012). Notable examples include Michael Jackson's *Scream* which utilised ambiguous sonic collages panned in naturally irreplicable spatial arrangements. Another more contemporary example is *4DSOUND*, a performance from Max Cooper, which comprised of 16 columns of omnidirectional speakers in a 12x12x4 array, spatially controlled by Ableton Live – although this spatiality is engineered to be experienced live, the performance was binaurally recorded and published on SoundCloud, so can be shared with a larger audience.

The principal researcher's past portfolio of surround-soundscapes (panned in 5.1), produced in the School of Simulation and Visualisation, provides diverse examples of mind-altering affects induced by spatially directed sounds. *Anti-Cocktail-Party-Effect*[2] (2013) replicates the sudden manifestation of irrational panic attacks in social situations. When an anxiety sufferer sits in a crowded restaurant, they can become hyper-attentive and paranoid of passers-by or fellow diners' scrutiny - this perception is conveyed by the dizzying swirling panning, as the chatter originates in a normal static surround (in all

---

[2] Argo, J. (2013) *Anti-Cocktail-Party-Effect.* www.youtube.com/watch?v=LmiEy9dqhqE

channels), then slowly jumps from one isolated point to the next, then runs around the room, the crowd transforming into a terrorizing poltergeist. The chatter is manipulated using interactive wavering tremolo on MAX MSP - the chatter fractures, becomes compressed and overloaded, speeds up, evolving to monstrous digital warping, sweeping to a totally incomprehensible high pitch. This is the antithesis of human's inherent perceptual ability to decipher language in a crowded room: the opposite of the psychoacoustic *Cocktail-Party-Effect*. Wine glasses clink with unnerving regularity blasting from various points in the room, in a lack of synchresis with the images of static glasses. The chatter and background music is at first familiar and amiable and then gradually the noise becomes overwhelming and the low-frequency effects channel is used liberally to physically shake the listener.

A sound composition can be encoded into a phenomenologically engaging spatial array through various panning styles. For example, *Blood Set in Motion*[3] (2013) is a simple hymnal synth harmonic progression with a simulation of mirror neural and circulatory responses, and corporeal imitation (imagined singing). Breathing, spatially pulsing movement of music replicates the idea of musical rhythms directly catalyzing the acceleration of the listener's heart rate. Sonic events include swooshes of a whipping stick, set in a rhythmic pulse, and the bubbling of a fountain to hyperbolize a rush of blood. *Trauma*[4] (2013) has an ominously quiet organ prelude, with an unsettling percussive a-rhythm, suddenly launching into a cacophony of messy oscillating, searing chaos. Like a brain swarming with traumatic assaulting memories, random strikes burst through from all directions, and the piece ends in a blare of tinnitus. A listener gave feedback that the timbres evoked "a digital machine gun" (Argo, 2013) . *Harmonising the Musical Present with the Musical Past*[5] emulates the notion of perceptual fusion of temporal events within a musical structure, as a familiar harmonic progression through G Major to E Minor, gradually morphing into to a wide overlap of notes through the delayed piano and layering of timbre. The tension between F-sharp and G recurs again and again, but always harmonized slightly differently. Tape ghosts from re-recording are simulated, using occasional bursts of discordant synths, panned to emerge from the rear speakers. The illusion of appearing and disappearing ghosts is created by short bursts drifting past the listener from front to back, in 5.1 surround-sound. A detailed description of the

[3] Argo, J. (2013) *Blood Set in Motion* www.youtube.com/watch?v=3VzDMNfsrbg
[4] Argo, J. (2013) *Trauma* www.youtube.com/watch?v=YoHUeD_BvKs
[5] Argo, J. (2013) *Harmonising the Musical Present with the Musical Past* www.youtube.com/watch?v=FaSKPuu_

spatialisation processes employed for the new *Immersive Soundscapes to Elicit Anxiety in Exposure Therapy,* in the current research can be found at 3.2.2.

2.3.5 Ambisonics – Conventions and Subversions

In this study, the original concept at the heart of ambisonic sound has been subverted. Usually, an accurate representation of a real-world soundfield from recordings is the aim, or acoustic simulation of an architectural model (Laird et al. 2014). Instead of faithful reconstructions of existing soundfields the principal researcher has created synthetic soundfields, using methods akin to those used by Dolby Surround Style sound mixers in cinema, where multiple stereo sound objects are panned across a planar array to animate sounds across movement paths. However, in ambisonics these individual stereo sounds are each panned to move across all three dimensions. (In a few specialist cinemas, Dolby Atmos is installed, which does integrate a height dimension, as speakers in the ceiling are also used.)

Ambisonic recordings (of e.g. complex ambiences such as the cacophonous blaring of music and children shouting at a fairground) or theatre productions, are often captured using soundfield microphones which record in first order B-Format (Inglis, 1977). B-formats are essentially a four-track recording where each track, referred to W, X, Y and Z, is recorded discretely from each of the four membranes in the tetrahedral microphone. The W channel acts as an omnidirectional microphone, whereas each of the X, Y and Z channels act as figure-of-eight capsules aligned to three dimensions (W refers to the overall sound pressure, X calculates a front-minus-back sound pressure gradient, Y is the left-minus-right, and Z for the vertical dimension, up-minus-down). Then these B-format recordings are imported into a Digital Audio Workstation like Reaper, and a decoder such as Blue Ripple mathematically converts these four channels into to either a mono, stereo, 5.1 or ambisonic mix. The co-ordinates of each speaker in the specific studio are first manually typed into the decoder (later saved as a template). The decoder uses these speaker co-ordinates to calculate the optimum level and EQ weighting for each speaker, for accurate ambisonic soundfield reproduction. This system differs to 5.1 mixing in that panned sounds are not fed discretely to each speaker, but instead the sound is allocated a locational weighting which distributes the sound across several speakers, but at differing levels. Usually, panning of these soundfields is very limited, either to or spin or tilt the soundscape as a whole. However, in this research this technique is subverted, instead methods akin to Dolby Surround Style are used (Kerins, 2010), as multiple point-source sounds are each animated synthetically – this technique is explained further in Section 3.2.

A key advantage to mixing using the ambisonic panner, is portability: if the soundscape needs to be played on another speaker array of different dimensions (consisting of at least four speakers) for public exhibition, the encoder in the new ambisonic layout will computationally remodel the weighting distribution to the new speaker co-ordinates. Thus, the synthetic soundfield originally mixed in the in the Arup Ambisonic Soundlab can be transported to new locations.

There are four key conceptual motivations for the use of ambisonics. Firstly, when presenting a huge collection of sounds in a short space of time, it makes sense to play them across many speakers, so listeners can hear and perceive more sound sources simultaneously than would be possible across two speakers. This is beneficial for two reasons: it overwhelms perceptual capabilities causing stress and thus anxiety, while also increasing the likelihood that a sound will be heard that resonates with a personal history to induce memory recall. It was observed during World War Two that when different alarms would emerge from different locations in the command centres it was much easier to instantly register the meaning of each alarm and act (Holman, 2008).

Secondly, Ambisonics allows the composer to flit between representations of reality and soundscapes which go beyond reality to emulate perceptual distortions during anxiety attacks and induce tension, dizziness and chills symptomatic of mood disorders. Third, sounds presented in stereo are limited as being symbols, listened to causally - there is emphasis on the cause of the sound, the source and the meaning. Conversely, sounds panned across a spherical array are perceived as antagonistic, animated, bombarding the listener – the listener might feel bullied by autonomous sound poltergeists which elicits a rich range of emotional responses (shock, fear, victimisation or paranoia) not possible when the sound is static. Whilst a 5.1 array also allows sound to be panned from behind the listener, a periphonic ambisonic speaker array allows sound to emerge from above and below, so the sound designer can simulate objects dropping from the ceiling onto the listener's head, or rising from the floor. (Dolby Atmos, the newest specialist cinema surround sound emulates this with overhead speakers and through the advancement of discrete channel mixing previously used in 5.1, effectively releasing the audio objects from discrete channels, weighting them across speakers in a similar computation to Ambisonics. Dolby Atmos has also been configured for the home, in a 7.1.4 set up, with seven surround speakers on the horizontal plane, one LFE channel and four overhead speakers.

Finally, the fourth reason Ambisonics is implemented is that immersing the listener in the centre of a spherical array of sixteen speakers (including a sub woofer to play back the Low Frequency Enhancement, or LFE channel) ensures that the body is totally enveloped by sound, simulating the pre-natal sensation of hearing which begins as early as four months in utero, where the foetus is surrounded by the mother's voice and "timpanic" heartbeat (Murch, 1994), in addition to the environmental sounds are filtered through the womb felt and heard as low frequency throbbing (Kerins, 2010). Crucially, the Arup Ambisonic soundlab was also chosen as it is an optimised test environment, acoustically isolated, private and with controlled conditions.

2.3.6 Repeated exposures, Novelty and Loudness Fluctuations

An important question is, what is the optimum length of soundscape exposure, to elicit maximum anxiety and then encourage habituation. As per standard therapeutic practice (Gerlach and Neudeck 2012), ideally a user should return for a second or third soundscape exposure session (with the same soundscapes) and this will undoubtedly affect the listener's experience: what was plotted to be a startle sound might actually fall flat if the participant now knows what to expect; or conversely, participants may become more immersed by the second and third hearing of the same soundscape. Ultimately the aim is physical habituation to anxiety eliciting sounds (and their sources), so anxious symptoms should noticeably diminish upon repeated listens. While habituation would work with repeated exposure sessions, it also works even within one attendance in soundscape exposure, at the level of individual sounds within a soundscape. (In this experiment, it is not the entire soundscape that is being repeated, but many of the sounds within each soundscape are arranged in a repetitive pattern.)

An inverted-U-shaped function (an increase in liking, followed by a decrease) was discovered by Schellenberg et al. upon repeated exposures to the same musical stimulus, with either 0, 2, 8 or 32 exposures (cited in Berlyne, 1970). The perception of the stimulus was seen to range from at first appearing as novel, but due to the unknown levels of arousal this would incite hesitation; then participants began to like listening (now they were aware of the song's arousal level); then after a reasonable number of listens it perceived as tediousness; finally, it becomes maddeningly overplayed (Berlyne, 1970). Indeed, excessive repetition of sounds is a much-contested form of torture, as the US military are known to excessively repeat playback of one song over and over again, using "futility music" try to crack prisoners into revealing information at Guantanamo Bay (from aggressive heavy metal, to seemingly benign but gratingly saccharine tunes such as the *I Love You* song from children's TV show, *Barney*) (Smith, 2008). The use of music and sound in warfare throughout history has come to light recently, from Steve Goodman's acknowledged collection of writings, *Sonic Warfare,* as well as the Scottish musicologist, Morag Grant's research group "Music, Conflict and the State" which focused largely on music used as torture. (Steve Goodman's accounts of *Sonic Warfare* (2010) such as the *Wandering Ghost* wailing voice blared to scare the Buddhist sensibilities of Vietnamese soldiers, and the nausea-inducing beating of ultrasonic bursts from the Squawk Box used in Ireland exemplify the extremes of psychoacoustic manipulation, using sound as a weapon to mentally disturb or cause permanent physiological harm.) Although the soundscape might become irritating if it is excessively repeated (in multiple soundscape exposure therapy visits), it is expected that upon participants' hearing of aversive or shock sounds repeatedly that the novelty and fright factor will eventually diminish - the listener may remember when exactly the loud shock is immanent. This is key to habituation and fear extinction: if psychophysical evidence is found (attenuation of GSR peaks-per-minute average by the third soundscape) to back up this desensitization hypothesis, this is incremental to proving the efficacy of soundscape exposure as an anxiety desensitization therapy.

Moreover, it has been experimentally demonstrated that when the user is in control of the startle-evoking stimulus, the attentional focus required occupies the brain to the extent that the startle-response is overshadowed. Thus the user can habituate themselves to a sound by taking control of the timing of playback: essentially engineering a consented-to, conscious anticipation. This effect is found in Hoffman's studies of *Attentional Factors in Elicitation and Modification of the Startle Reaction* (1995), where a human subject's reflex-blink reaction to a self-administered tap to the glabella is almost non-existent compared to the strong blink when another person supplies the tap – the motor engagement of self-administration distracts, and total awareness of the timing and force of the tap reassures the person tapping themselves that there is no need to blink as a reflex. Hoffman (among others including Bjorkstrand, 1973; Grings, 1960; Haggard, 1943; Maltzman & Wolff, 1970; Staub, Tursky & Schwartz 1971, all cited in Hoffman, 1995) has claimed that even forewarning of an aversive stimulus can elicit a weaker response than if the listener is genuinely surprised by the exposure. Hoffman noted that forewarning (which only revealed the sensory modality of the stimulus to be presented) attenuated the amplitude of the reflex response, when comparing glabella-taps to sudden loud bursts of noise at 110 dB SPL (decibels sound pressure level, the standard unit for acoustical loudness measurement). Indeed, the consensual scenario, the mere act of agreeing to undergo exposures to loud startle sounds primes the listener to anticipate these abrasions, to psyche themselves up as we would tense our bodies before a rollercoaster; unlike the uncontrolled intrusion of hyper-sensitizing sounds upon non-expectant ears and nervous bodies in everyday life. Essentially, there are five key techniques to diminish shock as seen in Figure 8: repetition of sounds, verbal forewarning, clues to generate a sense of dynamic expectations (such as gradual crescendos or diminuendos), the consensual scenario of agreed exposure to psychologically prepare the listener for loud sounds, and knowledge that the aural reflex kicks in to protect the inner ear following a sustained loud period.

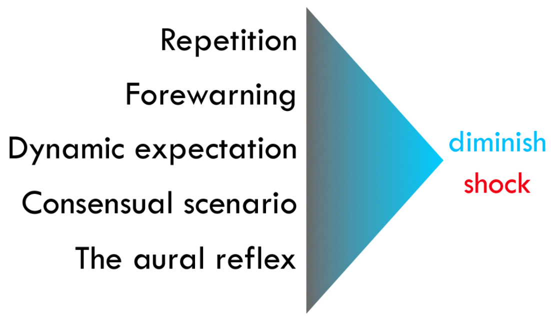


Figure 8: Perceived loudness and shock can be diminished through repetition, forewarning, dynamic expectation and manipulating the inbuilt protective aural reflex

Of course, the exact timing of the loudest abrasive sounds, or indeed the type of sound is withheld to a degree, in the soundscape exposure proposed in this research. Nevertheless, humans are often able to predict the events in a musical sequence, anticipating either a musical climax, or a shocking change of timbre or volume if the soundscape is remarkably placid for an extended length of time. The nature of musical predictive processing is in fact key to the musical induction of pleasure, either through surprise deviations from expected patterns (eliciting a release of dopamine), or satisfaction in correct predictions (serotonin) (Altenmuller and Schlaug, 2013; Hoffman, 1995). The composer can manipulate listener expectations, by deviating from traditional musical structures, or offering few musical clues, employing dramatic, unexpected changes of pace, timbre, volume, expressivity (use of vibrato) or melodic mode. A gentler exposure therapy should integrate musical warning signs within the soundscape (such as a gradual crescendo), so the listener can prepare themselves for a startle sound, thus focusing purely on habituating to the sounds. However, if the user must be habituated to the overarching scenario of intruding stimuli on the nervous system, a more surprising soundscape should be implemented, devoid of structural guidance. Overall the user of soundscape exposure therapy has contractually agreed to expose themselves to startles, so they may have already attuned their nervous receptors in advance, to minimize their startle reflexes. Hoffman reveals other methods to attenuate the startle reflex, such as instructing the participant to ignore startling stimuli, which inhibits the startle response, or by focusing the listener's attention on an alternative space. This effect was observed with rats, as it seemed that a background noise of gentle 70 dB SPL pulsing eradicated the startle response to a pistol shot. To further enhance this masking effect, a user of soundscape exposure therapy could be advised in advance of coping strategies, instructed to focus on either counting the drumbeats or following a bassline upon a swelling loudness or increasing frequency of another timbre. Thus, the soundscape exposure user is dually likely to have built up their confidence in the exposure setting: they have both demonstrated to themselves that they can withstand aversive stimuli for long periods, and should have newfound self-admiration for pro-actively confronting their anxiety symptoms and causes.

Although the long-term efficacy and cost-efficiency of established exposure therapy has been experimentally demonstrated, even surpassing other psychological treatments (Deacon and Abramowitz, 2004; Olatunji, Cisler and Deacon 2010), it is still widely underexploited. Often, when exposure therapy is employed the effects can be limited, due to the cautiousness of negative therapists (Deacon and Farrell 2013). Therapists can be concerned about the ethics of temporarily inducing suffering in their vulnerable clients, and perhaps even fear the litigation ensued if the client revokes consent. Thus, the therapists are likely to scale back the intensity of exposure, or implement avoidance methods to attenuate arousal. Ironically, relaxation exercises undermine the purpose of exposure: ultimately the client receives an exposure but does not fully embrace the symptoms. The therapists' fear of inducing anxious symptoms inadvertently reinforces the client's tendency to catastrophize, so they will ultimately lose faith in their resilience to tolerate challenging physiological stresses. The clients try to distance themselves from the gravity of the trauma, only half-heartedly re-experiencing the traumatic sensation – thus, they are likely unable to achieve true catharsis. The client must decide their most desired outcome: a mere desensitization to a sound stimulus; or habituation to anxiety symptoms themselves through psychoeducation and a catharsis of unresolved trauma. If the latter is the priority, the user should be fully immersed in the entirety of the anxious situation (completely absorbing the external stimuli and mindfully aware of the bodily response), rather than be overprotected, which ultimately stunts any chance of resolution or catharsis (Schmidt et al., 2000). Even if the client does not successfully achieve habituation within one session, the session can nonetheless instil a sense of pride that they sustained a highly anxious state without any long-term harm (Deacon, 2012). Optimally, the exposure should be intensely aversive, enough to elicit genuine anxiety, which the client gives informed consent to. To ensure ethical approval in this research, participants are only exposed to loud volume levels for a limited time, adhering to World Health Organization guidelines (Olatunji, Deacon and Abramowitz, 2009).

The anticipation is an important part of a shock, as expectantly waiting for an ominously quiet or sparse soundscape to become dense and overwhelming can be more unbearable than the startle itself. After all, the participant has been briefed that they will be exposed to abrasive sounds, so they will undoubtedly be unsettled by seemingly peaceful sounds. To produce a genuine shock sound, it essentially should be very loud (110 dB SPL is the preferred volume used in Hoffman's 1995 experiment), which brings ethical concerns. The participants receive a disclaimer in the *Information Sheet*, that the exposure will not be any louder than the legal threshold which people are willing to expose themselves to in the ever-increasing loudness of cinema. There is a strict World Health Organisation guideline, starting at 86dBA SPL for 8 hours, 90dBA SPL for 4 hours, 94dBA SPL for 2 hours, 1 hour at 98 dBA SPL (see Table 6). As can be seen in the table of legal exposure times to loud sounds (Table 6), part of the reason a shotgun is so frightening, other than the obvious violent threat association, is that it is so loud that it can harm our hearing. The sound of a shotgun is both a semantic indication of a violent weapon, which imposes a threat to end the hearer's life; but it's loudness alone invasively penetrates the ear, imposing a threat to kill our sense of hearing.

Table 6: Legal exposure times to loud sounds with examples, as a guide for realistic levels in composition whilst maintaining participant safety (Fox, 2010)

Noise level (dBA)	Example	Maximum Exposure / 24hrs
85	passing diesel truck	8 hours
91	squeeze toy, lawn mower, arc welder	2 hours
94	inside subway car	1 hour
100	riding a motorcycle	15 minutes
103	sporting event	7.5 minutes
112	rock band	56 seconds
115	emergency siren	28 seconds
121	thunderclap	7 seconds
124	balloon popping	3 seconds
130-140	peak stadium crowd noise	less than 1 second
140	air raid siren	NO EXPOSURE
150	fireworks	NO EXPOSURE
160	fighter jet take off	NO EXPOSURE
165	shotgun	NO EXPOSURE
170	.357 magnum revolver	NO EXPOSURE
180	safety airbag	NO EXPOSURE
194	rocket launch	NO EXPOSURE
	soundwaves become shockwaves	

As sound waves are inherently fluctuations in air pressure caused by vibrations, there are two prominent units with which to measure acoustic loudness: the original one being dB SPL, decibels Sound Pressure Level and which was then followed by dBA. The A-weighting given to dBA aims to gauge a sense of perceived loudness, the sound level that is perceived by the inner ear cochlea. Any level above 140dBA will cause permanent hearing damage (even for a very short exposure time). (There is yet another loudness unit, to measure digital amplitude levels, which will be used in the analysis of GSR response to loudness, using the amplitude statistics from the binaural recordings of the soundscapes: decibels relative to Full Scale (dBFS), in which 0dBFS is the upper limit, and very quiet sounds are often around -50 dBFS. dBFS is only used as it is difficult to accurately measure and record dB SPL without specialist equipment. dBFS should not normally be used as a measurement of loudness - as it is a measurement of peak digital audio amplitude. dBFS is a digital peak measurement mechanism where 0dBFS corresponds to the maximum digital number available.) In the Ambisonic SoundLab, even though the soundscape playback always adheres to ethical guidelines, it is still possible to implement very loud volume, as long as it is only for a short period. Nonetheless, the limit to what can still be deemed as pleasant is much lower than the legal threshold.

In addition to the actual loudness of the shock, mastery of the aural reflex is required to effectively manipulate the perceived loudness. A loud bang can follow a warning crescendo, or it can burst through a period of quiet, completely unexpected. Even if the shock sound is at the same volume in both situations, the unexpected will always be more jarring. A shock is also more potent with a powerful attack, an action attached (such as a strike) rather than just loudness; if it is extremely transient it can be disturbing as we have insufficient time identify the sound source; or if it is an extended stinger it can be unbearable as the loud sound continues much longer than expected. A gently encouraging approach for soundscape exposure therapy might be to honestly signal the exposure time, with a visually coded countdown (with white countdown for overall and red short-term countdowns for the stingers), so the user is aware exactly how long they will need to endure, so they do not have anxiety heightening "false hope" that the exposure may be ending (Stiegler and Davis, 2010). The entire exposure time should not be consistently high volume, due to the protectively diminishing aural reflex; most of the soundscape should be a quiet-moderate base, or even a meditative aural *mandala* of repeating patterns (which may provoke dreamlike cognitive dissociation) (Herbert, 2011) from which the shocks should leap out from unexpectedly, in contrast forcing an immediate sensory engagement and hypervigilance. Humans eventually become habituated to noise when it is a stable loud drone, as our aural reflex clams up to shield us from nerve damage: however, unpredictable sonic bursts from quiet are more powerful if our ears are sensitively attending to soft sounds, thus have not had the time to build an aural reflex response (Hegarty, 2013).

Miki Yui's music is part of a Japanese movement Onykyu, where they exclusively capitalise on the enhanced attentional perspective to small quiet almost imperceptible sounds (Rigby Hanssen, 2012). Relating to Don Ihde's notion of auditory imagination, Yui's small sounds seem insidious, as they merge easily into what could merely be the product of our imagination – it is difficult to discern whether they are real external stimuli or auditory hallucinations. We are not overwhelmed by these sounds, instead we concentrate on attending to them and try desperately to amplify them; at first we are frustrated by this straining, but gradually we become enamored by this microscopic mode of attention. It will be fascinating to see the physical and mental affects induced by the opposite end of the listening spectrum: too quiet can be equally unsettling as too loud, if not more. The listener is more attentionally involved if it's a soft sound, whereas the brain essentially protects the listener from the very loud sound - which would be counterproductive in exposure therapy. In fact, the yearning for a total silence has been a source of fascination for artists, especially John Cage whose seminal *4'33''* (1952) directed a piano player to be mute for the entirety of the piece. The piece was designed to reorient the audience to the incidental sounds in the auditorium (coughing, the footsteps of listeners who walked out) – this simulated his profound experience in an anechoic chamber. A keen follower of Zen Buddhism, Cage sought total silence, and mistakenly believed he could experience it in the heavily insulated acoustic laboratory at Harvard University – however he was stunned to hear the usually imperceptible buzzing of his nervous system. More recently, Sean Street was unnerved by the engineered silence in an anechoic chamber for the BBC Radio 4 programme, *The Sound of Fear*, and deemed it to be "the most frightening sound of all" (Street, 2011).

2.4 Physiological Monitoring to Inform Compositional Decisions

In this research experiment, *Immersive Soundscapes to elicit Anxiety in Exposure Therapy,* diverse audience-response data is collected: ranging from quantitative physiological data (unconscious response) to qualitative written feedback (subjectively perceived response). The benefit of employing portable physiological monitoring is that it enables frequent testing in the optimal sensory environment of the Ambisonics arrays at the Digital Design Studio. A physiological monitoring system is implemented, which takes into account the notion that signatures of acoustic processing are actually sometimes easier to see on the skin, rather than measuring brain activity. There are two psychophysical data collection approaches which were considered for this study, Electromyography and Electroencephalography, but these were ultimately rejected in favour of Galvanic Skin Response, Respiration and Heart Rate.

Electromyography (EMG) is a measure of muscle contraction and tension induced by abrasive sounds, or sonic shocks activating the startle mechanism as well as chills of musical frisson, often found of the trapezius muscle in between the spine and neck (Rickard, 2004). Electroencephalography (EEG), would allow a measure of accurate real-time brainwave patterns to locate brain stimulation and identify if memories are being triggered or there is a purely sensory engagement. The EEG device measures raw brainwaves, distinguishing mental states across a broad spectrum, meaning that a listener's instantaneous moments of musical pleasure can be identified: from when the listener has a relaxed state of engagement with the sensory environment (alpha brainwaves at 8-12 Hz), his/her expectation of changes in the sensory environment, e.g. due to stressed, anxious states (Beta brainwaves at 12-38 Hz), to the active processing of acoustic sensations (Gamma brainwaves 30-70 Hz). Thus, the *Immersive Soundscape to Elicit Anxiety in Exposure Therapy* should be provoking the stressed Beta waves, which can then lead to a sensory-euphoric Gamma state, encouraging a leap through and out of a depressive state. Significant attenuation of depression can be clinically indicated through long-term power rises of the left frontotemporal alpha and theta wavelength in a relaxed EEG reading (Fachner and Stegemann, 2013), with an immediate shift from a right-hemispheric dominant frontal alpha asymmetry to the left hemisphere when depressed teens experienced musical pleasure (Field et al., 1998). In general, the effects of music listening are largely observed in the right hemisphere (Tervaniemi and Hugdahl, 2003). A growth in Frontal midline Theta Power is said to be aligned with a lessening of anxiety (Mitchell et al., 2008), also associated with a focused mental exertion which could be stimulated by soundscape exposure.

For logistics purposes and to streamline the data to be analysed (prioritizing the methods most commonly used in psychological studies to detect moments of strong emotion), it was decided that this study would only record the participants' Galvanic Skin Response, respiration and pulse-rates (see Figure 9, images from Concord Health Supply, 2014, Stens Corporation, 2014 and Cooking Hacks, 2014). These are used to pinpoint moments of strong emotion induction: sudden peaks in signal are attributed to instantaneous sounds, gradual attenuation associated with habituation, whereas a gradual surge is seen as a response to building of sonic textures. Specifically, Galvanic Skin Response (GSR), measures the instantaneous sweat secretion and piloerection elicited by fear or musical frisson, and its increase may even be susceptible to individual timbres, reacting strongly to percussive sounds (van der Zwaag, Westerink and van den Broek, 2011). A record of the participants' pulse-rate (PR) allows an identification of moments of shock or waves of relaxation – particularly, a surge and then a consequent attenuation of heart-rate-reactivity is indicative of "emotional processing," that is, an arousal and then adaptation of the fear response (Lang and Cuthbert, 1984); Foa, Huppert, and Cahill, 2006). Anomalies in resting breathing rates are searched for in the recorded respiration data (RESP): gasps, sharp deep inhales or moments where participants forget to breath are indicative of a strong sensation triggered by a particular sound.

Figure 9: Pulse Rate (left), Respiration (centre) and Galvanic Skin Response (right) (images from Concord Health Supply, 2014, Stens Corporation, 2014 and Cooking Hacks, 2014)

Biofeedback is often used to visualize or notify a tangible reward for a user's strengthened endurance of exposure, or an excited bio-signal can even transform the music featured in a game, to empathetically match the player's nervous state (Champion, 2011). Ubisoft's O.zen uses a fingertip heart rate monitor (a photoplethysmograph) as an interface to play light-hearted racing or shooter games as part of a holistic bio-monitoring package (to instil personalized breathing and cardiovascular exercise programs). The O.zen also provides psychoeducation, to aid the user's understanding of the detriment to health caused by stress-inducing breathing (Yelena Kozlova, 2013). A Serious Game to aid paediatric treatment for anxiety and depression, *The Journey to the Wild Divine* (Knox et al., 2011), implements biofeedback-controlled guided-imagery situations, such as a bridge construction exercise, where any progress on the structure literally crumbles as the user becomes frustrated, only allowing completion upon sustained relaxation. So instead of merely perceiving a fleeting feeling of relaxation, the user achieves tangible outcomes. The game trains the user to recognise the physiological symptoms of anxiety, and encourages the user to control their own predicament through disciplined regulation of breathing states, by offering concrete short-term rewards. Indeed, it is also beneficial for the therapist to log all recorded biodata during exposures, to build a bank of psychophysical results with which to review the user's habituation progress over several sessions.

During soundscape exposure, facial expression tracking can be employed to visually detect emotion induction or utterances: this is a technique commonly used to pick up notable automatic gasp or moan reactions in real-time, or even when a particular sound spurs the participant to share their thoughts aloud (Leadley, 2011). Real time objective physiological data is absolutely necessary: if questioned long after exposure, test subjects forget certain nuances - we can notice when we feel chills, (for instance, in Loui et al.'s study, *Effects of Voice on Emotional Arousal* (2013), the participant documented their frisson using a joystick interface, which is problematic due to delay to allow for conscious realization. Accurate pinpointing of unconscious response is necessary to reveal which isolated sounds and images cause each emotion or physical sensation. In addition to memory loss from delayed questioning, the subjective verbal response will also be subject to social masking (Kim and Andre, 2004), varying introspective ability, and uncontrolled participant honesty meaning the validity of the questionnaire is always to an extent questionable; hence the necessity of real-time measure of unconscious, nervous-system responses. Furthermore, psychophysical monitoring can detect micro-reactions to more subliminal musical features (such as the aggression of pronounced percussiveness rather than an accelerando), which may not be noticeable enough to manifest in a conscious subjective awareness, but still have significant impact on the body (van der Zwaag, Westerink and van den Broek, 2011) (Gendolla and Krusken, 2002).

It was envisaged that the ideal form of the research would draw multiple comparisons (see Table 7). However, the hypothesis has been refined to the most pertinent research questions, such as does soundscape exposure elicit strong sensations, and if so, is it because the sounds are tailored to the individual. Another crucial question is whether those with higher levels of anxiety in everyday life experience a stronger sensation induction than those with low everyday anxiety. Originally, it was desired that the effects of mere stereo listening would be compared to effects from immersion in spatial arrays of 5.1 surround sound and Ambisonics. The effects of sound alone, versus synchronized audio-vision, versus audio with asynchronous visual accompaniment were ideally to be compared, to quantify a higher level of engagement when the two modalities are merged, or discern if the visual is a cognitive distraction from the visceral audio, or if mismatching audio-visual causes discomfort. (Many listeners to augmented soundscapes begin to feel nauseated and anxious upon encountering a subtle audio-visual mismatch, for example the pairing of the virtual sound of a car approaching through headphones whilst simultaneously seeing a bike in the real world in Marcus Leadley's *Reconfiguring the Acoustic Environment* experiment (2011). Listeners claimed it is "very nice" when by chance audio and visual become synchronised – it becomes a harmonious relationship akin to unaltered perception. The difference in response to a more tangible musical melody was to be compared with the response to more abstract, temporally extended use of sound in a non-musical manner. Importantly, the difference between the physiological effects induced by personalized soundscapes and those induced by non-relevant soundscapes can still be measured.

Table 7: Distinctions between physiological effects provoked by contrasting media outputs

Compare effects of	stereo listening	→	surround-sound immersion
	sound alone	→	synchronized audio-visual
	synchronized audio-visual	→	asynchronous audio-visual
	tangible musical melody	…to effects of…	non-musical use of sound
	personalized soundscapes	→	non-relevant soundscapes
	real world natural sounds	→	digitally synthesized sound
	real world video	→	abstract animation

The average physiological response across all participants will need to be discerned (to cancel out noisy physiological signal artefacts), as well as an average across subjects, to find correlations and distinct uniform responses, dispelling the subjective differences. However, the normal practice of exposing the listener to repeated listens of the same soundscape would be problematic, as it would evidently cancel the effects of musical novelty, diluting the initial shock factor of certain sounds, so these measures of repetition are instead thoughtfully integrated into the composition as a whole. (In fact, the method of looping, through isolating a sound event in a field recording and using it as a rhythmic musical structure, or continuous timbre enables this discern of an average response through repetition, or extension of sound.)

2.5 Quantifying Catharsis

A crucial answer sought in the project is not just to discern whether it is possible to momentarily scare participants, but to identify signs of the participant's physical desensitization, their ability to withstand sensory bombardment becoming more secure over repeated exposures. The other fundamental goal of soundscape exposure therapy is to drive users to confront and resolve underlying psychological issues, to enact a catharsis prompted by sonic memory triggers.

Catharsis studies reveal that this intense emotional consolidation is best quantified through longer-term qualitative data. In addition to the questionnaire posed one week following the soundscape exposure in this experiment, an analysis of a timeline of facial expressions provoked by the soundscapes would be ideal, as well as a record of verbal utterances and tracking participant's crying. In early psychoanalytic theories, Freud and Breuer stressed the necessity of catharsis for the shedding of trauma-induced pain: catharsis was defined by Freud as an un-supressed "energetic reaction" ranging from uncontrolled tears to a conscious "act of revenge" (1895, cited in Latham, 2013, p. 107). Crying is a critical sign of healing: many see tears as a mechanism to purge the body of stress-induced bio-toxins, facilitating a recovery period to return the body homeostasis after a peak emotional experience (Bylsma, Vingerhoets and Rottenberg 2008). Ethically, inducing tears in a participant should not cause long-term physical pain or deterioration, and it rarely causes mental deterioration. On the contrary, Bylsma, Vingerhoets and Rottenberg (2008) discovered that only 9.7% of participants reported that they felt mentally worse, and only 15.6% felt physically worse after their most recent crying episode – mentally, most felt better (51.4%) and some the same (38.3%); physically, some felt (27%) better while most felt the same (56.4%).

2.6 Conclusions and Hypotheses

Here the salient techniques from music therapy and psychiatric treatments such as fear extinction and exposure therapy have been identified, and an amalgamation has been suggested, a new psychotherapeutic soundscape exposure therapy, with painstakingly considered high-quality audio production at the helm. In this research, the impact of immersion in anxiety-eliciting soundscapes (panned across higher order ambisonics) is quantified, through the evaluation of the physiological reactions to the most consistent anxiety triggers, corroborated by rigorous qualitative questioning of participants. Upon collation of the physiological signals, it may become apparent these signals can be used as biofeedback, to manipulate the audio in real time using the listener's physical reactions, akin to methods used for serious games. Indeed, an integrated reactive playback system may be the optimal mode of engagement to soundscape exposures, to maximally challenge the user, although this is beyond the scope of the current research.

The soundscapes assembled through a survey of everyday anxiety triggers could also spread the awareness of the physicality of mental illness, by facilitating empathy from non-sufferers as sufferers' altered sense-perception is accurately replicated (rather than attempts at verbal explanation). This could reduce stigma of the less visibly understood mental disorders, and provide a sensorial avenue for psychological connection, between healthy audience members and the oft-alienated anxiety sufferer - to communicate a sensation that cannot be expressed in words.

This literature review has inspired several hypotheses: crucially, it is envisaged that the participants will likely experience a multitude of complex sensations and emotions, either in response to sounds that resonate with their personal memories (potentially unresolved emotional traumas) or in response to sounds which startle or unnerve the listener purely by their acoustic nature. Hypotheses are drawn from two disciplinary contexts: psychotherapies which use an external antagonist or stimulus (such as exposure and music therapies), and immersive sound design.

Drawing on established acousmatic sound design techniques such as *musique concrete* (Schaeffer 1966) and acoustic ecology (Schafer 1994), and Dolby Surround Style (Kerins 2010), five densely detailed soundscapes consisting of real world anxiety triggers have been arranged, placing each sound across a unique path in a state-of-the-art ambisonic array. These sounds are arranged in such a way as to provide auditory simulations of anxiety eliciting situations, providing narrative dramaturgies that directly incorporate non-musical sound sources, as opposed to purely tonal, instrumental music. These sounds are not presented in isolation, rather layered in sophisticated analogical relationships (either blending disparate sound sources with similar acoustic qualities, or bridging between acoustically diverse sounds by means of narrative links). This method is used to engage the listener for extended periods of time to induce an optimally challenging state of flow (Csikszentmihalyi, 1990), as non-musical sounds are coherently arranged in a symphonic manner. It is imagined that hyperreal spatialisation patterns, specifically designed to disorientate the listener might induce anxious physical sensations (such as dizziness) more readily than realistic spatialisation (although a realistic rendering of a frightening scenario may indeed cognitively trigger fear).

It is known that sound and music can elicit a wide array of psychological and physiological effects (Juslin and Vastfjall, 2008, Saarikailo 2008). Upon exposure to the immersive soundscapes in this research, it is hypothesised that there will be a higher frequency of galvanic skin response activity in addition to a greater number of respiration anomalies generated by the most sensitive groups (those with higher levels of pre-existing anxiety, or those participants who are hearing a soundscape as the first in the sequence). As indicated in established repetitive exposure therapies (Gerlach and Neudeck 2012), as time goes on and the participant reaches the third soundscape, it is imagined that elicitation of physiological activity will be dimmed somewhat, as the participant should become desensitized. On the whole, it is predicted that there will be a short-term increase in negative emotions, from immediately pre-exposure to immediately following the exposure, but there may be a long-term decrease in negative emotions. Additional long term benefits perceived a week following the exposure might also include a rise in participants' abilty to endure anxious sensations, and several instances of catharsis (resolution of underlying fear, trauma or grief). It is predicted that manageable low levels of negative sensations associated with anxiety may be directly induced upon listening to the soundscapes, in tandem with more positive sensations. This complex, multifaceted reaction to an explicitly antagonistic soundscape should act as an example to the participants that even in the face of adverse emotional and physical states in everyday life, several isolated positive sensations might also be perceived simultaneously.

3 Methodology

3.1 Introduction

The broad timeline of the methodology is as follows. At first academic literature and online mood disorder forums were surveyed to identify existing therapeutic frameworks and devise a database of frequently experienced sonic anxiety triggers. Then a diverse library of sounds was collected, either newly recorded across several site visits or sourced from libraries over the course of 2014: these were then arranged into five archetypal anxiety soundscapes from January 2014 to February 2015. Upon completion of the soundscapes, each individual sound was assigned a unique spatial path in the ambisonic array from February to June 2015. Ethical approval was granted following a meticulous 30-page document which outlined every step of the process: the logistics, the carefully considered recruitment of participants, the ensuring of data protection, participant anonymity, and health and safety. A multichannel monitoring system was installed in the ambisonic Soundlab for a five-participant pilot study to test a smooth running of the procedure, and to assess the validity of the questionnaires, over July and August 2015. Results from the pilot study were closely evaluated to confirm that indeed both the recorded physiological and perceived responses yielded rich and meaningful results. Although the data for the pilot was initially assessed participant by participant, new streamlined methods of analysis were devised for the experiment, to gain insights collectively (across all participants or between groups of participants) to gauge the short and long term impact of the exposure experience on sensation ratings. The experiment ran over October and November 2015, where thirty participants experienced the immersive soundscape exposure.

In Section 3.2.1, the editing of the soundscapes is explained, followed by the motivations for their higher order ambisonic implementation (Section 3.2.2). Then, a comprehensive overview of the physiological monitoring system is provided, which ties into experiment design, and the ethically considered participant recruitment. The entire experiment procedure is presented in more detail in Chapter Four, which covers the initial pilot phase.

3.2 Soundscape Production

At this stage, it is crucial to reveal the content of the soundscapes, and the dramaturgic motivations behind the inclusion of each sound. Broad sound libraries which symbolised archetypal anxieties were gathered form field recordings, foley, sound effects and musical instrumentation and vocalization. Anxiety can be internally generated, devoid of an external stimulus; the sufferer can just be alone in a silent room and anxiety can well up of its own accord (excessive mental rumination could be said to be a type of internal stimulus). However, when it comes to composing a soundscape, with real recorded sound stimuli, phobias have the most direct associative stimuli, an identifiable cause and effect – anxiety is the effect of exposure to fearful stimuli. More complex kinaesthetic sensorimotor vestibular sensations can also be sonified: for example, vertigo in response to height is not necessarily sound-based but can be evoked through the sounds of whirring ascension in a dilapidated creaky elevator. Phobias are anxiety-inducing fears, usually with a concrete stimulus, whereas Generalised Anxiety Disorder can have a socio-emotional cause, usually through specific damning social events involving insults to the sufferer's identity - experiences which cannot easily be recorded and scenarios a lot harder to symbolically sonify, other than through muffled non-specific shouting staged by actors (akin to the artfully constructed ambient arguments from sound designer Ren Klyce for David Fincher's *Se7en* (1997) (Kerins 2010)).

An imaginal exposure technique that incorporates a socio-emotional, cognitive language, is the client recounting a traumatic experience, at first writing the narrative in the present tense, including as much vivid imagery as possible, then dramatically reading the account into a sound recorder, constantly rating their anxiety levels. Then, the client must listen to the recording again and again until their anxiety lessens to a baseline rating (Dugas and Robichaud, 2007). Perhaps this technique can be used for soundscape exposure therapy in the future, but in a more abstracted manner, through incorporating short samples of a recording of the user's initial interview (to identify triggers) into a personalised soundscape (Koerner and Francalanza, 2012, p.209) or placing a microphone in front of the listener to pick up their utterances and echo them back unexpectedly in the soundscape.

The sound libraries collected for the study have been categorized into *Situational Phobias* (fear of flying, disaster, agoraphobia) *Social Anxiety*, *Body Anxiety* (anorexia or health worries), *Violence* (for PTSD sufferers) (see Figure 10-16), or just mere *Sensory Irritation*, for the many people who are antagonised by environment sounds that get on their nerves, as opposed to causing fear responses (as if to a threat). The relevance of each anxiety can be established by comparing the length of the lists of sounds (identifying which anxiety offers the broadest range of different sounds to work with). However, the most anxiety-eliciting category is likely to be the one where the sounds are the most frightening, or acoustically abrasive or emotionally engaging. In the primary results for the experiment (Chapter Five), the anxiety theme which has the greatest number of sounds pre-identified by participants as sound triggers is identified, as well as the anxiety theme that elicited the highest physiological peak rates and highest consciously perceived sensation scores.

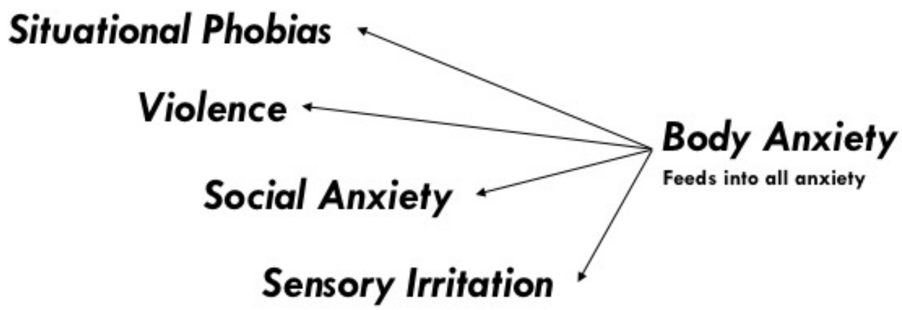


Figure 10: The anxiety themes best addressed with sounds

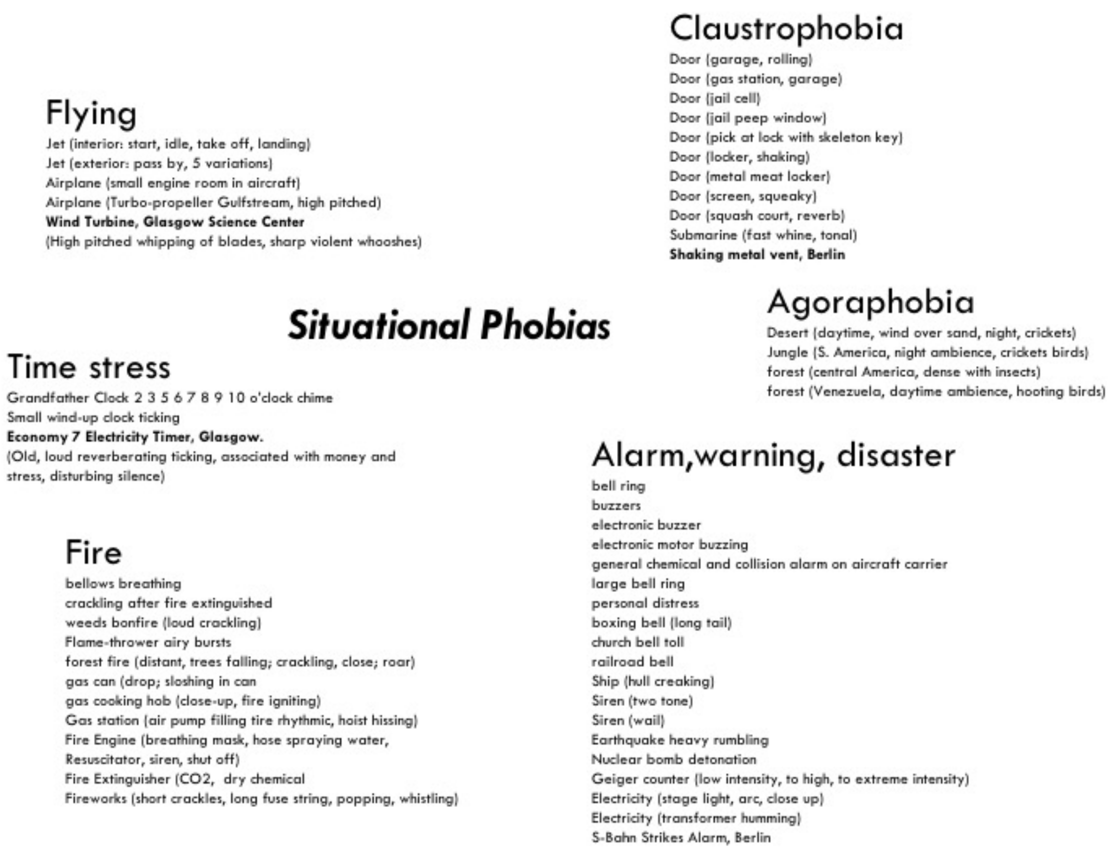


Figure 11: Sound Library for *Situational Phobias* soundscape

Horror
knife stab
screech
visceral blood splats and body squishing
body fall on concrete
Organ and Choir from Church exterior, St Andrews
muted, haunting ghostly voices, short organ loops.
Foley recording chopping and smashing vegetables

Weapons
machine gun (Thomson Sub, long burst, HK53 long burst, dull, M60 harsh, echo)
gun clicks
rifle boom shot
rifle clicks
camera timer
Knife (army, remove from sheath)
Knife (bayonet, remove from sheath)
Chains
Chainsaw
Glass (cras, heavy smash)
Metal (large crash, squeaks and movement, high pitched scrape, squeal metal trolleys, small drop, scrape high
Tin can crush (sharp piercing sound)
Handcuffs
Spray paint
Squash hits
Foley
Wooden sticks whipping
Childrens Music Play
cheap plastic Instruments played by 2 and 3 year olds
loud incessant monotone recorder blows, chaotic glockenspiel hits, rattles, wooden clappers, laughing.
Devil's Mountain, Berlin
overwhelming reverberation in listening domes
exploration of echo and amplified feedback, violent percussion performance using found objects (elastic band, stones glass, bottle tops foot stomping, wooden log)
Derelict warehouse on Pointhouse Road, Glasgow
Contact microphone on rusty spring
harsh distorted screaming, percussive pinging
Music Room, Edinburgh College of Art.
tinny recording, distortion through contact microphone and pocket amplifier.
Cymbals clanging, contact microphone on cymbals through amplifier; rustling soft beater circling cymbal. tinny bass guitar,bell like dinging, ascending. Cello resounding in snare drum and cymbal, high guitar pinging

Violence

Animal
alligator (hissing)
black leopard
dogs (barking, whining)
guinea pig (squeaks)
mice (squeaking) tiger (growls)
wolves (howling)
Glasgow green
Geese screaming, Pug snorting
Kilpatricks Forest, Glasgow
early morning birdsong, walking on mud

Auto Crash
crash (dive bomb)
cutlass (wet road, fast)
drag race (burn outs)
dragster (idle)
Formula 1 race
Formula 1 single car round corner
Formula 1 single car into corner
vintage race (several cars, fast)
Explosion (fire, car)
head on collision
roll (continuous)
skid
skid then head on collision
sledgehammer hood
sledgehammer window
spray water (exterior)
spray water (interior)

Power tools
Compressor
Compressor (two tone)
Hand planer (several passes)
Jointer plate narrow (high pitched)
Lathe wood (rhythmic)
Blowtorch (oxy-acyl, oxygen bursts)
Vice (ping)
Woodworkshop (hand planer)
Saws
Metal Grinder
whining buzz, sparking, metal on metal scratching
The Whisky Bond, Glasgow
Construction sounds in reverberant warehouse space into exposed lift shaft.
Drilling (long, quiet, short, crescendo, rolling), hammering, strikes, sharp attacks with ghostly long reverb tail, blowing dust, swishing

Military
Helicopter (Apache, engine idle)
Helicopter (Twin Huey, idle shut off defined blade sounds)
Helicopter (Bell 206 observation helicopter)

RAF Search and Rescue Helicopter, Glasgow
large helicopter circling back and forth outside silent domestic space, intensely threatening, caused marked physiological panic
extended duration and gradual crescendo of approach, paranoia-inducing churning, flitting between high frequency whipping blades and low frequencies of engine's roar.)

Orange Walk, Glasgow
long marching band slowly moving along open river gradually fading away,
distant muted whistling, arrhythmic drumming, unintelligible dissolving of any tune, out of focus sound, often interpreted as antagonistic intimidation

Construction of *Sound on Sea* stages, Glasgow
nautical sounds, booming construction, hammering in distance, drone banghra piano and ominous rumbling soundchecks.

National Pipe Band Championship, Glasgow Green
cacophony of multiple bands simultaneous rehearsals and warming up sounds
mismatching drum rhythms, complex multilayered drones with minor fluctuations as individual pipers stopped and started, stressfully indiscernible fractions of tunes, spatially approaching and receding solos, mix of distant low frequencies and close high frequencies

Figure 12: Sound Library for *Violence* soundscape

Viscera

Bones cracking (knuckles, neck)
Nail clipping
Skin scratch
Shaving
Haircut scissors and electric trimmer
Foley recording: body sounds
Skin rubbing, bones cracking, clapping
Penetrabile, Jesus Rafael Soto, LACMA. Los Angeles
people navigating the participatory sculpture,
plastic yellow tubes slapping against bodies, laughing

Exercise

Exercise equipment (treadmill)
Gymnastics (horizontal bar routine, squeaks)
Gymnastics (trampoline, bounce)
Swimming (indoor, dive off board, single person swim)
Swimming (outdoor, dive off board. single person swim past)
Dance steps
Gasping breaths during and after run
Swimming pool, Banff whooshing of ventilation
Swimming pool, Perth sprinkler spraying into swimming pool,
wind chimes, wind, swimming strokes

Body Anxiety

Eating

Bubbles (champagne fizz)
Bubbles (soda fizz)
Bubbles (spritz into glass, running dry)
Bubbles (faint, fizz beer)
Bubbles (faint, pour wine into glass)
bacon frying
liquid stirring in cup
Wine glasses (clinking)
dishes (rattling on table)
rubbing thumb across plate (squeak)
Chartier, Paris
Busy food court
glasses crunching and rattling, drunk St Patrick's Day singing,
cutlery rustling shattering, plates slamming on tables, hurried
stressed French waiters shouting commands.
Kitchen foley
eating (banana, crisps, orange gulping, open mouth); ice
cubes creaking, melting then sizzling and steaming on hot pan,
kettle boiling

Hospital

EEG pens scribbling
heart monitor (768bpm, heart attack then flatline)
ventilator
Dentist (drill and spray water)
Dentist (metal pick polish drill)
Dentist (surgical glove)

Breath

Air (fast release, slow release, regulator breathing)
Male breaths (unsettling spaces between repeated exhales)
Close and contact microphone recording:
Breathing and vocal sounds
intimate, disturbingly close human sounds,
Phonemes, contact microphone sloshing around in mouth,
between teeth saying mmm, on throat saying sss, tt-tt-tt
heartbeat, breathy rumble breathing in lungs inflate,
ommms, mmmms, oooos, sigh, throat clicks,
struggles to produce lowest sound possible.

Water

Bubble (small)
Bubble (underwater)
Bubble (violent)
Bubble (mud)
Drips in tin (fast, reverb, slow)
Dry ice on piano strings

Geysir, Iceland.
gentle bubbling, sudden whoosh burst explosion, splash. Surreal extreme pressure
temperature
Waterfalls, Waves Crashing, Iceland.
loud noisy rushing varying in proximity. At times indistinct roaring
Heavy Rainfall, Glasgow.
gradually fluctuating noise intensity, tropical rainstorm associations, worryingly heavy
freak storm. partially obscured traffic sounds, percussive loudness of raindrops hitting
against metal balcony floor.
Kitchen foley
drinking and blowing bubbles, aerosol spray into sink, bathroom sink drips, drips into
glass, percussive clang of metal spoon on filling glass, drips in metal sink, contact
microphone on metal sink with drips,
Water dripping into glass, tin in various intensities
SWG3 Warehouse
dripping leak
Princess Diana Memorial Fountain and Kensington Gardens, London.
long circular fountain with numerous different pumping mechanisms,
idyllic sunrise pastoral nature sounds,
sparsely populated with brief interjections of posh London accents or exercise sounds.
rumble, bubble, waterfall, woofing, alarm, French phone call, splashing, squawking,
scaling bird tweets, running, gasping, whistle.
the Louvre, Paris
fountain rushing, French exclamations.
Cathedral of our Lady of the Angels, Los Angeles,
holy water fountain rippling, bell tolling
Italian Memorial, St Andrews Cathedral
Fountain and faint choir singing

Figure 13: Sound Library for *Body Anxiety* soundscape

Clothes

leather jacket
rip cloth
suit jacket
zipper
Leather creaks
Foley
hearing another presence's clothing sounds may be perceived as
an aggressive removal, or intimidating display, with anxiety triggers
reminiscent of an attack eg. belt buckle, zipper
loaded with connotations.
Movement in bedsheets

Social Anxiety

Footsteps

Male (combat boots, walk on concrete)
male (leather sole on concrete)
male (on bedroom rug, floor creaky)
male (on dirt)
male (on grit)
male (leather sole on creaky wooden floor)
male (leather sole on marble, public space, formal)
male (leather sole, on metal, distorted)
male (on squelchy mud)
male (on wet sand)
female (heels, running on concrete)
female (heels, walk on metal)
Footsteps on lava sand, Iceland
distinct connotations of calm walking, lighthearted jumping or
urgent running;
difference in authority and purpose between leather and sneakers
running in sneakers is for exercise whereas running in combat boots is
threatening chase; hearing a female running in heels unusual,
as they are not made for running in
The reduced properties of the sound can be seen as invasively irritating,
Distracting, footsteps on gritty flooring are so much more grating to hear,
due to the sharp high frequency crunching and chaotic mess of sound.
Walking on metal sounds like a dreamlike, otherworldly perception of
what could be a standard wooden floor.

Crowd

hockey arena (booing)
indoor (whispering)
stock exchange (frantic, aggressive)
night club (medium laughter, creepy)
Casino (slot machines)
Griffith Observatory, Los Angeles,
noisy excited children.
The Art School, Glasgow; SmartBar, Chicago; Watergate, Berlin
distorted, oversaturated techno music. short recordings from nightclubs
Ballhaus, Berlin
Tango music and footshuffling, plates and cutlery, cheering.
The Sony Center, Berlin
Fountain rushing, plates and cutlery, children yelps, music
1am drunks on S-Bahn, Berlin
Shouting, low frequency hum, wailing
Yes March, Glasgow
chanting, cheering, sirens in distance
Times Square, New York.
chaotic cacophony of traffic, roadworks, bursts of music from shops,
phones and cars, tourists shouting, manic laughing, rrrr! Frustration at
congestion, unfamiliar languages and dialects spoken, drills, buzzing,
and hissing, evil sounding dissonant tone, ambiguous subway rumbling,
homeless chanting begging, grinding, squeaking, beeping, revving, tinny
drumbeats from phone ringtone, Cheesy pop music blaring from shops,
Chappelle Notre Dame du Lys School playground shouts from apartment
Window indistinct cacophony, strange shout, weird blare, motorbike,
Opera de Paris, Paris
hauntingly quiet empty auditorium, marble floors large atrium, long reverb,
baby crying reverberant squeaks, stilettos clacking, floorboards creaking,
footsteps, French tour guides, loud traffic revving, bicycle bells, muted sirens,
faint piano playing, wavering alarms, child singing, gaspy breaths, coughs,
Princes Square Shopping Centre, Glasgow
recording from top floor picking up sounds of childrens
play area on ground floor, fragments of children' s yelps rising through
chattered reverberant shopping centre
It' s a Knockout Championship, Glasgow Green
Megaphone commentary, tacky music, aggressive, indiscernible speech,
whistling, taunting
Glasgow Green Football Club
fierce competitive shouting, almost like violent fighting, whistles, cheers,
heavy accents
Macy's Department Store, Chicago
American salesperson jargon chatter, revolving door.

Figure 14: Sound Library for *Social Anxiety* soundscape

Domestic

air conditioner
dishwasher (running, draining, hissing)
Laundromat washer (running)
Clothes dryer (running)
ceiling fan exhaust
portable fan (slow speed, high speed)
Cooking range hood fan (blowing)
Fluourescent light (hum)
Hand-mixer (jingling)
Shaver electric
Shower person showering
bathtub drain gurgling
Hair dryer large
Refridgerator compressor low hum
Switch rotary timer
Vacuum cleaner
(carpet beater, movement)
Vacuum cleaner
(hose, constant, movement)
Venetian blinds (swoosh)
mortar and pestle (grinding)
vegetable Juicer (grinding)
Kettle (on stove top, whistling)
Knife sharpener (manual, grating,
electric, alien scream)
Plastic bag (crumple)
bacon frying
liquid stirring in cup
Wine glasses (clinking)
dishes (rattling on table)
rubbing thumb across plate (squeak)
Home Foley
Squeaky door hinges,
shower running, bath filling,
hair dryer, hoover, balcony steps

Environment

Hedge trimmer (electric, high-pitched)
lawn mower (gas, constant)
lawn mower (gas, movement, distant)
lawn mower (tractor)
leaf blower
garbage truck
A814 Motorway, Pointhouse Road, Glasgow
deafeningly loud cars whooshing past irregular intervals
Downtown Chicago
traffic, reverberation off skyscrapers
traffic rattling metal bridges, riverside sounds,
traffic noise, traffic ambience in unpopulated square in
Financial District
Las Vegas traffic squeaking quietly
Grand Canyon fast food van generator buzzing

Sensory Irritation

Office

Computer (dot matrix printer)
Computer (high speed line printer)
Computer (laser printer)
Computer (photocopier, ten high speed copies,
repetitive)
computer floppy disk beep
computer keyboard fast typing
scissor cutting
Deskspaces, DDS and the Mitchell Library:
office fidgeting, book flicking pages.
***Meaning Inc.*, Michael Fullerton,**
Glasgow Print Studio.
Isolated sound of neon and LED lights buzzing, fluctuation of
frequencies as different lights flash on and off.
Human Nature/Life Death, Bruce Nauman,
Art Institute of Chicago
neon lights buzzing, on and off
Super-8 projector humming

Factory

Saw mill (logging, highest pitch)
auto plant (heavy ambience)
auto plant puncher
Automatic folding machine
Binder (hissing, popping)
Box maker (repetitive hiss)
Conveyor belt
Letter press
Metal punch press
Plane mill (large planer, whining)
Plane mill (large planer higher pitched whining)
Printing press (high speed, slow speed)
Scoring creases into cardboard
Sheet fed lithography press, printing press
Wahlenburgh cutter (swiping)
Yarn weaver
forklift truck (lower and raise forks, start up)

Construction

Drill hammer (grating, several attempts)
asphalt rollers
John Deere Metal Track bulldozer squeaky
concrete cutter up close
grinder driving steel girder
jackhammer irregular
loader beeeeep
pile drivers
cement mixer
ambience repetitive
several jackhammers compressed air
single jackhammer compressed air
Demolition (ambience, machines pushing metal)
Demolition (hydraulic jaw ripping metal)
Demolition (knocking down wall)
Times Square, New York.
chaotic cacophony of traffic, roadworks, drills,
buzzing, and hissing, evil sounding dissonant
tone, ambiguous subway rumbling, grinding,
squeaking, beeping, revving, futuristic sounding traffic,
blower hiss, clicking, squeltch, doppler effect beep,
pulsing rev, warped rev, tonal squeaks.

Figure 15: Sound Library for *Sensory Irritation* soundscape

The myriad sounds were layered together by sub-category (for example, breath, visceral, water, eating, exercise and hospital sounds in the *Body Anxiety* soundscape) and both causal and acoustic associations were drawn between individual sounds in these subcategories, to allow an organic metamorphosis of these chopped sound sequences. Each soundscape has a unique dramaturgy, from *Situational Phobias* erring towards realism, to the haunting *Violence* soundscape which is often seen as especially aggressive.

3.2.1 Soundscapes mixed for Ambisonic Array – *Violence, Situational Phobias, Body Anxiety, Social Anxiety* and *Sensory Irritation*

Violence[6] extends the archetypal horror stinger into a prolonged Shaefferian music concrete (see Figure 16). Analogies are drawn between acoustically associated sources, the less harmful mechanistic sound-a-like dampening the reaction to body horror sound effects. The rushing of blood is matched by the dystopian frenzy of motorway traffic; a sledgehammer piercing through glass is aligned with a knife monotonously stabbing; a hydraulic jaw ripping scrap metal is simultaneous with flesh squishing; pounding jackhammers coincide with machine guns of varying intensity. A subtle form of counter-conditioning occurs, when the listener is presented with a multiplicity of neutral and negative sound sources.

A more overt counter-conditioning occurs when the listener is confronted with positive music coupled with abrasive material noises, rendering the listener less susceptible to panic attacks triggered by intrusive unpleasant sounds in everyday life. A throbbing piano underlay gradually modulates from foreboding deep, dissonant minor tones to a consoling major resolution in delicate high notes. Short extracts of cello are digitally cut up and multiplied; whilst strings have been heard as supra-expressive voices throughout history (mimicking human cries, but with the capability to be faster, with a more diverse dynamic and pitch range), in this soundscape the cello parts exceed this notion becoming physically unplayable in real-life. The frantically stuttering cello semiquavers somehow comfort the listener, due to the organic breathy timbre, but their digital manipulation hinders the listener's sense of ease simultaneously.

---

[6] Argo, J., 2015. *Violence*. Listen to Track 1 on memory stick or available at: <https://soundcloud.com/jessicaevelynargo/violence-stereo/s-PtBEO >

The listener is constantly being interrupted, never allowed to settle into the soundscape: there are numerous sudden interjections of metallic squeaks, but their repetition gradually numbs their initial shock value. The composition deviates from traditional musical smoothness, but paradoxically constructs a pattern of constant expected interruptions. Just when the sound reaches peak saturation, there is a sudden dropout, akin to intrusive fearful memories barging in and out of focal consciousness in Post-Traumatic-Stress-Disorder. There is a sense of relief when the soundscape eventually quietens – although the soundscape is still not perfect, it becomes bearable with the pleasant elements now more audible. The soundscape's gradual reduction of intensity is a hopeful metaphor: realistically, no-one is ever cured completely from anxiety – but given enough time and effort, the mind can become freer to become aware of positive attributes of the same stimuli (memory or situation), as negative voices eventually recede into the background.

The *Violence* soundmap shows the integrated control baseline sounds (ominous layering of piano, aircraft whirring, dogs whining, dissonant bagpipes and the occasional metallic squeaks), from which two obvious fearful peak periods burst out: the first, a ghostly series of synthesized ethereal horror shrieks; the second, an assault of machine gun fire.

The *Situational Phobias*[7] soundscape is a more rooted in reality than the musical *Violence* or rhythmic but esoteric *Body Anxiety*, as it depicts real-world feared situations (see Figure 17). Even so, the construction of the soundscape toys with the listener's perception of time, in order to frustrate and annoy rather than necessarily elicit fear – an example is the repeated dissonant clock bells chiming which seem to persist endlessly. There is also space dedicated to remind the listener of menial but pernicious worries, as coins delicately spin and drop on to drums, occasionally rattling more abrasively onto metallic surfaces. These sounds are rendered in ambisonics to drop onto the listener from above, as if there is a phantom piggy bank emptying onto their head. When this discordant cacophony of bells finally ceases, the listener is abandoned in a vast desert, with only the faintest brush of wind against sand audible. Out of nowhere, the listener is suddenly clamped into an old high-speed traction elevator, whose upward ascension is temporally extended (through repeating the whoosh in a seamless loop, and panning it floor-to-ceiling, dizzyingly). When the lift doors retract, the listener is repeatedly blocked by a labyrinthine succession

---

[7] Argo, J., 2015. *Situational Phobias*. Listen to Track 2 on memory stick or available at: < https://soundcloud.com/jessicaevelynargo/situational-phobias-stereo/s-y5u0J >

of meat locker, jail cell, garage, submarine, and bank vault doors slamming, each one perceived to be in closer proximity than the next. The distinctive snap of a rubber glove and sloshing of a gas canister alerts the listener to a change of threat, as a distant forest fire encroaches onto this imagined claustrophobic cell – within minutes, the listener is engulfed in deep roaring flames. Listeners in the ambisonic array reported tingling sensations as they were authentically immersed and frightened in this acoustically generated fire, at times even looking around to ensure that it was only synthetic.

The roaring of flames blends into a rush of extinguishing water, which in turn aligns with the broad noisy spectrum of frequencies heard when flying – any fluctuations in the engine's nearly constant roar or indeed unexpected whines of electronics onboard a plane automatically instill panic in those phobic of flying. After all, humans' brains have evolved with an innately sensitive fear center in the brain, the amygdala, which is rapidly triggered by sound – a crucial survival mechanism when we were living in the wild, as we were most likely to perceive threats aurally first.

The *Body Anxiety*[8] soundscape elicits discomfort, visceral disgust and eventually outright panic (see Figure 18). The listener is first gently haunted by intimate breathing sounds which gradually crescendo into uncanny mechanical hisses of respirator, exaggerated blowing up of balloons and electronically skewed sucking on cigarettes. A suite of visceral scratching, buzzing and bones cracking follows, which is then thankfully offset by soothing (albeit densely orchestrated) loops of waterfalls rushing and geysers erupting, and viscous mud bubbling. Gloopy liquid textures fade into aggravating munching, chomping, slurping of food, with intermittent frying bacon and pouring of cereal, which invokes nausea, feeling especially invasive in the Ambisonic array. Frenzied chomping gives way to anthropomorphic wheezing of rowing machines, pounding on treadmills and creaking balancing beams, all implicitly generating heightened scrutiny of the listener's own physical health.

These pounding footsteps run onto linoleum floors in reverberant clinical corridors, as the soundscape incorporates alarming tropes from hospital dramas (such as EEG pens

[8] Argo, J., 2015. *Body Anxiety*. Listen to Track 3 on memory stick or available at: < https://soundcloud.com/jessicaevelynargo/body-anxiety/s-69cIy >

scribbling, heart rate monitors flat-lining and even erratic lockdown sirens from Broadmoor Psychiatric Hospital), to explicitly evoke the soundscape of death. Overall the soundscape first acts as a guided meditation, a redirection of the listener's attention onto their own body, invoking strange but largely pleasant, enjoyable sensations. However, eventually the soundscape represents the anxiety sufferer's inherent catastrophizing, imagining the worst-case scenario and forcing the listener to confront underlying fears of their own death or indeed recall the past experienced grief of death of loved ones.

The *Body Anxiety* soundscape's control period largely consists of haunting breaths, visceral scrapings and physical exertions – the anomaly peak period is a calm dropout of waterfalls rushing, heavy rain and champagne fizzing, to lull the user into a state of relaxation.

The *Social Anxiety*[9] soundscape is designed to disorientate the listener with a paradoxical experience of being isolated in the ambisonic array, whilst being bombarded acoustically by signs of life, a soundscape densely populated with voices (see Figure 19). The effect is confusing, as voices saturate to the point that the listener is unable to make sense of any words – there are too many voices, and ambiences from too many spaces for it to accurately simulate one fixed reality. The listener eventually stops trying to locate themselves in one acoustic space and just listens reductively to the acoustic qualities of the ambience. The listener also gives up attempts to follow a coherent dialogue, instead surrendering themselves in an exposure to the noises of social space. There are instances of emotional contagion arising from the perceptive sharpness reinforced by walking alone in environments where people naturally gather in groups, like shopping malls, art galleries, and transport hubs. Unable to hear a dialogue for long enough to eavesdrop, and indeed unable to join in with these past conversations, the listener is just immersed in snippets of chatter, only receiving traces of information, not enough to gain a significant insight into another person's life. With such minimal materials, the listener instead attentively navigates nuances of tone: anger, energy, excitement. This soundscape also recreates the social dissonance that occurs when trapped in a shared public space, as one person's excitement can easily inspire another's irritation.

---

[9] Argo, J., 2015. *Social Anxiety*. Listen to Track 4 on memory stick or available at: <https://soundcloud.com/jessicaevelynargo/social-anxiety-stereo/s-plyY5 >

The soundscape begins in a consoling religious space, Berlin's Kaiser Wilhelm Memorial Church, a glass and concrete honeycomb structure, where soothing silence is gradually disturbed by the quietest of whispers. Suddenly, exaggeratedly loud metallic footsteps burst in and the listener can vaguely discern a man's heavier gait stalking a woman's hurried high-heeled walk. There are distinct connotations inferred by the pace of the walk as well as the material nature of the sound – the type of footwear gives clues about the character of the wearer. Without a visual or narrative explanation, the listener evaluates through sound whether a walk is bouncy and light-hearted or if it is a creepily careful, sneaking slow pace with a menacing authority and purpose, or an urgent panicked running. Further, the reduced acoustic qualities of the sound alone can grate upon the ears, with stepping on grit causes a sharp high frequency crunching, and footsteps on metal flooring is unlikely to occur in everyday life, so thus can sound otherworldly or dream-like.

Music, often seen as a tool for social cohesion, is inherently unsettling when syntactical structures are extracted and ripped apart. Hear, for example, nonsensical extracts of tango music sporadically emerge from the soundscape. Recording the crooning music through several stages of mediation (taped long ago, played over a PA system, and reverberating throughout a Berlin dancehall, and played over another speaker array) is a way of capturing the essence of the space, an account of the whole musical-social experience. This historical music is juxtaposed with post-post modern electronic dance music blasted over an amusement park tannoy. The soundscape concludes with unnatural repeated laughing, as if from a broken robot. Looping a natural laugh strips it of its hilarity, rendering it uncanny – an extract of the real but causing unease due to its partial wrongness. This references the weirdness of canned laughter, which is carefully constructed for TV (Smith 2005) – the repetition of a laugh cycle is paradoxical, as natural laughter is spasmodic.

Finally, the *Sensory Irritation*[10] soundscape fluctuates between pleasant tickling of Autonomous-Sensory-Meridian-Response induced by delicate spinning of household fans, and a mechanical assault on the senses (see Figure 20). The listener experiences an all-too-familiar (albeit exaggerated) intrusion of a safe, private domestic space by noisy garbage

---

[10] Argo, J., 2015. *Sensory Irritation*. Listen to Track 5 on memory stick or available at: < https://soundcloud.com/jessicaevelynargo/sensory-irritation-stereo/s-o8Bcd >

trucks, lawn mowers and power tools. The hypothetical listener of the soundscape is driven out from the domestic space, seeking refuge in the public sphere, although they continue to be bombarded by obnoxious beeps, revs and clicks of oncoming traffic, gradually enveloped between screeching subway cars. Amateur street musicians aggravate with their trebly feeble sound systems, and irritating electronic dance music timbres, alongside whining toddlers and disgusting coughs, and rude harassments. These societal noises are eventually quashed by an orchestration of factory presses and demolition slams.

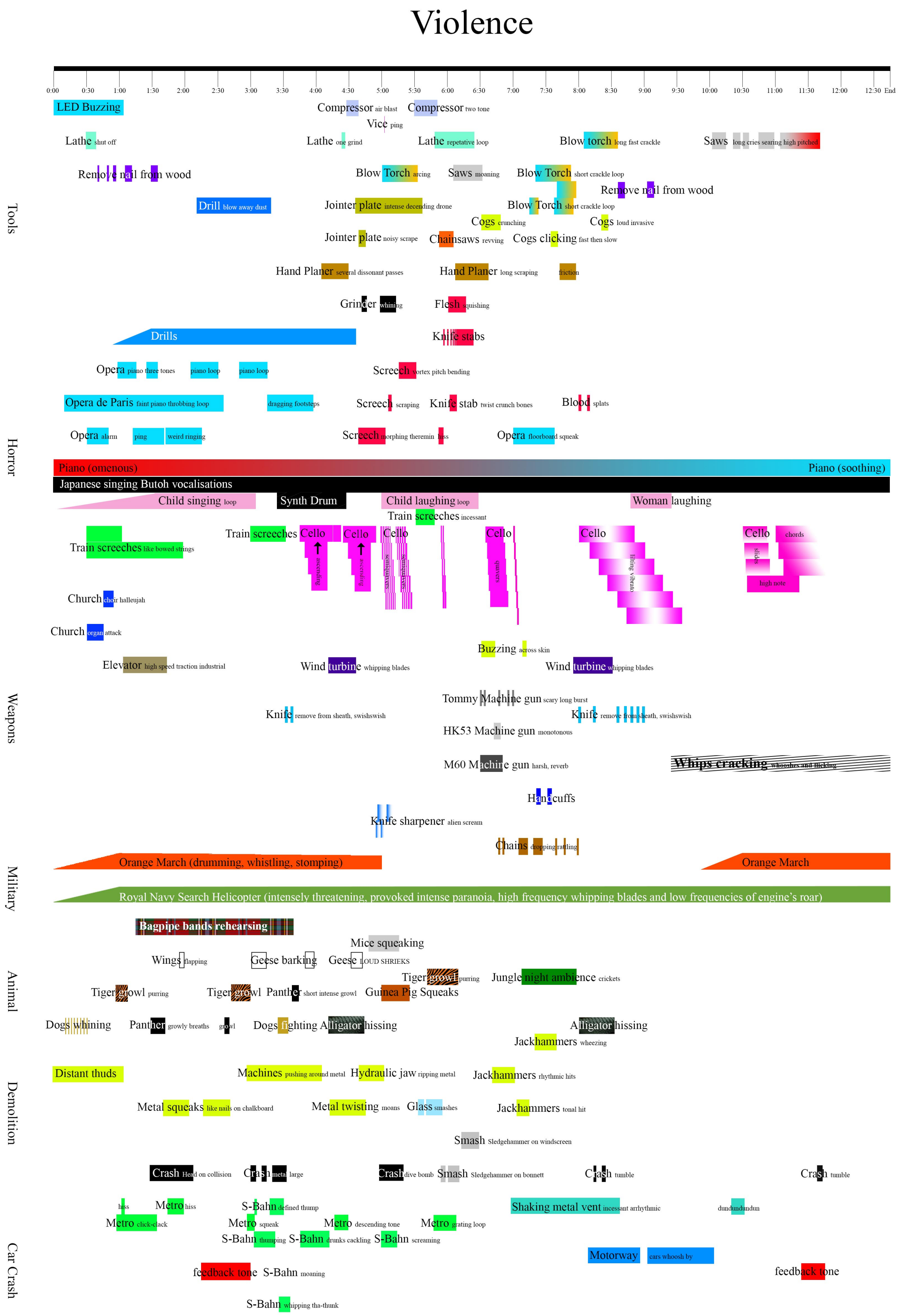


Figure 16: The graphical timeline of all sounds featured in the *Violence* soundscape

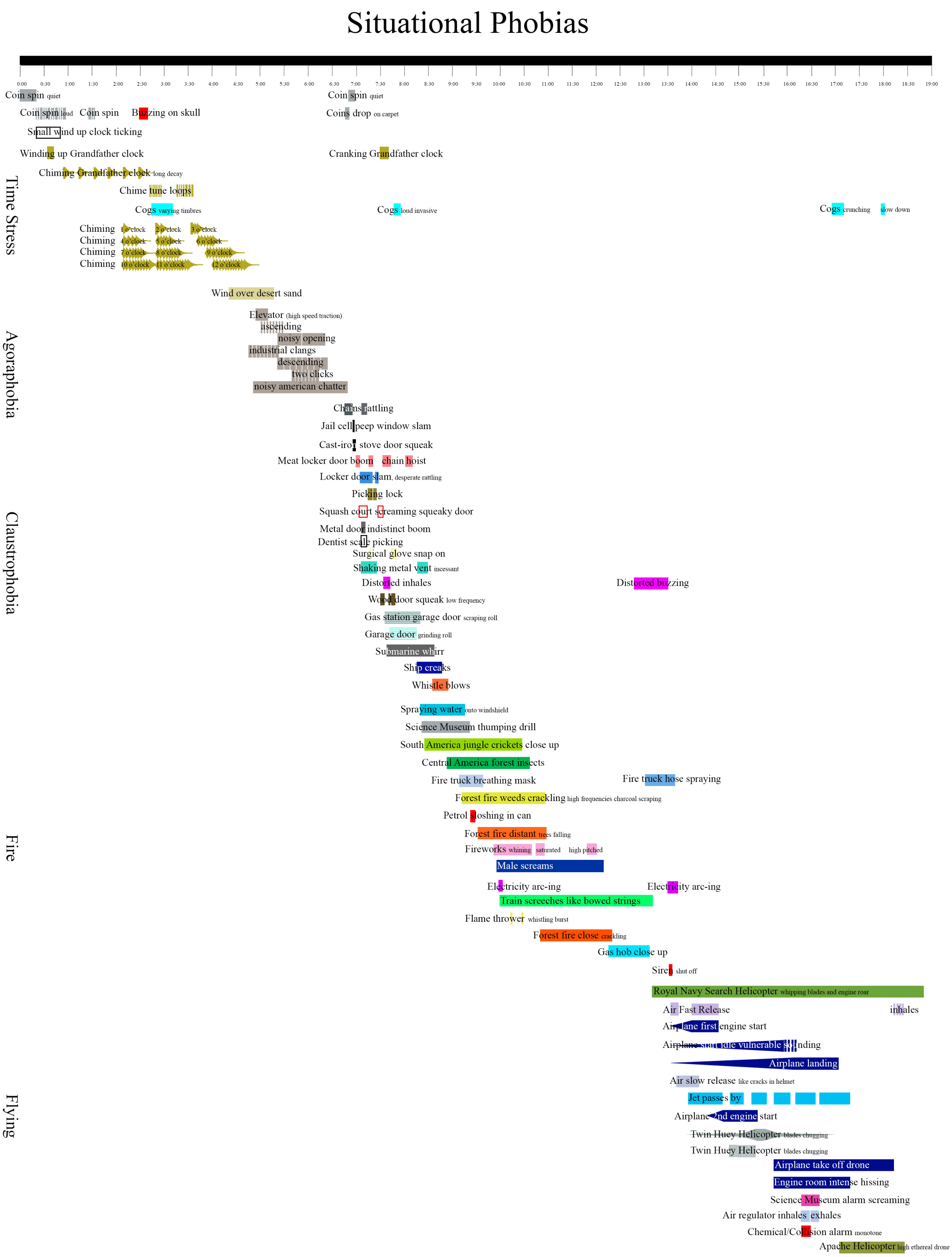


Figure 17: The graphical timeline of all sounds featured in the *Situational Phobias* soundscape

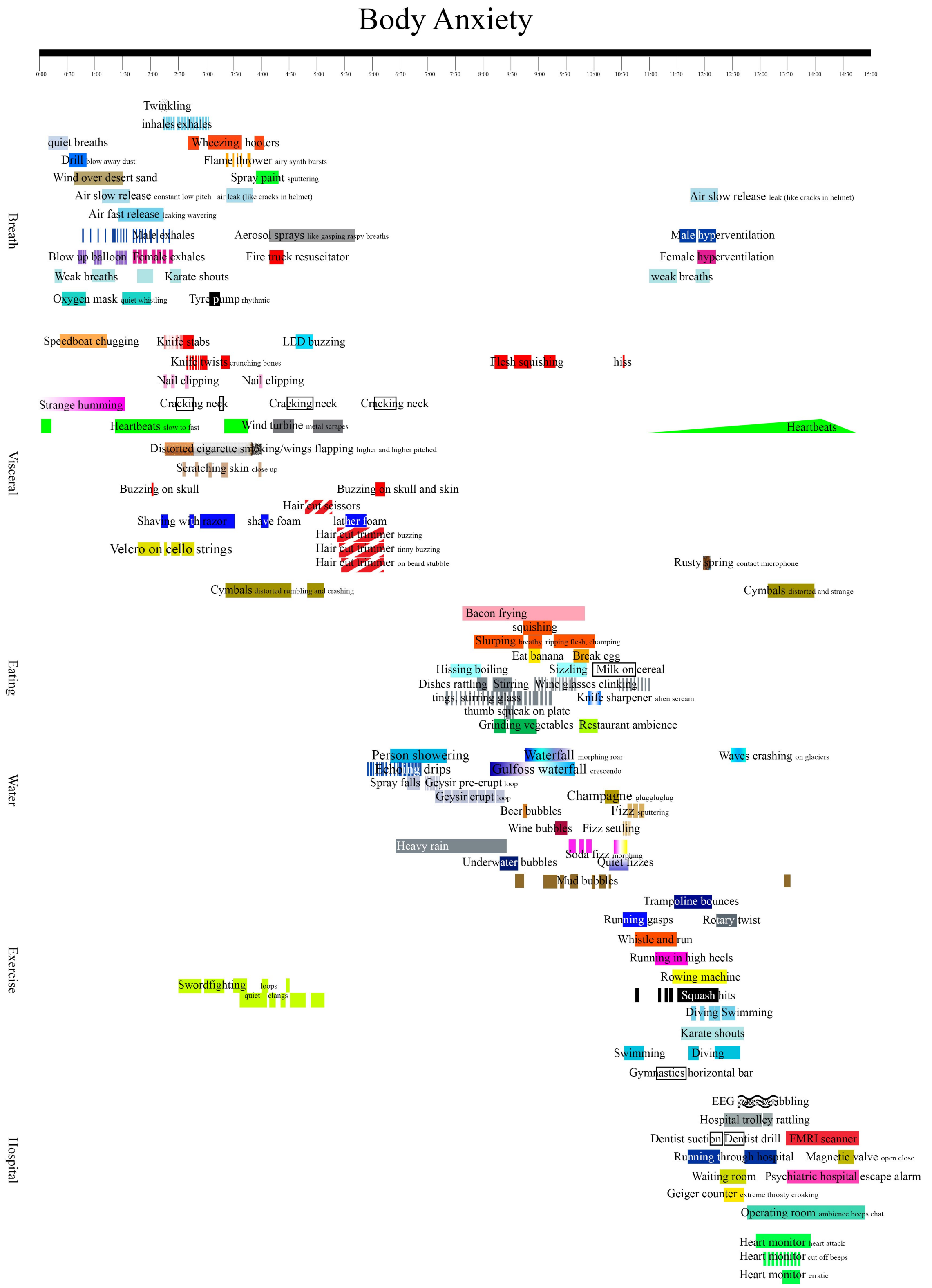


Figure 18: The graphical timeline of all sounds featured in the *Body Anxiety* soundscape

Social Anxiety

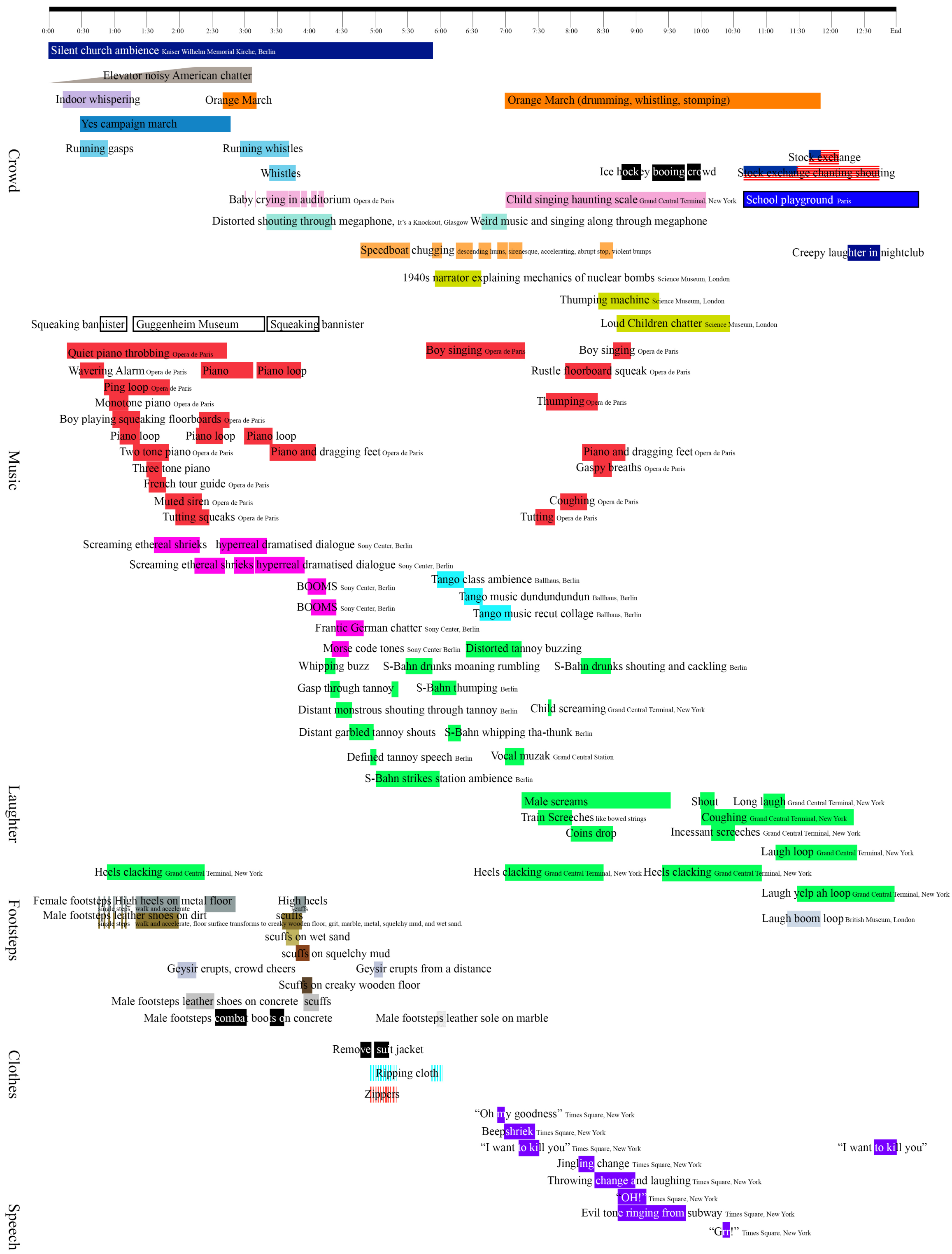


Figure 19: The graphical timeline of all sounds featured in the *Social Anxiety* soundscape

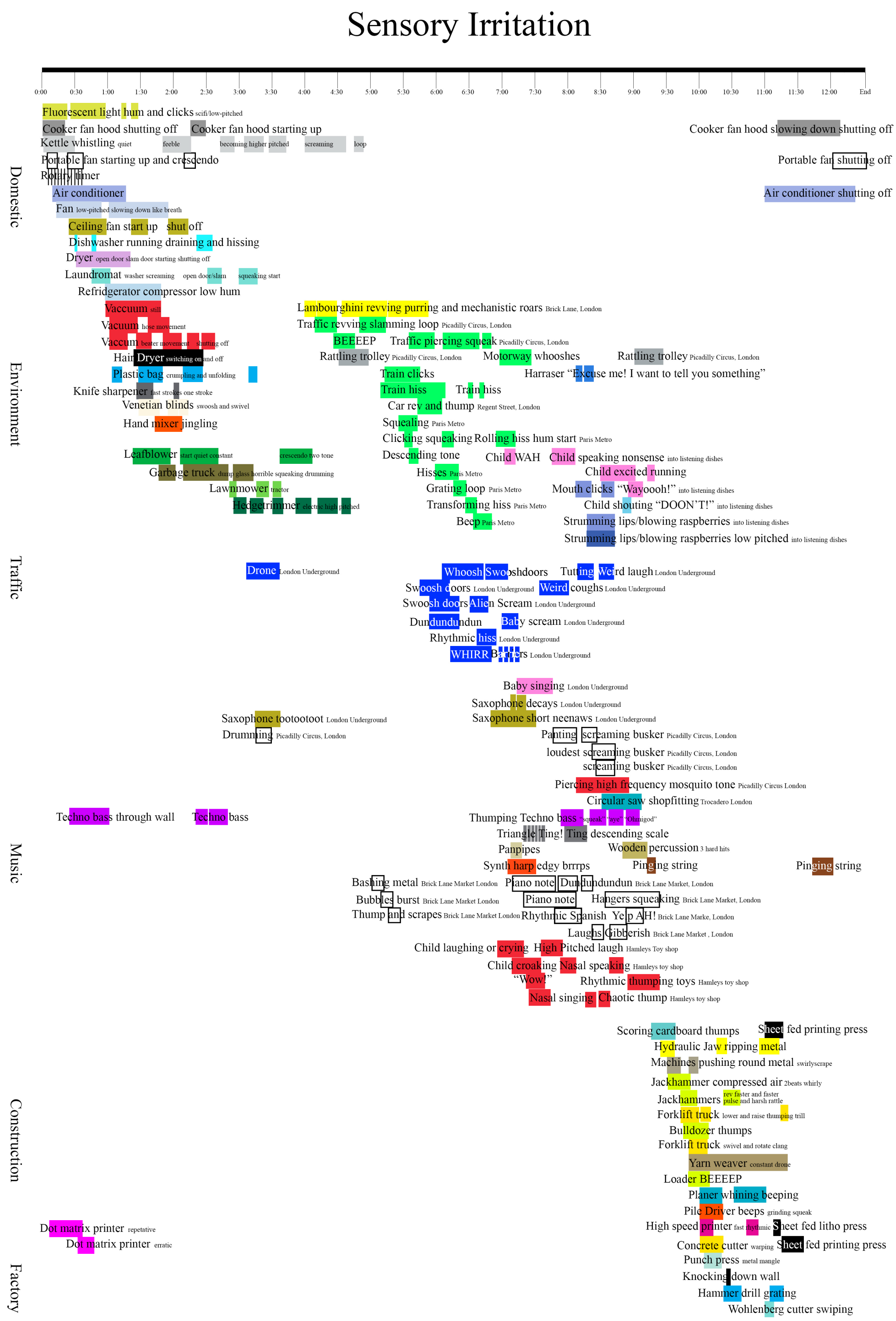


Figure 20: The graphical timeline of all sounds featured in the *Sensory Irritation* soundscape

3.2.2 Implementation of Ambisonics

An adaptation of the conventional Ambisonic recording methods was implemented in this study. It was decided that diversity of sound sources (which act as a symbol to induce memory recall or brain stem reflex responses) is paramount, rather than the consistent recreation of real-world sound fields. The soundscapes designed for use in Exposure Therapy are synthetic constructions of hundreds of individual stereo sound effects taken from Sound Ideas Effects Library, as well as personally-recorded Foley, musical performances, and ambiences recorded on location (which are each individually encoded into separate panners, to write a distinct movement path for each sound) (see Table 8). Moreover, recreation of real-world soundfields using traditional ambisonic recording techniques would not necessarily be the most emotionally manipulative method of soundscape production. Rather, synthetic, artificially constructed animated point-source sounds can portray specific actions of hypothetical characters, such as a stalker approaching the listener from behind, more readily than providing the entirety of an already existing sound field. Logistically, it was much more practical to use the researcher's own inconspicuous, portable Zoom H4N to obtain these sounds in stereo to be panned spatially in post-production, rather than use a bulky, delicate and expensive Soundfield microphone and recorder. The main reasons being the researcher's safety and insurance (as recordings were often taken in public locations) in addition to the frequency of sound recording sessions (quite often sounds appear spontaneously, and the Zoom H4N is always to hand).

To ensure the most precise localisation, the soundscapes in this study are encoded using higher order ambisonics, which goes beyond the first order WXYZ encoding – the additional channels are RSTUV, which have tighter localisation patterns. (A few sounds were tentatively panned in first order, but due to the rapid, hyperreal motions of the sound objects, it became necessary to use second order ambisonics, which offers much tighter localisation cues than first order, rendering a sound movement pattern truer to the original intentions as plotted on the panner interface.) The soundscapes have been mixed using an ambsionic encoder, and an ambisonic decoder mathematically distributes the sound signals across the 16 speakers, following a valid ambisonic workflow, adapted from more traditional implementations of ambisonics. It should be noted that second order ambisonics is implemented, which affords tighter spatialisation patterns, and gives considerably enhanced locational cues. Specifically, the method used is as follows:

- each sound is placed in its own stereo track
- a Blue Ripple Sound Third Order Ambisonic (TOA) Panner (set to second order in this case) is placed on each track.
- The user interface of the TOA Panner presents the two channels of the stereo sound as a red and a green cross, on a two-dimensional map of the sound array, akin to a global map of the space with key co-ordinates presented as above, below, left, right, back.
- The panning is written to the track in real time, by dragging the red and green crosses either together, in opposition or pulling them apart to widen the stereo image.

Table 8: Recording sites chosen by the Principal Researcher, their acoustic properties and sounds found

Recording Site	Acoustic Property	Sounds Found
Grand Central Terminal, New York	Ambience transitions from noisy to serene echo chambers transport of sounds in arches	Impromptu singing in Whispering Gallery Children singing, screaming, coughs High heels clacking on marble Buzzing of cleaning machines Coins rattling and dropping Trains screeching resembling bowed strings
Times Square, New York	chaotic cacophony of traffic road works bursts of music from shops, phones and cars	Tourists shouting, manic laughing “Grrrr!” Frustration at congestion Unfamiliar languages and dialects spoken Drills, buzzing, and hissing dissonant tone, ambiguous subway rumbling Grinding, squeaking, beeping, revving, Tinny drumbeats as phone ringtone, Cheesy pop music blaring from shops
Opera de Paris, Paris	hauntingly quiet, empty auditorium balcony with heavy traffic packed with tourists marble floors in large atrium’s long reverberance	baby crying in auditorium, child singing, stilettos clacking, floorboards creaking dragging footsteps French speech, gasping breaths, coughs, faint piano playing wavering alarms, camera shutters clicking
Search and Rescue Helicopter, Glasgow	Huge helicopter circling back and forth outside silent room	flitting between high frequency whipping blades and low frequencies of engine’s roar

The compositions are so dense that it is difficult for participants to directly pinpoint or recall individual pans - especially if they are new to ambisonic sound. The panning only perceivable if a sound is played in isolation or many sounds are moving in the same direction. The effects can be subliminal: if a sound source rises very slowly this might make the listener feel like they are melting or dizzy; the principal researcher perceived this to be close to sensations experienced during severe anxiety attacks. It is difficult for people to identify which spatialisation pattern affected them, because they are unlikely to be consciously aware of distinct movements during listening, let alone recall these instances post-soundscape. The participants are not able to identify spatialisation as definitively as they are able to identify the sound source or the acoustic quality.

The advantage of using the Ambisonic array over stereo or headphones is the composer can impose nightmarish distortions on the sounds, and indeed induce unsettling sensations in the listener such as:

- displacing the height of a sound event to induce vertigo
- making the listener feel small, by enlarging sound sources usually lower to the ground, e.g. a dog barking could emerge from above
- making a listener feel crept up on, by sending footsteps from the rear
- simulating absurd scenarios such as the listener standing in a hot frying pan, by placing the sound of oil bubbling at the listener's feet

Much of the panning is tailored to either replicate real-life spatial behaviours of original sound sources, or exaggerate and twist the sound to seem hyperreal, slightly strange or wrong:

- helicopter sounds are either static above, or synthetically circling above, or transformed into a more threatening vertical spinning from floor to ceiling, or thrashing indiscriminately around the room
- a waterfall sound at first pans from ceiling to floor, but then slowly rises - this would in fact be impossible, breaking the laws of physics. Rather than reversing the impact sounds in time, the sound's spatial pattern is inverted - as if the floor itself is rising.

3.2.3 Control and Peak Periods

A control condition is required to allow for meaningful insights from the physiological monitoring: the difference in the average number of peaks-per-minute is to be calculated between the reaction to the baseline sounds and the reaction towards the most powerful sonic anxiety triggers. The ideal control sound stimulus is largely emotionally neutral, but consisting of similar spectra-temporal energy to the rest of the soundscape: usually a drone chord, or noise sweep that gradually emits all featured frequencies. Luckily, it is a standard musical norm that the introduction acts as the control, establishing the tonal range and pace, acclimatising the listener to the spectral frequencies. Then, there is usually a swelling of volume as well as density of individual voices (instruments or real world sounds) either in the middle or towards the end of the piece, building up to a more intense array of timbres or challenging prosodic structure (see Figure 21). This peak sound can either suddenly cut off at the climax, and the suspenseful harmonic interval returns to the tonic home, or the mix gradually strips down to the initial, minimal arrangement of frequencies. The return to the tonic home in the ending, often resembles the introduction. Thus, it was possible to seamlessly integrate control condition periods into each soundscape naturally, as outlined in Section 3.2.1.

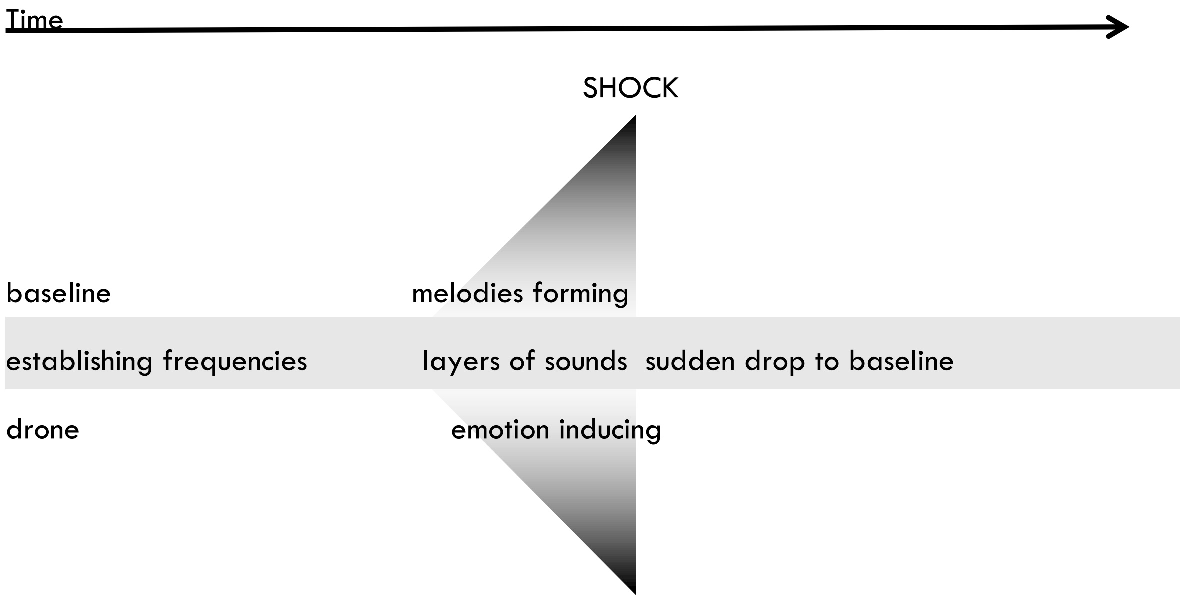


Figure 21: A gradual build from a control baseline to the peak shock period: followed by a sudden drop from the dense layering in the soundscape

3.3 Unmediated Physiological Response

3.3.1 Pulse Rate, Respiration and Galvanic Skin Response

For the duration of the experiment, the participant wore three Edu-Lab Scientific Resources Edu-Logger devices, the first a Pulse Logger either clipped onto the earlobe; the second a Respiration-Belt around the ribcage; the third, a Galvanic-Skin-Response-Logger strapped around the bases of two of their fingers. These devices recorded the participant's heart-rate, breathing rate and sweat secretion, only for the time that the soundscapes are playing (plus 30 seconds before and after for baseline measurements). These vital signs are strong indicators for emotional arousal – that is, amplified signals or accelerated speeds indicate anxiety, panic or excitement, whereas attenuating signals suggest relaxation or depression.

The pulse monitor uses a Light-Dependent Resistor to capture rate of blood flow, so its LED needs to be placed over a blood vessel to recognise a pulse. Once it has been confirmed through viewing the physiological data *Online* that the measurements are being picked up, the participant must keep their hand and head as still as possible, to avoid artefacts in the GSR and pulse reading. One worry was that a participant may become alarmed at a sudden noise and accidentally move their hand, causing a massive artefact: but that would still be an indicator of a jump or startle event. (However, this may also occur if they involuntarily raise their hand when they yawn if they are bored, or fidgeting). Some people's skin might be quite dry, so participants were asked to wash and moisturise their hands prior to the experiment to enhance the Galvanic Skin Response reading. Only dim lighting was employed in the Soundlab, as stray light from other sources interferes with the Pulse logger's infrared phototransistor receiver (light detector). Darkness also encouraged greater immersion in the soundscape, as the participant was less likely to be distracted by their visual environment. The pulse rate was recorded in BPM (beats-per-minute) numbers rather than ARB wave function, as numbers are easier to interpret. Ultimately the research team decided to omit recording of electroencephalography (EEG) as the analysis of this multiple-frequency-band measurement was believed to be beyond the scope of this three-year-project. Also, it was deemed to be too excessive to place this extra headband device on each participant, as it may have caused extra discomfort.

The participant's facial expressions were video-recorded (albeit in low-light) throughout the soundscape exposures. Monitoring the participant's fluctuating facial expressions during sound exposure helps to pinpoint notable emotions, enabling an identification of fast-acting catharsis (crying or frowning followed by calm relief). A Canon EOS 500D on a tripod was used. The video-recording is analysed only by the research team; to anonymise the participant for the published results, their facial expressions can be coded into an info-graphic timeline, a graph denoting either flat-line straight faces, a smile, a frown, or tears, aligning it with the sound event playing at the time.

3.3.2 Analysis of Physiological Signals

The key indicator from the GSR is the total number of peaks collated from all participants over a period of time, because emotional affect is being measured over a long time series, and the GSR signal drifts due to the participant's shifting posture or changes in room temperature. Thus, it is clearer to identify salient time epochs by reducing the number of peaks, emphasising the highest several peaks per participant. Previous, to filtering the GSR data through MATLAB, the raw data was drawn into graphs using Excel, which shows each participant's GSR signal rising and falling over time. Professor Christoph Kayser attributes these general rises and falls to the drifting sensitivity of the device rather than significant changes in emotional response. However, across the participant pool there seemed to be some quite consistent patterns – when the soundscape began the GSR signals always rose rapidly, and over time the signal gradually attenuates, even though there are still peaks occurring sporadically. This was originally believed to be a sign of participant habituation. However, filtering the GSR signal through MATLAB makes it much easier to observe the significant collective response patterns, as all signal lines were made to share a common zero-flatline-point in between the high peaks and low troughs. Previously, using the raw data in Excel, it was very difficult to grasp significant peaks, rises and attenuation trends at a glance when all participant signals were overlayed (even when narrowed down into smaller groups), as each participant's signal tended to rise and fall at different rates - the device seemed to be picking up drifts due to idiosyncratic skin types. The signal is filtered in a certain frequency band so very slow drifts and very fast noisy changes are omitted. Then essentially what can be seen is the derivative, filtered signal – all that remains are the salient peaks.

The average number of peaks per minute were calculated for each soundscape, to reveal the most frequently anxiety triggering soundscape. Peak rates were calculated for all participants, or for distinct groups (the participants with lower or higher pre-existing anxiety, or the participants who heard a particular soundscape as the first, second or third in the sequence. Whilst the average peak rate for an entire soundscape can be calculated, it is also insightful to identify if some moments were evidently more sensation triggering than others, by calculating minute by minute peak rates. Respiration data was analysed in a similar manner, but instead of just the high peaks being identified, moments of anomaly in the resting breathing rate were plotted on the soundscape timeline (sighs, pauses, or sharp large intakes of breath.) To pinpoint the most anxiety eliciting sounds, both the timeline of individual peaks and the minute-by-minute fluctuations in peak rates are superimposed onto the graphical timeline of sounds for each of the soundscapes. The individual peaks are presented as long thin black lines (resembling a barcode) and whereas the minute by minute peak rates are presented as bars at the top of the chart. At present, the Pulse Rate data is still to be analysed, as is the video-recording of facial expressions and the verbal feedback.

3.4 Ethics and Logistics

3.4.1 Healthy Subjects or Neurological Disorder Patients as Participants

Originally participants were to be identified from two distinct groups – anxiety support group members and the public (students, emerging artists, sound designers, researchers, academic staff). For Stage 1, it would have been ideal to recruit self-referred, non-vulnerable anxiety sufferers identified from a database of support-groups to complete a *Pre-Exposure Screening Questionnaire* and *Trigger Diagnosis* (questionnaires 1 and 1.2, see Appendix). However, due to the lack of response from the support group leaders who were invited, instead healthy participants were recruited from the public (selected from a network established by an advert placed on Callforparticipants.org which was shared widely on Facebook, as well as advertising on the notice board in the Institute of Neuroscience at the University of Glasgow, in addition to an advert on Gumtree). Although these were largely healthy participants, most demonstrated low-mid-level anxiety prior to the exposure - only one participant out of 35 seemed to live a life completely free of anxious symptoms.

For Stage 2, it was desired that only healthy participants (mostly students, sound designers, the public, and young professionals) were invited to the SoundLab at the School of Simulation and Visualisation, for the more emotionally and physically challenging soundscape exposure. It is acknowledged that a lengthy legislative process is required to invite participants diagnosed with a severe mental illness, outwith the scope of a three-year project. The NHS stipulates that the compositions must be tested thoroughly on healthy participants to show there are no adverse effects induced by the soundscape exposure therapy, before access to anxiety and depression sufferers is granted. Instead, it is proposed that healthy people's responses to the soundscapes will be tested first with a view to testing on anxiety and depression sufferers after (if time allows): so, initially there is a preference to recruit medically healthy people who feel anxious from time to time.

There is a dilemma as to whether the survey and the exposure test should be carried out on the same participants. Vulnerable people cannot be exposed to these aversive soundscapes without proof that healthy people have been exposed without harm, so in the exposure testing stage, the participants will be normal, healthy, not diagnosed, non-vulnerable people, giving informed consent. However, to obtain the most useful primary data of what people actually suffer from and which sensory stimuli trigger panic attacks, it would be more effective to question those who are actually afflicted with anxiety.

Table 9: The most ideal participant recruitment and the most ethically appropriate recruitment

	Stage 1 (Trigger Diagnosis)	Stage 2 (Sound Exposure)
IDEAL / LOGICAL	Self-referred Anxiety sufferers	Self-referred Anxiety sufferers
USEFUL richer source from which to identify trigger sounds	Self-referred Anxiety sufferers & Healthy non-vulnerable public	Healthy non-vulnerable public
SUFFICIENT	Healthy non-vulnerable public	Healthy non-vulnerable public

The initial survey is modelled on several Cognitive Behavioral Therapy anxiety gauges (the *Subjective Units of Distress Scale* (Foa, Hembree and Rothbaum, 2007), the *Beck Anxiety Inventory* (Beck et al., 1988), as well as mood change evaluations (Becht and Vingerhoets, 2002)) and a *Trigger Diagnosis* (questionnaire 1.2), to identify both external stimuli along with visceral and cognitive responses to a *Hypothesised Worry Scenario* (questionnaire 1.3) in which the participant is asked to "describe in vivid detail the environment, the situation, and the sensations and emotions felt in [their] most catastrophic worry scenario" (Hoyer and Beesdo-Baum, 2012).

3.4.2 Student Population and Public: Age Considerations

The ideal situation was that at least 30 non-vulnerable individuals from the support groups would complete Stage 1 questionnaires and continue to Stage 2, so all the participants for the sound exposure would be from this appropriately sensitive pool. However, it was expected that such a large positive response would be unlikely, and so recruitment was to be supplemented from elsewhere, primarily the student body from the University of Glasgow, as well as the local student body from post-graduate courses based at the School of Simulation and Visualization. The School of Simulation and Visualization students would be familiar with the environment and conveniently on-site, but sound students might also have a cultural bias, with advanced listening techniques taught on the course, which might distort results.

Students would be likely to take part due to the experiment or sound production being relevant for their own academic studies, as well as the offer of small monetary incentives. Another benefit of recruiting a limited demographic is that they will all have similar life experience, stress levels, not as many variables as if from a broader age range. Students are possibly more open to contemporary abstract music, with common exposure to loud techno music in clubs. Familiarity with musical features within recurrently listened to genres is said to amplify affect (Pereira et. al, 2011); the *Pre-Exposure Screening Questionnaire* and *Trigger Diagnosis* (questionnaire 1) allows participants to indicate idiosyncratic musical tastes if they have provoked a strong sensation, so any future tailoring of soundscapes incorporate familiar musical structures for each listener, is possible (however not for the timescale of this research): for example, prog-rock or ambient's extended temporality, electronica's loop based beats, classical timbres or cantability. Objective data could even be obtained (with permission) from the participant's *25 most-played* list on their MP3 player.

Only adults (over 18 years of age) were included, who can give fully informed consent, and who were non-hospitalized, fully functioning members of the public. Those who were recovering from a past experience of anxiety were also welcome, so long as the participant was not at their most critically vulnerable. There was no upper limit age restriction. Critically, recruiting mostly from the student body, emerging artists or young professionals ensures the population sample is at an average age of 18-45, thus they share a similar level of life experience. This was hoped to prevent extraneous variables such as the participants' experience of hard-hitting adult trauma (e.g. divorce, family deaths or inter-personal ordeals) that younger generations are usually yet to suffer. However, it is also acknowledged that widening the spectrum of ages might actually be beneficial, as it gives a research study a balanced demographic - there are myriad advantages and disadvantages of screening for age. Within the cohort there are some obvious sub-groups (sound practitioners/general public), and if necessary, differences in response can be discerned in the analysis. Remarkably, a consideration idiosyncratic to this study (which uses sound as an experimental stimulus), is that aging onsets a hearing loss, specifically the ability to perceive high frequencies or subtler sounds. Those under 22 actually have much more sensitive perception of high frequencies than the principle researcher and soundscape composer now, so the younger participants may hear sounds unintentionally placed within the soundscape. Obviously, a soundscape being tested on deafened, aging ears is not going to be as effective as it would be if tested on the younger age group.

A small pilot study comprised of five participants, mainly students and artists, was run over July and August 2015. It was discovered that among this group of seemingly healthy individuals, pre-existing anxiety levels were higher than previously expected: in fact, there was a wealth of sounds identified which triggered anxiety already pre-existing and during the soundscape exposure.

3.4.4 Invitation: Informed Consent and Capacity to Consent

It was acknowledged that many anxiety sufferers would be cautious, assuming the exposure will be an unpleasant experience they are not willing to endure. Thus, to attract a significant base of participants, many of the pilot and experiment participants were recruited from the student population and general public.

A concise *Information Sheet* was assembled that outlines the experiment procedure in detail, with a *Consent Form* for the participant to sign (and their own copy to retain). These both clarify the purpose of all data that will be recorded: from the initial questionnaire, to the full spectrum of quantitative and qualitative data monitored during the entirety of the participant's exposure to the soundscapes. Multiple consents were included such as: is the participant willing to expose themselves to this loud sound pressure level, potentially upsetting subject matter, and also to be monitored (both psychophysically and through video). The supplementary forms all include the Glasgow School of Art logo, the principal researcher's contact details, plus a third-party contact (the primary supervisor, Dr. Daniel Livingstone) so they can check with an external reference if they have any additional questions. It was made clear that prospective participants were in no way obliged to participate: only if they believe they can withstand a challenging sound exposure, and if it is convenient for them to attend the experiment at the Soundlab. Only adults (over 18 years of age), capable of giving fully informed consent are included in the experiment. Extra caution would be taken if there were prospective elderly participants with deteriorating understanding or age-related afflictions such as dementia, as it is acknowledged that they may be less able to give informed consent.

Prior to participation in the soundscape exposure, the participant undergoes a rigorous screening process composed of 5 questionnaires. Prospective participants would be excluded if they are acutely experiencing a nervous episode, indicated by a score exceeding 36.5 on the *Pre-Exposure Intensity of Perceived Sensations* scale (questionnaire 1.1.3) reflecting on the participant's past month (an adaptation of the *Beck Anxiety inventory*). Those who mark a score of 8 or above on the *Pre-Exposure Stress Thermometer* (questionnaire 1.1.1, an adaptation of the *Subjective Units of Distress Scale*) would also be excluded, as they marked that their past month mostly comprised of "HIGHLY unpleasant distress, physical tension, worry, fear or anxiety, intolerable sensations (trembling, nausea), with difficulty concentrating or thinking clearly." The *Emotion-Time Distribution* (questionnaire 1.1.2) is a graphical pie-chart evaluation of anxiety over the past month. Those who dedicate over 75% of this chart's area to negative emotions (sad, depressed, tense) with only 25% of the chart area allocated to positive emotions (relaxed, in control, happy, relieved) would also be excluded. So, if a participant generated a collective score of 71% (58% Beck + 80% SUDs + 75% ETD) from the *Pre-Exposure Participant Eligibility Screening,* then they would be excluded from the Stage 2 Soundscape Exposure. Instead, the participant would be able to access a comprehensive database of support groups and helplines such as the Samaritans and Anxiety UK (these two helplines are given to all in the *Information Sheet*, to avoid the acerbated stress of the gesture of singling a participant out to give these helplines). A basic take-home psycho-education was also on-hand if necessary, in the form of the NHS booklet, *Coping with Anxiety*. If they were a student and in need of counsel, they could be pointed in the direction of internal Student Support counselling, which is free of charge and would be the most effective treatment for them.

It was chosen that the research would not involve vulnerable groups. The recruitment of self-referred support group members to complete questionnaires (to identify the sonic anxiety triggers), would have enabled rich data-gathering from a whole pool of autonomous non-vulnerable sufferers, as would questioning a pool of healthier participants from the general public; therefore, it was not necessary to question hospitalized patients, thus NHS clearance was not required.

As there was absolutely no response from the local independent support group leaders, it was deemed appropriate to only invite healthy participants, and if there was time towards the end of analysis of this preliminary study, then more support groups would be contacted, with the proof that soundscape exposure did not cause harm. The ideal is that research should always be conducted with healthy volunteers first, and then only if it would be helpful recruit people who are self-referred to a support group, and only then if completely necessary proceed with NHS groups. It is best to build up the process in stages, to limit the negative effects of exposure for vulnerable people. The experimental techniques were refined slightly after the initial pilot, once the research team was informed of the types of response expected, and the principal researcher had built up robust professional experience. The *Pre-Exposure Participant Eligibility Screening Questionnaire* (questionnaire 1) was not even sent to those who are vulnerable, as the subject matter of the questionnaire alone may be upsetting.

Students, emerging artists and the public were recruited: but the principal researcher had no dual relationships with the students, as there was no tutor-student hierarchy at that time. There was no unequal relationship, thus hopefully no skewing of their responses to please an authority figure. The principal researcher was not a member of staff during the experiment run, and many of the participants had no personal relationships with the research team.

3.4.5 Measures to Avoid Coercion: Financial Incentive and Reasonable Reimbursement

The participants were not offered any monetary incentives, other than reasonable compensation for their time and travel expenses. Participants were reimbursed for travel to the School of Simulation and Visualisation (they were informed that the McGills 23, 26, or Stagecoach F1, X1, buses stop outside the front door or it is a 10 minute walk from Ibrox Subway station.) For the student participants, course credit could not be offered, as this would give unfair academic advantage to the eligible students: those too vulnerable to partake in exposure will be excluded and miss out on the extra credit. Instead, token gestures of thanks were offered: every participant was given a hand-written thank-you card with £5 note inside; also offered was a repayment of the principal researcher's time, in the form of technical audio advice or through participation in the participants' ongoing research experiments.

Consent was sought in writing or email signature, as it was most convenient for the researcher, and a reliable format for secure long-term storage. The participants were able to register anonymously if desired (so long as their email address did not give away their name) by saving their consent form as a pseudonym or abbreviation of their name. Their original emails could be deleted if desired. All indicators of identity and personal information provided are stored in a private password-protected hard drive, stored only in proximity to authorized School of Simulation and Visualisation staff, in encrypted documents. Any hard copies of questionnaires and consent forms, plus a digital back up of the project on another external hard drive are stored in a fireproof, lockable cabinet (also in the School of Simulation and Visualisation). Participants retained copies of their consent as they first saved them on their home computer before emailing to myself. Copies of consent will be kept for the duration of the study, until final graduation from the PhD course.

For Stage 1, the *Information Sheet*, *Consent Form* and *Pre-Exposure Participant Eligibility Screening* (questionnaire 1) was emailed directly to prospective participants. Participants were offered three different methods: either digital completion of the form using Adobe Acrobat; or printing out the form to complete in writing, to then email scans of these or post them back to the principal researcher, whichever was most convenient for them.

For Stage 2, the sound exposure took place in the Arup Ambisonic SoundLab, part of the School of Simulation and Visualisation, in The Hub at Pacific Quay. The Ambisonics lab is the most immersive sound array in the Glasgow School of Art, with a spherical 16-speaker formation. It is an ideal controlled environment: a private, soundproofed, windowless room, free of extraneous variables. The loudspeaker array offers adaptable playback – even a control test in stereo format would have been possible if required. The Health and Safety regulations of the The Hub and the Ambisonics Lab were explained to the participants in the Consent Form, also re-iterated on arrival.

4 Pilot

4.1 Introduction

The experiment has been designed to gather rich data ranging from the participant's perceived responses to their unmediated physiological responses. To gauge the level of impact on participants pre-existing anxiety levels throughout the course of contact, they are asked to reflect on the previous month's anxiety, and after each soundscape during the experiment. One of the reflections made upon the pilot results, was that it would be beneficial for participants to also complete an anxiety evaluation one week following participation in the experiment. Whilst all five soundscapes were played for the pilot participants, it was also decided that the procedure should be streamlined, down to only three soundscapes, so participants could write richer feedback on a more focused exposure session, and that the physiological feedback would be less diluted, as sensory habituation after the first soundscape decreases the number of physiological peaks elicited. The majority of testing is conducted onsite, in one session for the participants' convenience.

4.2 Activities: Pre-Exposure, Post-Soundscape and Long-Term Catharsis Evaluations

4.2.1 Activity 1: *Pre-Exposure Participant Eligibility Screening Questionnaire*

Upon receipt of interest, each prospective participant was emailed the *Information Sheet* to read in full and they were also asked sign the *Consent Form*. They were then asked to complete a *Pre-Exposure Participant Eligibility Screening* (questionnaire 1), to ensure that they were psychologically and physically able to endure the soundscape exposure. The participants were welcome to either email or post this back to the principal researcher.

So, prior to the participant's invitation to the Soundlab, the *Pre-Exposure Participant Eligibility Screening* (questionnaire 1) includes:

1.1 *Pre-Exposure Evaluation of Anxiety Levels* (long-term, for the previous month); 1.1.1 *Stress Thermometer,* 1.1.2 *Pre-Exposure Emotion-Time Distribution;* 1.1.3 *Pre-Exposure Intensity of Perceived Sensations,* 1.2 *Pre-Exposure Trigger Diagnosis;* 1.3 *Pre-Exposure Hypothesised Worry Scenario* (See Appendix).

4.2.1.1 Screening Methods borrowed from Cognitive Behavioural Therapy

The established anxiety evaluation inventories used in Cognitive Behavioural Therapy were adapted, to tailor-make questionnaires to be more suited to evaluating sound-provoked anxiety, and to ensure they were not merely copied verbatim. These pre-exposure questionnaires were ultimately used to:

- discern participant eligibility
- identify the most commonly cited pre-existing trigger sounds
- tailor the soundscapes in the future, for maximum universal efficacy
- discover if there are anomaly individuals with unusual triggers, or subgroups
- demonstrate that heightened arousal can be induced by soundscapes matched to idiosyncratic triggers

The *Beck Anxiety Inventory* (Beck, 1988) and the *Subjective Units of Distress Scale (*Foa, Hembree and Rothbaum, 2007) were both simplified and reworked, as they are standardized and previously evaluated, most commonly used in Cognitive Behavioural Therapy. Thus, it was ensured that participants are not burdened with poorly constructed research or unnecessary questions, but the researcher would still gain a significant insight in to the eligibility of the prospective participant, as relevant exclusion criteria was devised. A variation of a Likert scale was implemented for most, both to simplify the completion for participants by letting them choose from multiple-choice answers, and to enable a straightforward translation of participant responses into a series of easily compared numbers.

The *Pre-Exposure Intensity of Perceived Sensations* (1.1.3) is essentially the *Beck Anxiety Inventory* presented in different words and a different style, so a prospective participant's responses can be converted into a numerical score. On the Beck Anxiety Inventory, it offers 0, 1, 2, 3 to choose from, whereas in the new adaptation this format is replaced with verbal degrees for each symptom: 0 for "not at all", 1 for "mild", 1.5 for "noticeable", 2 for "chronic unpleasant", 3 for "severe distress and inability to function". If an individual's score for the original *Beck Anxiety Inventory* (which has 21 symptoms) is over 36 then this is a cause for concern, and they should be referred to counselling (0-21 is very low anxiety, 22-35 is moderate anxiety). The anxiety attributes listed in the *Pre-Exposure Intensity of*

Perceived Sensations (long-term, for the previous month, questionnaire 1.1.3) were originally found in the *Beck Anxiety Inventory* with an add-on mood evaluation questions with the states featured in Becht and Vingerhoets' (2002) *Crying and Mood Change* study. So, if a prospective participant's score for the *Pre-Exposure Intensity of Perceived Sensations* exceeded the threshold of 36.5 then that was cause for them to be excluded (as per the Beck Anxiety Inventory – the 7 additional questions adapted from the *Crying and Mood Change* study were not used as exclusion criteria). It would have been unethical to present the soundscapes to a prospective participant who is not well, who is firstly in need of conventional talk-therapy and medical guidance.

The *Pre-Exposure Stress Thermometer* (1.1.1) measures where each participant lies on the *Subjective Units of Distress Scale*, as a rough average over the past month. Variations on stress thermometers are often used in Cognitive Behavioural Therapy handouts, with a single-line summary of varying degrees of anxiety symptom intensity, as a quick mode of reference plotted on a scale from 1-10. The *Pre-Exposure Emotion-Time Distribution* (1.1.2) is a graphical pie-chart evaluation of anxiety over the past month, where the participant can allocate percentages to negative emotions (sad, depressed, tense) and positive emotions (relaxed, in control, happy, relieved).

All of the anxiety symptoms from the *Pre-Exposure Intensity of Perceived Sensations* (1.1.3) also appear in the *Post-Soundscape Frequency of Perceived Sensations* (2.2.2) and the psychological positive emotions listed also feature in the *Post-Exposure Intensity of Perceived Moods* (2.3.2), to enable pre- to post-test mapping analysis. Completion of a *Stress Thermometer* is required in the past month pre-exposure (1.1.1), immediately pre-exposure (2.1.1), immediately post soundscape (2.3.1), and even one week following the soundscape exposure experience (3.1), to enable an evaluation of long-term and short term impact of soundscape exposure. The *Emotion-Time Distribution* is featured only in the long-term reflection questionnaires, the *Pre-Exposure Participant Eligibility Screening* (questionnaire 1) and in the *Long-Term Catharsis Evaluation* (questionnaire 3), as it is most suited as a gauge for long term emotional reflection. A difference in levels of positive or negative emotion distribution for the pre-exposure month and the post-exposure week are discerned in the primary results of the experiment (Chapter Five), to quantify the impact in the average participant's emotion perception.

In its entirety, the *Pre-Exposure Participant Eligibility Screening* (questionnaire 1) has a dual function: both to be used as exclusion criteria, but also to collect interesting baseline data, to differentiate subgroups for comparative analysis. After the first pass of general analysis, comparative analysis between subgroups differentiated by the participant's initial scores in the screening will be undertaken. For instance, the GSR peaks-per-minute average response for the ten participants who had the highest anxiety in everyday life (indicated by the highest scores in the Pre-Exposure Intensity of Sensations) would be compared with the GSR response for the ten participants who had the lowest anxiety in everyday life.

4.2.1.2 Inclusion/Exclusion Criteria

Data was gathered using questionnaires, only from healthy, non-vulnerable people (although ideally those prone to anxiety from time to time), who were fully able to consent. It is crucial to use a screening questionnaire to identify participants who are at an ideal point on the spectrum of anxious symptoms - not completely anxiety-free but not in the midst of an acutely nervous episode. Questionnaire 1 is a *Pre-Exposure Participant Eligibility Screening*, using an adaptation of the *Beck Anxiety Inventory*, renamed as the *Pre-Exposure Intensity of Perceived Sensations* (1.1.3), and the *Subjective Units of Distress Scale,* renamed *as the Stress Thermometer* (1.1.1). It was assessed whether it was safe to then expose the questionnaire respondent to the soundscapes, or if the anxiety they experience was too acute at that moment in time, rendering them unable to take part in Stage 2. So, those who were acutely experiencing a nervous episode would be excluded, as originally indicated by a score exceeding 43 on the *Pre-Exposure Intensity of Perceived Sensations* questionnaire (1.1.3) reflecting on the participant's past month (an adaptation of the *Beck Anxiety inventory*). Those who marked a score of 8 or above on the *Pre-Exposure Evaluation of Anxiety Levels* (an adaptation of the Subjective Units of Distress Scale), marking that their past month mostly comprised of "HIGHLY unpleasant distress, physical tension, worry, fear or anxiety, intolerable sensations (trembling, nausea), with difficulty concentrating or thinking clearly." would also be excluded. The *Emotion-Time Distribution* is a graphical pie-chart evaluation of anxiety over the past month; participants were excluded if they dedicated over 75% of the chart's area to negative emotions (sad, depressed, tense) with only 25% of the chart's area allocated to positive emotions (relaxed, in control, happy, relieved). So if a participant generated a collective score of 64% (43/112 = 38% Beck + 8/10 = 80% SUDs + 75/100 = 75% ETD) (revised to 71% post-pilot ((36.5/63 = 58% Beck) + (8/10= 80% SUDs) + (75/100 = 75% ETD)) from the *Pre-*

Exposure Participant Eligibility Screening, then they would be excluded from the Stage 2 Soundscape Exposure.

4.2.1.3 Post-Pilot Revision to Inclusion/Exclusion Criteria

All five participants in the pilot study safely passed the *Pre-Exposure Participant Eligibility Screening* (questionnaire 1), and were then comfortably exposed to five soundscapes in the ambisonic Soundlab. The *Eligibility Screening* test was devised to protect vulnerable individuals in the midst of acute anxiety from being exposed to aversive soundscapes. However, upon recruiting new participants for the official experiment due which took place in October 2015, it became apparent that the exclusion threshold for one component of the screening was set disproportionally lower than those for the first two tests, which proved problematic.

The *Pre-Exposure Intensity of Perceived Sensations* (1.1.3) was originally set to have an exclusion threshold of 43, out of a possible maximum score of 112 - which established a very low cut off of 38%. Thus, participants might have been excluded if they had even felt a middling intensity of anxious symptoms. The threshold scores in the eligibility screening for the *Pre-Exposure Intensity of Perceived Sensations* (1.1.3) was raised to the same level of anxiety as the *Stress Thermometer* (1.1.1) and *Emotion-Time Distribution* (1.1.2) screening parameters. Three modifications were made to the *Pre-Exposure Intensity of Perceived Sensations* section of the screening following the pilot study:

1. The allocation of scores on the Likert scale answer options, were changed from "0, 1, 2, 3, 4" to "0, 1, 1.5, 2, 3", to account for the addition of one extra option to circle to the original Beck Anxiety Inventory model.
2. The exclusion threshold was increased to reflect a realistic amount of everyday anxiety, whilst still excluding participants who felt anxiety symptoms to a predominantly "noticeable" and "chronic unpleasant" degree (which would be 58% rather than 38%)
3. The additional 7 questions assessing mood levels were omitted from the exclusion criteria, as they do not focus specifically on anxiety symptoms, and have a different weighting of scores (due to the adjusted Likert scale options to choose from).

If the prospective participant felt an average amount of anxiety due to work or travel related stress and encounters with everyday phobias, they might have been more likely to score up to say 60-70%. To use this evaluation as a pragmatic screening tool for the experiment, it was decided that the exclusion threshold should be closer to those of the other *Pre-Exposure Stress Thermometer* (1.1.1) and *Emotion-Time Distribution* (1.1.2) measures, which are set at 80% and 75% respectively. This is more aligned with common sense and intuitive judgment, to only exclude prospective participants who were, at the time of the experiment, crippled by acutely high anxiety, who were feeling mostly "chronic unpleasant" symptoms. This would give a score of 42, which is 66%. To be even more cautious, it was deemed sensible to exclude those participants who rated 11 symptoms as "noticeable" and at least 10 as "chronic unpleasant", which would give a score of 36.5, which is 58%. (Only 2% above the original Beck Anxiety Inventory’s threshold for SEVERE ANXIETY.) A *Pre-Exposure Stress Thermometer* (1.1.1) was also offered on the day of testing, and if it exceeded 8 the participant was reminded that their participation is not compulsory if they do not feel well enough.

When devising the *Pre-Exposure Intensity of Perceived Sensations* (1.1.3), seven questions were added which would establish baseline mood levels and the changes post-exposure. The nature of these questions meant that they needed to be set an appropriate Likert Scale, which inevitably has a different weighting from the rest of the questionnaire. The questions were "How much pleasure/ how content/ relaxed/ in control/ relieved/ happy/ sad did you feel?"), either “completely” (0 points), “very” (1 point), “neither content nor discontent” (2 points), “quite” (3 points), “not at all” (4 points) (the reverse for sad). This system obviously allocated much higher value scores to even positive symptoms: the participant merely saying they were "quite happy" would have given them 3 points, which undoubtedly would have racked up their overall percentage and edged them closer to or even over the exclusion threshold. Also, these questions do not directly relate to the original *Beck Anxiety Inventory*, so it was decided that they should not be counted as markers of Anxiety, rather they are indications of the prevalence of positive or negative mood. So, those seven questions were allocated a separate score, which was not used as exclusion criteria.

According to these changes, the first participant who was only just over the original exclusion threshold actually became eligible, as their anxiety-symptom focused score was be 25 (39%) (11.5 below the new threshold). The second participant who was reported now scored 28.5 (45%) (8 below the new threshold) with these adaptations, so was also deemed eligible. This adapted exclusion threshold was much more appropriate than the first conceived threshold, allowing room for those who have experienced everyday anxious situations, whilst still protecting highly anxious individuals from sound exposure. It was also observed that participants tended to focus on one specific event, which can overshadow the average anxiety over a month. They were reminded: "Please account the overall intensity of symptoms, the average over the past month, rather than focusing on rating one isolated event."

4.2.1.4 Trigger Predictions

Primarily, the evaluation of the past month's anxiety in questionnaires 1.1.1, 1.1.2 and 1.1.3 was used to exclude prospective participants who were in too much physical or emotional pain to participate. On the other hand, the *Pre-Exposure Trigger Diagnosis* (1.2) is a means to gather predictive data, for example: "It was expected that Participant 1 would show stronger anxiety ratings when exposed to mechanical noises, given their original trigger diagnosis". Expectations are established, and anomalies to the expected behaviours can then be highlighted – those prone to anxiety everyday may even feel less stressed by the sounds, as they may be desensitized to the stress that they experience every day. The necessity of tailoring soundscapes to an individual can also be evaluated, by mapping one each participant's moments of peak anxiety during soundscape listening, onto to each participant's pre-informed individual anxieties. Thus, it can be calculated whether most participants had matched pre-exposure and post-exposure identified trigger sounds, or there were more participants who were surprised to be made anxious by a sound they previously unaware of. For example, those who have stated that they dislike mechanical noises may not react as obviously to mechanical sound events, as they are used to hating these in everyday life (their body may not be as surprised anymore, although they still cognitively dislike it). When the time comes for soundscape exposure to be used in a healthcare facility, the *Pre-Exposure Trigger Diagnosis* (1.2) can also be used to best allocate soundscapes to the user – if the user identifies people sounds as their main anxiety trigger then it would be optimal to play them the *Social Anxiety* first (so their responses will be strongest for the sound that they wish to desensitise themselves to). The whole soundscape exposure experience can be tailored to each user, assigning the most relevant soundscapes to each participant depending on their *Pre-Exposure Trigger Diagnosis* (1.2). The experiment results will allow the principal researcher to optimize the soundscape exposure therapeutic framework, as results will identify areas of the soundscapes that must be modified to enhance the reliability of anxiety elicitation. The most powerful sounds will be prioritized in the sound library compiled for the soundscape exposure therapeutic framework, according to the trends in the *Pre-Exposure Trigger Diagnoses* (1.2).

Sound categories were presented to the participants to select as multiple-choice answers that map directly onto the categories used to compose the soundscapes (essentially, a streamlined version of the full library of sounds). Participants will be asked circle a category, a sub-category, plus one example, with space to expand upon this to identify their own triggers e.g. “category: *Violence*, subcategory: weapons, e.g. M60 machine gun”. As the multiple-choice checkboxes map directly onto to the soundscape categories, it is easy to efficiently link one participant’s dislike of door sounds with their behavioural measurements recorded during exposure to the soundscapes (it is easy to locate on the soundscape timeline where the door sound comes, and it is expected that would also be when the GSR peak occurs).

Prior to the experiment, five soundscapes were constructed, based on the most common universal fear-inducing sounds (*Social Anxiety, Body Anxiety, Violence, Situational Phobias* and *Sensory Irritation*), and the responses from questionnaires were hoped to corroborate the rationale for choosing these five primary anxieties. It was helpful to collate quoted sonic anxiety triggers from online mood disorder forums before the experiment, to survey contextual data that was both easily graspable and non-invasive. Stage 1 contains the vital pre-exposure survey to identify common anxiety triggers, so the composition of the soundscapes can be optimized, and it can be certified that the sounds used are indeed universally relevant. Obvious scenarios have been identified, but these questionnaire responses will certify that the research team’s choice of triggers are relevant, as well as going beyond to identify new triggers which were previously unheard of. If many people identify a new sound, it should be added to the exposure therapy sound library post-experiment; also, if a situational trigger lends itself easily to be converted into sound then it should be included in the sound library. The soundscapes tweaked post experiment will become the optimized exemplars for the soundscape exposure therapy framework, with an additional comprehensive library of certified anxiety triggers (compiled from a large pool of people) with which to generate new soundscapes.

The *Pre-Exposure Hypothesised Worry Scenario* (1.3), based on an imaginal exposure therapy task detailed by Hoyer and Beesdo-Baum (2011), asks the participant to describe in vivid detail the environment, the situation, and the sensations and emotions felt in their most catastrophic worry scenario (the worst that could happen) and to do the same for their most regular worry scenario. This encourages participants to provide more in depth information about their deepest fears, which might be more engaging for some participants than the multiple-choice format of the *Pre-Exposure Trigger Diagnosis* form (1.2).

It is acknowledged that interviews might inspire richer, more in depth responses than questionnaires, as questions can be expanded upon and personalized to the interviewee; each method has its advantages and disadvantages. However, due to logistics and sensitivity reasons, only questionnaires were used. The crucial advantage of using a questionnaire is that responses can be more honest and revealing, as participants feel less inhibited than if they spoke out loud to an unfamiliar interviewer, as electronic or paper based questioning can be rendered completely anonymous. To exclusively use questionnaires meant that the Stage 1 participant pool was open to those further afield, nationwide or even worldwide. All participants who are deemed eligible from the questionnaires in Stage 1 were invited to participate in Stage 2, the sound exposure.

4.2.2 Activity 2: Soundscape Exposure

The main goal of the research is to discover whether the soundscape elicits anxiety reliably in everyone - although it is more crucial to know whether anxiety can be elicited reliably in the participants who have higher levels of anxiety in everyday life, as this is the clientele that soundscape exposure therapy is designed for. We ask, does the soundscape trigger feelings of anxiety in general, and more interestingly, are particularly strong psycho-physical reactions elicited during playback of the sounds that have previously been identified as anxiety triggers in everyday life? This will primarily be answered by mapping the peaks in physiological signals onto the soundscape timeline, with the expectation that the peaks coincide with the participant's predicted sound trigger. This can also be clarified in the *Post-Soundscape Body Map* (2.2.8), where the participant is asked to draw on a self-assessment manikin (a blank illustrated human figure), what they felt, where on the body, and which sound was playing at the time. The opportunity to identify particularly salient sounds is also emulated in the *Post-Soundscape Memory Record* (2.2.7), where the participant is asked if any memories were triggered and what sound was playing at the time. There are also some crucial questions about the nature of the sounds (e.g. "please list the sounds you found most frightening"), which are predicted to mirror the sounds (or at least link to the categories) the participant indicated in the *Pre-Exposure Trigger Diagnosis* (1.2). It is predicted that the peak sensations and emotions that the soundscape elicits do actually link to categories the participant is usually very sensitive to. The participant's list of sounds identified as "most frightening" in the *Post-Soundscape Subjective Perceptions* (2.2.2), *Body Map* (2.2.8) and *Memory Record* (2.2.7) questionnaires, will be mapped onto original responses on the *Pre-Exposure Triggers Diagnosis* questionnaire, to see if the sounds that made participant feel anxious in the soundscape are the same as the ones they previously indicated they are sensitive to in everyday life.

Some anxiety symptoms are more obviously associated with a musical stimulus (sound-provoked) where others are co-morbid or mentally-generated (the participant is winding themselves up). It is also possible to distinguish the symptoms into those two groups, so it can be deduced the extent that the sounds are the cause of strong sensations (rather than the experiment scenario or baseline participant sensitivity). For instance, a symptom in the sound-provoked group would be *heart pounding*, as an accelerando in music is known to increase heart-rate when the body attempts to match the rhythms heard. Conversely, feeling *nervous* is more of a situational attribute – the participant might be nervous about taking part in an experiment. This may change over time though, as the participant may have felt nervous at the start because they did not know what to expect.

Following successful completion of the *Consent Form* and of the *Pre-Exposure Participant Eligibility Screening Questionnaire* (questionnaire 1), the participant was invited to the Arup Ambisonic Soundlab, in The Hub at Pacific Quay, to listen to ambisonic soundscapes, and complete individual evaluation questionnaires following each soundscape. On arrival at Soundlab, the participant completed the following questionnaires:

2.1: *Pre-Exposure Evaluation of Anxiety Levels* (short-term) (see Section 4.2.2.1)

2.1.1: *Stress Thermometer* (as above, in 4.2.1.1)

2.1.2: *Intensity of Perceived Moods*

After listening to each soundscape, participants completed the questionnaire 2.2: *Post-Soundscape*, comprising;.

2.2.1 *Post-Soundscape Subjective Perceptions* (4.2.2.2)

2.2.2 *Post-Soundscape Frequency of Perceived Sensations* (4.2.2.3)

2.2.3 *Post-Soundscape Mood Change Assessment* (4.2.2.4)

2.2.4 *Post-Soundscape Breathing Assessment* (4.2.2.4)

2.2.5: *Post-Soundscape Affect Dichotomy* (4.2.2.4)

2.2.6: *Post-Soundscape Better or Worse* (post-pilot addition)

2.2.7: *Post-Soundscape Memory Record* (4.2.2.4)

2.2.8: *Post-Soundscape Body Map* (4.2.2.5)

2.2.9: *Post-Soundscape Liked and Disliked Sounds (*4.2.2.6)

After the final soundscape, participants completed the questionnaire 2.3: *Post-Exposure Evaluation of Anxiety Levels* (short-term) comprising:

2.3.1: *Post-Exposure Stress Thermometer* (in 4.2.1.1)

2.3.2: *Post-Exposure Intensity of Perceived Moods*

2.3.3: Post-Exposure Better or Worse (4.2.2.8)

2.3.4: *Post-Exposure Spatialisation Evaluation* (4.2.2.7)

4.2.2.1 *Pre-Exposure Evaluation of Anxiety Levels* (short term) (questionnaire 2.1)

The short term *Pre-Exposure Evaluation of Anxiety Levels* (questionnaire 2.1) is comprised of elements of that featured in *Pre-Exposure Participant Eligibility Screening* (questionnaire 1), featuring a *Stress Thermometer* (2.1.1) adapted from the *Subjective Units of Distress* scale, and a Likert scale evaluation of *Intensity of Perceived Moods* (2.1.2) featuring emotions listed in the *Crying and Mood Change* questionnaire (Becht and Vingerhoets, 2008), but with the questions adapted to a short-term timescale. The participant evaluates their anxiety felt on the day of testing (rather than the previous month), to evaluate a baseline rating of anxiety immediately prior to testing.

4.2.2.2 *Post-Soundscape Subjective Perceptions* (questionnaire 2.2.1)

The immediate impression of the soundscape was assessed: mainly how frightened, irritated, and immersed each participant was. Later on, it is discovered how these reactions map onto each participant's pre-disposed personal anxieties or personal trigger sounds. The responses can be summarised in various ways. At the end of the experiment run, conclusions can be made such as the average loudness rating allocated to the *Violence* soundscape is “mostly loud” for example, so it can be confirmed that the majority of participants thought the sounds were played at optimum volume. For questions such as “Did you enjoy listening to the soundscape?” a verbal Likert scale from 1 to 5 was offered, with Yes or No absolutes at either end for the participant to choose from, to increase the sensitivity of the questionnaire (some participants may feel indifferent or think yes, to a certain degree but not definitively a yes). For each question the average response is calculated. For example, “the majority of people were scared by the soundscape”, or “the majority of people were bored by the soundscape”, and general impact conclusions can be drawn. Sub-group conclusions can also be made, such as “the people who are more anxious in their everyday lives were highly antagonized by the soundscape”, or “surprisingly, those who experience anxiety everyday enjoyed the soundscape much more than those who never do, possibly because it matches their emotional state”. It is crucial to find out how emotionally disrupted participants are by the soundscape (and whether it is in a positive or negative sense). Verbal Likert scales which equate to 1 to 5 are offered, so it is easy for participants to give their answers and easy to summarize numerically: a streamlined experience for the participant, which also simplifies the analysis.

Asking participants to rate the loudness of the soundscape is informative, as it is hypothesised the sounds do not need to be deafeningly loud to elicit anxiety, if the sound source itself is quite scary and there is a long exposure time. If the exposure has an extended duration it should not be excessively loud. So ideally, the results should indicate that the soundscape is *mostly loud*, but not *unbearable*. If respondents think it is too quiet the soundscapes can be remixed to increase the volume (even if just for the peak loudest parts.)

4.2.2.3 *Post-Soundscape Frequency of Perceived Sensations* (questionnaire 2.2.2)

The primary results are first focused on the *Post-Soundscape Frequency of Sensations* (2.2.2) as it is the most rigorous, detailed element of the experiment, providing unique ratings for each individual sensation that could be triggered by the soundscape. The original *Beck Anxiety Inventory* asks the participant to rate how intensely they felt each of a list of anxiety symptoms, on average over the past month. However, the *Frequency of Perceived Sensations* questionnaire has been tailored to evaluate a short soundscape: the participant is asked to assess the frequency rather than the intensity of the symptoms. That is, they are asked: “how often did you feel [a sensation]?” answering along a Likert scale from 0 for “not at all”, to 1 for “once very briefly”, 1.5 for “2 or 3 times”, 2 for “throughout most of the piece”, or 3 for “constantly.” Although the rating is slightly different than the original test, frequency is almost the same as intensity when it comes to sensation - it is just another way of approaching it. Asking a participant how often they perceived a sensation means they think of it more objectively or empirically rather than emotionally. It can be seen as a neutral question, rather than “how deeply affected were you?” or “how upset were you?” It is a way of removing the sensation away from the participant’s psyche, emphasizing the power of the external stimulus, rather than blaming the participant for becoming upset, for example. It may be easier for the participant to answer if delivered in terms of frequency rather than intensity.

All the anxiety attributes from the *Pre-Exposure Intensity of Perceived Sensations* (1.1.3) from the *Pre-Exposure Participant Eligibility Screening* (questionnaire 1) appear in the *Post-Soundscape Frequency of Perceived Sensations* test (2.2.2), to enable pre- to post-test mapped analysis. The Beck attributes are combined with those listed in Becht and Vingerhoets’ (2008) *Crying and Mood Change* study (relaxation, a sense of being in control, happiness, relief, tension, depression and sadness).

One type of analysis reveals the most potent anxiety-eliciting sounds, those which participants frequently identified as a sensation trigger both pre- and post-exposure. The other type of analysis gauges the level of emotional involvement perceived by the participants, discerning the degree to which they felt specific sensations and emotions. The responses can be grouped according to much more general questions, to average the responses: overall, how physical the soundscape exposure experience was compared to how psychological, or whether the experience was perceived as largely positive or negative. So, each participant tallies twenty-eight scores indicating that they were either very emotionally involved or not so emotionally involved, and either very physically aroused or not so physically aroused. The attributes listed in the *Post-Soundscape Frequency of Perceived Sensations* (2.2.2) do seem to be mainly signs of over-arousal, or anxiety traits, but if the user cognitively re-evaluates them, they could actually be seen as markers of the sound’s power to stir up emotion, full stop. Whilst painful sensations are generally negative, tingling can be positive. For depressed people, who may be struggling to feel anything, the fact that they can be triggered to feel an emotion or sensation could be seen as a positive.

Quantifiable information must be extracted from participants, so a score system was developed to reduce the complexity of the questionnaires. The *Post-Soundscape Frequency of Perceived Sensations* (2.2) was assembled so as to easily calculate the strength of perceived anxiety attributes, by category. This list of anxious sensations was categorized into those that can be construed as physical positive (Phys+), such as “heart pounding” which can be seen a marker of excitement, or “pleasurable chills” down the back of the spine, which can be induced by musical bliss, often felt as pleasant if the user feels in control of it. There are several symptoms which can be deemed as physical negative (Phys-), such as “upset stomach” or “nausea” which is universally felt as unpleasant, or psychological negative (psych-) (“depressed”, “terrified”, “completely unable to relax”), or psychological positive (Psych+) (“happy”, “content”, and “relaxed”). Participant responses can be averaged within each of these four categories: physical positive (Phys+), physical negative (Phys-), psychological negative (Psych-) and psychological positive (Psych+). Four scores per participant are generated for each soundscape, and when these are averaged across all participants, then it can be calculated how psychologically involved participants were on the whole, whether they had mostly sad or terrified feelings for example, as well as how frequently physical sensations were induced. It is straightforward to run a comparison across soundscapes or participants. (See example score set below).

Table 10: List of symptoms from each sensation category, and example score set

Physical positive (Score: 5/15 = 0.333)	Physical negative (Score: 4/18 = 0.22)
Pleasurable chills (1/3) Numbness/tingling (1/3) Blush (0/3) Hot (2/3) Heart pounding (1/3)	Legs wobbly (2/3) Shaking hands (0/3) Unsteady/shaky (1/3) Sweat (0/3) Faint (0/3) Upset stomach (1/3)
Psychological positive (Score: 7/18 = 0.167)	**Pychological negative (Score: 6/30 = 0.2)**
Happy (2/3) Pleasure (1/3) Relieved (0/3) In control (1/3) Relaxed (1/3) Content (2/3)	Sad (1/3) Tense (2/3) Scared (0/3) Frightened (0/3) Nervous (1/3) Depressed (1/3) Fear losing control (0/3) Fear you were going to die (0/3) Fear the worst happening (1/3) Completely unable to relax (0/3)

The rating for each symptom in isolation can also be averaged across all participants: those that are seem to recur frequently (scored as "2-3 times," "throughout most of the soundscape" or "constantly") are revealed in the secondary results for the experiment (Section 6.2.1). The participants also have space to elaborate upon the nature of any strong sensations or musical bliss, and even note the sound trigger they associated with it (if recalled post-soundscape). When asking does the soundscape exposure elicit anxiety or strong sensations, the answer comes from the averaged *Post-Exposure Frequency of Sensations* (2.2.2) responses. For the most basic answer, it must be established whether the questionnaire responses were consistently zero, or if they were more than zero. The answer appears to be yes, soundscape exposure does elicit anxiety (strong sensations), and in the experiment, these were predominantly positive sensations. It is taken into account that physical positive (Phys+) sensations are still technically anxiety traits: however, this just means that the participants experienced a more frequent triggering of the more pleasant bodily sensations of anxiety. This means that soundscape exposure does indeed appear to be both an effective anxiety elicitor, but also importantly a humane treatment for anxiety sufferers. Nevertheless, the experience was still peppered with negative sensations, so the user can rehearse feeling the negative symptoms within an overall positive experience, in a controlled environment.

To sum up, before a participant's visit to the Soundlab was confirmed, they were asked to reflect on the intensity of sensations perceived over the past month (both to establish their baseline anxiety levels *and* ensure their eligibility). Next, the questionnaire was adapted to gauge the participant's anxiety at a specific moment in time, immediately following each soundscape during their exposure session. So, the questionnaire is effective for both long-term and short-term anxiety evaluations depending on the wording of the multiple choice responses. Space is offered underneath each sensation listed for a participant to identify the cause of the sensation, that is which sound was deemed to be the trigger for each feeling. Intriguingly, the principal researcher, in the process of composing and panning the soundscapes, has found that the scariest sounds are the ones that have become the most unfamiliar or unidentifiable. Thus, it is likely that the participants may be more scared by sounds that they were not expecting to fear, or those that the source of which could not even be recognised. This does complicate matters, as it is impossible to ask participants to take a note of sounds that they could not even identify in the first place. If it is discovered that the effective trigger sounds are different from what the participant previously listed in the *Pre-Exposure Trigger Diagnosis* (1.2), that would be very interesting.

4.2.2.4 *Post-Soundscape Mood Change Assessment* (questionnaire 2.2.3)*, Post-Soundscape Breathing Assessment* (questionnaire 2.2.4*), Post-Soundscape Affect Dichotomy* (questionnaire 2.2.5) and the *Post-Soundscape Memory Record* (questionnaire 2.2.7)

There are four very short sections of the post-soundscape questionnaire which ascertain the larger impact of each soundscape on the participant's psyche in addition to the measuring efficacy of the sounds in eliciting memory recall. The *Post-Soundscape Mood Change Assessment* (2.2.3) asks the participant to account for a difference in levels for eight moods with a multiple choice of either "-1" for a negative change, "0" for no change or a "+1" for positive change. The rise of happiness, pleasure, relief, a sense of being in control, relaxation, contentment, or the intensification of tension, depression, and sadness are all evaluated using the -1 for negative to +1 for positive scale. Whilst these moods are also rated in terms of the frequency of their perception during the soundscapes' playback (from 0 for "not at all" to 3 for "constantly"), it is useful to gauge whether the participant perceives the intensification of each mood as a positive or negative change overall. This measure is adapted from Becht and Vingerhoet's (2008) *Crying and Mood Change* study.

The *Post-Soundscape Affect Dichotomy* (2.2.5) forces the participant to choose either one extreme or the other on an emotional scale, to encourage participants to share their honest appraisal of their reactions to the soundscape, to negate any sense of dutiful politeness. They must choose the emotion they felt most predominantly: either "excitement" or "depression"; "pleasure" or "displeasure"; "arousal" or "sleepiness"; "distress" or "contentment"; "alarmed" or "sleepy"; "afraid" or "at ease"; "bored" or "astonished"; "frustrated" or "satisfied".

The *Post-Soundscape Breathing Assessment* (2.2.4) is even briefer, as participants are asked to check one or more options out of four to best describe their breathing during listening to the soundscape, either "breathless", "slow relaxed breath" "shallow breaths" or "fast breaths".

Finally, the participants are asked to record any memories that were triggered by the sound, in the *Post-Soundscape Memory Record* (2.2.7). Firstly, the participants are asked how frequently memories were triggered, or if they were reminded of any past real-life experiences from "not at all" (0) to "constantly" (3). They are then offered a blank space to elaborate on the nature of these memories, and a more structured form to fill in prompting the participant to reveal the environment, situation, and sensations remembered, and of course the trigger sound responsible for the memory recall. Then the participant is asked to roughly pinpoint the time that the memories were triggered, near the beginning, middle or end of the soundscape (to allow for cross correlation with other data channels, in case the sound identified is too vague).

4.2.2.4 Post-Soundscape Body Map (questionnaire 2.2.8)

Although there is a digital record of physiological peak responses (pulse rate, respiration, sweat secretion), it is still necessary that the participants are asked to evaluate how they perceived their physiology to change. It will be interesting to compare participant's perceptions of their breathing or heart rate to the reality: they may not have actually been breathing fast panicked breaths for the duration of the soundscape, but if they think that they were, then that means they were in fact psychologically affected.

The *Post-Soundscape Body Map* (2.2.8) is an accessible way for the participants to identify the symptoms felt, as they join up the sensation (from a list of given exemplar symptoms) with the location on the body, and can then identify the sound they thought caused the sensation. Doctors commonly implement this method to diagnose illness, as patients use symbols for different types of pain: for example, lines to symbolise stabbing pain and dots to illustrate tingling. Similarly, the participant indicated a negative sensation through using a red pencil or a positive sensation with a blue pencil. Then, after digitizing all of the *Body Maps*, these are overlaid transparently in Photoshop to generate a pictorial average of all participant responses. The result could be that there is most dense colour is blue around the neck area (probably musical chills) and red around the forehead (tension headache from frowning), so an average will be visually quantified. It may also indicate that even though the participant is immersed in an ambisonic sound array the affect is still largely concentrated around the ears, or that the sound vibrations might be perceived across the whole body. This would prove that it is not just the semantic content or acoustic nature of the sounds that elicits anxiety, that the immersivity of the ambisonic mode of presentation has a significant role to play in elicitation of strong sensations. However, this is a specialised tangent, secondary to the fundamental research question of whether soundscape exposure does actually elicit anxiety. The *Post-Soundscape Body Map* (2.2.8) helps to answer secondary research questions, of how soundscape exposure elicits anxiety, or which areas of the body it directly affects.

4.2.2.5 *Post-Soundscape Liked and Disliked Sounds* (questionnaire 2.2.9)

When the participant reports the sounds that triggered each emotion or sensation whilst listening to the soundscape in the *Post-Soundscape Frequency of Perceived Sensations* (2.2.2), either a good overlap or dissociation will be found against the sounds originally identified in the *Pre-Exposure Trigger Diagnosis* (1.2). Of course, if the participants fail to accurately pinpoint or name the sounds from memory, an alternative means for them to indicate the correct sounds is required. Thus, each soundscape has a dedicated graphical sound event timeline (or *Soundmap,* as seen in Section 3.2.1), so the participants can browse over the list of sounds, enabling them to rate the anxiety induced by the correct sound in the questionnaires, or reveal the nature of the memories it triggered. A long, comprehensive timeline of sounds appears visually similar in format to a timeline in a Digital Audio Workstation such as Reaper or ProTools, with every single sound presented in isolation as a distinct rectangular block of colour with a brief descriptor of the sound source. Essentially, this *Soundmap* is intended to be a universally legible form of a musical score. A *Soundmap* for each soundscape is printed on A3 for every participant to use as a memory prompt from the beginning of each *Post-Soundscape questionnaire* completion period. Participants were then asked to directly annotate the *Soundmap* drawing a cross (✗) on sounds that they disliked or a tick (✓) on sounds that they liked. The participant might have had a vague idea that their anxiety trigger was near the beginning, then by looking at the *Soundmap* they can figure out it was the busy part where lots of sounds were playing simultaneously, and eventually they decide it was specifically a “Horror Screech”, for example. If they could not remember or identify a sound source unprompted, seeing the sounds mapped out graphically may clarify their memory. A *Soundmap* for each soundscape is presented in A3 size, so the participant could see it all on a large scale, so they are able to isolate thematic sections at a glance or differentiate between denser and sparser sections, then zoom in and see each sound source. A print-out sheet for each participant allows them to directly mark and annotate it, which an efficient means of data collection.

(There was an idea of presenting the *Soundmap* on an iPad, so the participants could click on the individual sound to hear it solo and verify it was the one they were thinking of. However, this was deemed too time-consuming to create, and not strictly necessary. Another approach would be to display the Reaper session on the monitor, scroll up and down and solo a track to let the participant hear it – however that would take up too much time in the experiment. A physical handout is quicker to fill out and simpler to use, whilst also ensuring a good record of the participants' notes is kept.) If the participant draws their responses to the sounds directly on the timeline, then mapping them against the *Pre-Exposure Trigger Diagnosis* becomes much easier. The *Memory Record* will be also more effective if the participant can pinpoint on the timeline, although it might be difficult to understand for someone who has never seen such a graph. The sound blocks on the *Soundmap* were intuitively colour-coded (red for alarming, blue for soothing, grey for neutral, pink for vocal, olive green for military, blue for water) and each sound block was plotted to scale, its length representative of the exact duration of each sound sample.

4.2.2.6 *Post-Exposure Spatialisation Assessment* (questionnaire 2.3.4)

Following the soundscape exposure, several isolated sound pairs are played, asking whether which of the two panning motions are the most realistic – then once a consensus is formed as to which is the most realistic sound and which is the most hyperreal, it can be discerned whether the realistic or hyperreal sound motion is deemed to bethe most unnerving, frightening, irritating or panic-inducing by the average participant. The participant is asked to compare as follows:

> "*Listen to Sound 1 and Sound 2.*
>
> *Which sound was the most realistic?*
> *Sound 1 (chains, static mono)* ☐
> *Sound 2 (chains, slow drop from above to below)* ☐
>
> *Which sound was the most unnerving?*
> *Sound 1 (chains, static mono)* ☐
> *Sound 2 (chains, slow drop from above to below)* ☐
>
> *Which sound was the most frightening?*
> *Sound 1 (chains, static mono)* ☐
> *Sound 2 (chains, slow drop from above to below)* ☐
>
> *Which sound was the most irritating?*
> *Sound 1 (chains, static mono)* ☐
> *Sound 2 (chains, slow drop from to above to below)* ☐
>
> *Which sound was the most panic-inducing?*
> *Sound 1 (chains, static mono)* ☐
> *Sound 2 (chains, slow drop from above to below)* ☐"

The use of the ambisonic array is justified, as the research team is utilising the exaggerated affect that a participant feels when immersed in spatialised sound compared to two-channel stereo; further, the Soundlab is a professional test environment. The research is contextualised among the larger scope of public entertainment venues: if people want to stimulate their senses, they often go to theme parks, or the IMAX cinemas - the success of the IMAX despite the extra cost is testament to how much extra people are willing to pay to be immersed as possible. It can be argued that the higher order ambisonic soundscape exposure therapeutic framework even exceeds cinema's widely employed 5.1 or 7.1 surround sound technology, as the 16-speaker array has a personalized single-person sweet spot with precisely localised sounds. Soundscape exposure should be tested in the optimum conditions, so it makes sense to use this space.

4.2.2.7 *Post-Exposure Evaluation of Anxiety Levels* (short term) (questionnaire 2.3)

The *Post-Exposure Evaluation of Anxiety Levels* (2.3) follows the same format as the adapted *Crying and Mood Change* and *Subjective Units of Distress* Scales featured in *Pre-Exposure Evaluation of Anxiety Levels* (1.1), but with the questions adapted to suit short term reflection on the exposure experience, rather than reflection upon the previous month. The participant evaluates their anxiety felt in the period immediately following the completed soundscape exposure experience, so this can be compared to their baseline ratings of anxiety (on the day, and the previous month). Questionnaires to be completed upon the end of the exposure session include the *Post-Exposure Stress Thermometer*, based on the *SUD* scale (2.3.1), the *Post-Exposure Intensity of Perceived Moods* (2.3.2), and the *Post-Exposure Better or Worse* (2.3.3).

Finally, the participant must decide at the end of the exposure whether they feel better, worse or the same as when they walked in. Although this gauge seems very general, and one could argue that there are many nuances of emotions (as no-one would just feel either completely better or completely worse), evaluation of this basic scale is vital to discern overall wellness after exposure. The participant can perceive the question as "has your general well-being improved?", or "have you achieved catharsis?". Even if a participant has been upset by certain sounds, they may feel better than they did at the start of the experiment, as they have been allowed time to fully process a previously repressed upsetting issue. For the pilot, this scale was only offered in the *Post-Exposure Evaluation of Anxiety levels* (as questionnaire 2.3.3). Upon learning how valuable this binary scale is in discerning the overall positive or negative impact of soundscape exposure in the pilot, it was decided that this scale is also to be completed after each soundscape in the experiment, so it can be discerned which soundscapes most consistently made participants feel better or worse.

4.2.3 Activity 3: *Long-Term Catharsis Evaluation* (questionnaire 3)

Following initial analysis of the results from the pilot study, it became apparent that it would be hugely beneficial to ask the participants to complete a brief follow-up questionnaire one-week after the experiment, to evaluate possible improvements on their physiological and psychological wellbeing (compared to the *Pre-Exposure Participant Eligibility Screening,* questionnaire 1). Long term pre-post analysis essentially quantifies the level of positive or negative impact on participants, whilst also revealing if the participant has experienced a psychological catharsis after addressing emotional issues triggered by the soundscapes. The experiment is designed to elicit anxiety in a participant on a short-term time-frame, so the participant can re-visit and re-evaluate unpleasant memories and physical sensations, to encourage mental and bodily resilience to anxiety in real life. The participant's physical and mental state can be accurately gauged in-situ, but understandably the participant will to need time to recover from the mental work and tiring conditions of being confined in the Soundlab for extended duration, to reach a more optimal state. Thus, for detection of catharsis it was deemed essential to question the participants about their wellbeing one week following the experiment.

The *Long-Term Catharsis Evaluation* (questionnaire 3) is not overly demanding, and it was made clear to the participants that it was not compulsory. It is sufficient for the participants to complete the questionnaire remotely, via email. It is a condensed version of the *Pre-Exposure Participant Eligibility Screening* (questionnaire 1), consisting of the same three essential components of the *Stress Thermometer* (1.1.1), the *Emotion-Time Distribution* (1.1.2), and the *Intensity of Perceived Sensations* (1.1.3) to enable an accurate cross-reference of the pre-exposure scores to the long-term post-exposure scores. Additional straightforward questions were also asked, based on Saarikallio et al.'s *Music in Mood Regulation Scale* (2012) and Bylsma, Vingerhoets and Rottenberg's 2008 study, *When is Crying Cathartic?* Questionnaires included in the *Long-Term Catharsis Evaluation* (questionnaire 3) are as follows:

3.1: *Long Term Stress Thermometer (as in 4.2.1.1)*

3.2: *Long Term Emotion-Time Distribution (as in 4.2.1.1)*

3.3: *Long-Term Intensity of Perceived Sensations (as in 4.2.1.1)*

3.4: *Long-Term Emotional Impact of Soundscape Exposure*

3.5: *Long-Term Mood Change (as in 4.2.2.4)*

3.6: *Long-Term Better or Worse (as in 4.2.2.8)*

3.7: *Long-Term Soundscape Exposure Affects*

During soundscape exposure, the participant's psychophysical signals are recorded to quantify the participants' real-time arousal during exposure. To record traces of emotional transformation, rigorous pre-exposure, post-soundscape and post-exposure questionnaires are crucial to record the physical and psychological affects that the participants perceived, but verbal utterances are also recorded post-soundscape, and the fluctuation of facial expressions is video-recorded during the soundscape's playback, especially searching for crying reactions (thought to be indicative of or conducive to catharsis). In addition to the *Post-Exposure Evaluation of Anxiety Levels* (2.3), a long-term window for introspective reflection is necessary – once the participant has left the exposure environment, and the sound events and thematic connotations have sunk in, connections may have formed in their mind which lead to a form of catharsis.

In the *Long-Term Emotional Impact of Soundscape Exposure* (3.4), participants are asked if they were initially upset by the soundscape exposure, either during the experiment or later that day, or if they cried in the days following the Soundscape Exposure. More optimistically, participants were also asked if they gained confidence in their ability to withstand anxious sensations, as a result of the soundscape exposure. They were asked if they excessively ruminated on negative issues (more than usual) in the week following the soundscape exposure, and if the effects of the soundscape exposure lasted beyond the visit to the SoundLab. As a measure of catharsis, participants were asked if they resolved any underlying fear, trauma or grief either during the soundscape exposure, or in the days following it. As an indication of increased mindfulness, participants were asked if they became more aware of the fluidity of their moods, and mindful of their physical sensations since the soundscape exposure (and crucially, if this heightened awareness had been helpful or distressing). Participants were also asked if they re-heard any of the sounds heard during the Soundscape Exposure, as a form of ear-worm.

To conclude, for the *Long-Term Soundscape Exposure Affects* (3.7), participants were asked to tick one or more of the possible applications of soundscape exposure that was perceived in their experience: soundscape exposure as entertainment, energizing, relaxation, vibrating sensations throughout their entire body, inducer of strong sensations, distraction from other worries, intensified anger and frustration, saddening, an aid to better understanding their emotions, or a comfort.

4.3 Minimised harm, distress or anxiety for participants

4.3.1 Listener Fatigue

Ideally, exposing all five soundscapes to each participant would mean there is increased likelihood to match individual sensitivities, as each participant may have varying musical preferences and emotional biases from a diverse range of personal circumstances. Also, it would be an effective use of travel expenses to maximise the data produced by each participant. Whilst it would be ideal to cover all five soundscape themes with each participant, realistically this was not possible - whilst they would have been exposed to all soundscapes, it may only yield results that indicate boredom or tiredness. The experiment would likely prove ineffective if every participant had to listen to all the soundscapes. Different ways of reducing exposure time were considered: either trimming the duration of each soundscape, or reducing the number, which was decided to be the most sensible. There are similarities between the soundscapes, so it was thought not be too detrimental to the data to only present three soundscapes of the five available to the participants in the large scale experiment. Initially, it was envisaged that three most sensible soundscapes would be chosen for each participant (possibly chosen to suit their individual anxieties), so the soundscapes can remain their original length, untrimmed. For 30 participants, there could be 30 different combinations of 3 soundscapes, so all soundscapes will be distributed evenly across the participants. There could be 60 different combinations, with different orders (5 x 4 x 3 = 60). A minimum of 10 exposure sessions ensures that each soundscape played an equal number of times. So for 30 participants, each soundscape will be played 18 times, and each will be framed by a different preceding or following soundscape:

Table 11: The total time of each exposure programme, when shuffling all five soundscapes across a maximum of three per participant

Participant 1	*Violence*	*Body Anxiety*	*Phobias*	46 min16sec
Participant 2	*Body Anxiety*	*Phobias*	*Social Anxiety*	46 min32sec
Participant 3	*Sensory Irritation*	*Social Anxiety*	*Phobias*	44 min15sec
Participant 4	*Social Anxiety*	*Violence*	*Body Anxiety*	40 min35sec
Participant 5	*Phobias*	*Sensory Irritation*	*Violence*	43 min59sec
Participant 6	*Violence*	*Body Anxiety*	*Sensory Irritation*	40 min 6sec
Participant 7	*Body Anxiety*	*Social Anxiety*	*Sensory Irritation*	40 min22sec
Participant 8	*Violence*	*Phobias*	*Social Anxiety*	44 min28sec
Participant 9	*Violence*	*Social Anxiety*	*Sensory Irritation*	38 min18sec
Participant10	*Body Anxiety*	*Phobias*	*Sensory Irritation*	46 min 3 sec

(An alternative approach to omitting two soundscapes per participant, would have been to trim down the duration of each soundscape. Rather than trying to fit all of the same sounds in and compress each section, which would be possible, but it may take a lot of work and yield unsatisfactory results, changing the piece to a point that the sound relationships do not work anymore, what would have been more effective is to remove chunks or clusters of sounds, cutting out a section from each. For example, the *Time Stress* section of *Situational Phobias* is intentionally repetitive, sparse, and intended to make the participant think that listening to that part of the composition is a waste of their time. This was more of a psychological concept rather than being the most crucial test stimuli central to the research.)

Participants should not know the theme of the soundscape before hearing it, as this may skew reactions or spoil surprises, if they had preconceived notions of how they think they would feel. Thus, this rules out the option that participants choose their own soundscapes. (Also, many people might have chosen the same one, and some soundscapes may not have been picked.) So instead the soundscapes were prescribed for each participant. Converse to the method of choosing each soundscape to match each participant's pre-existing anxiety triggers, it was decided that the dataset would be far stronger if each soundscape was played 30 times each by limiting the soundscapes to be the same set of three per participant, rather than shuffling all five soundscapes to appear 18 times each. Analysis of preliminary data from the pilot informed the decision as to which three soundscapes should be played. Following the pilot, bar graphs were devised to show: the average responses in terms of frequency of trigger points per soundscape (a peak or increase in each channel of physiological monitoring); the frequency of written responses per soundscape (and the number of triggers listed in these responses); and the number of likes and dislikes of sounds as annotated on the *Soundmap* for each soundscape. It appeared that *Violence, Body Anxiety* and *Situational Phobias* were the most anxiety-eliciting soundscapes (but not dramatically so). While it was considered as perhaps beneficial to design a more balanced exposure experience by using *Social Anxiety* as one of the three, in the end this soundscape was deemed too calm to be used as a main exposure stimuli. Further, more bar graphs were drawn up which corroborated that *Violence, Situational Phobias* and *Body Anxiety* seem to be the most powerful in causing consciously perceived physical positive (Phys +), physical negative (Phys -), psychological negative (Psych -) and psychological positive (Psych +) sensations, according to data from participants' Likert scale scores in the *Post-Soundscape Frequency of Perceived Sensations*, (2.2.2).

One might argue that the long duration is in fact a necessary part of the soundscape exposure therapy. When anxiety sufferers go to counselling or talk therapy they are usually allocated a 40mins or 1hr session. Even if the client becomes uncomfortable or upset, all parties have agreed to dedicate the set amount of time, and they should speak or sit with the therapist for the duration. The clients are free to leave before their time is up, but they are not completing treatment. At times, when the concept of soundscape exposure therapy is explained to prospective participants or researchers, some comment on the similarity to techniques viewed in Stanley Kubrick's *A Clockwork Orange* (1972) as they imagine the user would be strapped in and forced to endure torturous sounds for an extended period. Whilst the user is not restrained as in the barbaric fictional "Ludivico treatment", it is an essential part of the treatment that the user perseveres for a length of time so they build up resistance to aversive stimuli. Nonetheless, a panic button is available to the participants, which instantly stops the sound whenever the participant chooses. It is acknowledged that soundscape exposure will be a tiring process, but it is an endurance test and the participant should become desensitized (in effect, bored) by the end. The novelty should wear off, and in fact it will be valuable if we have data that shows the physiological signals are less dramatic, more reflective of calm or boredom during the last soundscape.

The thrust of the project is to quantify whether or not soundscape exposure can be therapeutic. If soundscape exposure is implemented in treatment, the therapist would first diagnose the specific type of anxiety and tailor a soundscape. So, from the collection, only one might be necessary. First, the tests will deduce if the collection of soundscapes work, and discover what exactly it is that makes people engage with the soundscapes, and whether or not there is a correspondence between the sounds played and their pre-disposed anxiety triggers.

For the pilot, five enthusiastic individuals were recruited, keen to hear all five of the soundscapes - so the soundscape order was shuffled as below:

Table 12: The order in which all five soundscapes were presented for the pilot

Participant	Played 1st	Played 2nd	Played 3rd	Played 4th	Played 5th
1	*Violence*	*Body Anxiety*	*Situational Phobias*	*Sensory Irritation*	*Social Anxiety*
2	*Body Anxiety*	*Situational Phobias*	*Social Anxiety*	*Violence*	*Sensory Irritation*
3	*Sensory Irritation*	*Social Anxiety*	*Situational Phobias*	*Body Anxiety*	*Violence*
4	*Social Anxiety*	*Violence*	*Body Anxiety*	*Sensory Irritation*	*Situational Phobias*
5	*Situational Phobias*	*Sensory Irritation*	*Violence*	*Social Anxiety*	*Body Anxiety*

Pilot participants were also asked a few additional questions elaborating on the participant's tiredness or boredom - it was a trial, so they were probed a little further afterwards, feedback conversations about the endurance level required were recorded. For the experiment, the soundscape order permutations were plotted as in Table 13 below:

Table 13: The six possible permutations in which soundscapes were presented for the large-scale experiment.

Participant no.	Played 1st	Played 2nd	Played 3rd
6, 12, 18, 24, 30	*Violence*	*Phobias*	*Body Anxiety*
7, 13, 19, 25, 31	*Phobias*	*Body Anxiety*	*Violence*
8, 14. 20, 26, 32	*Body Anxiety*	*Violence*	*Phobias*
9, 15. 21, 27, 33	*Body Anxiety*	*Phobias*	*Violence*
10, 16. 22, 28, 34	*Phobias*	*Violence*	*Body Anxiety*
11, 17. 23, 29. 35	*Violence*	*Body Anxiety*	*Phobias*

4.3.2 Loudness

It is an ethical concern as to how loudly the soundscape can be played. The *Information Sheet* reassures a prospective participant that the exposure will not be any louder than the legal threshold which people are willing to expose themselves to in the ever-increasing loudness of cinema. There is a strict World Health Organisation guideline, starting at 8dBA for 8 hours, 90dBA for 4 hours, 94dBA for 2 hours, 1 hour at 98 dBA (see Table 7) – the exposure soundscape can become quite loud as long as it is for a short exposure time. Nonetheless, limits were imposed on what might just be too unpleasant (even if it is legally safe), as the exposure should not necessarily be just at the threshold of pain throughout. All soundscapes were tested with a Sound Pressure Level meter to ensure that the peak loudness was 90dBA, only for a few seconds at a time. On average the SPL level was closer to 70dBA, well within the legal threshold.

Whilst part of what makes up a shock sound is the *actual* volume, an important characteristic of a shock is the perceived volume. That is, whether listener is prepared for a loud bang as it follows a warning build up crescendo, or if the bang is completely unexpected, bursting through a period of quiet. Like the *simultaneous brightness* illusion visualised in Figure 22, even if the shock sound is at the same volume in both situations, the unexpected shock from a quiet base will always seem louder and thus more jarring.

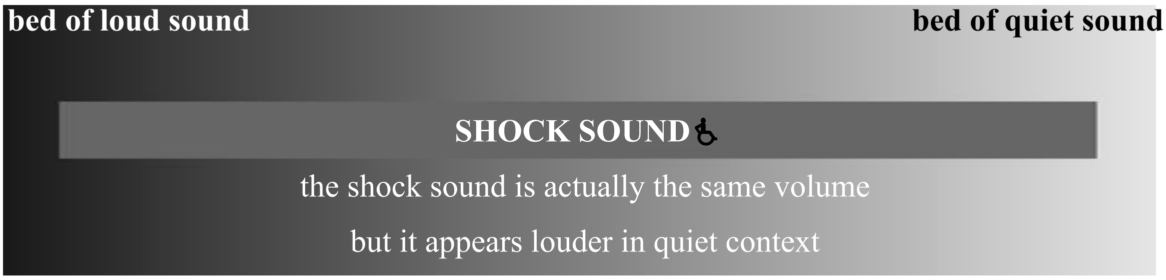


Figure 22: A shock sound will always appear louder when emerging from a bed of quiet sound, as shown by analogy with the *Simultaneous Brightness* illusion

4.3.3 Upset

It was predicted that participants might become mildly upset if they are sensitive to certain anxiety trigger sounds – but they were somewhat prepared, due to their prior identification of featured sound categories in the *Pre-Exposure Trigger Diagnosis*. Participants were informed of their entitlement to stop the playback of the soundscape at any time, using a clearly indicated button. The *Post-Exposure Evaluation of Anxiety Levels* (2.3) assesses the participant's lasting distress - if a participant show a high score on the adapted *Post-Exposure Stress Thermometer* (2.3.1) or the *Post-Exposure Intensity of Perceived Moods*

(2.3.2), then they are offered a database of local self-help groups, in addition to professional helplines indicated on the Information Sheet (see Appendix).

If a participant became very upset, the principal researcher was prepared to personally offer comfort, by asking if they'd like to discuss any issues raised. (They are also welcome to use the helplines provided for counselling and advice, if preferred). Refreshments such as tea, coffee, juice and snacks were also provided to all participants, to boost energy levels upon their departure. The soundscapes were consciously engineered so that they gradually build in intensity towards the abrasive sounds and then morph back to a more pleasant frequency range and sound density. This should naturally calm people down during the experiment, but an extra respite composition was also offered post exposure, including nature sounds and soothingly bare cello melodies. Whilst it was preferred not to unnecessarily extend the duration of the experiment, all participants were welcome to immerse themselves in soothing sounds in the Soundlab, or to sit in a comfortable armchair with headphones if preferred.

4.3.4 Comfort

A reasonably comfortable chair with a backrest was obtained for the Soundlab, however the principal requirements were that it not absorb or deflect too much of the sound, to let the sound resonate in participants' muscles and ensuring the sound is not obstructed on its journey to the ears. Other limiting factors were that the chair could not be on wheels (so the participant did not roll out of the sweet spot), and it also had to be high enough so that the participant's ears aligned with the central ring of speakers - so unfortunately the only chair available (within budget constraints) that fit these requirements was a basic rubberised plastic kitchen stool. However, the participants were also offered different combinations of cushions for them to make themselves more comfortable: one for their back, as well as one to be sat on if necessary.

4.3.5 Time Commitment

Although every participant experience is unique, with some soundscapes that resonate with personal histories eliciting far richer written responses than others, an indicative time commitment was offered in the information sheet. The *Pre-Exposure Participant Eligibility Screening* (questionnaire 1) should take up to 10 minutes to complete, and can be filled in remotely, via email, to ensure eligibility prior to travelling to the Soundlab.

Each soundscape lasts 12 to 18 minutes, but 5 to 8 minutes is allotted in between to fill in the *Post-Soundscape Questionnaire* (2.2) whilst simultaneously resting the ears. Although it is a lengthy test, a great wealth of data is procured per participant, to make the trip to the Soundlab worthwhile. It is a prolonged exposure to sound, but the testing is not repetitive, as each participant is exposed to five different soundscapes in the pilot and three different soundscapes in the experiment.

Pilot experiment procedure (July 2015)

Activity 1 (at home): 15 minutes total

• Questionnaire 1: Pre-Exposure Participant Eligibility Screening	7-10 minutes
• Information Sheet and Consent Form Reading:	5 minutes

Activity 2 (at Soundlab): 2 hours 4 minutes total

• Information Sheet Re-Reading and Consent Form Signing:	5 minutes
• Questionnaire 2.1: Pre-Exposure Evaluation of Anxiety Levels	1-2 minutes
• Set-Up of Physiological Monitoring Equipment:	3-5 minutes
• Soundscape 1 playback	12min 55sec
• Questionnaire 2.2: Post-Soundscape 1	5-8 minutes
• Soundscape 2 playback	14min 48sec
• Questionnaire 2.2: Post-Soundscape 2	5-8 minutes
• Soundscape 3 playback	18min 42sec
• Questionnaire 2.2: Post-Soundscape 3	5-8 minutes
• Soundscape 4 playback	12min 32sec
• Questionnaire 2.2: Post-Soundscape 4	5-8 minutes
• Soundscape 5 playback	13min 01sec
• Questionnaire 2.2: Post-Soundscape 5	5-8 minutes
• Questionnaire 2.3: Post-Exposure Evaluation of Anxiety Levels	3-5 minutes

Total soundscape playback time: 71 min 49 sec.

Total Post-Soundscape Questionnaire time: 25-40 minutes

Total Pre- and Post-Exposure Questionnaire time: 9-12 minutes

Total stage 2 time: 106-124 minutes (estimated 1 hour 46 minutes – 2 hours 04 minutes)

Note that the soundscape playback time is less for the experiment, as only three soundscapes are played, and thus only three post-soundscape questionnaires are required.

The total duration of the experiment should be 1 hour and 23 minutes at most: including pre-exposure and post-exposure questionnaires, playing three soundscapes to each participant. The pilot participants were enthusiastic enough to listen to all five soundscapes: this added 25 minutes extra sound presentation and up to 16 minutes extra *Post-Soundscape* Questionnaire time to the ideal proposed procedure for the experiment.

Experiment procedure (October-November 2015)

Activity 1 (at home): 15 minutes total

- Questionnaire 1: Pre-Exposure Participant Eligibility Screening 7-10 minutes
- Information Sheet and Consent Form Reading: 5 minutes

Activity 2 (at Soundlab): 1 hour 23 minutes total

- Information Sheet Re-Reading and Consent Form Signing: 5 minutes
- Questionnaire 2.1: Pre-Exposure Evaluation of Anxiety Levels 1-2 minutes
- Set-Up of Physiological Monitoring Equipment: 3-5 minutes
- Soundscape 1 playback 12min 55sec
- Questionnaire 2.2: Post-Soundscape 1 5-8 minutes
- Soundscape 2 playback 14min 48sec
- Questionnaire 2.2: Post-Soundscape 2 5-8 minutes
- Soundscape 3 playback 18min 42sec
- Questionnaire 2.2: Post-Soundscape 3 5-8 minutes
- Questionnaire 2.3: Post-Exposure Evaluation of Anxiety Levels 3-5 minutes

Total soundscape playback time: from 38 min 18 sec - 46 min 32 sec.

Total Post-Soundscape Questionnaire time: 15-24 minutes

Total Pre- and Post-Exposure Questionnaire time: 9-12 minutes

Total stage 2 time: 62-83 minutes (estimated 1 hour 2 minutes – 1 hours 23 minutes)

4.4 Pilot Results

4.4.1 Introduction

The fundamental change from the pilot to the large-scale experiment was to shorten the soundscape exposure procedure, by cutting out two of the soundscapes, *Social Anxiety* and *Sensory Irritation*. Data from the pilot experiment was used to inform this decision:

Violence, Situational Phobias and *Body Anxiety* were the soundscapes to elicit the strongest physiological and written responses overall. There were only five participants in the pilot, so each soundscape was only heard as the first, second, third, fourth or fifth in the sequence by one participant each, so conclusive averages cannot be discerned until the large scale experiment, but there are signs of habituation evident after the first soundscape. This can be observed in the Galvanic Skin Response peak rate diminishing when *Violence* was heard as the second or third in the sequence: the participant who heard it first demonstrated a peak rate of 0.64 peaks per minute, which was replicated in the participant who heard it as the second in the sequence, but the participant who heard it third only elicited 0.16 peaks per minute. The GSR peak rate diminished even further over time for *Body Anxiety*, initially eliciting an average rate of 1.35 peaks per minute for participant who heard it first, but the participant who heard it as the second soundscape only demonstrated a peak rate of 0.61 peaks per minute, and the participant who heard it as the third soundscape in the sequence demonstrated 0.81 peaks per minute. *Situational Phobias* strangely elicited the reverse of this pattern, as the participant who heard it first showed the lowest peak response and the participant who heard it third showed the highest, although this may be due to individual differences as each peak rate is a single participant figure, not an average. More reliable averages are discerned from groups of ten participants who heard each soundscape as the first second or third in the sequence during the experiment (see Section 5.5). (The diminishing of GSR peak rates for the *Social Anxiety* and *Sensory Irritation* soundscapes is not analysed here, as the GSR signals for these soundscapes has not been filtered through Matlab, as they were only played to five participants).

4.4.2 Selection of the three most provocative soundscapes

Five datasets from the pilot were evaluated to significantly inform the decision as to which two soundscapes should be omitted from the experiment. Firstly, the total number of written remarks about each soundscape was counted (as well as the number of sound triggers identified from each soundscape) as found in the *Post-Soundscape Questionnaire* (2.2). Secondly, the total number of likes and dislikes of sounds was calculated, as annotated on each soundscape’s graphical timeline of sounds (2.2.9). Thirdly, it was calculated which soundscape garnered the highest average scores attributed to the sensations listed in the *Post-Soundscape Frequency of Perceived Sensations* (2.2.2). Fourth, the number of pre-existing anxieties identified in the *Pre-Exposure Trigger Diagnosis* (1.2) for each soundscape has been counted. Fifth, the average number of trigger points elicited by each soundscape was calculated: that is, the number of occurrences of an indication of arousal from each channel of physiological monitoring (unfiltered), often represented by a peak or anomaly in the otherwise constant response curve.

On average, each participant wrote 21.2 remarks about *Body Anxiety* in the post-soundscape questionnaires, 15.4 about *Violence*, 12.6 about *Social Anxiety*, but only 11.6 remarks were made about the sounds in *Phobias* (on average), and 9.2 about *Sensory Irritation*. So, *Body Anxiety* triggered a richer perceived response and was the most written about soundscape in the pilot, followed by *Violence* and *Social Anxiety*, with *Situational Phobias* not far behind but *Sensory Irritation* was written about far less than the rest of the soundscapes.

The soundscapes with the greatest number of liked or disliked sounds (as annotated on the Soundmap) were *Body Anxiety* (24.8 for the average participant), *Situational Phobias* (14.4), *Violence* (13.8), *Sensory Irritation* (9) *Social Anxiety* (4.4). So, again *Body Anxiety* also contained the most sounds which warranted a like tick or dislike cross annotated on the *Soundmap*, followed by *Phobias* and *Violence*, with pilot participants feeling much more ambivalent about the sounds played in the *Sensory Irritation* and *Social Anxiety* soundscapes.

The average sensation score (as calculated from the *Post-Soundscape Frequency of Perceived Sensations*, questionnaire 2.2.2) elicited by both *Situational Phobias* and *Body Anxiety* was 0.18, and *Violence* garnered a sensation score of 0.16 (as did *Social Anxiety*), whereas Sensory Irritation's average sensation score was only 0.12. It seemed that *Violence*, *Body Anxiety* and *Situational Phobias* elicit the strongest sensation ratings, but not dramatically so.

Further, the total number of sounds identified in the *Pre-Exposure Trigger Diagnosis* (1.2) largely corroborated this, as there were 44 pre-exposure identifications of *Violence* sounds as anxiety-eliciting, as well as 40 *Body Anxiety* trigger sounds, 33 *Sensory Irritation* trigger sounds, 30 *Social Anxiety* trigger sounds – however only 16 sounds associated with *Situational Phobias* were identified in the *Pre-Exposure Trigger Diagnoses* (1.2).

The *Body Anxiety* soundscape elicited the greatest average number of (unfiltered, visible) GSR trigger points per minute averaging at 2.000 peaks per minute (for the average participant) followed by *Sensory Irritation* at 1.674, *Violence* at 1.641, and *Situational*

Phobias at 1.582, whereas *Social Anxiety* only elicited 1.414 peaks per minute on average.

Sensory Irritation elicited the most respiration trigger points per minute with 1.310 peaks/minute/ for the average participant, followed by *Situational Phobias* with 1.294 and *Body Anxiety* with 1.230, followed by *Violence* (1.161), , and *Social Anxiety* (0.968).

Trigger points are much more difficult to identify following the rises and attenuation in pulse rate (in units of beats per minute over time), but nonetheless the visible alterations in constant rates were tallied for the pilot participants. The highest occurrence of pulse rate surges on average was elicited by the *Violence* soundscape at 0.728 surges per minute for the average participant, followed by *Social Anxiety* (0.676), *Sensory Irritation* (0.552), *Phobias* (0.449), *Body Anxiety* (0.297)

An average indicative strength score for each soundscape is calculated by totalling the number of data modes in which each soundscape was deemed the strongest affect elicitor, and then dividing by the number of modes. For example, *Body Anxiety* was the strongest in three modes (written, likes and dislikes in addition to the GSR peak rate), the second strongest in three modes (sensation score, the number of pre-existing trigger sounds identified, and RESP peak rate), the weakest in one mode (HR surge rate), so the score is deviated as 1+1+1+2+2+2+5=14 – the total score of 14 is divided by, the number of data modes used here, seven, to generate an average strength of 2.

Table 14: Six data sets analysed to identify the three strongest soundscapes in the pilot (physiological and perceived responses.

	strongest	2nd strongest	mid-strength	2nd weakest	weakest
Strongest Soundscape	*Body Anxiety* (2.143)	*Violence* (2.429)	*Phobias* (3)	*Sensory Irritation* (3.571)	*Social Anxiety* (3.857)
Most Written remarks	*Body Anxiety*	*Violence*	*Social Anxiety*	*Phobias*	*Sensory Irritation*
Most Likes/Dislikes	*Body Anxiety*	*Phobias*	*Violence*	*Sensory Irritation*	*Social Anxiety*
Highest Sensation score	*Phobias*	*Body Anxiety*	*Violence*	*Social Anxiety*	*Sensory Irritation*
Most Pre-Existing Triggers	*Violence*	*Body Anxiety*	*Social Anxiety*	*Phobias*	*Sensory Irritation*
Highest GSR peak rate	*Body Anxiety*	*Sensory Irritation*	*Violence*	*Phobias*	*Social Anxiety*
Highest HR surge rate	*Violence*	*Social Anxiety*	*Sensory Irritation*	*Phobias*	*Body Anxiety*
Highest RESP peak rate	*Sensory Irritation*	*Phobias*	*Body Anxiety*	*Violence*	*Social Anxiety*

Thus, it can be discerned that *Body Anxiety, Violence* and *Phobias* elicited the strongest responses when all seven datasets are averaged together. The *Body Anxiety* and *Violence* soundscapes are often perceived as having more musical and rhythmic structures, and are acoustically aggressive in nature, including reliable anxiety triggers and aversive sounds. Conversely, the *Situational Phobias* and *Social Anxiety* soundscapes feature realistic arrangements close to how these sounds would be encountered in everyday life – the *Social Anxiety* soundscape in is only perceived as anxiety-eliciting to those who know themselves to be socially anxious, and was even deemed as a pleasant hubbub by one participant not afflicted with this anxiety. Further, the *Situational Phobias* soundscape was also selected as is acoustically distinct compared to the *Violence* and *Body Anxiety* soundscape, in that it has prolonged quiet periods, which heighten the listener's anticipation and thus perceived fear.

4.4.3 *Post Soundscape Subjective Perceptions* (questionnaire 2.2.1): Ideal Loudness Ratings, and the soundscapes with the strongest emotive attributes.

The soundscapes were cautiously mixed to ensure playback at a realistic and comfortable volume, except at key moments which engineered a shock response. After all, the participants underwent a 72-minute exposure to five soundscapes in the pilot experiment, so it was ensured that the soundscapes were not gratuitously blasting at high volumes throughout. Thus, it was important to evaluate whether the soundscapes were loud enough to elicit reactions. The first questions asked of participants immediately following each soundscape were designed to gauge their immediate reactions, as they rated the acoustic attributes of the soundscape, in the *Post-Soundscape Subjective Perceptions* (2.2.1). Each soundscape's loudness was rated, as well as the degree to which they induced fright, irritation and a sense of immersion. Likert scales were used so that these responses could be easily quantified, allocating 0 for the opposite of the attribute, to 3 for unbearably so (except from immersion, where 3 was "constantly").

On the whole, participants believed the soundscapes were between "no louder than everyday" (1.5) and "mostly loud" (2) with an overall average score of 1.84 (see Figure 23) – although the *Violence* and *Body Anxiety* soundscapes were actually perceived to be the loudest of the soundscapes with an average 1.867 for *Body Anxiety*, closely followed by *Violence* (1.858) and there was not a widely discernable difference but *Situational*

Phobias, Social Anxiety and *Sensory Irritation* were perceived as quieter on average, both receiving a score of 1.8 on average.

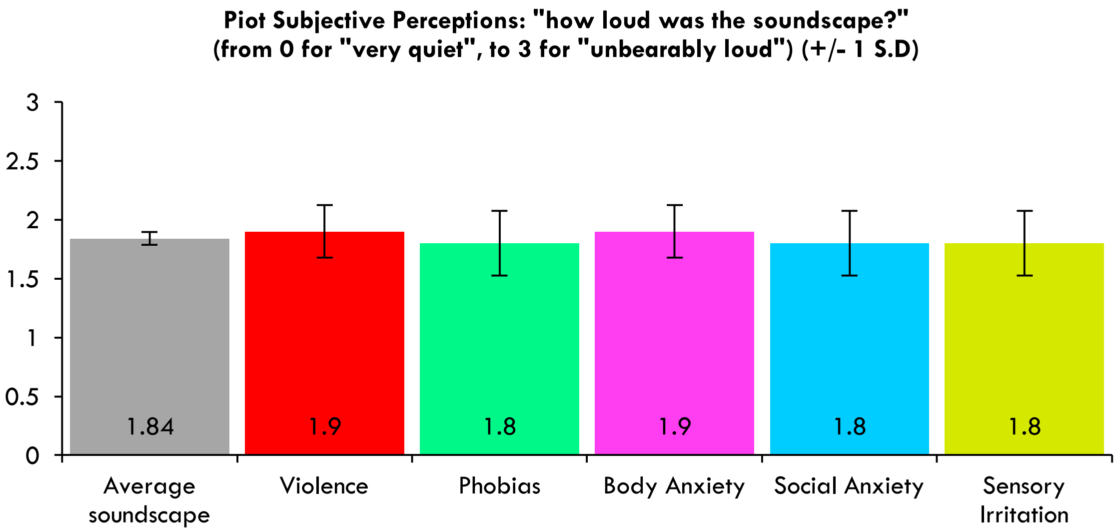


Figure 23: The average "loudness" ratings for each soundscape (pilot)

When asked to rate how frightening the experience was, it was largely deemed as "emotionally neutral" with an average overall score of 1.47 (see Figure 24). The most frightening soundscape was *Violence* with an average rating of 1.8, which was to be expected given the soundscape's overt horror cues, stingers and sounds imbued with physical threats (machine guns, aggressive animals, stabs). The joint second most frightening soundscapes were *Body Anxiety* (1.5), and *Social Anxiety* (1.5) which was probably due to the unnatural cacophony of artificial breaths and perhaps the clichéd abrasive hospital beeps and dentist drills in *Body Anxiety*, or the aggressive shouting over tannoys and children screaming in *Social Anxiety*. The second least frightening was *Situational Phobias* with a significantly lower average rating of 1.3 and the least frightening overall was *Sensory Irritation* with an even lower average rating of 1.25. Both *Situational Phobias* and *Sensory Irritation* feature arrangements of sounds much truer to everyday life, so again this was predicted.

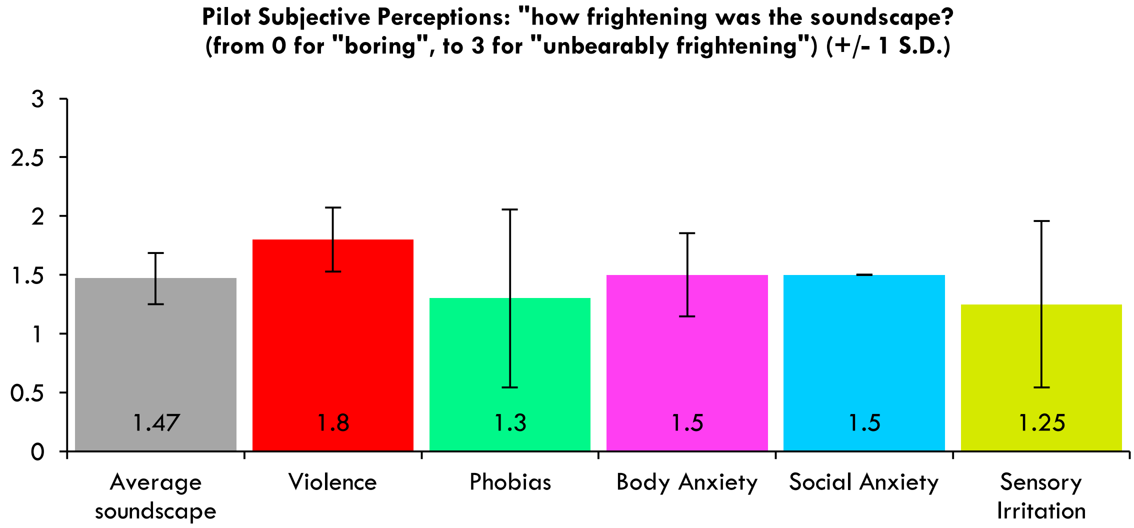


Figure 24: The average "frightening" ratings for each soundscape (pilot)

Participants rated the soundscape exposure somewhere between "neither irritating nor pleasant" (1.5) and "mostly irritating" (2) with an overall average score of 1.66 (see Figure 25). *Sensory Irritation* was perceived as the most irritating (as expected, given the name) with an average rating of 1.95, with *Body Anxiety* perceived as second most irritating (1.8), followed by *Situational Phobias* (1.7), and *Social Anxiety* (1.65), whereas the *Violence* soundscape was significantly less so at 1.2, a score closer to "pleasant" (1) on the Likert scale.

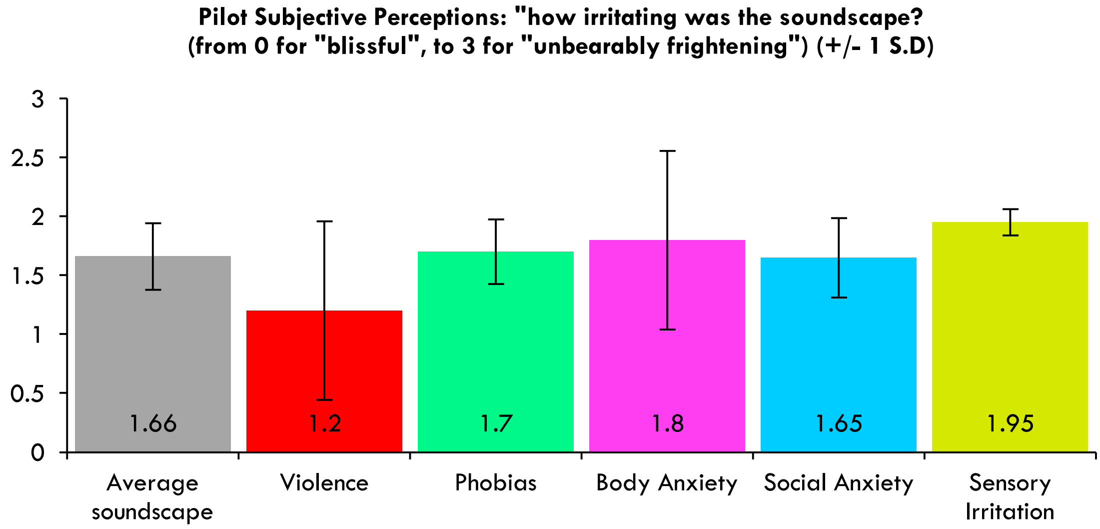


Figure 25: The average "irritating" ratings for each soundscape (pilot)

Out of all the acoustic attributes which the participants were asked to rate, the highest ratings were for the sense of immersion (see Figure 26) – overall, participants felt immersed in sound "throughout most of the piece" (2), nearly "constantly" (3) with an average overall rating of 2.14 (the average ratings for other acoustic attributes were much lower, with loudness at 1.84, frightening at 1.47, irritating at 1.66). It was felt that the most immersive soundscapes were *Situational Phobias* and *Body Anxiety* (both with an immersion rating of 2.3 out of 3, see Figure 27), followed by *Violence* (where immersion was rated at 2.2), and then *Sensory Irritation* and *Social Anxiety* were the least immersive with average ratings of 2 and 1.9 respectively. Nevertheless, even for the soundscapes perceived as the least immersive, participants usually felt immersed in sound at least "2 to 3 times" (1.5) or "throughout most of the soundscape" (2).

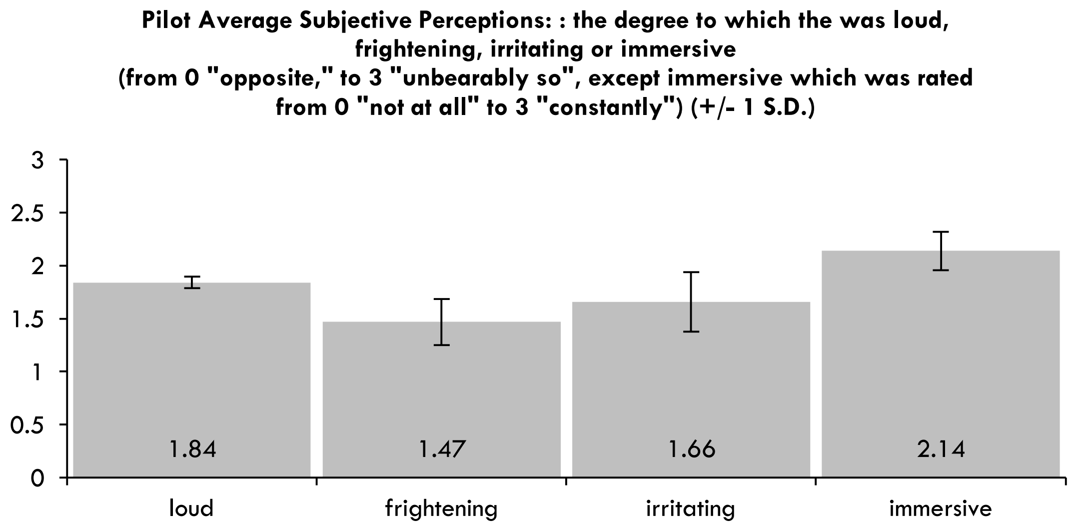


Figure 26: The average "loudness" "frightening" "irritating" and "immersive" ratings for the average soundscape (pilot)

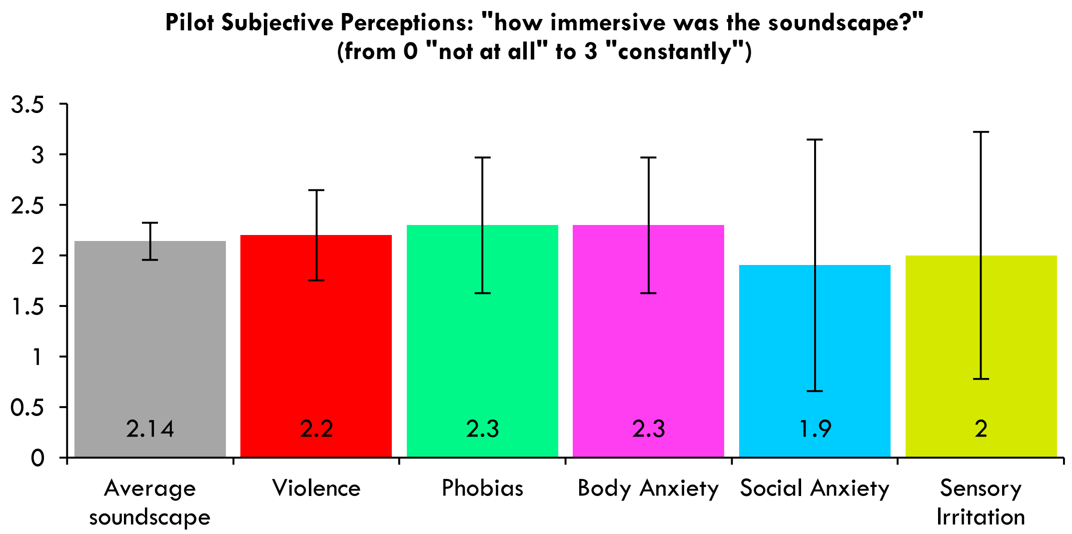


Figure 27: The average "immersive" ratings for each soundscape (pilot)

The second half of the *Post-Soundscape Subjective Perceptions* (2.2.1) asks the participants to evaluate the emotive attributes of soundscape exposure. Participants seemed to enjoy soundscape exposure a great deal in the pilot, with average overall "enjoyment" ratings of 2.08, which is between "a little" (2) and definitively "yes" (3) (see Figure 28). The most enjoyable was *Situational Phobias* (rated at 2.3 out of 3), followed by *Violence* (rated at 2.2) and *Body Anxiety* (rated at 2.2) and then *Social Anxiety* (1.9) and *Sensory Irritation* (rated at 1.8) (see the left column cluster of Figure 29). There was a limited degree of "revival" provoked by soundscape exposure, as the overall average was 1.14, out of a possible 3.00. The soundscapes which revived participants most significantly were *Violence* (rated at 1.5) and *Body Anxiety* (also rated at 1.5), followed by *Sensory Irritation* (rated at 1.3) whereas *Social Anxiety* elicited average ratings of 0.8 and *Situational Phobias* even less at 0.6 (see the second column cluster from the left in Figure 29).

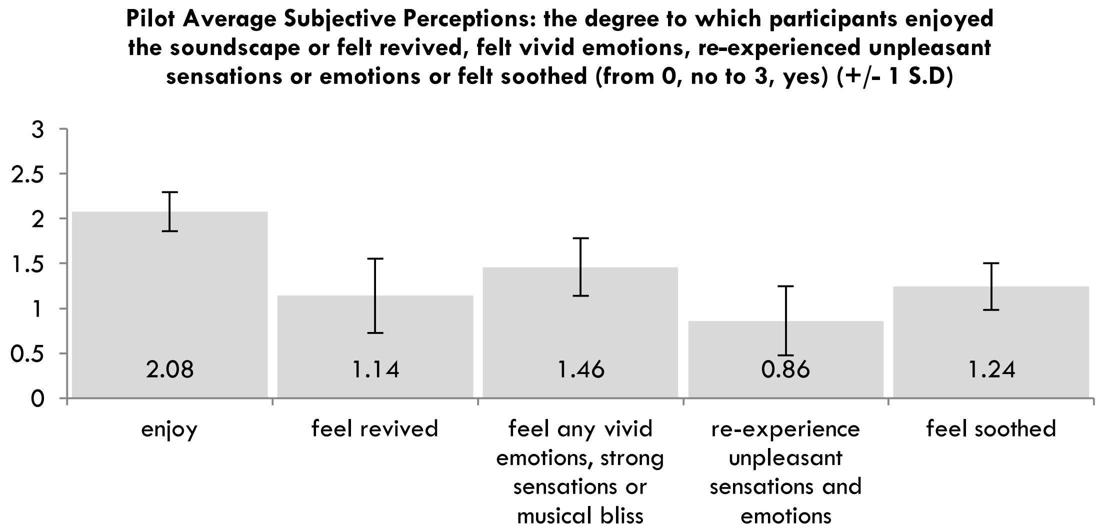


Figure 28: The average "enjoyable," "revival," "vivid sensations and emotions," "re-experience unpleasant sensations and emotions," and "soothe" ratings for the average soundscape (pilot)

When participants were asked if they felt any vivid emotions, strong sensations or musical bliss, the overall average response was 1.46, close to "neither yes nor no" (see Figure 28). Again, *Violence* and *Body Anxiety* triggered higher ratings on average (both at 1.8), followed by *Situational Phobias* and *Sensory Irritation* (both at 1.3) with *Social Anxiety* triggering vivid emotions the least, rated at only 1.1 (see the central column cluster of Figure 29).

Interestingly, the overall average rating for the soundscapes' triggering a re-experience of unpleasant sensations and emotions was 0.86 out of 3.00 ,much lower than the more positive vivid emotions rating of 1.46 – *Violence* was the soundscape to most frequently trigger unpleasant re-experiences with a rating of 1.3, followed by *Body Anxiety* with 1.2.

The other three soundscapes brought the average levels down significantly, as *Situational Phobias* prompted an average rating of 0.8, followed by *Sensory Irritation* with 0.6, and *Social Anxiety* with a minimal 0.4 (see the second from right column cluster of Figure 29).

On the whole participants were relatively “soothed” by the soundscape exposure experience, with an overall average rating of 1.24 out of 3.00. Although *Violence* was perceived as being the most frightening soundscape, paradoxically it stands out as being significantly one of the most soothing along with *Situational Phobias* and *Body Anxiety* all prompting average ratings of 1.4. *Social Anxiety* was found to be slightly less soothing at 1.2, but *Sensory Irritation* was definitively the least soothing, only scoring 0.8 on average (see the right column cluster of Figure 29).

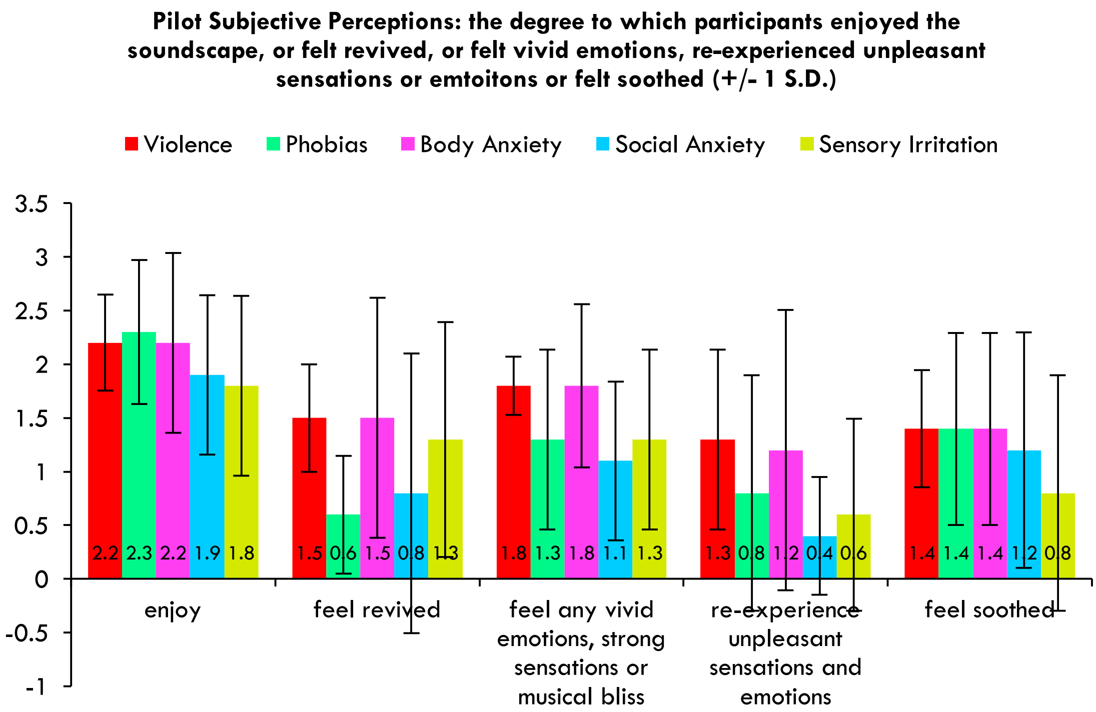


Figure 29: The average “enjoyable,” “revival,” “vivid sensations and emotions,” “re-experience unpleasant sensations and emotions,” and “soothing” ratings for the average soundscape for each soundscape (pilot)

When the *Subjective Perceptions* ratings are cumulatively averaged, it appears that *Body Anxiety, Violence*, and *Situational Phobias* elicited the strongest emotive ratings, with *Social Anxiety* and *Sensory Irritation* eliciting much weaker responses (see Figure 30). *Body Anxiety* produced an average subjective rating of 1.75, followed by *Violence* with

1.71, *Situational Phobias* with 1.53, but *Sensory Irritation* only elicited an average response of 1.46, and *Social Anxiety* fared even weaker with 1.40.

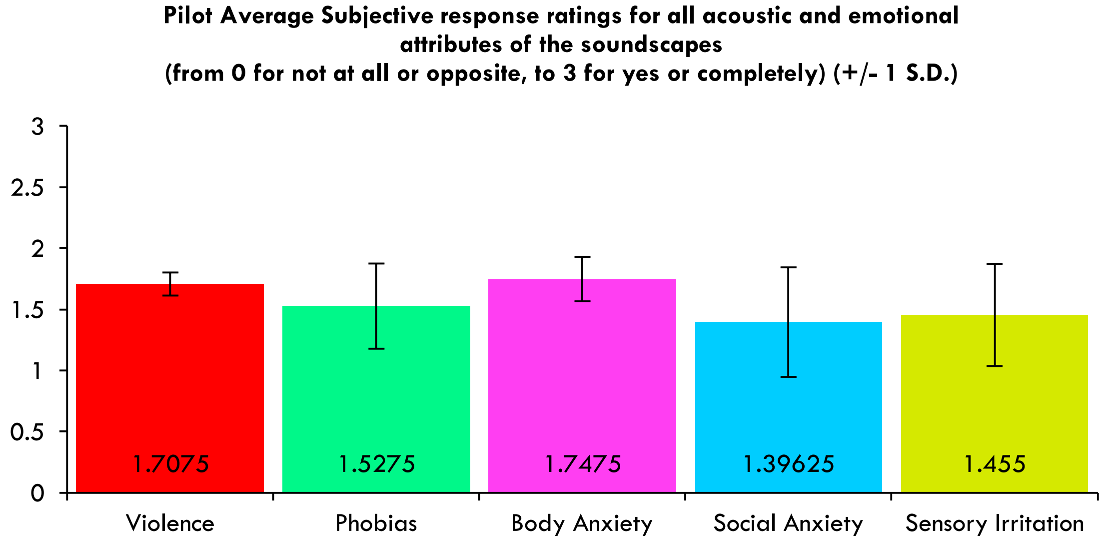


Figure 30: Cumulative average of all subjective perception ratings for each soundscape (pilot)

4.4.4 Tracking changes in mood from pre-exposure (past month), pre-exposure on the day and immediately post-exposure.

A major improvement upon the pilot experiment procedure, implemented for the experiment, was the addition of an optional *Long-Term Catharsis Evaluation* (questionnaire 3), to be completed by participants one week following the exposure session. Thus, for the experiment, the lasting positive impact can be traced as the levels of anxiety are found to increase immediately upon soundscape exposure (from questionnaire 2.1, *Pre-Exposure Evaluation of Anxiety Levels (short-term),* to questionnaire 2.3, *Post-Exposure Evaluation of Anxiety Levels (short-term)),* but anxiety levels are found to attenuate in the long run, from the *Pre-Exposure Evaluation of Anxiety Levels (long term)* (questionnaire 1) to one week following the experiment in the *Long-Term Catharsis Evaluation* (questionnaire 3). Whilst a long-term impact cannot be discerned from the pilot results (as there was no *Long-Term Catharsis Evaluation* offered), it is useful to track the changing levels of positive and negative emotions from pre-exposure scores appraising the month prior to exposure (questionnaire 1), to pre-exposure on the day of the experiment (questionnaire 2.1), to post-exposure, immediately following the experiment (questionnaire 2.3). The overall *Post-Soundscape Mood Change* (2.2.3), noted after each soundscape during the experiment are also averaged to prove the efficacy of immersive soundscapes to elicit anxious emotions on a short-term basis.

Figure 31 demonstrates the difference between average positive emotion induction (the three columns to the left, outlined in black) and negative emotion induction (the three columns to the right) over time. The most significant emotion increase seen from the onset of the soundscape exposure to immediately following it, is in the negative emotions, as was originally hypothesized. Reassuringly, the negative emotion level did not surge beyond that of the pre-existing (past-month) anxiety, only matching it exactly at 1.13 out of a possible 3.00. There was a marked increase from the initial negative emotion score on the day immediately preceding the experiment (questionnaire 2.1.2), which began at 0.33, to the post-exposure score rise to 1.13 (questionnaire 2.3.2). Nonetheless, it is reassuring that positive emotions also increased, even though the increase was to a lesser degree. The average participant's past-month's pre-existing positive emotion levels began at 1.62 (as seen in questionnaire 1.1.3, the *Pre-Exposure Intensity of Perceived Moods,* past month) but on arrival to the Soundlab this was a little lower at 1.15 (as recorded in questionnaire 2.1.2, *Pre-Exposure Intensity of Perceived Moods,* on the day), which eventually increased to 1.28 upon departure (questionnaire 2.3.2). Overall, this emotional surge (predominantly negative but with an element of positive) confirms that the soundscape exposure is having the desired effect on the pilot participants as an exposure to anxious sensations, so the procedure should largely continue unchanged for the experiment.

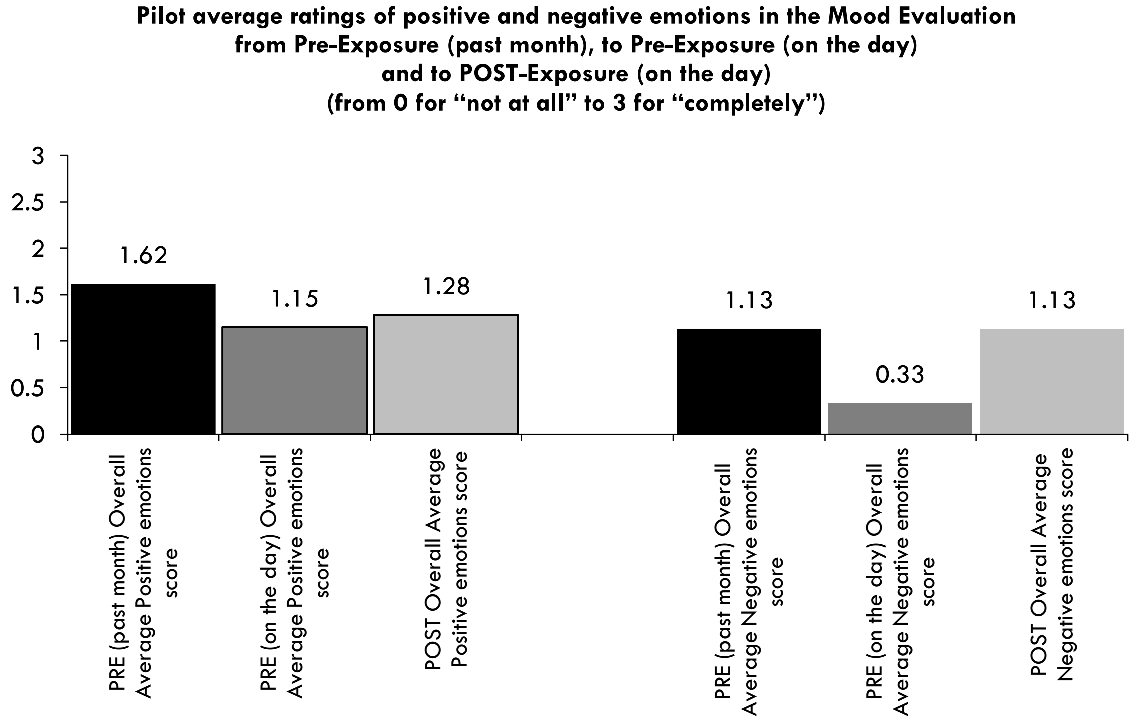


Figure 31: Average ratings of positive and negative emotions from pre-exposure to post-exposure (pilot)

The individual negative emotions with the most notable increases (as traced from the *Pre-Exposure Intensity of Perceived Moods,* questionnaire 2.1.2, to the *Post-Exposure Intensity of Perceived Moods,* questionnaire 2.2.3) were sadness which increased (by 0.8) from a level of 0.3 on arrival to 1.1 on departure, as did tension from 0.7 to 1.5. Depression also increased on average from 0 ("not at all") to 0.9 (close to "quite"). Crucially though, a sense of relief was originally rated at 0.9 on arrival, but rose to 1.5 on departure, on average. Further, a sense of being in control was rated at 1.4 ("neither in control nor out of control") on arrival, but 2 ("very") on departure. The significant rises in relief and perception of control serve as a vital confirmation of the soundscape exposure providing a boost to participant's confidence overall, despite the concurrent rise in intensity of negative emotions.

In the *Post-Soundscape Mood Change Assessment* (2.2.3), participants were asked to rate their levels of happiness, pleasure, relief, feelings of being in control, relaxation, contentment, tension, depression and sadness immediately after each soundscape, when they are in the middle of the exposure experience. Participants were asked to denote a positive change by marking "+1" beside an emotion, whereas a negative change with a "-1", or if there was no perceived change in levels elicited by the soundscape this is marked as a "0". For example, diminished happiness would be represented by a "-1" (as it is a negative change in a positive emotion), or increased depression with a "-1" (as it is an increase in negative emotion), but increased happiness is marked with a "+1" (a positive change in a positive emotion), and a lessening of depression is a "+1" (a positive change in a negative emotion). The complexity of immediate reactions is clear to see in Figure 32, as happiness, pleasure and relief was said to increase on average by 0.12, and feelings of being in control increased marginally by 0.04; tension was found to be alleviated by a level of 0.12, and sadness by a small margin of 0.04. On the other hand, there were significant negative changes in relaxation (-0.24) and contentment (-0.36) and depression (-0.08). This is to be expected as the immersive mode of soundscape presentation was perceived as a novel and pleasurable experience, but the subject matter of the sounds forced participants to confront unpleasant memories and sensations.

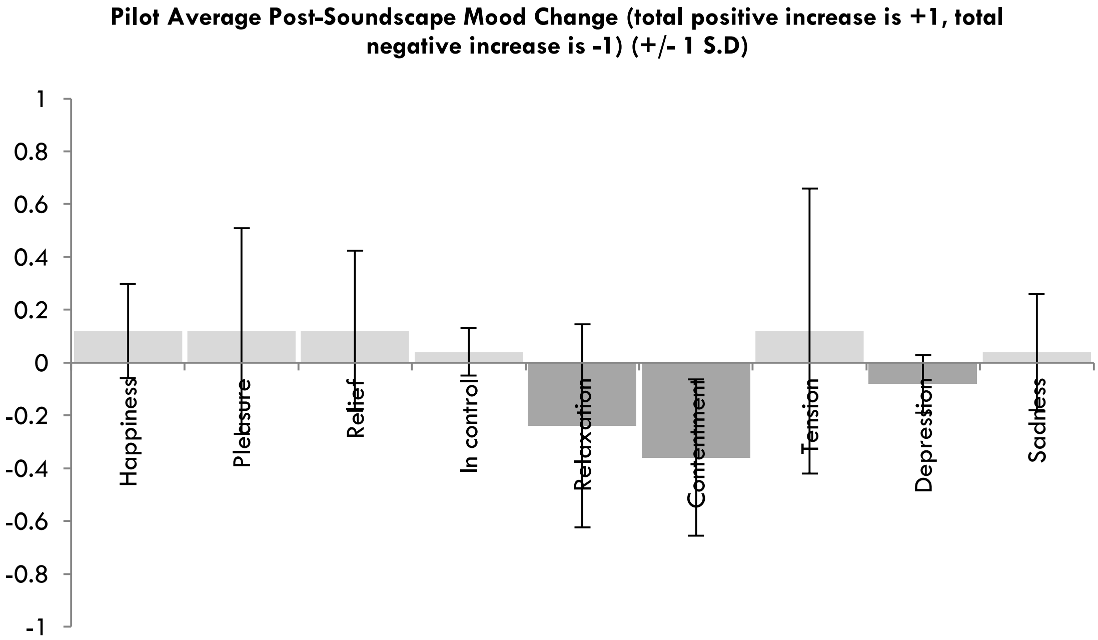


Figure 32: The average positive and negative changes in mood, *Post-Soundscape Mood Change* (questionnaire 2.2.3)

4.4.5 Pilot Conclusion

The pilot served to confirm that the experiment procedure was logistically and ethically sound, with only three adaptations implemented for the subsequent experiment. Firstly, it was found that the exclusion criteria set initially was too strict, which meant that prospective participants who experience moderate everyday anxiety were being excluded. Thus, this was addressed, so that all three elements of the eligibility screening had a similar threshold percentage which averaged out to an overall threshold of 71% of the possible ratings on the form. Importantly, the soundscape exposure also appeared to have a discernible emotional and physiological impact on the participants.

The second issue was the length of soundscape exposure: it became apparent that exposing the participants to 72 minutes of sound (over five soundscapes) is too exhausting, and that both the unconscious and perceived response data would be more meaningful if each participant was only exposed to three soundscapes over 46 minutes. Using only three soundscapes for thirty participants, the soundscape order is shuffled along six permutations, so the impact of listener fatigue is distributed equally among the soundscapes. If five soundscapes were played to each participant, the impact of soundscapes as observed in the collective response data would inevitably become diluted, when the data from participants who heard a soundscape as either the first, second, third, fourth or fifth in the sequence is averaged in analysis. It was decided that the three soundscapes which are the most diverse in nature (which also happened to elicit the highest response rates across all modes of analysis) would be more than sufficient for the experiment. *Situational Phobias* includes sound categories which are representative of real world situations, whilst also featuring the widest dynamic range, opening with a very sparse quiet sequence which is then interrupted by several loud percussive breaks. *Violence* is distinct in its musical implementation, as a transformative piano, cello and vocal melody glues many disparate, horrific sounds together, which enhances listener engagement but also softens the blow of the trauma triggers, acting as a form of counter-conditioning. *Body Anxiety* is essential, as it is the only soundscape that features a soothing sequence of waterfalls in amongst a cacophony of visceral and disgusting sounds.

Thirdly, a *Long-Term Catharsis Evaluation* (questionnaire 3) is issued in the experiment, to be completed by participants one week following exposure. This discerns a difference between long term affect and short term affect, ultimately gauging the overall impact of the treatment.

5 Soundscape Exposure Experiment Primary Results

5.1 Introduction

The primary results from the experiment (in this chapter) are the crucial broad overview results, whereas secondary results (in Chapter Six) zoom into the detail of the data in addition to charting the intriguing deviations from the common trends. The primary results are presented first, to familiarise the reader with the analysis methods for the physiological data and questionnaire responses, providing at-a-glance interpretations of what the facts and figures mean. Here, the essential research questions are answered, and evidence of physical desensitization and psychological catharsis is shown. In essence, the reader is given proof that soundscape exposure therapy works, and that it is a relatively enjoyable experience for participants.

Firstly, evaluation of the commonly perceived nature of the soundscape exposure experience indicates that the procedure is effective and safe, as the average anxiety sensation scores are actually lower than those experienced in everyday life, and the sensations were in fact mostly positive (as recorded in the *Post-Soundscape Frequency of Perceived Sensations*, questionnaire 2.2.2). Secondly, the difference in the strength of perceived response (also in questionnaire 2.2.2) between participants with the lowest or highest pre-exposure anxiety evaluation scores is calculated. Then, the implications from overall average GSR peak rates for each soundscape are evaluated, across all participants, in addition to the calculating the difference in GSR peak rates between groups (participants with higher or lower pre-existing anxiety, and the participants who heard each soundscape first, second or third in the sequence).

The Galvanic Skin Response data (the average number of rises and attenuations in sweat secretion) is interpreted here primarily to identify the soundscape that elicited the greatest number of peaks per minute. Difference in GSR peak rates between groups is also calculated, by means of a simple bar graph for each soundscape, to discern whether the participants with the highest pre-existing anxiety did in fact show more GSR peaks per minute than the lowest-anxiety participants. The primary GSR interpretation also demonstrates physical desensitization over the course of the experiment - the ten participants who were listening to a particular soundscape as the first in the sequence of three had notably more GSR peaks than the ten participants who were listening to that soundscape as the second or third in the sequence. This was the case for all soundscapes.

Also evaluated in the primary results of the experiment, is the efficacy of spatialising sounds to induce emotions, to justify the implementation of ambisonic sound in this research. Firstly, the soundscapes are identified which gathered the greatest number of reports that the spatialisation of sounds was perceived to be a direct trigger of strong sensations, using data from the *Post-Soundscape Frequency of Perceived Sensations,* (2.2.2). Then, the results of the *Post-Exposure Spatialisation Evaluation* (2.3.4) are analyzed, to discover whether the sounds panned realistically, in a manner that is true and appropriate to the original source, are more fear-eliciting than sounds which have been panned in a hyperreal manner, altered especially to heighten anxiety.

Then, the average minute-by-minute GSR peak rates are compared between the group of participants with matched pre-exposure and post-soundscape identified trigger sounds, the group with mismatched pre-exposure and post-soundscape triggers and the group with surprise trigger sounds which were only identified in the *Post-Soundscape Questionnaire*, (2.2). This comparison of average minute-by-minute GSR peak rates for participants with matched or surprise triggers helps to confirm whether it is necessary to compose a soundscape only from sounds tailored to pre-existing anxieties to generate enhanced physiological reactions, or whether it is actually more beneficial to surprise the listener with unfamiliar anxiety trigger sounds. Global differences were also surveyed, by comparison of the minute-by-minute GSR peak rates of all participants for a section of the *Situational Phobias* soundscape that features a universally surprising trigger of anxiety, fire sounds, to a section of the *Body Anxiety* soundscape that was commonly predicted to be anxiety eliciting, visceral sounds, but this method yielded muddied results. In Section 6.9 (part of the secondary results) the global differences are discovered in minute-by-minute GSR peak rates for all participants during the sound category which was frequently identified as an anxiety trigger in the *Pre-Exposure Trigger Diagnosis* (1.2), and the peak rates for all participants during the sound category which proved to be a surprising anxiety trigger, only identified in the *Post-Soundscape Frequency of Perceived Sensations* (2.2.2).

5.1.1 Primary Hypotheses and Objectives

There are several crucial hypotheses and objectives sought in the primary data analysis, based on the current knowledge established in both the literature review and the pilot:

1. Soundscape exposure is safe and enjoyable, even if some unpleasant sensations are elicited (Section 5.2.1)
2. Positive physical and psychological sensations are rated as more frequently occurring during soundscape exposure than negative physical and psychological sensations (Section 5.2.1)
3. Participants experience a positive long-term impact, showing physical and psychological improvement in the *Long-Term Catharsis Evaluation* (questionnaire 3) from how they originally felt prior to the soundscape exposure, in the *Pre-Exposure Evaluation of Anxiety Levels* (1.1) (Section 5.2.2)
4. Participants experience a slightly negative short-term impact, from the *Pre-Exposure Evaluation of Anxiety Levels* (2.1) to the *Post-Exposure Evaluation of Anxiety Level*s (2.3) (Section 5.2.2)
5. Participants with higher pre-existing anxiety demonstrate an amplified perception of all sensations in the *Post-Soundscape Frequency of Perceived Sensations* (2.2.2) compared to participants with low pre-existing anxiety (Section 5.3)
6. A hyperreal sound spatialisation is the more anxiety-eliciting than a realistic sound spatialisation (Section 5.4)
7. Participants with higher-pre-existing anxiety generate a higher GSR peak rate than participants with low pre-existing anxiety in response to anxiety-inducing sounds (Section 5.5)
8. When a soundscape is heard as the first in sequence, the GSR peak rate is higher than when the soundscape is heard as the second or third in the sequence (Section 5.5).
9. Participants with *matched-anxiety-elicitation* report higher sensation scores in the *Post-Soundscape Frequency of Perceived Sensations* (2.2.2) than participants with *surprise-anxiety-elicitation* (Section 5.6)
10. Participants with *matched-anxiety-elicitation* demonstrate higher GSR peak rates than participants with *surprise-anxiety-elicitation* (Section 5.6)

5.2 Nature of Soundscape Exposure experience

5.2.1 Deciphering whether the soundscape exposure was experienced as physical or psychological, positive or negative

Visual column graphs are generated by totalling up the average participant's four categorical sensation scores, for physical positive, physical negative, psychological negative and psychological positive sensations; first for the *Pre-Exposure Intensity of Perceived Sensations* (1.1.3) and then for the *Post-Soundscape Frequency of Perceived Sensations* (2.2.2). The score for each category is converted into a decimal percentage, for example, a total score of six out of a possible eighteen (for a section with six questions, each with a maximum score of three) is converted to 0.333. For every participant, each sensation category's decimal percentage score was input into Excel spreadsheets and graphs, in a variety of orders, either to evaluate the prevalence of each type of sensation, or to generate an overview of each soundscape's efficacy in sensation induction. Using these numbers, it can be calculated whether the participants' average experience was most commonly positive or negative, and whether the soundscapes were physically or psychologically affecting, and find out if sensations were induced as strongly as they are in everyday life situations. Overall, the highest scores were found in the psychological positive category of sensations, so the participants largely had a mentally pleasant experience during soundscape exposure. However, there was also widespread triggering of unpleasant sensations within this overall pleasant experience – thus the participants' complex emotions induced in the soundscape scenario served as a psycho-educative demonstration that it is possible to still enjoy everyday life even when it is peppered with the odd anxious, unpleasant feeling. Here, a comparison is drawn between the intensity of sensations that the participants generally feel in their everyday life (or the month preceding the soundscape exposure), to how frequently each group of sensations were induced during the soundscape exposure on average. Then the soundscape that elicited the highest score on average for each sensation categories is also identified.

It appears that everyday life appears to be more anxiety-inducing than the soundscape exposure experience, for every sensation category. The average physical positive sensation score (represented as a decimal percentage) from the *Pre-Exposure Intensity of Perceived Sensations* (1.1.3, reflecting on the previous month) is 0.33, compared to 0.17, the average overall physical positive sensation score from all three soundscapes (as recorded in the *Post-Soundscape Frequency of Perceived Sensations*, 2.2.2). For physical negative sensations, the pre-exposure average score (from questionnaire 1.1.3) is 0.16, whereas the physical negative average overall score (from questionnaire 2.2.2) was only 0.07. The psychological negative average sensation score pre-exposure (questionnaire 1.1.3) is 0.24, but the overall average psychological negative score post-soundscape is only 0.16. Finally, the average psychological positive sensation score as recorded in the pre-exposure (questionnaire 1.1.3) is 0.54, again higher than the post-soundscape (questionnaire 2.2.2) overall average psychological positive score, which is only 0.47. So, from pre-exposure (questionnaire 1.1.3) to post-soundscape (questionnaire 2.2.2), the physical positive sensation score dropped by 0.16 (from 0.33 to 0.17), the physical negative score dropped by 0.09 (from 0.16 to 0.07), the psychological negative score dropped by 0.08 (from 0.24 to 0.16), and the psychological positive score dropped by 0.07 (from 0.54 to 0.47). Thus, the most dramatic difference in sensation rating from reflection on everyday life to the soundscape exposure experience was in physical positive sensations, as these were the most difficult to elicit synthetically in the Soundlab.

On the whole, the majority of soundscape-induced strong sensations were psychological and positive, as found in the *Post-Soundscape Frequency of Perceived Sensations* (2.2.2): the average overall psychological positive score was 0.471 (see the furthest right column in Figure 33), followed by physical positive at 0.172, psychological negative at 0.163, and physical negative 0.073. So fundamentally, the participants viewed the soundscape exposure experience as positive, as illuminated further by the combined physical and psychological positive average score of 0.643, compared to a total physical and psychological negative score of 0.236) and more often psychologically engaging rather than physical (as the overall average psychological score is 0.634, in contrast to the physical score of 0.245).

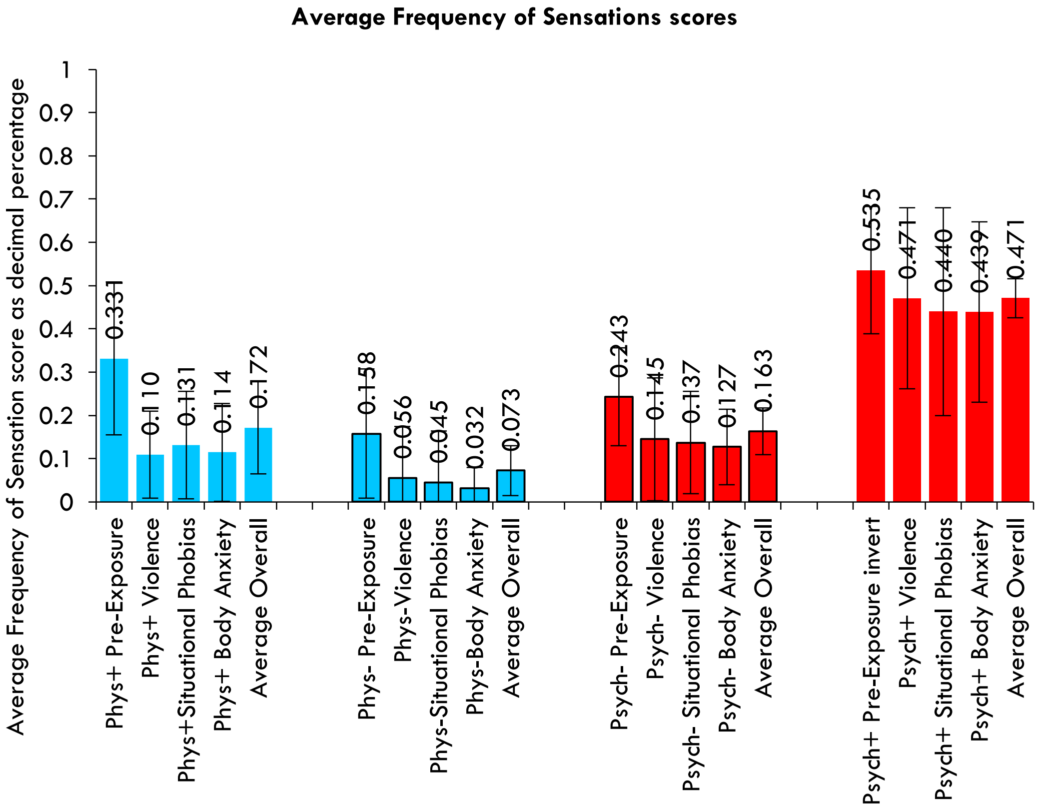


Figure 33: Average Scores (+/- 1 SD) for the *Pre-Exposure Intensity of Sensations/Post-Soundscape Frequency of Sensations* questionnaires (arranged by the type of sensation)

The soundscape that generated the highest sensation scores for each category is sought using Figure 33. For physical negative, psychological negative and psychological positive sensations, the *Violence* soundscape elicited the highest perceived ratings scores (0.056, 0.145, 0.471 respectively), followed by *Situational Phobias* (0.045,0.137, 0.440 respectively) and *Body Anxiety* (0.032, 0.127, 0.439 respectively). However, the *Situational Phobias* soundscape elicited notably higher physical positive ratings on average (0.131) compared to *Body Anxiety* (0.114) and *Violence* (0.110). So, perhaps the nature of the phobic sounds (associated with time, agorophobia, claustrophobia, fire and flying) were consistently capable of provoking pleasant bodily sensations (such as pleasurable chills and heart pounding), or hearing these sounds in a more realistic, sparse arrangement encouraged good physical feelings. The acoustic qualities of the sounds themselves are less confrontational and assaulting than the notorious screeching, scraping violent sounds or viscerally antagonistic body sounds.

As seen in Figure 34, there is quite a significant decrease in the intensity or frequency of – perceived sensations, from the total sensation scores recorded in the *Pre-Exposure Intensity of Perceived Sensations* (1.1.3) to the *Post-Soundscape Frequency of Perceived*

Sensations (2.2.2). The average overall sensation score pre-exposure is the highest at 0.317 (as a decimal percentage), compared to the average overall sensation score post-soundscape even for the most powerful soundscape, *Violence*, at 0.195, then the second most powerful *Situational Phobias*, at 0.188, and the least powerful soundscape, *Body Anxiety*, 0.179. Whilst the soundscape exposure experience may be seen to elicit lower levels of perceived sensations, it must be taken into consideration the differing timescales of these measurements – the *Pre-Exposure Intensity of Perceived Sensations* (1.1.3) reflected upon the participant's previous month, whereas the *Post-Soundscape Frequency of Perceived Sensations* (2.2.2) surveyed a short-term fifteen-minute window. Also, it may be construed as a benefit that whilst soundscape exposure does indeed simulate sensations associated with anxiety, rendering it effective as training mechanism, users need not be scared that it will be an unpleasant experience. On the contrary, the soundscapes were seen to elicit less anxiety than commonly experienced in everyday life.

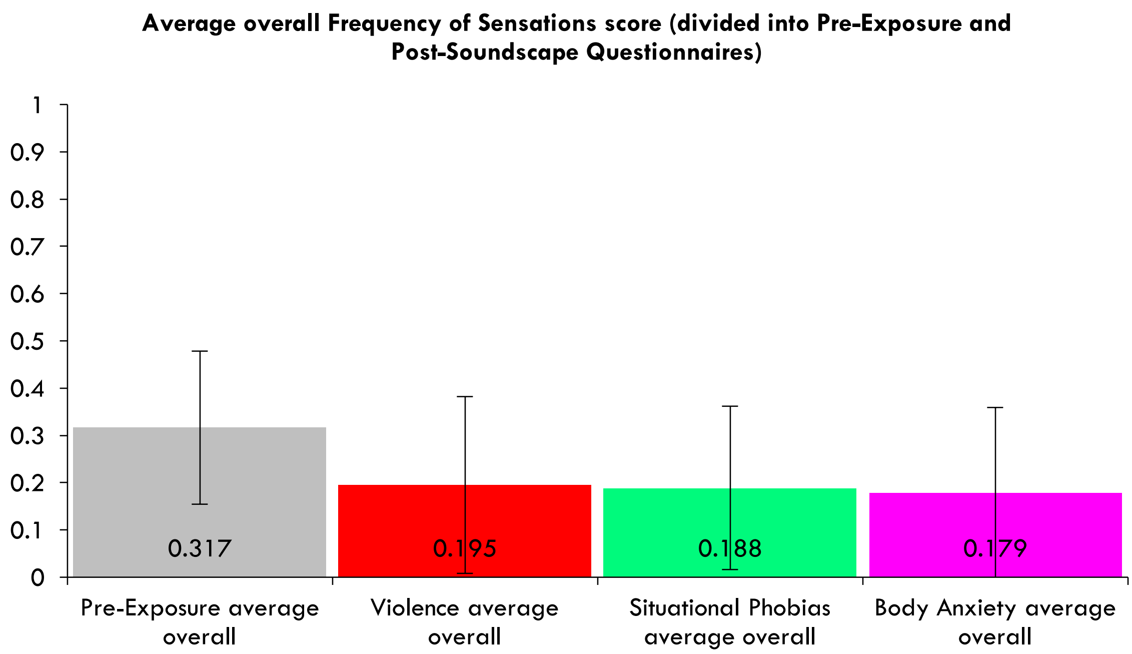


Figure 34: A significant decrease in frequency of perceived sensations from pre-exposure to post-soundscape

The thirteen participants who completed the optional *Long-Term Catharsis Evaluation* (questionnaire 3) were asked to tick multiple choices out of ten qualities that could be attributed to soundscape exposure. This section of the questionnaire, the *Long-Term Soundscape Exposure Affects* (3.7) is loosely based on Sarakaillo et al's music for mood regulation uses. Ten out of thirteen participants perceived the soundscape exposure as entertaining, and the same number saw it as a distraction from other worries; there was a total of seven participants who classed the experience as energizing, seven who found it comforting, six who found it relaxing, six who found it induced strong sensations, four who understood it as an aid to better understand their emotions, two found it saddened them and one felt it vibrated throughout their entire body. Thus, it is reassuring that the soundscape exposure was perceived as transformative and an effective mood regulator (or at least manipulator) with positive attributes being the most commonly picked.

From the two crucial hypotheses and objectives in the primary data analysed here (Hypothesis 1 and Hypothesis 2), it can be confirmed that yes, soundscape exposure is safe and enjoyable, even if some unpleasant sensations are elicited. Also confirmed is that positive psychological sensations are rated as most frequently occurring during soundscape exposure than negative physical and psychological sensations - but contrary to previously hypothesised, the physical positive sensations have proved especially difficult to synthetically elicit.

5.2.2 Tracking changes in anxiety levels from Pre-Exposure to Post-Exposure

It must be clarified here that in this work, “long-term” is considered as a minimum five-week period as reflections on the month prior to the soundscape exposure are recorded in the *Pre-Exposure Evaluation of Anxiety Levels (long-term)* (1.1) and the *Long-Term Catharsis Evaluation* (questionnaire 3) reflects on the week following the exposure. Here, “short-term” pertains to the day of the experiment, from the *Pre-Exposure Evaluation of Anxiety Levels (short-term)* (2.1) completed on arrival, to the *Post-Exposure Evaluation of Anxiety Levels* (2.3), offered immediately post-exposure. It was discovered that the immediate impact of the soundscape exposure (on average) is a slight increase in positive sensations and a greater increase in negative sensations. Nonetheless, the long-term effects appear make this short-term discomfort worthwhile, as the attenuation of negative emotion in the long-term is much more significant than the decrease of positive emotions. Results from the *Long-Term Catharsis Evaluation* (questionnaire 3) go further to indicate that some participants even resolved underlying traumas as a result of the soundscape or gained a helpful heightened awareness of the fluidity of their moods. The long-term data also revealed that participants were said to have largely felt better one week later than they did before the experiment (and even more so than directly following soundscape exposure).

Most of the psychological section of the *Pre-Exposure Intensity of Perceived Sensations* (1.1.3) and the equivalent *Post-Soundscape Frequency of Perceived Sensations* (2.2.2), (which ask participants to individually rate over 20 different emotions and sensations on a Likert scale of zero to three) focuses predominantly on positive and negative moods: happiness, relief, pleasure, being in control, relaxation, contentment, sadness, tension and depression. To survey a general overview, average scores for all positive and all negative emotions for each stage of the experiment are calculated. The average rating for positive emotions as recorded in the *Pre-Exposure Intensity of Perceived Sensations* (1.1.3, which reflects on the past month) is 1.549, which had decreased by the day of exposure to 1.513, as recorded in the *Pre-Exposure Intensity of Perceived Moods* (2.1.2). The average positive emotions score increased by a small margin immediately post-exposure to 1.547, as recorded in the *Post-Exposure Intensity of Perceived Moods* (2.3.2). One week later, the rating for positive emotions decreased very slightly to 1.535 as revealed in the *Long-Term Intensity of Perceived Sensations* (3.3). Thus, the average positive emotion score changed very minimally over time, starting at 1.549 (pre-exposure past month), then dropping marginally to 1.513 (pre-exposure on the day of experiment), increasing to 1.547 (post-exposure on the day of the experiment), and dropping slightly again to 1.535 (post-exposure one week later).

The key transformation from participants' first involvement with the project is regarding the rating of negative emotions. In the *Pre-Exposure Intensity of Perceived Sensations* (1.1.3) evaluation of the month prior to the experiment, the average rating for negative emotions is recorded as 1.022, and this dramatically dropped on the day of the experiment. The average negative emotion rating immediately preceding the experiment, as recorded in the *Pre-Exposure Intensity of Perceived Moods* (2.1.2) is 0.569; immediately post-exposure this negative emotion average rating rose significantly to 0.675 in the *Post-Exposure Intensity of Perceived Moods* (2.3.2) – however, it is reassuring that this figure is still much lower than the very first pre-exposure negative emotion score of 1.022. One week after the exposure, the average negative emotions rating decreased very slightly from the post-exposure (but greatly from the long term pre-exposure figure of 1.022) to 0.667, as shown in the *Long-Term Intensity of Perceived Sensations* (3.3). One reason for this drop might be that the introduction of cognitive behavioral therapeutic techniques might have encouraged participants to evaluate their emotional states in a less negative light. Cognitive behavioral therapy is partly psychoeducation, but mostly the act of attentively monitoring the multitude of sensations throughout the body, and proactively seeking out the cause, be it an external trigger or a tendency to internally generate anxiety – this conscious appraisal of the mind and body teaches the user that anxiety is not necessarily the fault of the afflicted, as it is not an inseparable part of their identity - it is merely a state change that drifts in and out of their perception.

Clear improvements in mood can be tracked over the course of the soundscape exposure process from the emotion transformation reported in the *Intensity of Perceived Moods/Sensations* (questionnaires 1.1.3, 2.1.2, 2.3.2, and 3.3) featured at every step of the soundscape exposure, from initial recruitment to the follow up one week later. Crucially, differences can be discerned between the long-term emotional impact and short-term impact. The rating for positive emotions decreased ever so slightly in the long-term, with an overall average score of 1.549 from the *Pre-Exposure Intensity of Perceived Sensations* (1.1.3), reflecting on the past month, and a positive emotion score of 1.535 in the *Long-Term Intensity of Perceived Sensations* (3.3). More significant, the rating for negative emotions dropped dramatically in the long term, starting at 1.022 in the *Pre-Exposure Intensity of Perceived Sensations* (1.1.3) and ending up at 0.667 in the *Long-Term Intensity of Perceived Sensations* (3.3).

The short-term impact is much subtler. Positive emotion ratings increased marginally in the short-term, with an overall average rating of 1.513 in *Pre-Exposure Intensity of Perceived Moods* on the day of the experiment (2.1.2) and 1.547 in the *Post-Exposure Intensity of Perceived Moods* (2.3.2) completed immediately after soundscape exposure. Negative emotion ratings increased to a slightly greater degree in the short-term: just before the experiment, the average rating was 0.569 (as seen in the *Pre-Exposure Intensity of Perceived Moods,* questionnaire 2.1.2), but immediately post-exposure the average negative emotion rating rose to 0.675 (in the *Post-Exposure Intensity of Perceived Moods*, questionnaire 2.3.2). So, although the immediate effects of soundscape exposure impact mood slightly negatively, the long-term effects are worth the temporary distress - as the long-term attenuation of negative emotion is much more significant than the attenuation of positive emotions. Essentially, although the soundscape exposure itself makes the participants feel more negative emotion on the day (an increase of 0.106) the beneficial transformation from the previous month to the week following the experiment was much more significant (as negative emotions dropped by 0.355). So, the decrease in negative emotions in the long term (0.355) is over three times the increase of negative emotions on the day of the experiment (0.106), a relationship illustrated in Figure 35 below. Long-term attenuation in average levels of negative mood is seen in the column pair second from the left (outlined in black), which greatly outweighs the slight increase in negative mood on the day of the experiment, as seen in the farthest right column (also outlined in black).

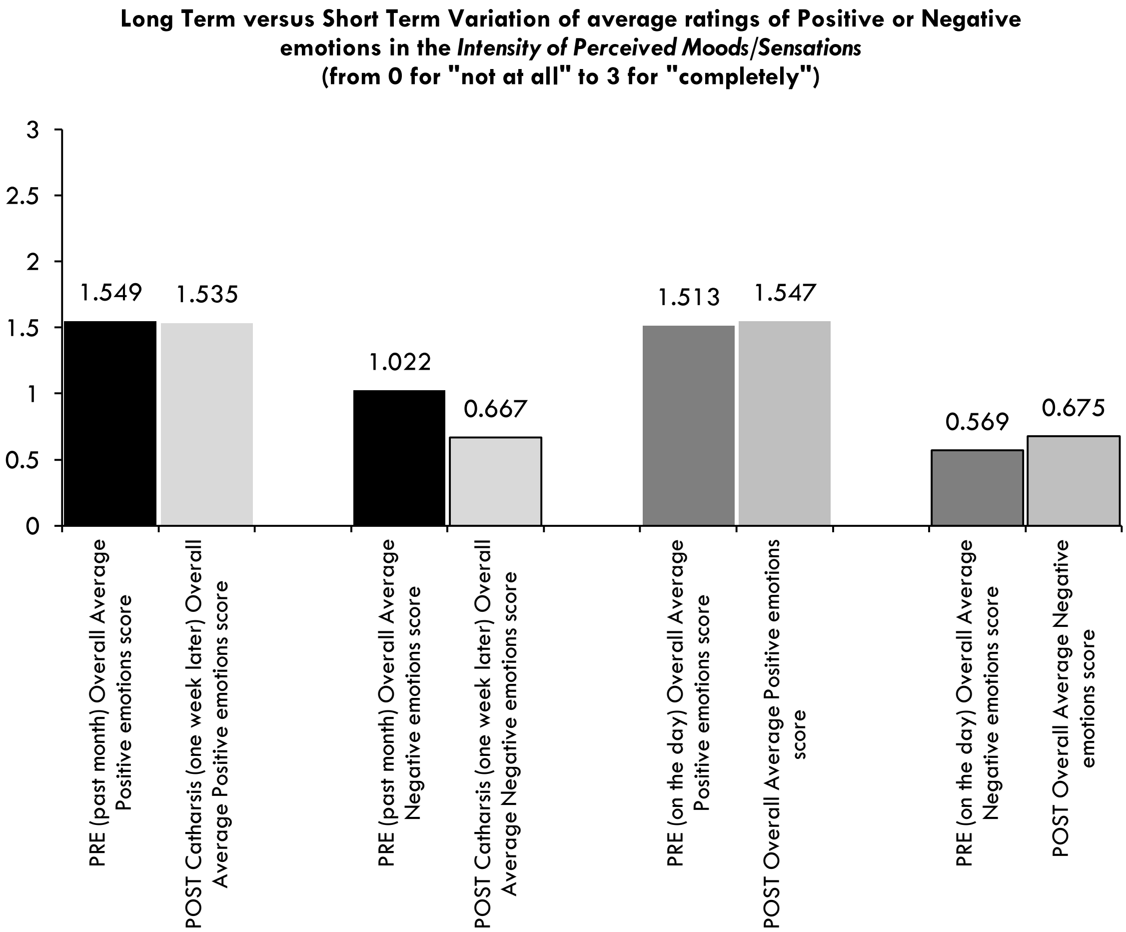


Figure 35: Differences between long-term impact and short-term impact on positive and negative emotions

This pre-exposure to post-exposure impact in the *Intensity of Perceived Mood/Sensations* (questionnaires 1.1.3, 2.1.2, 2.3.2 and 3.3) can also be tracked for each individual emotion. One of the most notable positive emotion transformations is that immediately post-exposure, in the *Post-Exposure Intensity of Perceived Moods* (2.3.2), the overall average participant's rating of being *"*in control" had increased dramatically from the original month prior to soundscape exposure (by approximately 0.300) to a score 1.975, from the original average "in control" rating of 1.608 (as recorded in the *Pre-Exposure Intensity of Perceived Sensations* (1.1.3, reflecting on the past month) and the immediately pre-exposure average of 1.681, from the *Pre-Exposure Intensity of Perceived Moods* (2.1.2), on the day of the experiment. One week later, the rating of being "in control" dropped to

1.75, as seen in the *Long-Term Intensity of Perceived Sensations* (3.3) – nevertheless, this was still approximately 0.100 higher than both the pre-exposure ratings.

Participants also perceived higher ratings of "relaxation" following the soundscape exposure, with average ratings of 1.617 immediately post-exposure (as recorded in the *Post-Exposure Intensity of Perceived Moods*, questionnaire 2.3.2), and 1.583 one week later (from the *Long-Term Intensity of Perceived Sensations*, questionnaire 3.3), compared to the original average relaxation rating of 1.233 for the previous month, recorded *Pre-Exposure Intensity of Perceived Sensations* (1.1.3), and 1.457 immediately preceding the experiment (in the *Pre-Exposure Intensity of Perceived Moods*, questionnaire 2.1.2). Unsurprisingly, the average participants' rating for tension rose immediately following the exposure, as the average tension rating found in the *Post-Exposure Intensity of Perceived Moods* (2.3.2) is 0.941, compared to the tension rating of 0.707 from the *Pre-Exposure Intensity of Perceived Moods* (2.1.2), immediately preceding the experiment. The tension rating perceived post-exposure had subsided slightly (by 0.024) one week later, reducing the average rating to 0.917 in the *Long-Term Intensity of Perceived Sensations* (3.3) – it is worth bearing in mind that all these post-exposure figures are at least 0.259 units lower than the very first tension rating, from the *Pre-Exposure Intensity of Perceived Sensations* (1.1.3, evaluating the past month) which was originally 1.200.

In fact, whilst average sadness ratings had decreased from the original *Pre-Exposure Intensity of Perceived Sensations* (1.1.3) sadness rating of 1.033, to 0.586 immediately pre-exposure (questionnaire 2.1.2) and 0.567 immediately post exposure (questionnaire 2.3.2), the average rating rose again one week later to 0.833, in the *Long-Term Intensity of Perceived Sensations* (3.3). Overall this was still a decrease in sadness from the month prior to the experiment to week following experiment, by 0.200 units. The average rating for depression significantly decreased over the course of the experiment: from a rating of 0.833 in the *Pre-Exposure Intensity of Perceived Sensations* (1.1.3) to 0.250 one week following exposure, recorded in the *Long-Term Intensity of Perceived Sensations* (3.3). There was an immediate increase in the intensity of depression on the day by 0.103 units, from the immediately *Pre-Exposure Intensity of Perceived Moods* (2.1.2) depression rating of 0.414, to 0.517 in the *Post-Exposure Intensity of Perceived Moods* (2.3.2). However, this short-term increase in depression intensity to 0.517, is still below the original rating long term pre-exposure depression rating of 0.833, found in questionnaire 1.1.3.

Again, it is insightful to evaluate the difference between the long-term and short-term intensity impact for each emotion. In the short term, from the *Pre-Exposure Intensity of Perceived Moods* (2.1.2) to the *Post-Exposure Intensity of Perceived Moods* (2.3.2) ratings for most positive emotions increased ("relief", feeling "in control", "relaxation" and "contentment"), although "happiness" ratings decreased as did those for "pleasure" (quite dramatically from 1.560 to 1.216 on average). Tension and depression also increased in the short-term - tension by 0.235, and depression by 0.103 - but the average rating for "sadness" decreased slightly. Overall, there was mostly a rise in intensity of perceived moods by the end of the experiment, both positive (relief, feeling in control, relaxation and contentment) and negative (tension and depression) – only happiness, pleasure and sadness ratings decreased. However, in the long-term (from the *Pre-Exposure Intensity of Perceived Sensations*, questionnaire 1.1.3, to the *Long-Term Intensity of Perceived Sensations*, questionnaire 3.3), the rating of every negative emotion decreased, remarkably. It must be clarified that a few positive emotion ratings (for relief, pleasure, and contentment) ratings also decreased from the *Pre-Exposure Intensity of Perceived Sensations* (1.1.3) to the *Long-Term Intensity of Perceived Sensations* (3). Crucially though, the ratings for being "in control" increased, and relaxation ratings increased the most dramatically by 0.350 (rising from 1.233 to 1.583 on average), and the average rating for happiness remained exactly the same, in the long-term, from questionnaire 1.1.3 to questionnaire 3.3. Thus, the short-term discomfort immediately elicited by the soundscape exposure, perceived as an increase in tension and depression, in addition to a decrease in happiness and pleasure is outweighed by the beneficial long-term impact: a decrease in intensity for all negative emotions, but an increase in perception of being in control and relaxation one week following the soundscape exposure.

In the *Post-Soundscape Better or Worse* (2.2.6), a post-pilot addition following each soundscape, participants were asked whether they felt better, the same or worse than when they walked into the Soundlab. Participants were welcome to place a mark in between if they did not feel completely better or worse, and this was measured and converted into a numerical score (between +1 for better and -1 for worse). The average degree to which participants felt better, the same or worse after each soundscape (as well as the total number of participants who felt better, the same or worse after each soundscape) was calculated. For the most part, participants felt better after each soundscape, with the most dramatic change being induced by the *Violence* soundscape (+0.412), followed by *Situational Phobias* (+0.300) and whilst participants still felt better on average after *Body*

Anxiety, this was less consistent as the average score was +0.237. Indeed, twenty out of thirty participants felt better after *Violence*, eighteen out of thirty after *Phobias*, and only fourteen out of thirty after *Body Anxiety*. Five participants felt the same as when they walked into the Soundlab after *Violence* and *Situational Phobias*, whereas ten participants felt that their wellbeing was unchanged by the *Body Anxiety* soundscape. The *Situational Phobias* soundscape made seven participants feel worse than when they walked into the Soundlab - one more than *Body Anxiety* (where six participants felt worse after listening), and two more than *Violence* (five participants felt worse after listening).

Further, there were high incidences of positive reflections in the *Long Term Better or Worse* (3.6) from the thirteen participants who completed the optional *Long Term Catharsis Evaluation* (questionnaire 3). Most participants felt better rather than worse in the short term, as recorded in the *Post-Exposure Better or Worse* (2.3.3), completed immediately after the entire exposure experience. For those who answered the optional *Long Term Catharsis Evaluation* (questionnaire 3) the following long-term improvements in state were noted:

- Participant 6 felt 39% worse on the day, but 100% better one week later
- Participant 9 felt 100% worse on the day, but 25% better in the long-term
- Participant 18 felt 62% better on the day, but 100% better one week later
- Participant 20 felt 64% worse on the day, but only 40% worse one week later
- Participant 29 felt 6% better on the day, but 100% better one week later
- Participant 31 felt 30% better on the day, but 100% better one week later.
- Even more dramatically, participant 32 felt 38% worse on the day, but 100% better one week later.
- Participant 34 felt exactly the same on the day, but 100% better one week later.
- Participant 10 felt 100% better on the day, but exactly the same as before the experiment one week later. This was also the case for participant 11.
- Participant 12 felt 22% better on the day, but exactly the same one week later.
- Participant 23 felt 68% better on the day, but exactly the same one week later.
- Participant 33 felt 100% better on the day, but exactly the same one week later.

Thus, from the thirteen participants who filled out the *Long Term Catharsis Evaluation* (questionnaire 3), eight felt better to an even greater degree than they did immediately following the experiment as recorded in the *Post-Exposure Better or Worse* (2.3.3). The participants with long-term improvement in wellbeing were participants 6, 9, 18, 20, 29, 31, 32, 34. Participants 9 and 32 even changed from feeling worse immediately after the experiment (in questionnaire 2.3.3), to feeling better once a week had passed (questionnaire 3). Five participants (participants 10, 11, 12, 23, 33) felt exactly the same as before the experiment according to their *Long Term Better or Worse* (3.6), whereas they had originally felt better immediately following soundscape exposure, as logged in the *Post-Exposure Better or Worse* (2.3.3).

On average, participants who answered the optional *Long Term Catharsis Evaluation* (questionnaire 3) felt 45% better than before the experiment, whereas immediately following the experiment (according to the *Post-Exposure Better or Worse*, questionnaire 2.3.3), participants felt 33% better than when they walked into the Soundlab. Thus, participants are likely to feel even better one week later, compared to the immediate perception following soundscape exposure. It appears that some of the psychological benefits are not immediately effective, as the participant must allow time for the emotions elicited to sink in and to reflect over a longer-term basis than in the relatively short exposure session.

This long-term improvement in emotion is corroborated by the results of the *Long-Term Emotion-Time Distribution* (3.2), which is presented as a pie chart where the percentage of a set period of time spent feeling each emotion is represented as a slice of the pie chart. In questionnaire 1.1.2, it is recommended that participants roughly allocate a portion of the chart to represent the percentage of time in the past month that they had felt content, relaxed, in control, happy, relieved, tense, depressed, or sad – but some participants added their own relevant emotions (elated, detached, vacant, lethargic, hurried, anxious, nervous, stressed, worried). The *Long-Term Emotion-Time Distribution* (3.2), is presented in the same format, but the participant must reflect on the emotions felt in the week following the soundscape exposure.

Consistently, the percentage of negative emotions such as tension, depression and sadness all decreased in the long-term, from questionnaire 1.1.2 to questionnaire 3.2, for the average participant. Tension decreased from 17.991% of the month in the *Pre-Exposure Emotion Time Distribution* (1.1.2) to 12.077% of the week reflected upon in the *Long-Term Emotion-Time Distribution* (3.2). The percentage of the month that participants felt depressed was originally 7.442% in the *Pre-Exposure Emotion Time Distribution* (1.1.2), but depression was only perceived for 4.77% of the week following soundscape exposure.

The percentage of time the participants felt sad dropped from 10.438% in the month pre-exposure, to 5.923% during the week following exposure. Participants only mentioned feeling “detached”, “lethargic”, “hurried”, “anxious”, “nervous”, “stressed” and “worried” in the *Pre-Exposure Emotion Time Distribution* (1.1.2) but did not include these emotions one week following the experiment, in the *Long-Term Emotion-Time Distribution* (3.2), so by default, they essentially decreased. One negative emotion that only appeared one week post exposure in the *Long-Term Emotion-Time Distribution* (3.2), was feeling “vacant”, so that increased from 0% to 3.333%. Most of the average percentages for positive emotions increased from the *Pre-Exposure Emotion Time Distribution* (1.1.2) to the *Long-Term Emotion-Time Distribution* (3.2). “Elation” increased in the long-term from 0.267% to 0.636%, relaxation from 15.058% to 19.770%, control from 16.063% to 18.461%, happiness from 21.341% to 23.69%. Contentment and relief are the only positive emotions which decreased very slightly from the *Pre-Exposure Emotion Time Distribution* (1.1.2) to the *Long-Term Emotion-Time Distribution* (3.2): contentment started at 2.2% of the pre-exposure month and dropped to 2.181% on average in the post-exposure week, and relief dropped from 9.932% to 9.846% on average. Overall, the average percentage of time spent feeling positive emotions rose by over 13%: a significant increase from 61.008% over the month prior to exposure, for the average participant as measured in the *Pre-Exposure Emotion Time Distribution* (1.1.2), to 74.154% in the week after the soundscape, as recorded in the *Long-Term Emotion-Time Distribution* (3.2) a rise of over 13%. Thus, the drop in negative emotions was also 13% (the total percentage of negative emotions dropped from 38.991% to 25.846%, from the *Pre-Exposure Emotion Time Distribution*, questionnaire 1.1.2, to the *Long-Term Emotion-Time Distribution*, questionnaire 3.2).

There were ten measures of exposure-induced long-term emotional impact, predicted to be perceived in the week following participation in the experiment. Participants were asked to rate the degree to which they felt each of these impact measures, from 0 for a definitive no, and 3 for a conclusive yes, in the *Long-Term Emotional Impact of Soundscape Exposure* (3.4). Whilst averaging the overall intensity ratings for the long-term effects is useful, it is more meaningful here to count the number of participants who perceived these effects (regardless of the strength of the affect). All thirteen of the participants who completed the optional *Long Term Catharsis Evaluation* (questionnaire 3) noticed they had “gained confidence in their ability to withstand anxious sensations”, whilst ten out of thirteen perceived “the effects of soundscape exposure lasting beyond the soundlab” visit. Ten out of thirteen participants also felt “heightened awareness of the fluidity of [their] moods”, and increased “mindfulness of physical sensations”. Eight of the ten participants who had perceived the heightened awareness and mindfulness found this “helpful”, but two found it “distressing”, the hypervigilance regarding their fluctuating sensations perhaps perpetuating their fear of fear. Seven out of the thirteen participants who completed the *Long Term Catharsis Evaluation* (questionnaire 3) experienced “initial upset”, three cried, five found themselves “excessively ruminating on negative issues”, and two “re-hear[d] sounds as an imaginary earworm”. Four out of the thirteen “gained a sense of resolution of underlying fear, trauma or grief as a result of the soundscape exposure”. Thus, the majority of the participants who evaluated the long-term impact of soundscape exposure (in questionnaire 3) perceived beneficial changes to their state of mind, lasting at least a week, and a few even indicated a form of catharsis had taken place, as indicated by tears, catalyzed by soundscape-induced rumination on unresolved fear, trauma or grief.

For the most part, the average rating for the *Intensity of Perceived Sensations* was seen to reduce in the long term. The average sensation rating in the *Pre-Exposure Intensity of Perceived Sensations* reflecting on the past month (1.1.3) is 1.216: this figure dropped significantly (by 0.319) to 0.897 in the *Long-Term Intensity of Perceived Sensations* (3.3) recorded one week later. More telling though, is to calculate the difference in drops between positive sensations and negative sensations in the long-term. The average rating for physical positive sensations reduced from the *Pre-Exposure Intensity of Perceived Sensations* (1.1.3) figure of 0.348 to a mere 0.183 in the *Long-Term Intensity of Perceived Sensations* (3.3) (a drop of 0.165, almost half the original figure). However, the average rating for physical negative sensations decreased less dramatically from 0.144 to 0.084 (a difference of 0.060). So physically, the positive sensations decreased more dramatically than negative sensations in the long term - from questionnaire 1.1.3 (which gauged the *Intensity of Perceived Sensations* in the month pre-exposure) to questionnaire 3.3, the *Long-Term Intensity of Perceived Sensations*.

Psychological negative sensations decreased in the long term: from the *Pre-Exposure Intensity of Perceived Sensations* (1.1.3) psychological negative average rating of 0.228, to 0.141 in the *Long-Term Intensity of Perceived Sensations* (3.3) (a drop of 0.087, over a third of the original score). The drop in psychological positive sensations was much less, from 0.497 to 0.489 (a minute difference of 0.008 between questionnaire 1.1.3 to questionnaire 3.3). Thus, the long-term mental impact showed as a much more significant decrease in the psychological negative sensations, than the minimal drop in psychological positive sensations. Overall, the thirteen participants who had completed the *Long Term Catharsis Evaluation* (questionnaire 3) perceived the intensity of strong sensations to be dimmed somewhat from the month prior the soundscape exposure, to the week following the exposure. This attenuation in *Intensity of Perceived Sensations* was only very slight for the psychological positive sensations (0.008) and physical negative sensations (0.060), but there was a more significant attenuation for physical positive sensations (0.165) and psychological negative symptoms (0.087). Thus soundscape exposure might be said to have a more beneficial effect psychologically (as there is a significant decrease in psychological negative sensations), rather than physically (as there was only a minimal decrease in physical negative sensations). Nevertheless, the overall dimming of intensity of involuntary strong sensations over time, might be construed as a pleasant relief for persons who are afflicted with higher levels of pre-existing anxiety.

Whilst it is important to comprehend the bigger picture of overall attenuation of intensity ratings of perceived sensations, it is also insightful to look in greater detail, to identify any anomaly participants, and to evaluate the degree to which each participants' sensations ratings diminished. Participant 33 was the only participant whose overall sensations intensity rating increased from the *Pre-Exposure Intensity of Perceived Sensations* (1.1.3, reflecting on the past month) *to Long-Term Intensity of Perceived Sensations* (3.3, completed remotely, one week later): their original sensation strength was 0.470, but this rose to 0.591 one week following the exposure (a difference of 0.121). Participants whose sensations intensity ratings decreased to the greatest degree include:

- Participant 14, whose *Pre-Exposure Intensity of Perceived Sensations* (1.1.3) rating started at 1.773 but dropped to 0.994 one week later in *Long-Term Intensity of Perceived Sensations* (3.3) (a difference of 0.780)
- Participant 18, whose original sensation rating started at 1.055 but dropped to 0.305 one week after exposure (a difference of 0.749)
- Participant 11 whose sensation rating dropped from 1.3 to 0.74 (a difference of 0.560)
- Particpant 6, whose sensation rating began at 1.127 but diminished to 0.721 (a difference of 0.405)

Most other participants' sensation ratings diminished by a degree of 0.250 out of 3, on average.

Here, Hypothesis 3 and Hypothesis 4 have been confirmed, as participants experience a positive long-term impact, showing physical and psychological improvement in the *Long-Term Catharsis Evaluation* (questionnaire 3) from how they originally felt prior to the soundscape exposure, in the *Pre-Exposure Evaluation of Anxiety Levels* (1.1) (Section 5.2.2). Also, participants experience a slightly negative short-term impact, from the *Pre-Exposure Evaluation of Anxiety Levels* (2.1) to the *Post-Exposure Evaluation of Anxiety Level*s (2.3) as is expected given that the soundscape exposure is designed to be anxiety eliciting.

5.3 Increased efficacy of Soundscape Exposure Therapy for participants with higher pre-existing anxiety

An intriguing research question regarding the implementation of soundscape exposure as a therapy, is whether the participants with the highest anxiety in everyday life are actually more receptive to the emotional stimulation elicited by soundscapes, than the participants with the lowest anxiety. Here, the difference in the rate of perceived elicitation of strong sensations between participants with the lowest or the highest pre-exposure anxiety evaluation scores is calculated (as recorded in the *Post-Soundscape Frequency of Perceived Sensations,* questionnaire 2.2.2). It is expected that participants who are pre-disposed to anxiety in everyday life (indicated by the highest scores in the *Pre-Exposure Intensity of Perceived Sensations* questionnaire 1.1.3, reflecting on the month prior to soundscape exposure) would be more susceptible to anxiety triggers than those who do not experience noticeable anxiety in everyday life (indicated by the lowest scores in the *Pre-Exposure Intensity of Perceived Sensations,* questionnaire 1.1.3). This difference in sensitivity to the dynamic changes (from quiet to loud), and shock cues or potent trigger points of the soundscapes can be deducted by splitting the participant pool into three groups: those with higher, medium and lower *Pre-Exposure Intensity of Perceived Sensations* scores (abbreviated as HPE, MPE, LPE). Then, it can be discerned whether the higher-pre-exposure anxiety group (HPE) generated higher post-soundscape questionnaire scores (showing stronger physical positive, physical negative, psychological negative and psychological positive sensation ratings), than the lower pre-exposure anxiety group (LPE). (The group who demonstrated more frequent GSR peaks is later identified in Section 6.5)

It must be clarified, that the lower pre-exposure anxiety (LPE) group are the ten participants whose pre-exposure sensation scores were the lowest, and higher pre-exposure anxiety (HPE) group are the ten participants with the highest pre-exposure sensation scores. The ten participants with middling pre-exposure sensation scores are omitted from this comparison, as the middle group's physiological data is expected to be mid-ranging in the overall analysis. The LPE and HPE group scores are distinctly different, compared to the overall average, so differences in the questionnaire responses and GSR peak rates are clearer to see. There is a consistent difference in sensation scores between the participants with higher pre-existing anxiety (HPE) and the participants with lower pre-existing anxiety (LPE), as gathered in the *Post-Soundscape Frequency of Perceived Sensations*, questionnaire 2.2.2, for all soundscapes averaged together. The HPE group had higher *Post-Soundscape Frequency of Perceived Sensations* (2.2.2) scores than the LPE group in three of the four sensation categories: psychological negative, physical negative, and physical positive. However, the LPE group reported higher psychological positive post-exposure scores than the HPE group, which is to be expected, as they tend to have a more positive outlook on their reactions to the soundscape. Thus, we can gather that those already pre-disposed to anxious sensations perceived a higher frequency of anxious sensations during soundscape exposure, on the whole – and indeed they were more aware of their physical symptoms, even those which may be construed as positive (such as heart pounding and pleasurable chills).

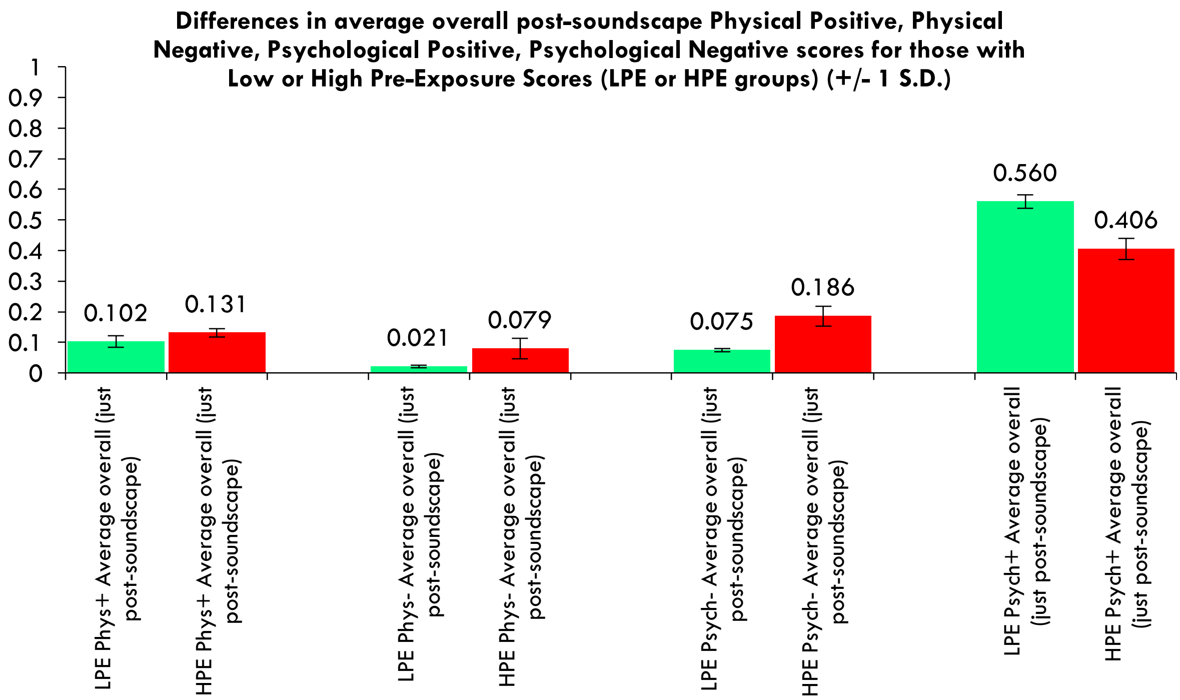


Figure 36: Differences in the average overall post-soundscape sensation scores (questionnaire 2.2.2) for LPE and HPE participants

The average overall scores for the physical positive sensations (as recorded in the *Post-Soundscape Frequency of Perceived Sensations*, questionnaire 2.2.2) for the HPE group is 0.131 compared to 0.102 for the LPE group: so the HPE group's physical positive sensation score is 0.029 units higher than the LPE group's physical positive sensation score (see the column pair at the far left of Figure 36). The difference in response between the two groups was even greater for the perceived strength of physical negative sensations: the average HPE rating was 0.079 compared to the LPE's 0.021, a difference of 0.058 (see column pair second from the left of Figure 36). Higher still is the difference between the overall average psychological negative scores – 0.186 for the HPE group and 0.075 for the LPE group, making a difference of 0.111 (see the column pair second from the right in Figure 37). The largest difference in the low pre-existing anxiety group response and the higher pre-existing anxiety group response is seen in the perception of psychological positive sensations: the LPE group's average overall scores exceeded those from the HPE group, by a factor of 0.154. The LPE group's average overall psychological positive score was 0.560 but the HPE group's average was 0.406, making a difference of 0.154. This makes sense, as those who are less affected by anxiety's negative effects in everyday life may have naturally had a more positive mental reaction to the sounds they heard, and to the laboratory experience in general.

The HPE group shows a higher frequency of sensations and emotions overall than the LPE group for the *Pre-Exposure Intensity of Perceived Sensations,* questionnaire 1.1.3, as the average intensity rating is 0.380 for the HPE group compared to the LPE group's intensity rating of 0.248, making a difference of 0.132. This trend continued for the *Violence* soundscape, as *Post-Soundscape Frequency of Perceived Sensations* (2.2.2) score for the HPE group is 0.217 compared to 0.187 for the LPE group's sensation score, a difference of 0.030. Again, the HPE group's sensation frequency score for the *Body Anxiety* soundscape is marginally higher than the LPE group's (by 0.010): the HPE group's sensation frequency score for *Body Anxiety* is 0.192 compared to the LPE group's sensation rating of 0.182. However, the LPE group shows slightly higher average ratings of sensations and emotions than the HPE group for the *Situational Phobias* soundscape: the LPE average for Situational Phobias is 0.199 but the HPE group's was 0.195, a difference of 0.004. So not only did the *Violence* soundscape elicit the highest sensation frequency ratings on average overall, but it also elicited largest difference in response between the two groups of participants, as the HPE group's sensation frequency score was 0.030 higher than the LPE group's for *Violence*, but only 0.010 higher for *Body Anxiety* and only 0.004 higher for *Situational Phobias*.

This data becomes more meaningful when the soundscape-induced sensation frequency scores (derived from the *Post-Soundscape Frequency of Perceived Sensations*, questionnaire 2.2.2) are split into individual scores for positive or negative sensation ratings. The LPE (lower pre-existing anxiety) group consistently shows higher ratings of positive sensations and emotions than the HPE group for all soundscapes, so the participants with low pre-existing anxiety could be said to have enjoyed the soundscape exposure experience more than the participants with higher pre-existing anxiety. The *Situational Phobias* soundscape generated the largest difference in positive response between the two groups: the LPE group's average positive sensation frequency score for *Situational Phobias* was 0.349, whereas the HPE group's average positive sensation frequency score was 0.253, a difference of 0.096. The *Body Anxiety* soundscape caused a less dramatic difference between the two groups' ratings of positive sensations: the LPE group's average positive sensation frequency score for *Body Anxiety* was 0.320 compared to 0.285 for the HPE group, a difference of 0.035). As predicted, the HPE group consistently shows higher ratings of negative sensations and emotions as recorded in the *Post-Soundscape Frequency of Perceived Sensations* (2.2.2) than the LPE group. These scores are represented in Figure 37 as columns outlined in black. *Violence* provoked the largest difference between the two groups' ratings of negative sensations: the HPE average negative score for Violence was 0.161 compared to the LPE group's 0.050, a difference of 0.111. Again, there was less of a difference in the responses of the two groups towards the *Body Anxiety* soundscape (the HPE average negative sensation frequency score for *Body Anxiety* was 0.099 and the LPE's was 0.044, a difference of 0.055). The LPE group consistently reports positive sensations more frequently for all soundscapes (see the third, fifth, and seventh column pair from the left in Figure 37), whereas the HPE group always reported the negative sensations more frequently than the LPE group, throughout the soundscape exposure experience (see the column pairs outlined in black, the fourth and sixth and eighth column pairs from the left in Figure 37).

In this section, Hypothesis 5 has been confirmed to an extent: participants with higher pre-existing anxiety demonstrate an amplified perception of most sensations in the *Post-Soundscape Frequency of Perceived Sensations* (2.2.2) compared to participants with low-pre-existing anxiety – with the exception of psychological positive sensations, which are perceived far more frequently by the low pre-existing anxiety participants. Further, the higher pre-existing anxiety participants consistently report higher frequencies of negative sensations than the lower pre-existing anxiety participants for every soundscape, and indeed overall. The lower-pre-existing anxiety participants report higher frequencies of positive sensations than the higher-pre-existing anxiety participants for every soundscape.

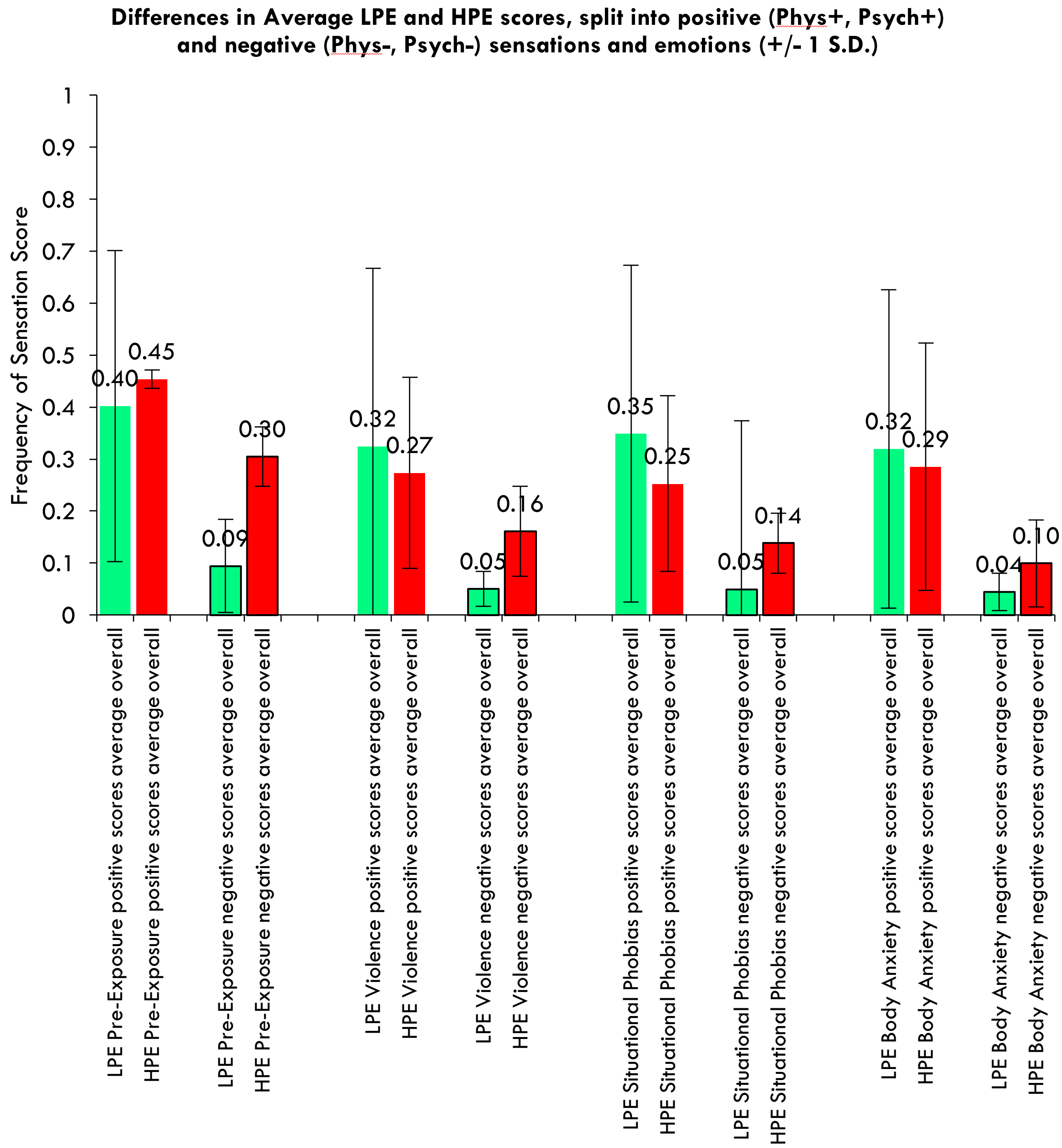


Figure 37: HPE participants consistently report higher negative sensation frequency scores than LPE participants

5.4 Analysis of efficacy of spatialisation

It is crucial to justify the use of ambisonic soundscapes in this study, by outlining the benefits of spreading sounds out across a spatial array during soundscape exposure therapy. Evidence of the enhancement of sensation elicitation directly attributed to the spatialisation of sounds across a higher order ambisonic array can be found in two areas of the participant's written response. Firstly, the *Post-Soundscape Frequency of Perceived Sensations* (2.2.2) is designed for participants to rate individual sensations in terms of their frequency, whilst also prompting the participant to identify the trigger sound responsible for particularly notable sensations. At times, a sensation rated highly in the questionnaire was reported to be triggered by the movement pattern of a particular sound, or the general sense of immersion. Secondly, the difference in psychological affect elicited by either realistic or hyperreal panning of individual sounds, played at the end of the exposure experience, can be discerned in the stand-alone *Post-Exposure Spatialisation Evaluation* (2.3.4).

Overall, observations of the spatialisation of the sound as the direct cause for fear or awe were made by many participants, as there were 46 reports that spatial sound was the trigger for a strong sensation (in total, throughout the experiment run) as recorded in the *Post-Soundscape Frequency of Perceived Sensations* (2.2.2). There were many more comments made about the spatialisation of sound in the post-soundscape conversational feedback from participants, which was all recorded during the experiment, but these voice recordings are still yet to be transcribed and analysed. Most comments referred to the pertinent moments of unexpected spatialisation or unnatural movements of sound, which deviated from an accurate representation of a naturally occurring soundfield. (The most salient panning choices and the sensations they were designed to elicit are explained in detail in Section 3.2.2 – these carefully nuanced sound movements might differ from the most noticeable ones, which are probably the loudest, or the most attention grabbing.) After listening to the *Violence* soundscape, there were two instances where a "growl [that] moved across the room behind [the participant]" triggered a strong sensation, as well as one report of each of the following as a strong sensation trigger: "sounds like travelling directly towards you", "nice pan sounds", "sounds in the back speakers", and "immersive, disorientating" sounds (see the red bars at the top of Figure 38). So, there are six reports of spatialized sound induced anxiety from the *Violence* soundscape in total.

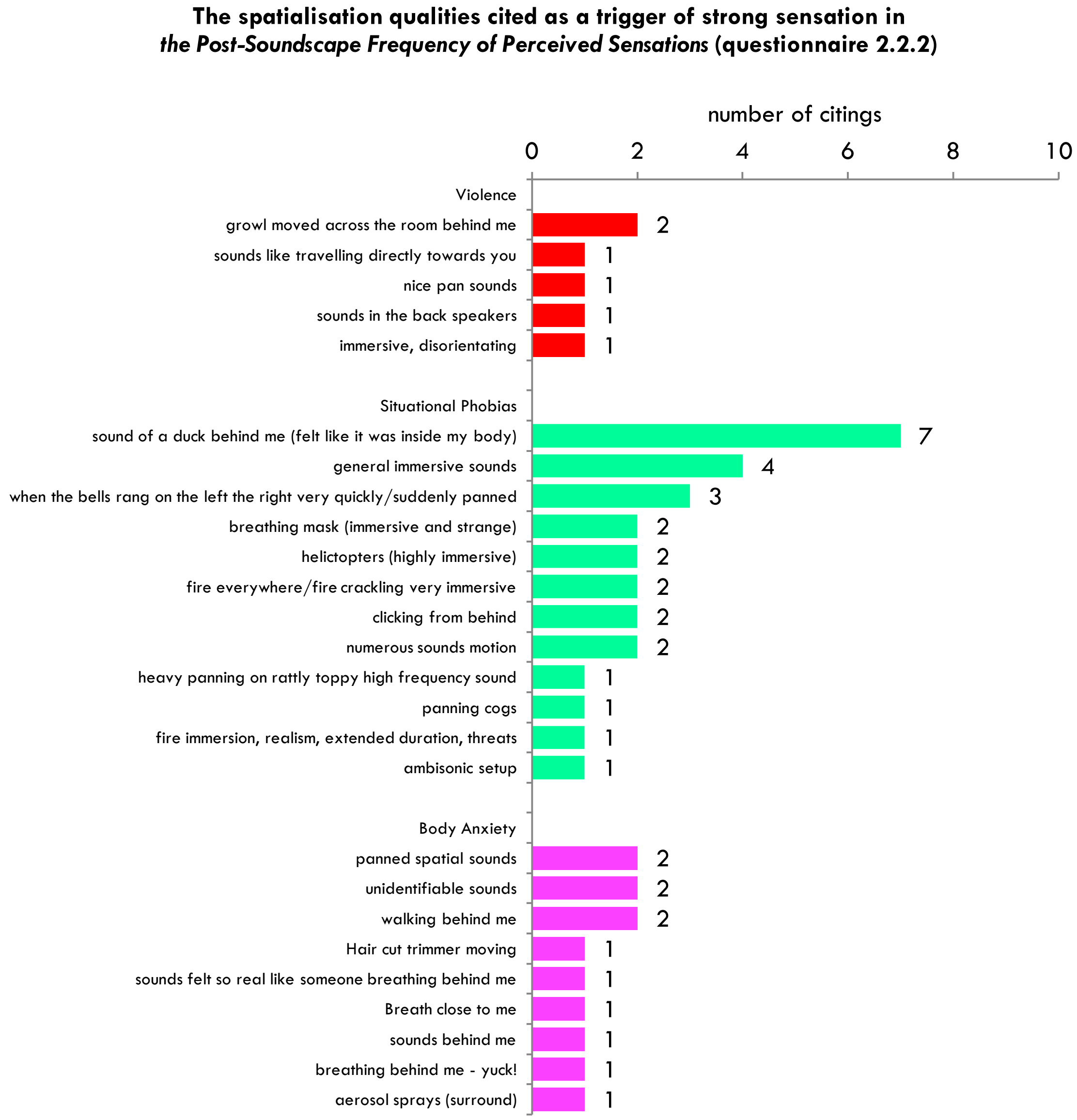


Figure 38: The spatialized sounds responsible for triggering strong sensations, according to the *Post-Soundscape Frequency of Perceived Sensations* (2.2.2)

There were many more comments made about the spatialisation of sounds in the *Situational Phobias* soundscape, 28 in total. Some of these sounds were mentioned by several people, whereas the very specific ones may have only been identified as a sensation trigger several times by the same person. For instance, there are seven mentions of “the sound of a duck behind me, felt like it was inside my body” – although it was only identified as a source of anxiety for one person, the number of mentions means that the effect of the sound’s spatialisation is still particularly notable (see the green bars in Figure 38). The next most frequently reported spatialized sensation triggers in the *Situational Phobias* soundscape include the “general immersive sounds” which were reported as sensation triggers four times; “when the bells rang on the left and the right very quickly or suddenly panned” reported three times; “breathing mask (immersive and strange),” “helicopters (highly immersive),” “fire everywhere/fire crackling very immersive”, “clicking from behind”, “numerous sounds motion” were all reported as sensation triggers twice; “heavy panning on rattly toppy high frequency sound” (sic), “fire immersion, realism, extended duration, threats”, and “the ambisonic setup” are also reported as causing anxious sensations, once each.

There were twelve instances that spatialized sounds are reported as anxiety triggers in the *Post-Soundscape Frequency of Perceived Sensations* (2.2.2) for *Body Anxiety*. “Panned spatial sounds”, “unidentifiable sounds”, and “walking behind me,” were each reported as sensation triggers twice, whereas “haircut trimmer moving”, “sounds felt so real like someone breathing behind me,” “breath close to me,” “sounds behind me,” “breathing behind me – yuck!” and “aerosol sprays (surround)” were each mentioned once (see the pink bars in Figure 38).

As recorded in the *Post-Soundscape Frequency of Perceived Sensations* (2.2.2), there were six reports of sound movements attributed to causing sensations in the *Violence* soundscape and twelve reports for *Body Anxiety* soundscape, but it is remarkable that there were by far the most comments on the spatialisation of sounds in the *Phobias* soundscape - 28 in total. This is likely due to the higher levels of realism in the way recognisable scenarios were constructed and the sounds were layered less densely than those in the *Violence* and *Body Anxiety* soundscape, with more space around them - thus individual sound movements are easier to identify and later recall. *Phobias* is constructed as a journey through several real-world simulations, whereas the *Violence* and *Body Anxiety* soundscapes are perceived as musique concrète, so participants tended to focus on following musical structures and rhythmic patterns rather than seek out or recall the unusual spatialisation of sounds. Moreover, there are many more sounds playing at any one time in these two soundscapes; in the *Violence* soundscape especially, but also to an extent in the *Body Anxiety* soundscape. Thus, individual sound movements may be obscured as several sounds play simultaneously, each sound panned in differing spatial paths. Upon reflection, for the sound spatialisation to be more noticeable during periods of densely layered sound, perhaps several sounds should be grouped and panned together (only if the grouping makes sense thematically; for example, all shrieking sounds moving along the same vector will be perceived as one sound object).

The spatialisation patterns which were most frequently noticed in the soundscapes as prompted by the *Post-Exposure Spatialisation Evaluation* (2.3.4) are as follows:

- "random darting around the room," noticed by nineteen out of thirty participants;
- "horizontal spinning" noticed by thirteen participants;
- "rear to front," noticed by nine participants;
- "front to rear," noticed by eight participants;
- "stereo image widening like a jaw," noticed by six participants;
- "vertical dropping" was picked up by three participants
- "drop from ceiling to floor," "circling from below," which were each noticed by one participant.
- A "slow rise from floor to ceiling" was not perceptible by anyone.
- "rear," "panning," "left to right pan," and "side to side" were additional unprompted sound movements each written about once

Thus, six panning methods were clearly perceptible to a significant number of participants, so it was worthwhile to implement spatialized sound. There was a 22% recognition rate from the list of notable panning methods offered in the questionnaire checklist.

Further, in the *Post-Exposure Spatialisation Evaluation* (2.3.4), the psychological effects elicited by a hyperreal spatial sound heard in isolation were compared to the effects elicited by the same sound heard in stereo or that sound panned with realistic movements. Evidence is sought in questionnaire 2.3.4 that isolated sounds which have been panned in unusual ways across an ambisonic array are perceived as more anxiety-eliciting than a static stereo equivalent (or a sound with a realistic movement path). Specifically, the psychological effect elicited by a sound panned in a hyperreal spatial path (especially designed to heighten anxiety) was compared to the effect elicited by the same sound panned along a realistic spatial path appropriate to its original source. Participants were asked whether the realistic or hyper-realistic sound is perceived to be the "most realistic", the "most unnerving", the "most frightening", the "most irritating" or the "most panic inducing". At times participants consistently saw one sound to have most or all of the above attributes, but some sounds garnered a mixed reaction among participants.

Participants were asked to choose which of the two or three spatialisation patterns imposed on four sets of isolated sounds were the most emotion inducing, as seen in Table 15.

Table 15: The four isolated sound sets which are presented along a hyperreal or realistic panning motion, for comparison in questionnaire 2.3.4

Isolated sound set	Hyperreal/exaggerated panning movement	Realistic panning movement
1. chains dropping	From ceiling to floor	Static mono
2. jet passing by	Dropping fast from ceiling to floor	Dropping slowly from ceiling to floor
3. footsteps	Approaching from rear to front; circling	Approaching from front to rear
4. leopard growling	Circling at ear height	Circling from below

Overall, the reaction is mixed: sounds panned across hyperrealistic, exaggerated spatialisation paths were picked to be the potent emotion inducers in eight out of sixteen opportunities, and realistic spatialisation patterns were also chosen to be strong emotion inducers in eight out of the sixteen opportunities (see the black bars in Figure 39). (Each of the four sound sets has four mood inductions to attribute to either the realistic or hyperreal sound movement, unnerving, frightening, irritating, or panic-inducing). “Chains dropping in static mono” is deemed the “most realistic” (chosen by two more participants than the “chains dropping from ceiling to floor”), and also the “most unnerving” (chosen by two more participants), the “most frightening,” (chosen by five more participants), the “most irritating”, (chosen by two more participants) and the “most panic inducing” (chosen by five more participants).A “jet passing by, slowly from top to bottom” was unanimously chosen to be the “most realistic” by sixteen more participants than a “jet passing by, fast from top to bottom”. Moreover, a “jet passing by, fast, from top to bottom” was deemed to be the “most unnerving” (chosen by sixteen more participants than the “jet passing by, slowly from top to bottom”), the “most frightening” (chosen by four more participants), the “most irritating” (chosen by nine more participants) and the “most panic-inducing” (chosen by three more participants) than a jet passing by “slowly, from top to bottom”. Thus, for the airplane sound it appears that when a sound movement pattern deviates from the expected norm it elicits the most fright – this makes sense, as a plane dropping faster than expected alludes to a plane crash.

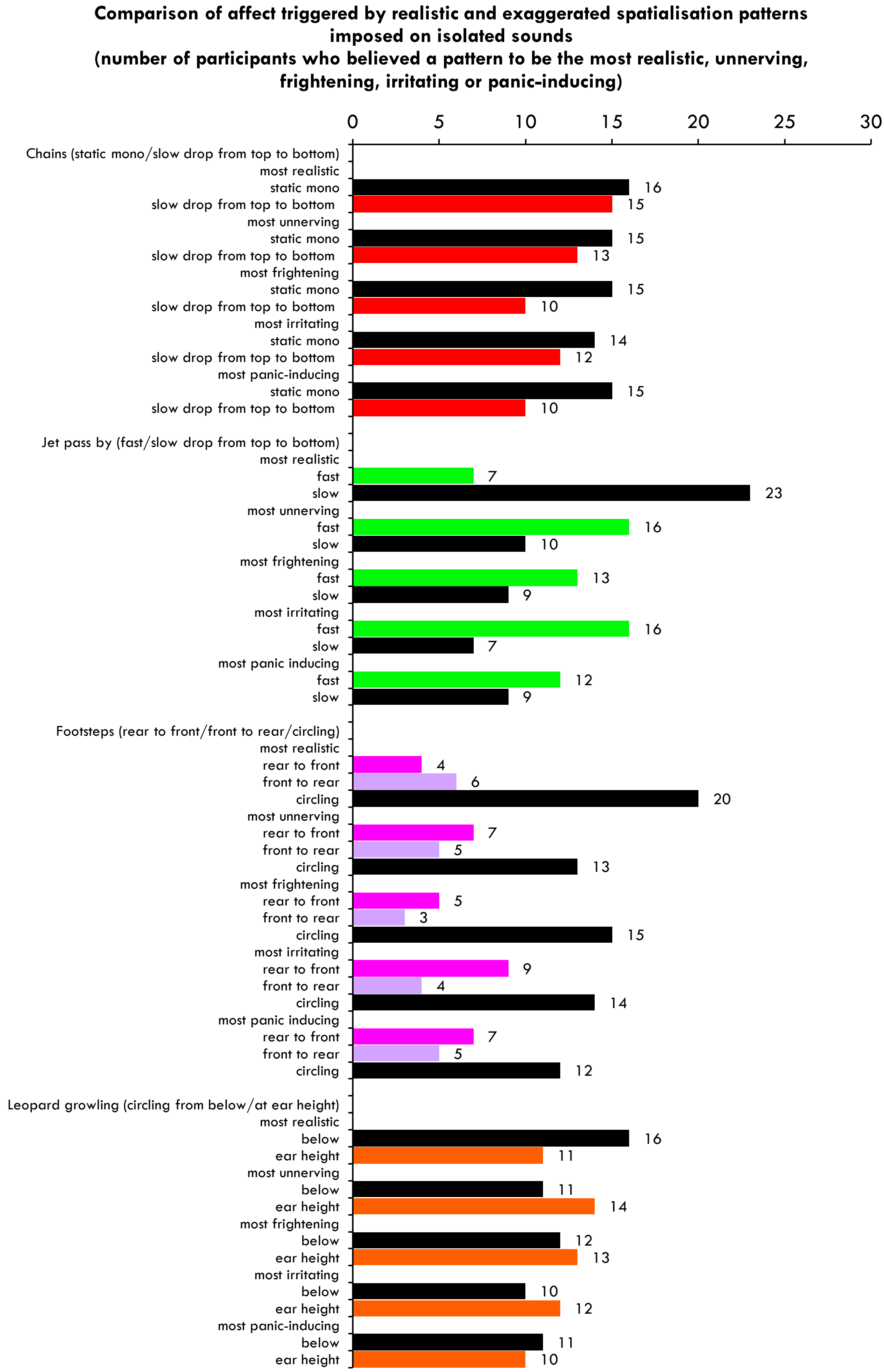


Figure 39: The number of participants who deemed each spatialisation pattern the most realistic, unnerving, frightening, irritating or panic inducing.

“Footsteps circling” are chosen as the most realistic by twenty participants, whereas “footsteps approaching from front to rear” is deemed the most realistic by only six participants, and “footsteps from rear to front” is perceived as the most realistic by even less, just four participants. So, even though “footsteps circling” is commonly seen as the most realistic, many of the participants also saw the sound as:

- the “most unnerving” (thirteen participants chose “footsteps circling,” seven chose “footsteps from rear to front”, and five chose “footsteps from front to rear”),
- the “most frightening” (fifteen participants chose “footsteps circling,” five chose “footsteps from rear to front”, and three chose “footsteps from front to rear”),
- the “most irritating” (fourteen participants chose “footsteps circling”, nine participants chose “footsteps approaching from rear to front”, and four chose “footsteps from front to rear”)
- the “most panic-inducing” (twelve participants chose “footsteps circling,” seven chose “footsteps from rear to front”, and five chose “footsteps from front to rear”).

It is logical that the most realistic “footsteps circling” is perceived to be the most unnerving, frightening, irritating and the most panic-inducing, as a realistic replication of disembodied human sounds in an acousmatic setting is often construed as uncanny. Further, the sound is moving around the listener in a manner indicative of menace, the way a bully or torturer might pace around a hostage. It also makes sense that the footsteps approaching from rear to front are the second most unnerving, frightening, irritating and the second most panic-inducing, as many participants have likely experienced the unease provoked by footsteps following them when walking alone in the dark in everyday life, for fear of mugging, assault or worse. “Footsteps approaching from front to rear” are indeed likely to be the least anxiety-inducing sound, as the connotations are far less fearful.

The “leopard growling, circling from below” was rightly deemed to be the “most realistic” by most participants: sixteen chose this faithfully panned sound as the most realistic, whereas only seven participants chose the “leopard growling, circling at ear height” as the most realistic. If a leopard’s growl was circling the listener at ear height, this would mean that the leopard would be exaggeratedly huge, therefore anxiety would be amplified. The reaction to this hyperrealistic sound panning was mixed, but participants largely perceived the larger than life “leopard growling, circling at ear height” to be the most anxiety-inducing (by a small margin). The “leopard growling, circling at ear height” was chosen to be the “most unnerving” by fourteen participants (chosen by three more participants than the more realistic “leopard growling, circling from below”); thirteen participants found the “leopard growling, circling at ear height” to be the most frightening, one more than the twelve participants who chose “leopard growling, circling from below”); and two more participants chose the “leopard growling, circling at ear height” to be the most irritating (twelve, compared to the ten who chose the more realistic growl from below). However, one more participant perceived the “leopard growling, circling from below” to be more panic-inducing than the “leopard growling, circling at ear height” (only chosen by ten participants). Thus, the reaction to this altered growl was quite mixed.

In conclusion, whether the realistic sound movements are more anxiety-eliciting than hyperreal, exaggerated sound movements ultimately depend on the nature of the sound source being examined. If a sound is panned in such a way that breaks from the anticipated norms inherent in the sound source – for example a reassuringly steady, slow movement of a jet passing by is transformed into a frighteningly accelerated whoosh, or a tiger is rendered larger than life with its growl towering above the listener – then this is likely to be unnerving and frightening to hear. When hyperreal, exaggerated movement paths are assigned to sounds which we unconsciously rely on for reassurance, then of course a fear response should be elicited. A salient case in the experiment is Participant 13’s pre-existing anxiety triggers and their resulting experience of the *Situational Phobias* soundscape, where they describe their everyday reliance on listening to aircraft for reassurance, and that the fear induced by flying is directly associated with worrying sounds indicating engine trouble. Airplanes and “all aspects of flying noises”, including “engines starting” and a “jet passing by” were cited in the *Pre-Exposure Trigger Diagnosis* (1.2) for Participant 13. A plane crash was described in detail as “the worst that could happen” to them in their *Pre-Exposure Hypothesised Worry Scenario* (1.3):

> *“Plane Crash. Being in a plane where I become aware there is a problem e.g. engine failure, fire. Hearing each mechanical noise associated with problem. e.g. revving, explosion, alarm bells. Hearing people panicing [sic] loss of control, impending doom, fear, terror, need to escape.”*

Further, Participant 13 also described all the aspects of flying which contribute to it being their most regular anxiety-inducing source, also in their *Pre-Exposure Hypothesised Worry Scenario* (1.3):

> *"Flying… Am acutely conscious of all sounds, engine, gear change, wheels, calling bells. If anything sounds different or done in different order, out of ordinary (e.g. turbulance) become rigid with fear breathing affected + stomach churns - Everytime!!"*

In the *Pre-Exposure Intensity of Perceived Sensations* (1.1.3), Participant 13 reflected that they had felt "terrified" to a "chronic unpleasant" degree "briefly during turbulence" on a recent flight, but they had felt "completely relieved on landing". Immediately after exposure to the *Situational Phobias* soundscape, in the *Post-Soundscape Subjective Perceptions* (2.2.1), Participant 13 reflected that there was "a little" re-experience of unpleasant sensations and emotions, as the "plane engine noise is something [they] generally dread". Participant 13 continued to list "the plane engines" as the sounds they found the most frightening and the most panic-inducing. Also frightening was the collage of innocuous interior ambient plane sounds with deliberately antagonistic sound effects indicative of impending crash: Participant 13 "thought [they] could hear alarms + panic which [they] associated with the plane sounds". In the *Post-Soundscape Frequency of Perceived Sensations* (1.1.3), Participant 13 continued to elaborate that they "fear[ed] the worst happening… once, very briefly" during "plane engines+alarm, [as the] crowd seemed to be panicking", and they were "completely unable to relax… two to three times", at "various stages but mostly with the plane engine sounds." Next, in Participant 13's *Post-Soundscape Memory Record* (2.2.7), they described a memory that was triggered "two to three times" during the *Situational Phobias* soundscape of "hearing a sound [they] did not like" during a recent flight, the trigger sound being "a whirring sound during the flight sequence". Finally, in the *Post-Soundscape Body Map* (2.2.8), Participant 13 reveals that they physically perceived "restlessness," with a "constricted throat" during "all flying" sounds. However, when one of these aircraft noises, "jet passing by" was played in isolation in the *Post-Exposure Spatialisation Evaluation* (2.3.4), Participant 13 perceived the "jet pass by, slow drop from top to bottom" as being the more realistic than the "jet pass by, fast drop from top to bottom". Consequently, they perceived "jet pass by, slow drop from top to bottom" as the "most unnerving", the "most frightening", and the "most panic inducing" of the two spatialisation paths assigned to the sound. Further, Participant 13 perceived the "jet pass by, fast drop from top to bottom" as being the most irritating of the two sound movements. Therefore, it can be construed that for this participant, the exaggerated panning, originally designed to heighten fear and anxiety (by accelerating the plane drop in an unnatural manner), may be too obvious when a sound is heard in isolation, drawing attention to the artificial means of production.

Another example of the efficacy of sound spatialisation being heavily dependent on the acoustic and semantic nature of the sound source, is the trend that realistic panning of footsteps elicited a fear response much more reliably than the hyperreal panning of footsteps. If a commonly heard, seemingly innocuous sound, such as pacing footsteps, is panned to symbolise a tormenting bully by circling around the listener, or resembles a creepy stalker as it approaches the listener from behind, this is unnerving even if it is just highly representative of a realistic scenario. Perhaps this sound spatialisation is made even more unnerving *because* of its realism: the sound seems real but the footsteps are disembodied, detached from a visible body, when played in the Soundlab without accompanying visuals (generating the unease evoked by the uncanny, and causing the listener to turn around to discern if it is just a recording). The realistic movement of footsteps elicits also fear *because* this sound panning accurately recreates real-life fearful situations. The "chains dropping, from floor to ceiling" may have been dismissed as the sound panning was too exaggerated, and drew too much attention to the artificial mode of soundscape production, distracting from the alarming, sudden onset of a sharp, violent clunking – the sound alone, presented in static mono without extraneous movements is acoustically frightening in and of itself.

These observations about the psychological effects of hyperreal panning of isolated sounds (compared to more realistic panning) from the *Post-Exposure Spatialisation Evaluation* (2.3.4) are also corroborated to an extent by observations recorded during the larger soundscape exposure, as seen in the *Post-Soundscape Frequency of Perceived Sensations* (2.2.2). However, there are some differences, as the complete soundscapes elicit much richer psychological insights than the short sounds heard in isolation, as they immerse the listener in a substantial fifteen minute, densely layered sound world with complex interrelations between sounds as well as engaging rhythmic and harmonic relationships. In fact, it appears that the denser the soundscape is (that is, when many sounds are playing simultaneously at any one time), the more that the recognition of sound spatialisation diminishes. The sounds in the *Violence* and *Body Anxiety* soundscape are individually panned across the ambisonic array, in the same manner as those in *Situational Phobias.* Yet there is a significantly higher incidence of reports of the spatialisation of sounds being the trigger for strong sensations in the *Post-Soundscape Frequency of Sensations* (2.2.2) following Situational Phobias (there were 28 comments on spatialisation induced anxiety), compared to *Body Anxiety,* which only inspired twelve reports of spatialisation induced anxiety, and *Violence* where only six comments on spatialisation were made post-soundscape. The *Violence* soundscape is especially dense, with many sonic themes overlaying and continuing throughout the entire thirteen minutes, and *Body Anxiety* also features periods where many disparate sounds play concurrently. Thus, it can be discerned that for the spatialisation of sounds to be influential on the listener's physical and psychological state (or at least for listeners to become consciously aware of the sound's movement), the sounds should be either sparse (up to 3 sounds playing at a time) or grouped, with aligned pans which do not cancel each other out. Further, a sensitivity to the nature of the sound source is essential: the spatialisation path should either be realistic if the aim is to emulate real world fearful situations, or sophisticatedly hyperreal to unnerve the listener, subliminally eliciting fear, but not becoming irritating or bringing the artifice of the production to the listener's attention. Overall, Hypothesis 6, "A hyperreal sound spatialisation is the more anxiety-eliciting than a realistic sound spatialisation" cannot be verified conclusively here, as it appears that it is very much context dependent – the nature of the sound dictates whether a deviation from a norm is frightening (a plane descending fast) or a realistic representation is frightening (the uncanny replication of footsteps circling the listener).

5.5 Crucial Implications from GSR data (all participants, and by group)

The measure of Galvanic Skin Response is essentially a physiological signal often attributed to perception of strong emotions (such as shock or sadness). Data is recorded by fastening two surface electrodes onto the base of the participants' fingers, which detect the minute fluctuations in sweat secretion whilst the data is captured as a stream of numbers. This data stream can be visualised as a line graph over time, with notable periods of physiological arousal indicated as peaks or troughs. Although it might be construed that the height of the peak is significant, this is not the case (for example, *Violence* elicited the tallest GSR peaks, so this might be interpreted as a sign that it is the most potent). Actually, the height of the GSR waveform is likely due to differ among participants, because the strength of the signal is reliant on the unique moisture patterns of each participant's skin. Also, slight movements of the participant's hand might make the sensor less tightly pressed against the skin, altering the electrical resistance, resulting in drifts in signal strength. It is just the peak as an event that is physiologically meaningful, an indicator of an instantaneous strong sensation induction. (As explained in 3.2.2, the recorded signals for the large-scale experiment have all been filtered through MATLAB, to identify salient peak events much more precisely than by eye alone.)

Thus, the most sensible way to interpret the GSR data is to calculate the peak rates, in peaks per minute per participant, for each soundscape. The overall peak rate is calculated by counting the total number of these peak events from all 30 participants' GSR data streams, and then dividing by the number of minutes in the soundscape, and by the number of participants. Thus, the soundscape with the highest average peaks-per-minute can be identified as the most frequent GSR activator, thus the most powerful at inducing strong sensation. This simplifies what would otherwise be a visually overwhelming 30 participant waveform overlay into a series of average numbers, presented as singular bar graph. (The implications from GSR data are analysed in greater detail in Section 6.3, as the salient moments within each of the soundscapes are pinpointed by calculating the minute-by-minute peak rates for each soundscape. In 6.3, the minute-by-minute peak rates are found by adding the total number of peaks found in each minute of a soundscape for all participants, and then dividing this figure by the number of participants. Further, clusters of individual peaks are plotted over the soundscape timeline, to identify split-second sounds which prove to be consistent anxiety triggers.) In this section, the implications from the overall GSR peak rates from all participants (for each soundscape) are assessed, in addition to differences in the overall peak rates of participants with higher pre-existing anxiety (HPE) or lower pre-existing anxiety (LPE), as well as differences in the peak rates of participants who heard each soundscape as the first, second or third in the sequence.

Overall, the *Violence* soundscape elicited the highest peak rate of 0.86 peaks/minute for the average participant, followed by *Situational Phobias* (0.73 peaks/minute for the average particpant) and *Body Anxiety* (0.69 peaks/minute for the average participant). For the participants in the HPE group, *Violence* elicited a peak rate of 0.96 peaks/minute – this figure is significantly higher than the LPE group's reaction to *Violence,* which resulted in a much lower than average peak rate of 0.71 peaks/minute/participant (hereafter abbreviated to pk/m/pt, a difference of 0.25 pk/m/pt) The peak rate induced by the *Situational Phobias* soundscape for the HPE group is 0.79 pk/m/pt, which is much higher than the LPE group's *Situational Phobias* peak rate of 0.56 peaks per minute (a difference of 0.23 pk/m/pt). However, an intriguing anomaly to this trend (the HPE's peak rates exceeding the LPE peak rates) occurs regarding the *Body Anxiety* soundscape: the HPE group's peak rate for *Body Anxiety* is 0.62 pk/m/pt, a figure that the LPE group exceeds (by 0.05 pk/m/pt) at 0.67 peaks/minute (see the green and red columns on the bottom chart in Figure 40, and compare to green and red columns in the top and middle charts). It should be noted that during the *Body Anxiety* soundscape, the participants who were predisposed to higher levels of anxiety in everyday life (the HPE group) were more receptive to the relaxing water sounds featured mid-soundscape, as shown by a significant dip in the Galvanic Skin Response activity (seen in greater detail in Section 6.2). Hence the HPE group demonstrate an average peak rate lower than the LPE group's, and lower than average peak rate for all participants. This finding deviates from the otherwise consistent trend that the participants with higher pre-existing anxiety (HPE) also have higher GSR peak rates on average than the participants with lower pre-exposure scores (LPE).

As expected, the participants' peak rates decrease as listener fatigue set in (see the grey columns to the right-hand side of the charts in Figure 40). The ten participants who heard *Violence* first in the sequence of soundscapes had a higher than average peak rate of 0.95 pk/m/pt (0.09 higher than the all participant average), whereas those who heard it second had a slightly lower than average rate of 0.83 pk/m/pt (0.03 lower than the all participant average), and those who heard it last demonstrate an even lower average peak rate of 0.80 pk/m/pt (0.06 lower than the all participant average). For the participants who heard *Situational Phobias*, the effects of listener fatigue are even more pronounced: for participant who heard *Phobias* first, the average peak rate was 0.94 pk/m/pt (0.21 higher than the overall average), whereas those who heard it second had a much lower peak rate of 0.65 pk/m/pt (0.08 lower than the all participant average), and those who heard *Phobias* last in the sequence had an even lower peak rate of 0.61 pk/m/pt (0.12 lower than the all participant average). Similarly, the participants who heard *Body Anxiety* first had a much higher peak rate of 0.87 peaks/minute (0.18 higher than the average for all participants), and those who heard it second had an average peak rate of 0.58 (0.11 lower than the all participant average), and those who heard it third a peak rate of 0.59 (0.10 lower than the all participant average). Therefore, using the GSR signal alone, the consistent dampening of physiological response after the first soundscape can be confirmed much more definitively in the large-scale experiment than could previously be observed in the pilot experiment, as here there are ten participants who have experienced each soundscape permutation and thus peak rates can be averaged - so results are more consistent.

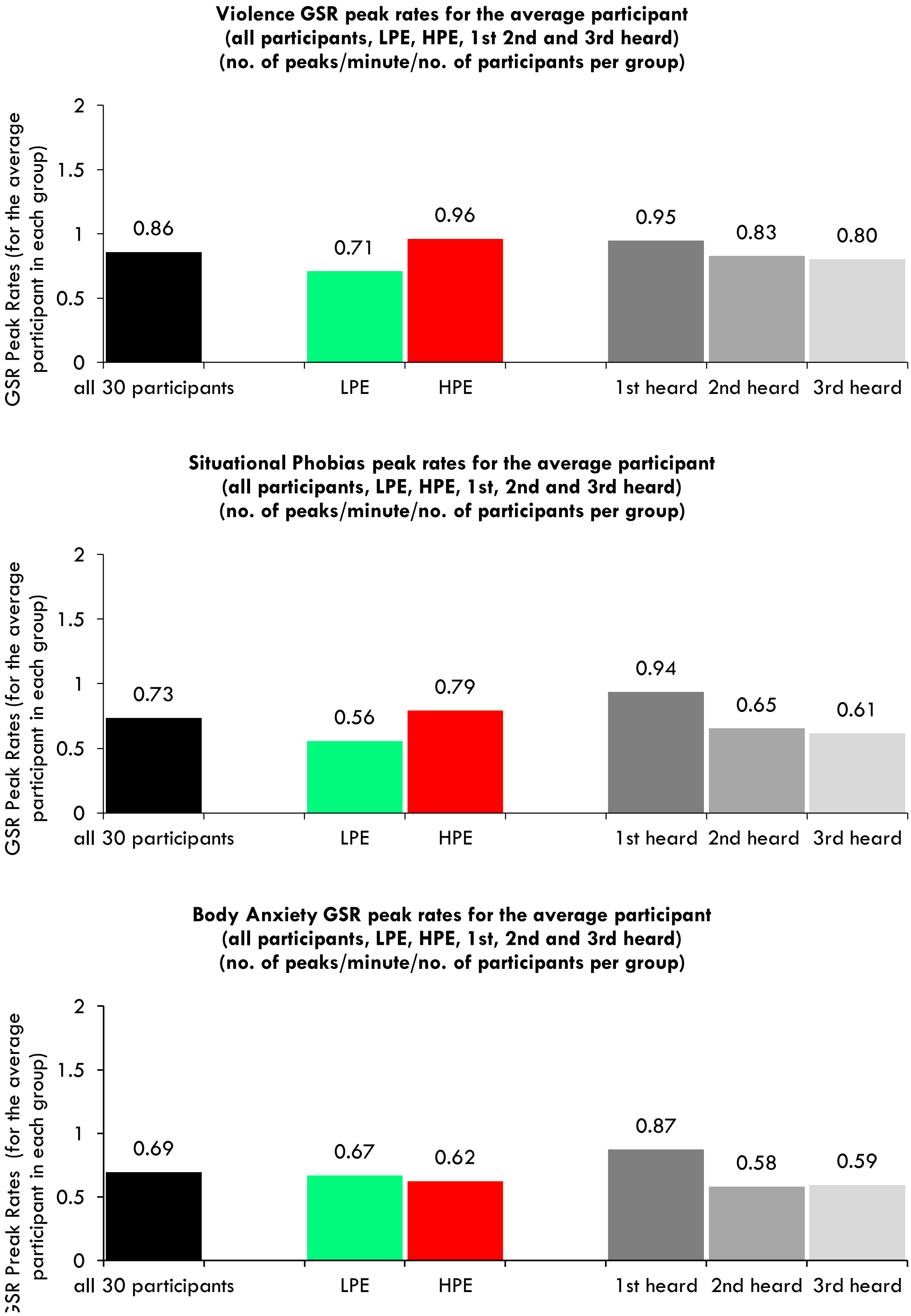


Figure 40: Average GSR Peak Rates during each soundscape (all participants, LPE and HPE groups, and 1st, 2nd and 3rd heard groups).

Thus, Hypothesis 7 is largely verified, that participants with higher-pre-existing anxiety generate a higher GSR peak rate than participants with lower pre-existing anxiety in response to anxiety-inducing sounds - except for an intriguing anomaly during the *Body Anxiety* soundscape. As imagined in Hypothesis 8, when a soundscape is heard as the first in sequence, the GSR peak rate is higher than when the soundscape is heard as the second or third in the sequence – indicative of time-induced listener fatigue.

5.6 Increased efficacy of trigger sounds if matched to pre-existing anxieties, or if they surprise the listener (by participant groups)

For visual Virtual Reality exposure therapy, the consensus is that the closer a simulation is to a user's previous experiences, the more vivid the re-experience and thus the more effective the treatment will be (Goncalves et al 2012). For example, if a traumatised soldier is undergoing VR exposure therapy, the simulation will be designed precisely to match their description, and if it is inaccurate then it is less likely to be effective. However, this is not likely to be the case with sound, as there is a multitude of sounds which are not necessarily present in participants' personal histories that nevertheless induce fright, disgust or other strong emotions nearly universally, due to humans' innate emotional responses to abrasive acoustic properties. It will greatly inform the therapists who might use soundscape exposure therapy in practice, if this study can confirm whether the most notable anxiety trigger-elicitation-moments occur when a sound personally resonates with an individual's life experience. A way of honing in on the key sounds that we assume would cause the most anxiety, is to establish the most commonly cited everyday anxiety triggers in the *Pre-Exposure Trigger Diagnosis* (1.2), and the *Pre-Exposure Intensity of Perceived Sensations* (1.1.3*)*. These could be interpreted as the sounds that most frequently trigger anxiety in daily life, or sounds that the participant finds unpleasant to listen to – which, in turn, would negatively affect their mood through cognitive recognition and evaluation of the source. Each participant's individual pre-exposure diagnosed sound triggers (from questionnaire 1.2) are compared with the sounds identified as triggers of strong sensation post-soundscape, as recorded in the *Post-Soundscape Frequency of Perceived Sensations* (2.2.2), to assess whether participants correctly predicted the sounds which they would find the most anxiety eliciting in the soundscape exposure.

Then conclusions can be made by spotlighting several individual instances of correlation between the anxiety trigger sounds identified in the *Pre-Exposure Trigger Diagnosis* (1.2) and those reported *Post-Soundscape Frequency of Perceived Sensations* (2.2.2): the instances when participants had noted one sound as an anxiety trigger in the *Pre-Exposure* questionnaire 1.2 , and then also noted a sensation elicitation to that same sound in the *Post-Soundscape* questionnaire 2.2.2. In this scenario, you could say that this part of the soundscape was tailored to the participant's idiosyncratic anxiety, which the participant recognised and thus an affect was triggered cognitively; if the GSR peak coincides with the moment that predicted trigger sound was playing, then there is also evidence of a physical affect being triggered. A group of participants who have a pre-exposure to post-soundscape sound *match* can be identified (from questionnaire 1.2 to questionnaire 2.2.2), in addition to a group of people whose anxiety triggers are *mismatched* between the pre-exposure and post-soundscape questionnaires. Another group of participants have only identified a sound as an anxiety trigger post-soundscape, which comes as a *surprise* (prior to the soundscape exposure, they were unaware that it was a personal anxiety trigger).

Primarily, it is crucial to discover if there are more participants are in the *matched anxiety-elicitation* group than the *surprise anxiety-elicitation* group, as this better informs the soundscape designer as to how the soundscapes should be constructed for maximum efficacy (whether they should be tailored to the individual's pre-existing anxiety, or filled with unfamiliar sounds). As it turns out, for the *Violence* soundscape there were 32 instances of a match between pre-exposure to post-soundscape anxiety trigger sounds, but 57 instances where participants were completely surprised by an anxiety trigger, post-soundscape. For *Situational Phobias*, there were 21 exact sound trigger matches from pre-exposure to post-soundscape, but 60 reports of surprise trigger sounds only reported post-soundscape. For *Body Anxiety*, there were 31 matched pre-exposure to post-soundscape trigger sounds, but 52 surprise trigger sounds, only reported in the *Post-Soundscape Frequency of Perceived Sensations* (2.2.2). So, overall, there are more instances where participants were surprised by newly discovered anxiety-eliciting sounds in the experiment, than instances where participants experienced moments of personal resonance with the sounds.

Secondly, the strength of the *matched anxiety-elicitation* group's GSR average peak rate for each soundscape is compared to the *surprise anxiety-elicitation* group's GSR average peak rate for each soundscape (pk/m/pt). If the *matched anxiety-elicitation* group have higher sensation scores (the rating of sensations and emotions collated from the *Post-Soundscape Frequency of Perceived Sensations*, questionnaire 2.2.2) for each trigger sound, and a greater GSR peak-per-minute average than the *surprise-anxiety-elicitation* group, it can be concluded that yes, tailoring the soundscapes to individual anxieties heightens sensation induction, per both the written reflection and physiological response data. Thus, it will be discerned whether the predicted anxiety triggers (identified both pre-exposure and post-soundscape) were also the ones that were most consistently inducing anxiety during soundscape exposure.

5.6.1 Comparison between the *matched-anxiety-elicitation* groups' and the *surprise-anxiety-elicitation* groups' sensation scores

First it is relatively straightforward to present the average sensation scores from the two groups of participants in Figure 41. The sensation score for the *matched anxiety-elicitation* group is presented as solid red (participants with an anxiety trigger sound reported in the *Post-Soundscape Frequency of Perceived Sensations*, questionnaire 2.2.2 which matches a previously-identified sound in the *Pre-Exposure Trigger Diagnosis*, questionnaire 1.2). The sensation score for the *surprise-anxiety-elicitation* group is shown as a white column with a red outline (those who were totally surprised have strong sensations triggered by a sound, only reported post-soundscape, in questionnaire 2.2.2). When the scores for all sensations, from each of sound categories within a soundscape are averaged together, the difference between the two groups' written sensation scores is very slight, but consistent. It appears that the *matched-anxiety-elicitation* group rate the frequency of perceived sensations marginally higher, with an average score for the *Violence* soundscape of 0.662 out of a possible three points, compared to the surprise-anxiety-elicitation group's average score for *Violence* being 0.591 (a difference of 0.071). For *Situational Phobias* the difference in average scores is even narrower (a difference of 0.012), with an average sensation score of 0.570 for the *matched-anxiety-elicitation* group, and a score of 0.558 for the *surprise-anxiety-elicitation* group. Again, in response to the Body Anxiety soundscape, the *matched-anxiety-elicitation* group reported slightly a higher sensation score on average, 0.552, than the *surprise-anxiety-elicitation* group, which averaged at 0.509 (a difference of 0.043).

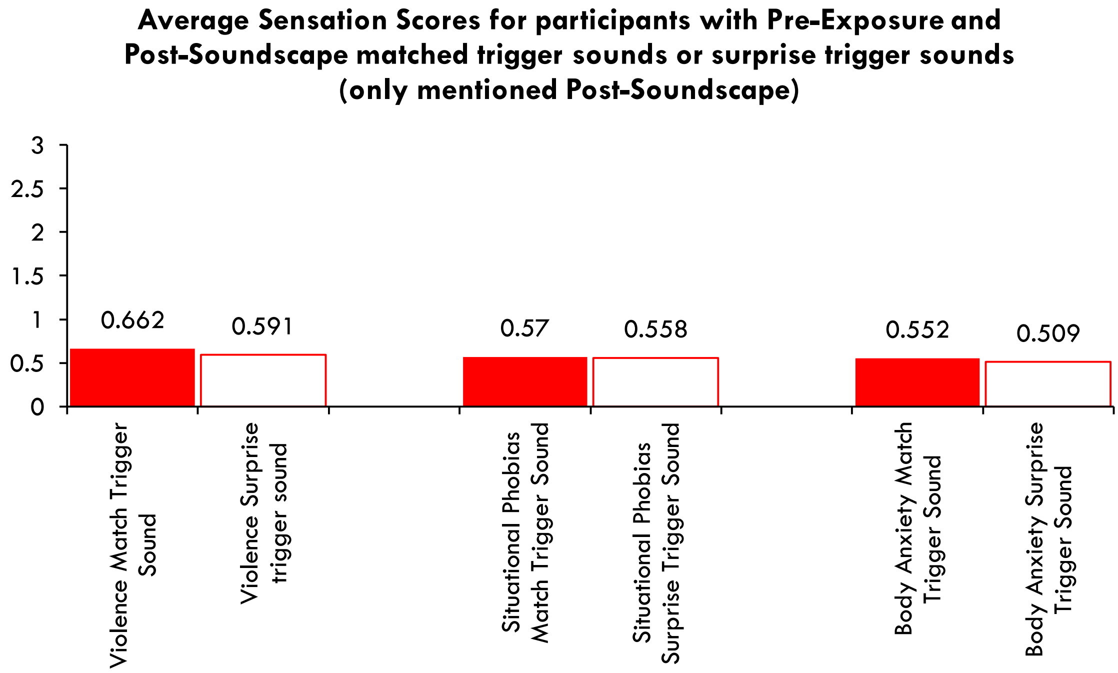
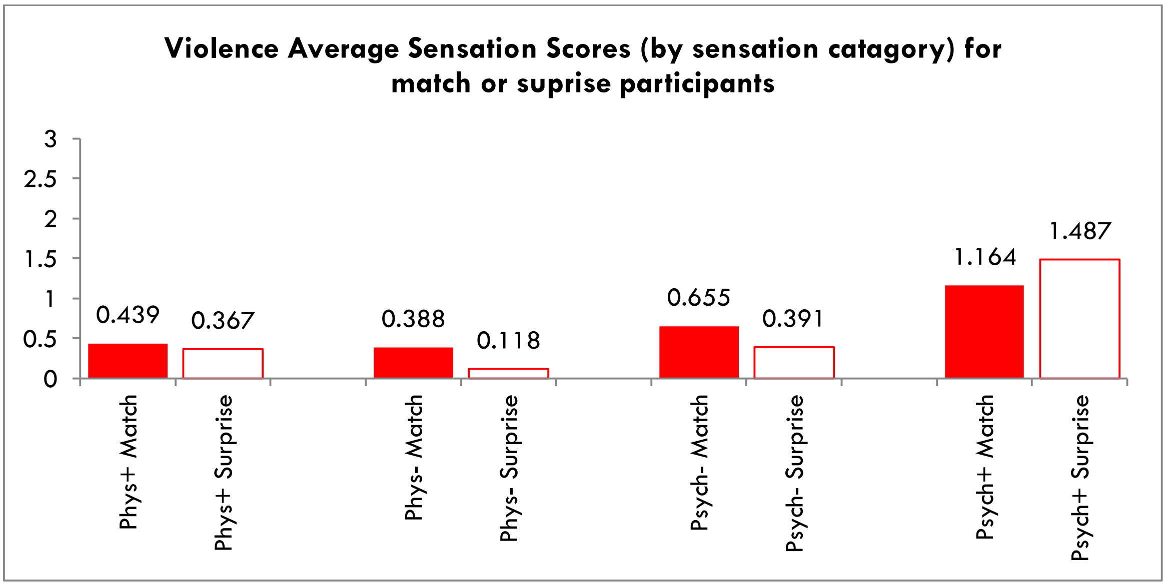
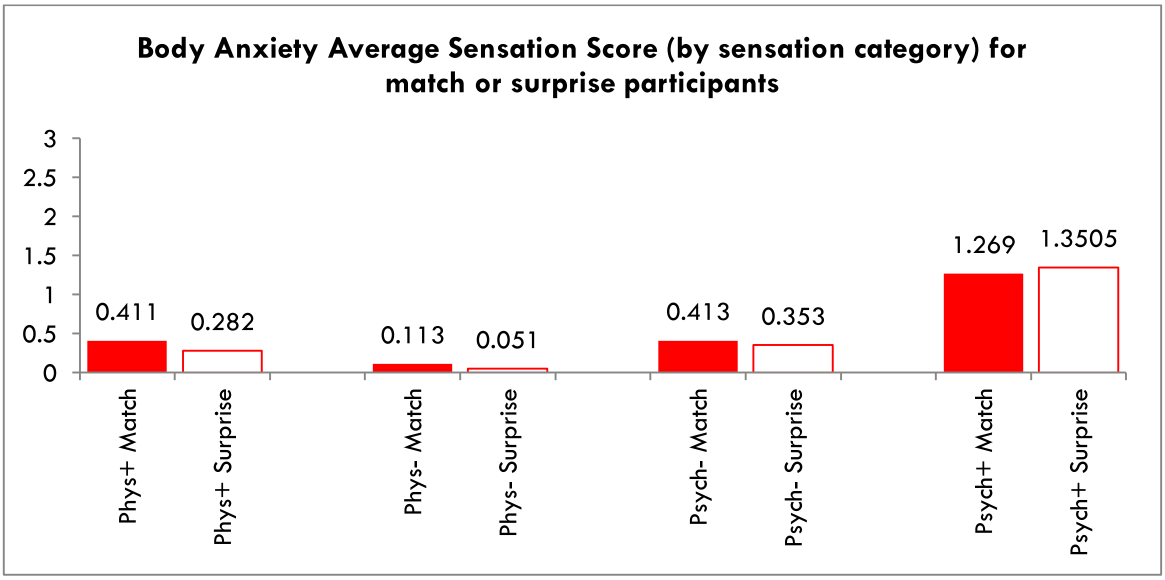


Figure 41: Average sensation score (as reported in questionnaire 2.2.2) for *matched-anxiety-elicitation* groups and *surprise-anxiety- elicitation* groups, for each soundscape

As the *matched-anxiety-elicitation* and the *surprise-anxiety-elicitation* groups were sorted by trigger sound categories, and indeed sensations were scored by distinct physical or psychological positive and negative categories, the average scores for each soundscape above obscure some of the more revealing insights. See, for instance the pattern that the *surprise-anxiety-elicitation* groups consistently reported higher ratings of psychological positive sensations than the *match-anxiety-elicitation* groups reflecting on the *Violence* and *Body Anxiety* soundscapes as demonstrated by the column pairs at the far right of the first two charts in Figure 42, but consistently lower scores for the physical positive, physical negative and psychological negative sensations (although this does not apply to the *Situational Phobias* score).





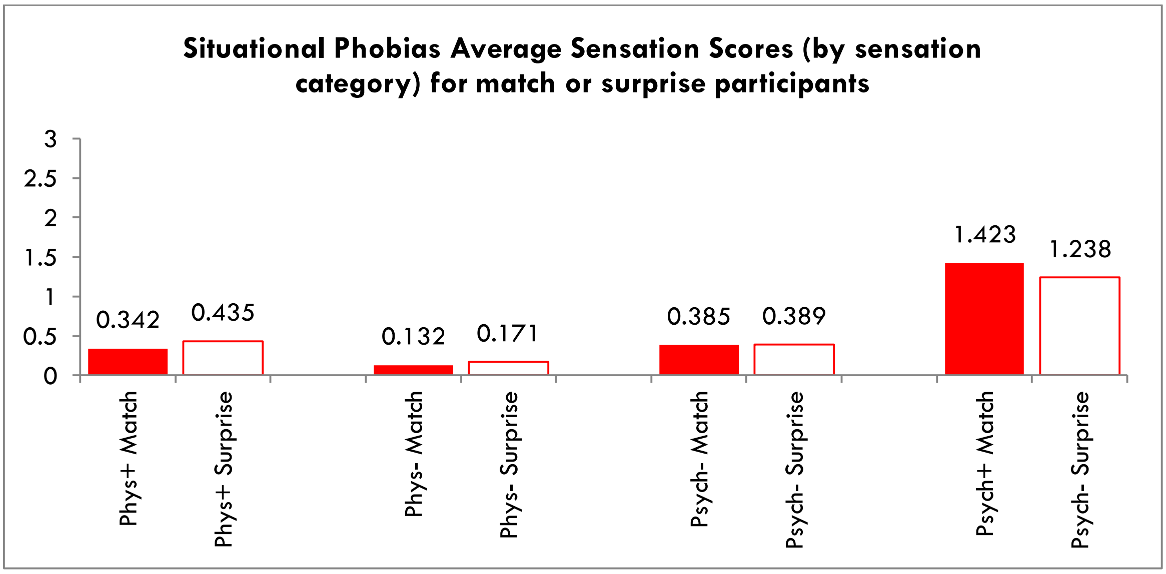


Figure 42: Average sensation score (as reported in questionnaire 2.2.2) for *matched-anxiety-elicitation* groups and *surprise-anxiety-elicitation* groups (by sensation category)

5.6.2 Comparison of the matched-anxiety-elicitation, mismatched-anxiety-elicitation and the surprise-anxiety-elicitation group's GSR peak rates

Next, the differences in physiological response between the two groups are evaluated. The GSR peak rates for *surprise-anxiety-elicitation* groups (the participants who were surprised to be made anxious by a particular soundscape, as they had not identified any of the featured sounds as a personal trigger in the *Pre-Exposure Trigger Diagnosis*, questionnaire 1.2) and the GSR peak rates for the *matched-anxiety-elicitation* groups (who generally expected to be made anxious by a soundscape, as indicated by one or more pre-exposure trigger identifications) are compared here. Initially, for a surface overview of the difference in GSR peak rates, participants have been sorted into groups of those who, in the *Pre-Exposure Trigger Diagnosis* (1.2), diagnosed themselves as body anxious, phobic or scared of violence (fears which directly map onto the soundscapes *Body Anxiety*, *Situational Phobias*, and *Violence*). The GSR average peak rates for participants who expected to become anxious upon hearing a soundscape, according to their *Pre-Exposure Trigger Diagnosis* (1.2) are compared to the peak rates for participants who had not previously reported any triggers from the soundscape pre-exposure, but had reported sounds featured in a soundscape as a trigger for a strong sensation in the *Post-Soundscape Frequency of Perceived Sensations* (2.2.2).

As seen in Figure 43 there are notably higher GSR peak rates for the *surprise-anxiety-elicitation* group in response to both the *Violence* soundscape (red columns) and the *Situational Phobias* soundscape (green columns)- the participants who had not previously disclosed an aversion to any of the sounds featured in these soundscapes. The participants surprised by *Violence* generated an average peak rate of 0.97 pk/m/pt, compared to those who had already listed sounds featured in *Violence* in their *Pre-Exposure Trigger Diagnosis* (1.2) who only generated an average peak rate of 0.77 pk/m/pt (a significant difference of 0.20 pk/m/pt). For *Situational Phobias*, the surprised participants peak rate is 0.17 pk/m/pt higher than those who listed known anxiety trigger sounds in this soundscape previously (the *surprise-anxiety-elicitation* group's GSR peak rate is 0.86 pk/m/pt, compared to the *match-anxiety-elicitation* group's peak rate of 0.69 pk/m/pt). However, the difference in peak rate between participants who predicted an aversion to the *Body Anxiety* soundscape and those who were surprised by its potency was minimal (only 0.01 pk/m/pt), as the *Body Anxiety matched-anxiety-elicitation* group's GSR peak rate is 0.70 pk/m/pt, compared to the *surprise-anxiety-elicitation* group's peak rate of 0.69 pk/m/pt.

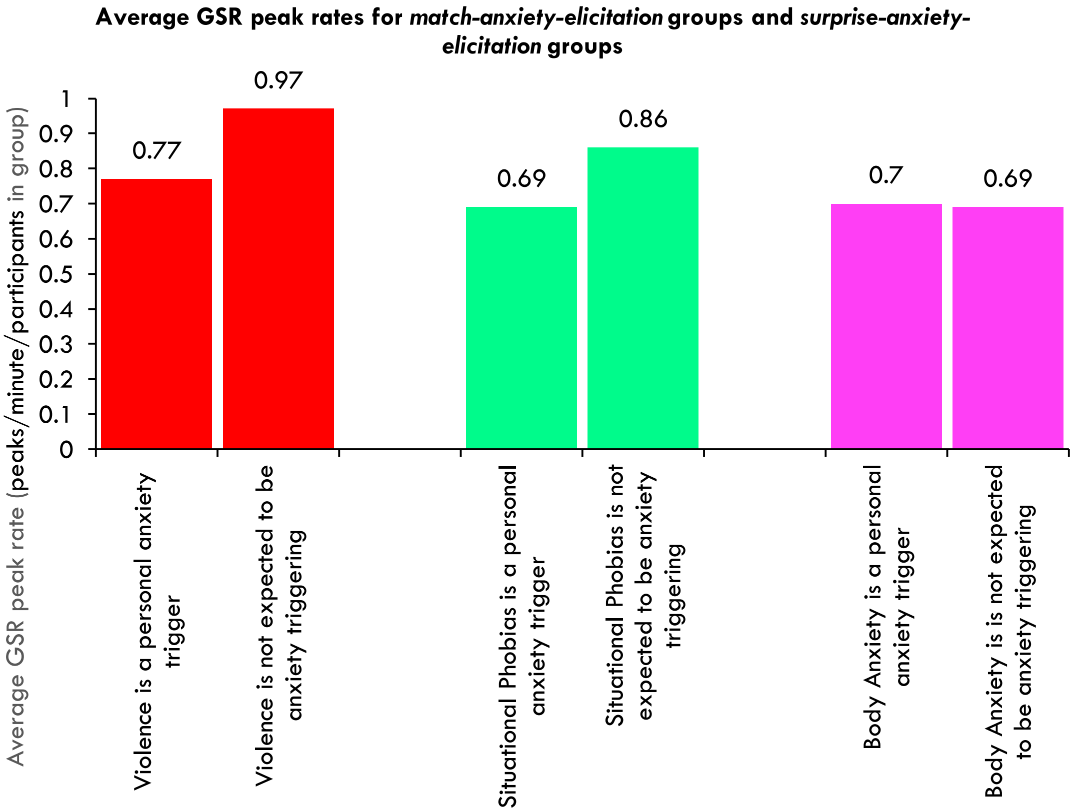


Figure 43: A surface overview of the heightened average GSR peak rates elicited by participants who were surprised to be affected by *Violence* or *Situational Phobias*

For a more sensitive analysis of the data, there are two complex interpretations of the GSR peak rates, to discover whether or not physiological response is notably amplified in participants whose soundscape exposure is tailored to their pre-existing anxieties (as the soundscape features sounds already known to the participant as anxiety-eliciting), compared to the physiological response of participants who are surprised to be made anxious by sounds featured in the soundscape exposure, which do not resonate with their personal histories. One approach looks at global differences covered later in Section 6.9, as the GSR peak rates for the whole participant group, during periods of a soundscape which was commonly expected to be anxiety-eliciting (as indicated by many reports of the soundscape's featured triggers in the *Pre-Exposure Trigger Diagnosis* (1.2)), are compared to the GSR peak rates of all participants during a period of a soundscape which was not expected to be anxiety-eliciting (as there were no reports of the sounds featured at that time in questionnaire 1.2). The method outlined in this section below is more sensitive though, as the GSR peak rates are compared between three types of participant groups: the *matched-anxiety-elicitation* group, the *mismatched-anxiety-elicitation* group and the *surprise-anxiety-elicitation* group. As at the beginning of 5.6, the *matched-anxiety-*

elicitation group are those participants whose sounds identified in the *Pre-Exposure Trigger Diagnosis* (1.2) matched the sounds they later reported as a sensation trigger in the *Post-Soundscape Frequency of Perceived Sensations* (2.2.2) and the *surprise-anxiety-elicitation* group are those who had surprise trigger sounds, which were only reported in the *Post-Soundscape Frequency of Perceived Sensations* (2.2.2). The *mismatched-anxiety-elicitation* group identified one sound from a category in the *Pre-Exposure Trigger Diagnosis* (1.2) but a different sound from the same category as a sensation trigger in the *Post-Soundscape Frequency of Perceived Sensations* (2.2.2). For ease of comprehension, the more precise and sensitive method will be focused on here in the primary results, and the global method will be looked at in the secondary results.

All 30 of the *Pre-Exposure Trigger Diagnoses (*1.2) have been collated, into more easily navigable data plots. Initially, the blank *Pre-Exposure Trigger Diagnosis (*1.2) format is used as a template, so that each theme of anxiety (*Anxiety Triggers, Violence, Phobias, Body, People, Sensory Irritation, Acoustic Qualities*) is assigned one page. Within each anxiety theme there are six categories, each with a few examples offered for participants to circle and three blank lines per subcategory for participants to identify their own sounds. For this collated data plot, if Participant 1 noted "barking dogs" in the *Animals* category of *Violence,* then this would be listed in the *Animals* cluster as "1. Barking dogs". Thus, a more streamlined database has been generated from the entire filing cabinet of questionnaires, mostly for the principal researcher to navigate.

Each participant is allocated a number (Participant 1, Participant 2…). All of the sound triggers identified in the *Pre-Exposure Trigger Diagnosis* (1.2) are written in black, whereas the sounds reported as triggers of strong sensation in the *Pre-Exposure Trigger Diagnosis* (1.2) are written in red. Participants are split into groups as follows:

- Participants who identified a sound as anxiety eliciting pre-exposure and subsequently reported exactly the same sound as triggering a strong sensation post-soundscape again have both a black and a red entry on their numbered line, and are coded by a solid circle which is half red and half black (these participants belong to the *matched-anxiety-elicitation* group).
- Participants who have identified one sound from a particular category pre-exposure (e.g. dripping tap), but a different sound from that category post-soundscape (e.g. waterfall) have both a black and a red entry, but are coded with a hollow red and

black circle outline (these participants belong to the *mismatched-anxiety-elicitation* group).

- Participants who had only reported sounds from a particular category as anxiety-eliciting post-soundscape will only have an entry written in red (they are part of the *surprise-anxiety-elicitation* group).
- There are also participants who identified a sound as anxiety eliciting pre-exposure, but did not report it as a trigger of strong sensation post-soundscape, who only have an entry written in black. Their data was not grouped for analysis, as the sound was unlikely to have triggered notable GSR peaks if the participant did not recall the sound as triggering strong sensations.

At a glance of each page, it is also easy to predict which category of sound within each soundscape should be the most anxiety inducing, and by comparing each page side-by-side it is also visible which soundscape on the whole should be the most anxiety inducing, by comparing the coverage of the page in text. For each category in every soundscape featured in the large-scale experiment (*Violence*, *Body Anxiety* and *Situational Phobias*), there are three groups of participants, the *surprise-anxiety-elicitation*, *mismatched-anxiety-elicitation* and *matched-anxiety-elicitation* groups, whose average peak rates (in units of peaks/minute for the average participant) are compared for the four to five minutes that each sound category is playing. So, it can be discerned whether the participants in the *matched-anxiety-elicitation* or *mismatched-anxiety-elicitation* groups had higher GSR peak rates than the *surprise-anxiety-elicitation group*, for each category of every soundscape.

Comparisons between the *matched-anxiety-elicitation*, *mismatched-anxiety-elicitation* and *surprise-anxiety-elicitation* groups' GSR peak rates are first evaluated at the specific level of minute-by-minute, which is ideal seeing as the trigger sounds are often only playing for a short section of the soundscape. The total number of GSR peaks for a group is tallied in each minute, then these figures are divided by the number of participants in the group, to generate a high-resolution minute-by-minute peak rate. For the flying section in the *Situational Phobias* soundscape, it is evident that the participants who had previously identified a fear of flying (both the *matched-anxiety-elicitation* group and the *mismatched-anxiety-elicitation* group) nearly exclusively had the highest GSR peak rates whereas the *surprise-anxiety-elicitation* group for the flying sounds only had the highest GSR peak rate in the 18th minute of the soundscape when alarm bells are also added to the sound mix (see the column triplets on the right of Figure 44). Furthermore, the *surprise-anxiety-elicitation* group's GSR peak rate was only marginally higher than the *matched-anxiety-elicitation* group's peak rate in the 18th minute, by 0.05 pk/m/pt (with the surprise group's peak rate at 1.05 pk/m/pt compared to the matched group's peak rate of 1.00 peaks/minute to participant).

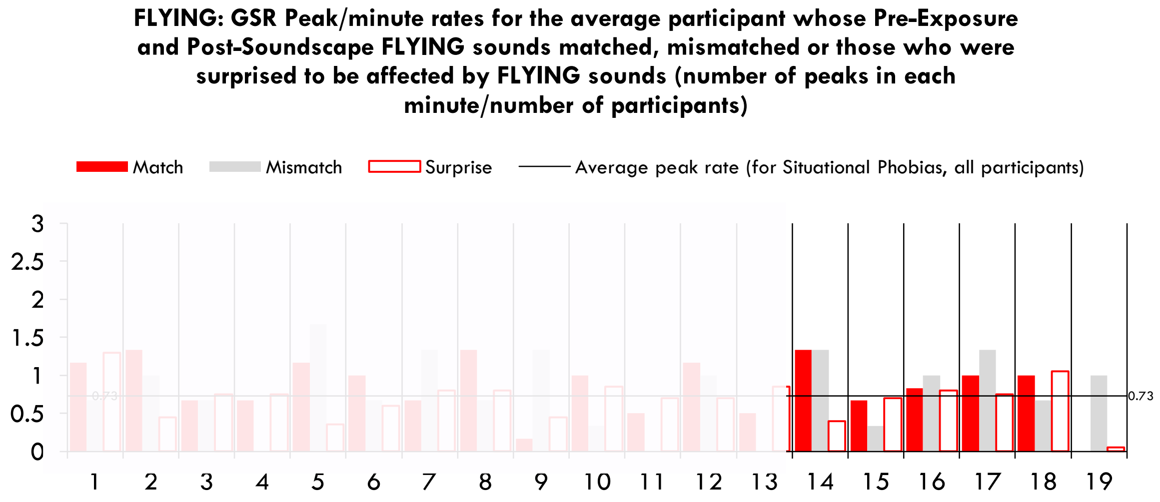


Figure 44: Minute-by-minute peak rates for the *matched-anxiety-elicitation* group, the *mismatched-anxiety-elicitation* group and the *surprise-anxiety-elicitation* group, for flying sounds

Crucially, an average peak rate for an entire soundscape (for each of the surprise, mismatch and match groups) can be also be calculated as follows: to find the average peak rate of the matched trigger group for *Body Anxiety*, for example, average peak rates for the Breath, Visceral, Water, Eating, Exercise and Hospital categories are added together and then divided by the number of categories, six. For *Body Anxiety* it seems that if the strong sensations were induced by a surprising trigger (only reported in the *Post-Soundscape Frequency of Perceived Sensations*, questionnaire 2.2.2) participants would generally demonstrate a higher GSR peak rate (0.667 peaks/minute/person), than the participants whose Pre-Exposure and Post-Soundscape trigger sounds were a match (0.48 peaks/minute per person) and those whose pre-exposure and post-soundscape triggers did not match (0.421) (see the column triplet on the right of Figure 45).

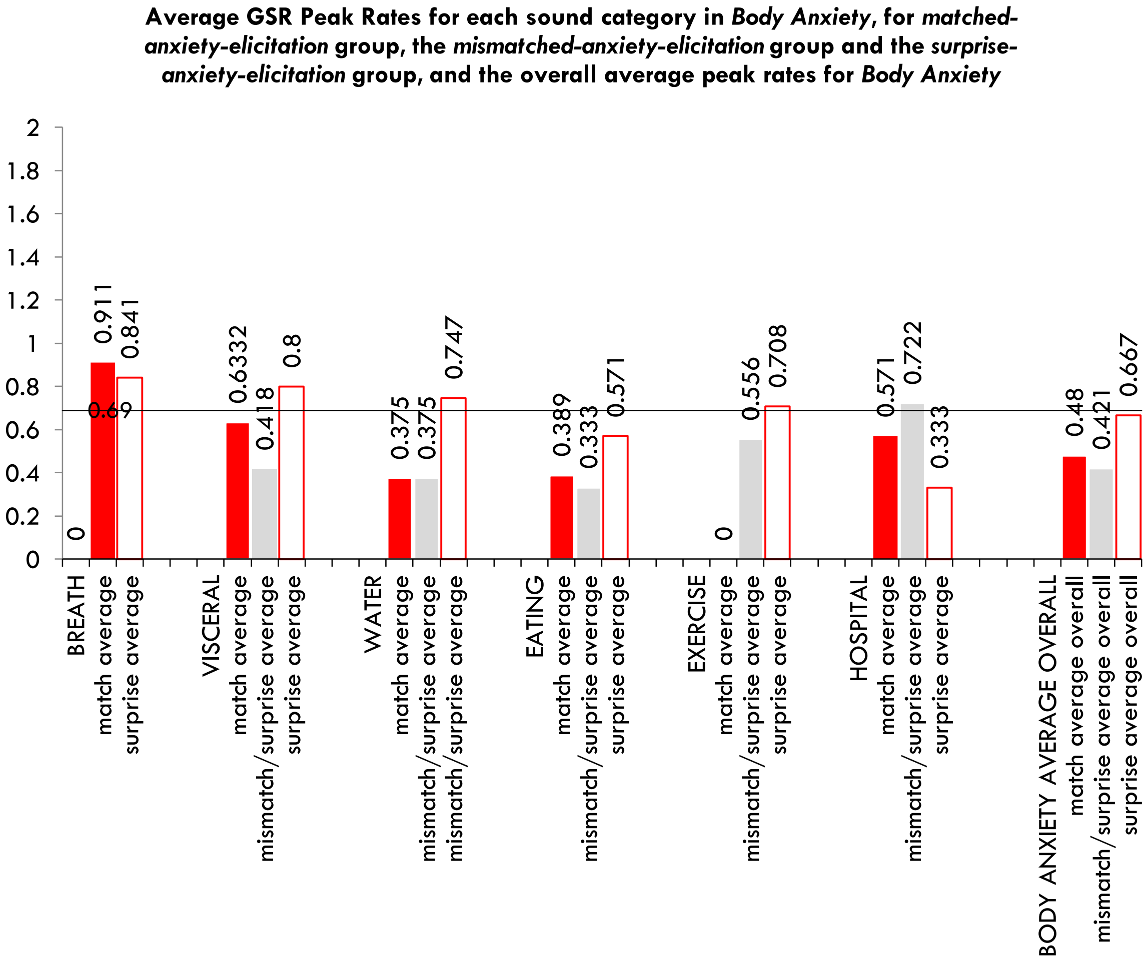


Figure 45: Calculation of the overall average GSR peak rates for *Body Anxiety* (right), for *matched-anxiety-elicitation* group, the *mismatched-anxiety-elicitation* group and the *surprise-anxiety-elicitation* group.

Overall, it can be discerned that for the most part, there was a marginal increase in GSR activity, thus an indication of more instances of unconscious strong sensation, when participants were surprised to be affected by sounds that had not previously caused anxiety in everyday life (the *surprise-anxiety-elicitation* group of participants who identified a sound as a sensation trigger in the *Post-Soundscape Frequency of Perceived Sensations* (2.2.2), but did not identify that sound as a trigger of anxiety in the *Pre-Exposure Trigger Diagnosis* (1.2)). It has been calculated that for the *Violence* soundscape, the *matched-anxiety-elicitation* group demonstrate a higher number of GSR peaks than the *surprise-anxiety-elicitation* group. On the other hand, the *Situational Phobias* and *Body Anxiety* soundscapes both elicited a higher GSR peak rate on average for the *surprise-anxiety-elicitation* group than the GSR peak rate for the *matched-anxiety-elicitation* group. So, for two out of three soundscapes (*Situational Phobias* and *Body Anxiety*) the highest GSR peak rates were generated by *surprise-anxiety-elicitation* group. However, for *Violence*, the matched-anxiety-elicitation group showed the highest GSR peak rates.

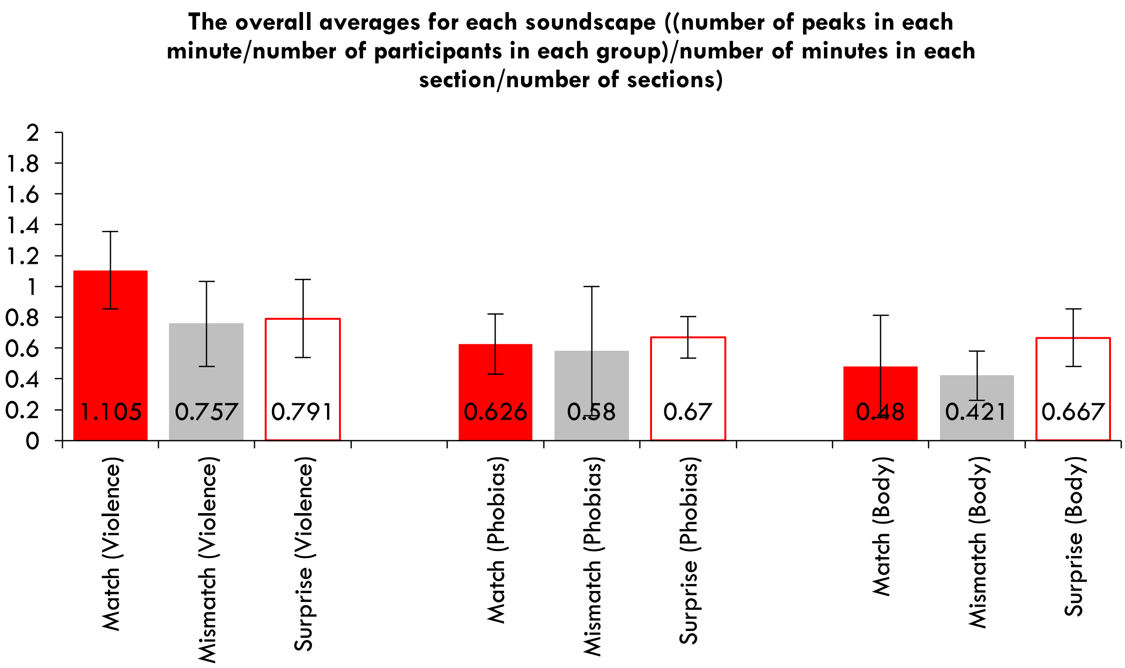


Figure 46: The *surprise-anxiety-elicitation* group have a higher average GSR peak rate than the *matched-anxiety-elicitation* groups for the *Situational Phobias* and *Body Anxiety* soundscape, but the opposite is true for *Violence*.

Keeping the average peak rates for each soundscape separate, it is apparent that for the *Violence* soundscape, the *matched-anxiety-elicitation* group had a much higher GSR peak rate overall than the *surprise-anxiety-elicitation* group and the *mismatched-anxiety-elicitation* group: the *matched-anxiety-elicitation* group's GSR average peak rate is 1.105 pk/m/pt, compared to 0.791 for the *surprise-anxiety-elicitation* group and 0.757 for the *mismatched-anxiety-elicitation* group (a difference of 0.314 or 0.348) (see Figure 46). For *Situational Phobias* and *Body Anxiety,* it was the *surprise-anxiety-elicitation* group who had the highest GSR peak rate. The starkest difference is found in response to *Body Anxiety*, as the *surprise-anxiety-elicitation* group's average peak rate was 0.667 pk/m/pt, compared to the *matched-anxiety-elicitation* group's rate of 0.480, and the *mismatched-anxiety-elicitation* group's rate 0.421 (a difference of 0.187 or 0.246). The difference between *surprise-anxiety-elicitation*, *matched-anxiety-elicitation* and *mismatched-anxiety-elicitation* groups' GSR peak rates is subtler for the *Situational Phobias* soundscape, with a rate of 0.670 pk/m/pt for the *surprise-anxiety* participants, and 0.626 pk/m/pt for *matched-anxiety* participants, and 0.580 pk/m/pt for *mismatched-anxiety* participants (a difference of 0.044 or 0.090). For *Phobias*, the difference in average GSR peak rates for matched and surprise participants is less significant, but for *Body Anxiety* the difference is valid. So, in two out of three soundscapes it was the participants who had strong sensations triggered by surprising sounds who had the highest GSR peak rates, and in only one out of three soundscapes (*Violence*) it was the participants whose post-soundscape triggers matched their pre-existing anxieties who had the highest peak rates.

The *Violence* soundscape is also the one to elicit the largest difference in physiological response between the groups (the difference was 0.348 for *Violence*, compared to 0.246 for *Body Anxiety*, and 0.090 for *Situational Phobias*). One possible reason for the *Violence* soundscape's *matched-anxiety-elicitation* group having the highest GSR peak rate compared to the *mismatched-anxiety-elicitation* groups and *surprise-anxiety-elicitation* groups, might be that there are many conventional, expected unpleasant sounds in this soundscape, so there may have been more participants who had identified sounds associated with *Violence* as a source of anxiety in the *Pre-Exposure Trigger Diagnosis* (1.2). The *Violence* soundscape includes sounds which are widely recognised as fear-inducing, so many more came to mind when participants completed the *Pre-Exposure Trigger Diagnosis* (1.2), whereas many everyday sounds featured in *Situational Phobias* and *Body Anxiety* were not identified as anxiety inducing pre-exposure. Thus, there were more participants who encountered surprising anxiety triggers in the *surprise-anxiety-elicitation* groups for the *Situational Phobias* and *Body Anxiety* soundscapes, and more participants in the *matched-anxiety-elicitation* group for the *Violence* so this might skew the averages slightly. However, this does not account for the greater triggering of physiological peaks, as the results were averaged and the number of matched participants was considered. (It should be noted that the participants with *mismatched-anxiety-elicitation* groups had the lowest GSR peak rates on average.)

So, for two out of three soundscapes the *surprise-anxiety-elicitation* groups demonstrate highest GSR peaks rates on average, compared to the *match-anxiety-elicitation* groups. Whilst this statement is as close to a comprehensive answer to the research question of whether a soundscape tailored to personal anxieties is more anxiety-eliciting than one which is not personalised, this method is quite opaque. Nonetheless, it is insightful to discern if a generic soundscape (using a broad cross-section of sounds across an anxiety theme) works for everyone, or to confirm that it is it crucial that the soundscape comprises of the participant's specific sounds to effectively elicit anxiety, as the results will have direct implications on the design of the soundscape exposure to be implemented in anxiety therapy. The use of “off-the-shelf” soundscapes can be justified as there are a significant number of participants who still identify sounds as anxiety-triggering in the *Post-Soundscape Frequency of Perceived Sensations* (2.2), even if they had not previously identified the sounds in the *Pre-Exposure Trigger Diagnosis* (1.2), such as the *Fire* or *Flying* categories in *Situational Phobias*, see 6.9).

However, given that the *matched-anxiety-elicitation* group of participants, who identified the same sound as anxiety-eliciting in both the pre-exposure and post-soundscape questionnaires generated a much higher GSR peaks-per-minute the *surprise-anxiety-elicitation* for the *Violence* soundscape, then it would appear that the argument for tailoring the soundscape to the individual is also strong one. Further expanding on the unconscious physiological data (GSR) is the consciously evaluated data (questionnaires): the *matched-anxiety-elicitation* participants consistently gave higher sensation ratings when averaged overall, compared to the *surprise anxiety-elicitation* group for every soundscape, as recorded in the *Post-Soundscape Frequency of Perceived Sensations* (2.2.2). The only exceptions to this rule appear when the average scores for each of the different types of sensation are kept separate (as physical positive, physical negative, psychological negative or psychological positive sensations), as it appears that the *surprise-anxiety-elicitation* group consistently reported higher frequency of psychological positive sensations for the *Violence* and *Body Anxiety* soundscapes, although opposite is true for the *Situational Phobias* soundscape.

One limitation with this method of comparing responses from *matched-anxiety-elicitation* groups, *mismatched-anxiety-elicitation* groups and *surprise-anxiety-elicitation* groups, is a question of how reliably personal trigger sounds are being recalled by participants in the *Pre-Exposure Trigger Diagnosis* (1.2). The triggers being identified might be dependent, to an extent, on which sounds the participants happen to recollect in advance –sounds that are quite unusual or that participants do not hear very often (such as fire sounds or jungle insects) might not be at the forefront of participants’ minds, in terms of sounds that upset them. The format of the *Pre-Exposure Trigger Diagnosis* (1.2) is specially designed to aid the participant, by offering three examples of sounds featured in each sound category (for every soundscape), so minimal prompting should help to remind participants of the slightly more obscure sounds. Nevertheless, there might be a bias, as participants are likely to be more familiar with their unpleasant reactions to some of the *Violence* sounds, from horror film, television and video games, whereas the *Situational Phobias* and *Body Anxiety* sounds might be less commonly heard and less thought of as frightening.

This subject needs further investigation, as the data cannot be massaged to show a particularly clear conclusion as to whether there is a significant benefit to tailoring the soundscape to individual anxieties. What the data does show however, is that when constructing soundscapes for people with known triggers, there is a high chance that when a soundscape is played that includes a wide range of triggering sounds, there will likely be many that were not known about in advance, which nonetheless trigger a response. This is due to vestigial fear associations with acoustically abrasive, fearful or cry-mimicking sounds, which can universally trigger fear in humans, as our ancestors were heavily dependent on the fight-or-flight response to auditory stimuli to survive. The only logical conclusion to be drawn from this section, is that even if sounds have not been previously identified as anxiety triggering for a participant, they are still likely to cause a response. This is helpful for therapists and sound designers creating bespoke, custom soundscapes for exposure therapy – the sounds that have been frequently reported as an anxiety trigger in *the Post-Soundscape Frequency of Perceived Sensations* (2.2.2, see the conclusive database of sensation triggering sounds in Section 6.5) are very likely to elicit strong sensations in a prospective listener, even if these sounds are not actually identified as a personal anxiety trigger. Neither Hypothesis 9 nor Hypothesis 10 can be conclusively verified here. Participants with *matched-anxiety-elicitation* only report higher sensation scores in the *Post-Soundscape Frequency of Perceived Sensations* (2.2.2) than participants with *surprise-anxiety-elicitation* for the *Violence* and *Body Anxiety* soundscapes, but the opposite is true for the *Situational Phobias* soundscape. Further, participants with *matched-anxiety-elicitation* demonstrate higher GSR peak rates than participants with *surprise-anxiety-elicitation* only for the *Violence* soundscape, whereas the reverse is true for *Situational Phobias* and *Body Anxiety*.

5.7 Conclusion

5.7.1 Confirmation of Primary Hypotheses and Objectives

There are several crucial hypotheses (outlined in Section 5.1.1) projected from the existing knowledge on anxiety treatments in the literature review and from the indicative pilot results. Many hypotheses were confirmed, while a few were disproved or corrected upon the primary data analysis from the main experiment:

1. Soundscape exposure is safe and enjoyable, even if some unpleasant sensations are elicited (Section 5.2)
2. Positive physical and psychological sensations are rated as more frequently occurring during soundscape exposure than negative physical and psychological sensations (Section 5.2)
3. Participants experienced a positive long-term impact, showing physical and psychological improvement in the *Long-Term Catharsis Evaluation* (questionnaire 3) from how they originally felt prior to the soundscape exposure, in the *Pre-Exposure Evaluation of Anxiety Levels* (1.1) (Section 5.2)
4. Participants experienced a slightly negative short-term impact from the *Pre-Exposure Evaluation of Anxiety Levels* (2.1) to the *Post-Exposure Evaluation of Anxiety Level*s (2.3) (Section 5.2)
5. It was hypothesised that participants with higher levels of pre-existing anxiety would demonstrate an amplified perception of all sensations in the *Post-Soundscape Frequency of Perceived Sensations* (2.2.2) compared to participants with lower-pre-existing anxiety (Section 5.3) – however, it appears that the higher pre-existing anxiety participants only consistently report an amplified perception of negative sensations, compared to the lower pre-existing anxiety participants.
6. It was hypothesised that hyperreal, exaggerated spatialisation patterns imposed on the sounds would be more anxiety-eliciting than realistic spatialisation – however, it appears that acoustic and semantic nature of the sound has a profound influence on whether a hyperreal or a realistic sound spatialisation is the most anxiety-eliciting (Section 5.4).
7. It was hypothesised that participants with higher levels of pre-existing anxiety would generate a higher GSR peak rate than participants with lower pre-existing anxiety in response to anxiety-inducing sounds. This is largely true, but the higher-pre-existing anxiety group demonstrate a lower GSR peak rate than the low-pre-existing anxiety group during relaxing sounds – it appears that the sensitive HPE

group is more receptive to both anxious and relaxing sounds, than the lower-pre-existing anxiety group. (Section 5.5)

8. When a soundscape is heard as the first in sequence, the GSR peak rate is higher than when the soundscape is heard as the second or third in the sequence (Section 5.5).
9. It was hypothesised that participants with *matched-anxiety-elicitation* would report higher sensation scores in the *Post-Soundscape Frequency of Perceived Sensations* (2.2.2) than participants with *surprise-anxiety-elicitation.* This appears to be the case for only for two out of three soundscapes *(Violence* and *Body Anxiety)* (Section 5.6).
10. It was hypothesised that participants with *matched-anxiety-elicitation* would generate higher GSR peak rates than participants with *surprise-anxiety-elicitation.* However, participants with *surprise-anxiety-elicitation* demonstrate higher GSR peak rates than participants with *matched-anxiety-elicitation* for two out of three soundscapes (*Situational Phobias* and *Body Anxiety*) (Section 5.6).

6 Soundscape Exposure Experiment Secondary Results

6.1 Introduction

The secondary results are aimed towards practitioners wishing to implement soundscape exposure therapy, as the analysis goes into far deeper detail than the primary results, and complex data visualisations allow the reader to appraise the efficacy of individual sounds. Moments of high anxiety are pinpointed down to the level of individual sound objects (such as “gunshots”), as well as the most potent sound categories (for example, “gunshots” are one of the sounds included in the larger *Weapons* category, within the *Violence* soundscape). These meticulous analyses will enable practitioners to design new soundscapes with a carefully constructed, predictable timeline of affect. The ideal anxiety exposure soundscape should begin with more innocuous, neutral sounds which largely go unnoticed by participants according to the large-scale experiment results. These establishing sounds should either gradually build in intensity as the soundscape continues to unnerve the listener and heighten tension. Alternatively, to elicit a shock, the mid-volume introductory sounds could be suddenly interrupted by a loud burst of sounds which were consistently identified as triggers of strong sensation by participants in the *Post-Soundscape Frequency of Perceived* Sensations (2.2.2). The secondary results are included in the thesis, but streamlined as much as possible: only a limited range of visualisations are shown, as much of the information can be distilled verbally.

Using the questionnaire responses, the secondary results provide more nuanced appraisals of the nature of the soundscape exposure experience, as the primary results focused on the long-term impact, by calculating the average increase in wellbeing from one month prior to the soundscape exposure to one week following the soundscape exposure. Here, the participants’ broader subjective perceptions of each soundscape are averaged from the *Post-Soundscape Subjective Perceptions (acoustic and emotive attributes),* questionnaire 2.2.1. Also, the most frequently perceived individual physical and psychological sensations (such as “pleasurable chills” or “thoughts racing”) are revealed from the results of *the Post-Soundscape Frequency of Perceived Sensations* (2.2.2). It appears that the trends are quite complex across the pool of thirty participants, with a blend of both positive and negative, physical and psychological sensations perceived throughout soundscape exposure. Some sounds even elicited both positive and negative sensations simultaneously, such as the “bells chiming” in the *Time Stress* section of *Situational Phobias*. Further insight into the nature of the sensations frequently elicited by a soundscape are shown in a collation of sensation maps, directly drawn onto a blank body image (the *Post-Soundscape Body Map*, questionnaire 2.2.8).

Next, the moments of peak physiological activity recorded during soundscape exposure are closely evaluated. GSR data is appraised here in far greater detail than in the primary results, where it was only the overall average peak rates for each soundscape which were evaluated looked. Here, moments of universal GSR peak activity pinpoint individual sounds as sensation triggers. The sounds that generated notable physiological activity can be deducted from high-resolution *GSR Peak Timelines* for all participants, directly overlaid onto the graphical timeline of sounds, the *Soundmap* for each soundscape. Individual peaks are presented as thin lines spanning the entire page of soundscape timeline, with fluctuating frequency over time (which, in effect, resembles a barcode), alongside the GSR peak rates for each minute, which are presented in a bar chart at the top of the soundscape. Then, the differences in *GSR Peak Timelines* (presented as barcode strips at the foot of each soundscape timeline) are evaluated for participants with the highest pre-existing anxiety levels (the HPE group) and those with the lowest pre-existing anxiety levels (the LPE group) – the rises and falls in minute by minute peak rates are demonstrated as a colour coded line graph in these comparative *GSR Peak Timelines*. The next group comparison demonstrates that participants largely habituate to soundscape exposure over time (also equated with listener fatigue), by comparing *GSR Peak Timelines* (as barcode strips) for the participants who heard each soundscape first, second or third in the sequence. The respiration data-plots follow a similar model to the *GSR Peak Timelines*, but the respiration peaks (large inhales) are not the only instances that are represented by the thin lines on the soundscape timeline. Anomalies in breathing patterns are also included in this representation, such as pauses and short stifled breaths, as they are likely to be caused to individual sounds.

The analysis of the efficacy of sounds (Section 6.5) is primarily to aid exposure soundscape designers to differentiate between the sounds which were most frequently mentioned as triggers of strong sensation in the *Post-Soundscape Frequency of Perceived Sensations* (2.2.2) and those sounds which were largely ignored by participants (at least in terms of these conscious reports). Also, a comprehensive overview is provided of the consistently liked (enjoyable) and disliked (anxiety-eliciting) sounds, as prompted by the presentation of a full graphical timeline of sounds to the participants (*Post-Soundscape Liked and Disliked Sounds,* questionnaire 2.2.9). The attribution of most “liked” or most “disliked” is significant, in that it reveals the complexity of the reaction to different sensation triggering sounds. For example, “machine guns” were almost unanimously disliked but there was a mixed reaction to “bells chiming” (as was the case for fire sounds) and the water sounds were consistently liked. Cross-correlation between modes of data collection can be discerned here also, as the time periods with a high concentration of likes or dislikes should correspond to the time periods with clusters of GSR peaks. Further, the influence of the loudness of the soundscape on GSR peak activity is assessed, by figuring out if an increase in the minute-by-minute GSR peak rate coincides with an increase of the minute-by-minute amplitude in dBFS. The physiological impact of loudness is also analysed in greater detail by overlaying the entire waveform of each soundscape (as recorded binaurally in the Soundlab) onto the corresponding *GSR Peak Timeline* (every participant’s individual GSR peaks are presented as a barcode comprised of one thin line representing each peak).

Finally, the global approach to answering the research question of whether tailoring the soundscapes to pre-existing anxiety garners especially high GSR peak rates is presented. The average minute-by-minute GSR peak rates of all participants are compared, focusing on the signals recorded during playback of two sound categories which were both unanimously identified as anxiety-triggering in the *Post-Soundscape Frequency of Perceived Sensations* (2.2.2.). One of these sound categories resonated highly with many participants’ personal anxieties: *Visceral* sounds featured in the *Body Anxiety* soundscape, were reported as an anxiety trigger many times in the *Pre-Exposure Trigger Diagnosis* (1.2). The other sound category, *Fire* (in the *Situational Phobias* soundscape), was not mentioned as a personal trigger by any of the participants prior to the exposure. The *Visceral* sound category could be seen as a period of *matched-anxiety-elicitation* whereas the *Fire* sound category seemed to provoke a *surprise-anxiety-elicitation*. The overall average GSR peak rates (from all participants) during these five-minute sections of the soundscapes are compared, but the most significant difference between the GSR response generated by the *matched-anxiety-elicitation* sound category and the response generated by the *surprise-anxiety-elicitation* sound category appears to be in the speed of attenuation of minute-by-minute peak rates. After the differences between personally resonant (*matched-anxiety*) soundscape exposure and *surprise-anxiety* soundscape exposure are revealed, a database of the anxiety-trigger sounds which were the most or the least frequently predicted in the *Pre-Exposure Trigger Diagnosis* (1.2) is established. The sounds which were largely pre-conceived to be anxiety eliciting will be distinguished from those that proved to genuinely surprise listeners (as well as those neutral sounds which were not mentioned in either the *Pre-Exposure Trigger Diagnosis*, questionnaire 1.2 nor the *Post-Soundscape Frequency of Perceived Sensations*, questionnaire 2.2.2) to better inform therapists and composers to generate ideal anxiety-exposure therapy soundscapes.

6.1.1 Secondary Hypotheses and Objectives

There are several hypotheses and objectives for the secondary results which further expand upon those for the primary results. Some of the secondary hypotheses are distinct though, which reflects on the level of specificity and detail of analysis offered here (this list continues from the primary hypotheses, which were numbered one to ten). These hypotheses are also rooted in the psychophysical studies and psychotherapeutic methods outlined in existing literature.

11. The most frequently perceived physical sensations are those widely attributed to auditory and musical processing (such as “pleasurable chills”, “numbness/tingling”, “heart pounding”) or caused by the hyperreal spatial panning of sounds (“dizziness” or “upset stomach”). (Section 6.2.1)
12. The most frequently perceived psychological sensations are those attributed to memory recall, emotional processing of past traumas and eventually catharsis (“sad”, “nervous”, “tense”, and “depressed” or “in control” and “relief”). (Section 6.2.1)
13. The most frequently affected body parts are likely to be the head (given the psychological nature of the experience), as well as the core (in moments of panic breathing may be altered and sound-induced chills and shivers are usually perceived down the spine). It is fascinating if the extremities and the limbs are also affected, as these reactions are beyond the usual sensations induced by sound and music or the standard anxiety symptoms – instead these might be a result of immersion in ambisonic sound, or phantom pain memories. (Section 6.2.2)
14. The participants’ immediate subjective perceptions of the soundscape exposure should be that the soundscapes are slightly louder than everyday, and that they are highly immersive. The participants’ moods should be changed from soundscape to soundscape, and memory recall should be induced by the sounds. (Section 6.2.3)

15. The sounds that elicited the greatest GSR peak rates will be those which are the most antagonistic, in terms of acoustic abrasiveness (high frequency, chaotically noisy, rhythmically erratic, dissonant musical forms, percussive) or negative causal associations (physical threats, violent connotations, mechanistic sounds or disgusting taboo sounds) (Section 6.3)
16. Attenuation of GSR peak rates will coincide with more pleasant sounds, in terms of acoustic smoothness (lulling repetition, harmonic musical forms, or soothing quality) or positive causal associations (natural sounds, vibrant social atmospheres) (Section 6.3)
17. The hypothesized GSR peak rate increases in response to abrasive shock sounds and attenuations in response to relaxing pleasant sounds are more pronounced in the hyper-sensitive groups, such as the HPE group (higher pre-existing anxiety) and the participants who are listening to a soundscape as the first in the exposure sequence. (Section 6.3)
18. A greater concentration of respiration anomalies should occur during the already established triggers of strong sensation identified in *Post-Soundscape Frequency of Perceived Sensations* (2.2.2), particularly the most alarming, suspenseful or pleasant sounds. (Section 6.4)
19. The sounds most frequently perceived as a trigger of strong sensation in the *Post-Soundscape Frequency of Perceived Sensations* (2.2.2) will be those which were also reported as pre-existing anxiety triggers numerous times in the *Pre-Exposure Trigger Diagnosis* (1.2). (Section 6.5)
20. The sounds most frequently perceived as a trigger of strong sensation in the *Post-Soundscape Frequency of Perceived Sensations* (2.2.2) will be those which are the most antagonistic, in terms of acoustic abrasiveness (high frequency, chaotically noisy, rhythmically erratic, dissonant musical forms, percussive) or negative causal associations (physical threats, violent connotations, mechanistic sounds or disgusting taboo sounds). They might also be the more pleasant sounds, in terms of acoustic smoothness (lulling repetition, harmonic musical forms, or soothing quality) or positive causal associations (natural sounds, vibrant social atmospheres). (Section 6.5)
21. The *matched-anxiety-elicitation* sound category will elicit higher GSR peak rates or a differing speed of attenuation of GSR peak rates than the *surprise-anxiety-elicitation* sound category. (Section 6.6)

6.2 Detailed review of Soundscape Exposure experience

6.2.1 Identification of the most frequently perceived sensations

The *Post-Soundscape Frequency of Perceived Sensations* (2.2.2) asks participants to rate the frequency of occurrence of 30 individual sensations and emotions, over the course of a soundscape. Participants choose one of the following frequency descriptors to apply to each sensation, which convert to numbers on a Likert scale: each sensation was either experienced "not at all" (0), "once, very briefly" (1), "two or three times" (1.5), "throughout most of the piece" (2), or "constantly" (3). The *Violence* soundscape elicited sensations the most frequently on the whole, as the overall average sensation score is 0.604 out of a possible score of 3.00 for *Violence*, but only 0.567 for *Situational Phobias* and 0.541 for *Body Anxiety*. This general sensation score is telling but it is interesting to discover whether a soundscape triggered any particular sensation categories more frequently than others (as previously assessed in 5.2.1), or indeed whether a soundscape appeared to elicit an individual sensation more frequently than the others, which is the focus of the analysis below.

Violence held the highest overall average frequency score for physical positive sensations, closely followed by *Situational Phobias* and *Body Anxiety* (see the column triplet fourth from the bottom in Figure 47). Again, the overall average frequency score generated by *Violence* for physical negative sensations is significantly higher than the score for physical negative sensations elicited by Body Anxiety, with the physical negative sensations rating for *Situational Phobias* falling somewhere in between. The highest average psychological negative sensation score is again generated by the *Violence* soundscape, followed by *Situational Phobias* then *Body Anxiety*. *Violence* also generated the highest psychological positive sensation frequency score of 1.458 out of a possible three, significantly higher than the score of 1.367 for *Body Anxiety*, and 1.200 for *Situational Phobias*.

One of the main differences between the soundscapes in the frequency of individual physical positive sensations elicited can be seen in the first column triplet of Figure 47. The *Violence* soundscape generated "pleasurable chills" the most frequently out of all the soundscapes. This was the same for "numbness or tingling," where the average frequency score for *Violence* was 0.400, but the sensation frequency score was half that for *Body*

Anxiety (*Situational Phobias* elicited "numbness or tingling" at a relatively moderate frequency). Regarding individual physical negative sensation elicitation, *Violence* also made participants feel "unsteady or shaky" more often than the *Situational Phobias* or *Body Anxiety* soundscapes, with sensation frequency scores of 0.283, 0.167 and 0.150 respectively.

Psychologically, participants were "frightened" much less frequently by the *Body Anxiety* soundscape (by a factor of one third), compared to the *Violence* and *Situational Phobias* soundscapes (see the central column triplet in Figure 47). Moreover, *Violence* "terrified" participants more often than the *Body Anxiety* or *Situational Phobias* soundscapes**.** It appears that the many cinematic horror tropes implemented in the *Violence* soundscape were effective in frightening and terrifying the listener: threatening sounds, a haunting voice, foreboding ominous piano tones, and string instrument "stingers". Further, *Violence* notably elicited the most "sadness" by the most significant degree of difference seen thus far (seen at the top of the third large column cluster of Figure 47). *Violence* generated an average "sadness" frequency score of 0.675, compared to *Situational Phobias* and *Body Anxiety* which each only garnered an average score of 0.267 – this is a difference of 0.408. A possible reason for this is that *Violence* is the only soundscape which used music, which happened to be highly emotionally manipulative. Seemingly paradoxical, "happiness" ratings were also highest for the *Violence* soundscape on average, higher than the sensation frequency ratings for the *Situational Phobias* or *Body Anxiety soundscape***.** Ratings of "contentment" were also clearly the highest during the *Violence* soundscape. The sensation frequency ratings for *Violence*-induced "pleasure" far exceeded the sense of pleasure discerned during listening to *Situational Phobias* and *Body Anxiety*: *Violence's* average "pleasure" frequency score is 1.483, compared to a score of 1.133 for *Situational Phobias* and 1.200 for *Body Anxiety* (a difference of 0.350, or 0.283).

An exception to the trend that *Violence* usually generates the highest frequency of perceived sensations, is that "fear of the worst happening" is the most frequently provoked by the *Situational Phobias* soundscape – the average sensation frequency rating was 0.100 above that elicited by either *Violence* or *Body Anxiety*. This is likely induced by catastrophic real-world flying and fire sounds. Further, participants reported "heart pounding" much more frequently during the *Situational Phobias* and *Body Anxiety* soundscape, compared to the *Violence* soundscape. "Tension" was also perceived less frequently during the *Violence* soundscape, as the average sensation frequency score is 0.198 lower than the “tension” frequency score for *Situational Phobias*, and 0.256 lower than the “tension frequency score generated by the *Body Anxiety* soundscape. Participants were made to feel “nervous” far more often during the *Situational Phobias* soundscape with an average sensation frequency rating of 0.867, compared to *Body Anxiety* rated at 0.583 on average and *Violence* at 0.500 (a significant difference of 0.300, or 0.217). Participants felt “relieved” most frequently when listening to the *Body Anxiety* soundscape, followed by *Situational Phobias* and then *Violence* – this heighted sense of relief can be attributed to the respite period of water sounds in the middle of the *Body Anxiety* soundscape.

As per Hypothesis 11, it appears that the physical positive (musical processing) sensations are perceived much more frequently, across the board, than the physical negative sensations (caused by hyperreal spatial panning). The most frequently perceived individual physical sensations are indeed those widely attributed to auditory and musical processing and deemed as positive (such as “pleasurable chills”, “numbness/tingling”, “heart pounding”). These were perceived much more frequently than the physical negative sensations likely induced by the hyperreal spatial panning of sounds (participants quite frequently perceived an “upset stomach” during the *Violence* soundscape (0.25 out of 3.00) but minimally during the other soundscapes). Also, the most frequently induced physical negative sensation was “unsteadiness/shakiness” rated as slightly more frequent than the sensation previously expected to be frequent, “dizziness”. Hypothesis 12 can also be demonstrated here with some minor modifications, as the most frequently perceived psychological sensations are those attributed to memory recall, emotional processing of past traumas (“sadness”, “nervousness”, and “tension” were correctly predicted to be frequently elicited, whereas “depression” was reported far less frequently than expected) and eventually catharsis (as expected, the perception of being “in control” was by far the most frequently perceived sensation across the board - “relief” was also high, as expected, but exceeding relief was the frequency of perceived “contentment”, “relaxation”, “pleasure” and “happiness”).

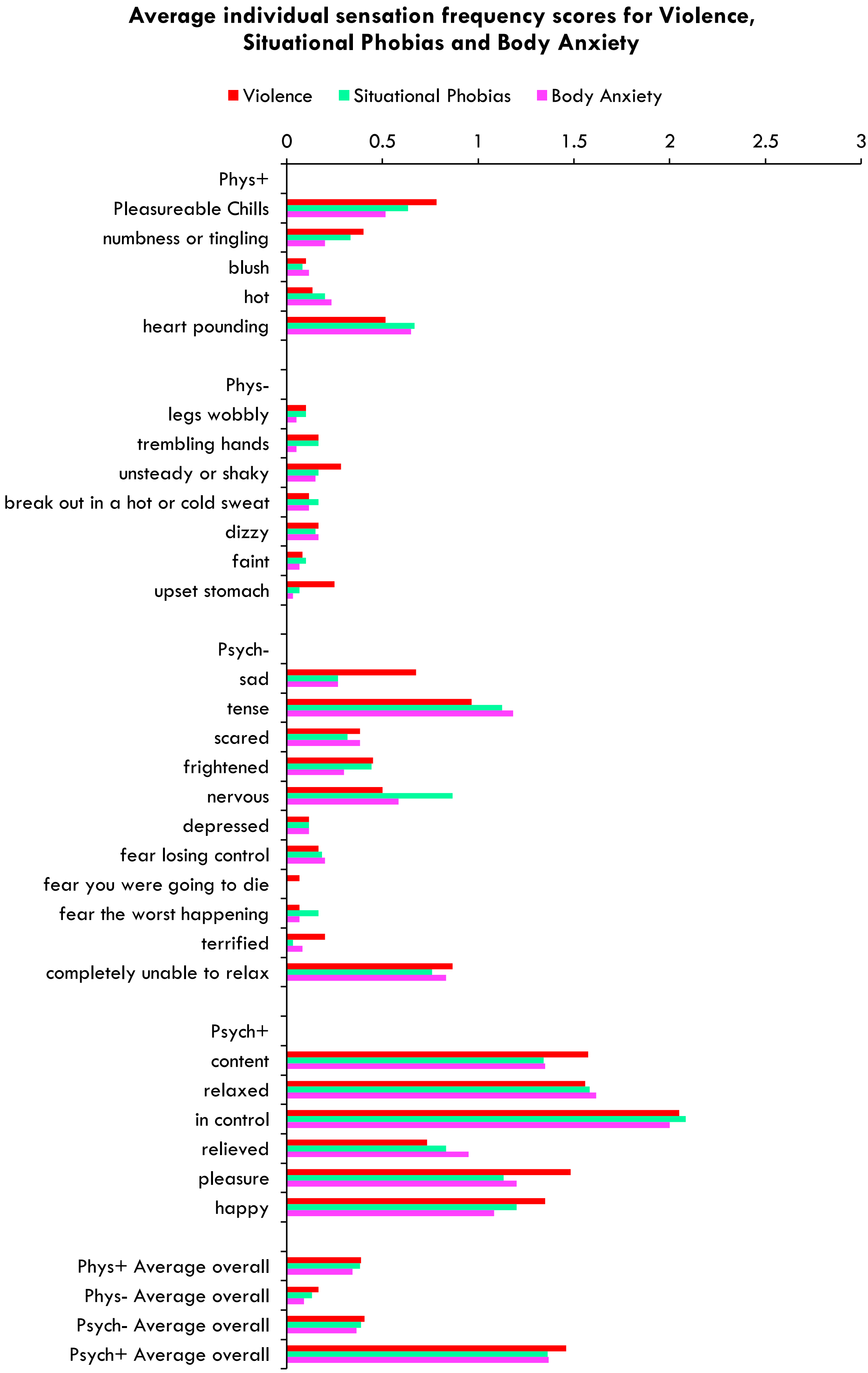


Figure 47: Identification of the most frequently perceived individual sensations, and differences in these numbers between the soundscapes

6.2.2 The sensations reported and body parts affected according to the *Post-Soundscape Body Map* (questionnaire 2.2.8)

The collation of many participants' drawings of positive and negative sensations onto blank outlines of a body diagram gives a broad overview of the most commonly affected body parts (head, ears, back of the neck, breathing) with a few interesting anomalies (restless hands, or an idiosyncratic "fizzing in arm"). After each soundscape, participants were asked to draw their perceived physical sensations, directly onto a blank *Post-Soundscape Body Map* (2.2.8), marking negative sensations with a red pencil and positive sensations with a blue pencil. This technique allows participants to vividly depict sensations that can be difficult to verbalize – a device borrowed from medical pain diagnosis. The body maps have been collated in several ways to discover differences between groups of participants. However, only a general collation of body maps from all 30 participants is focused on here. First, the number of ticked individual sensations recorded as being perceived during soundscape exposure (by a tick) allows a discovery of which soundscape induced the most of each sensation. However, this duplicates the data surveyed in Section 6.2.1 to an extent, so instead the distribution of sensations drawn across the *Body Map* (2.2.8) is analyzed here, for each soundscape. This offers insight on the body parts most commonly affected by immersion in the soundscapes: whether focused around the head, the core or in the extremities.

As can be expected, given that the nature of the soundscape exposure experience is deemed as predominantly psychological and positive according to the *Post-Soundscape Frequency of Sensations* (2.2.2), much of the sensation drawings on the *Post-Soundscape Body Map* (2.2.8) are concentrated around the head and the ears, and much of these are coloured with blue pencil (denoting a positive sensation). A high number of the head related sensations drawn represent the psychological "thoughts racing" or the physical "dizzy lightheadedness". However, there is also plenty of responses depicting sensations perceived throughout the body – often around the chest, for changes in breathing, or an upset stomach. For the collated *Post-Soundscape Body Map* (2.2.8) for *Violence* and *Situational Phobias*, the image of the top of the head is completely coloured in blue, denoting positive sensations (clarified as many instances of "thoughts racing").

For the *Violence Post-Soundscape Body Map* (see Figure 48) there are three red scribbles partially covering the back of the head, explained to be negative “thoughts racing,” and either during an imagined “child/baby crying” at the end of the piece (perhaps the singing vocalizations), “crackling 15s,” “machine gun 5s,” “piano, violin, cello (multiple times),” “throughout, apart from 30s” or even "the entire piece.” Notable sensations include a negative prickly back scribbled in red, but positive sensations in the ears are also denoted in blue. Negative sensations in the extremities are also drawn up, such as “sweating” hands and feet, restless legs and feet are elicited by the *Violence* soundscape. “Legs like jelly”, and “numbness” have been scribbled up and down the legs as a negative sensation, coloured in red. A positive “trembling” and a positive “shivering” down the back of the neck are drawn in blue, and a “prickly neck” have also been reported during *Violence*. A “stabbing” sensation has been scribbled across the top of the shoulder blades, specifically described as during the “20 seconds gunshots”. Crucially, there were two participants who reported crying during the *Violence* soundscape – one saw these tears as positive, perhaps a form of catharsis, but one saw these tears as negative.

On the collated map for *Situational Phobias* (see Figure 49) there are four red scribbles densely concentrated at the centre of the top of the head, loosely trailing on the back of the head, and looping around the forehead to illustrate negative feelings of “dizziness and lightheadedness” (see Figure 49). This was said to be provoked by “the start of the chimes (dissonant),” “ticking clocks” and “bells” for about one minute. Pleasant sensations appear to envelope the back of the head (in blue), but a tension headache is also scribbled in red. Again, the negative sensations in the extremities are highlighted in red several times in the collated *Post-Soundscape Body Map* (2.2.8) completed regarding the *Situational Phobias* soundscape, such as “sweating” and “restless” feet and hands. Hands were also said to be “shivering,” and there are also negative “shivers” drawn down the spine. Strangely a positive “burning” is also drawn down the spine, caused by the “imagination of fire.” One sensation drawn on the *Situational Phobias Body Map* that does not feature on the *Violence* or *Body Anxiety Body Maps*, is an array of spikes around the arms and the shoulders, coloured in red to insinuate that it is a negative sensation, clarified as “shivering” from Participant 35. This is said to be triggered by “irregular bangs and clock dongs gave [them]a fright/startled [them]”. Almost all the spaghetti like looping, tangled red scribbles throughout the body were drawn by Participant 20, who appeared to have a very intense embodied reaction to the *Situational Phobias* soundscape: “pleasurable chills” and an “ache” were felt in the back and the top of the head; “dizziness” and “lightheadedness" was located in the forehead; "breathlessness", "slow relaxed breath", "shallow breaths" and "fast breaths" were all noticed in the nostrils and all over the chest. Both "nausea" and an "upset stomach" are drawn as a messy spiral on the abdomen; even severe panic symptoms such as "heart palpitations" and "chest pain" are drawn up and down the chest; "stabbing" was perceived in the back, and "burning" on the top of the head, in addition to "restless" feet. This participant also reported "crying" during the soundscape.

There also appears to be one instance of "crying" induced by the *Body Anxiety* soundscape (see Figure 50), but this has been coloured in blue to indicate that these were positive tears, perhaps as a result of catharsis. Participant 29 attributed these tears to the hospital sounds, where they accounted a "warm" re-experience and processing of grief, as accounted throughout their *Post-Soundscape Questionnaire* (questionnaire 2) and in their *Long-Term Catharsis Evaluation* (questionnaire 3). On the other hand, there is a comically exaggerated grin drawn in blue by one participant, to record the "smiling" induced by the soundscape, although the exact sound trigger is not reported. "Pleasurable chills" have been charted in blue down the spine and at the back of the head, along with positive "shivering" around the left of the back, and many times a negative "shivering" is drawn around the chest. "Restless" and "sweating" legs have again been reported, and it appears that a physical memory of a "big fracture in ankle" was induced by the *Hospital* sequence, resulting in an "aching" ankle drawn in red by one participant. The image of the top of the head on the *Body Anxiety Body Map* is dominated by red scribbles to illustrate negative sensations (mostly "thoughts racing," "dizziness and lightheadedness" and "ear pain" as well as "itchiness"). These red scribbles are concentrated at the center and the back of the head, as well as across the top (from ear-to-ear) and four crosses at the top of the forehead. There is a less dense blue scribble, that covers the back half of the head, which denotes positive "thoughts racing". These sensations were caused by the sounds of a "hair trimmer," "loud hissing noises," "memories of medical procedures," "for the entire piece," "popping sounds," and even by the act of "trying to identify sounds (start to finish)". Positive sensations are far fewer during the *Body Anxiety* soundscape, as there is far less blue pencil in this collated *Post-Soundscape Body Map* (2.2.8). There appears to have much discomfort perceived around the chest, possibly elicited through the uncanny breath collage at the start which fluctuates between organic (human breaths) and inorganic (ventilation machines). The piece begins with deep exhales which are strangely missing their corresponding inhales, and towards the end there is also a period of hyperventilation.

Overall, most participants plotted at least two sensations on their *Post-Soundscape Body Maps* (2.2.8), and that these sensations were not just limited to the semantic, causal listening (cognitive appraisals of the sounds). Although "thoughts racing" was the most frequently perceived sensation on the *Body Map*, there were many other anxious sensations elicited that can be attributed to acoustic processing and music listening (such as pleasurable chills, sweating, or increase of heart rate). Fascinatingly though, several anxious sensations seem to have been induced as physical re-experience of past pain, triggered by sounds that resonate with memories. Some sensations, such as "crying" or chest pain" are caused by intense emotional processing, which allude to forms of catharsis taking place for a select few. Hypothesis 13 is thus confirmed, that the most frequently affected body parts are the head (given the psychological nature of the experience), as well as the core (in moments of panic breathing may be altered and sound-induced chills and shivers are usually perceived down the spine). It is fascinating that the extremities and the limbs are also affected, as these reactions are beyond the usual sensations induced by sound and music or the standard anxiety symptoms – instead these appear to be a result of immersion in ambisonic sound, or phantom pain memories.

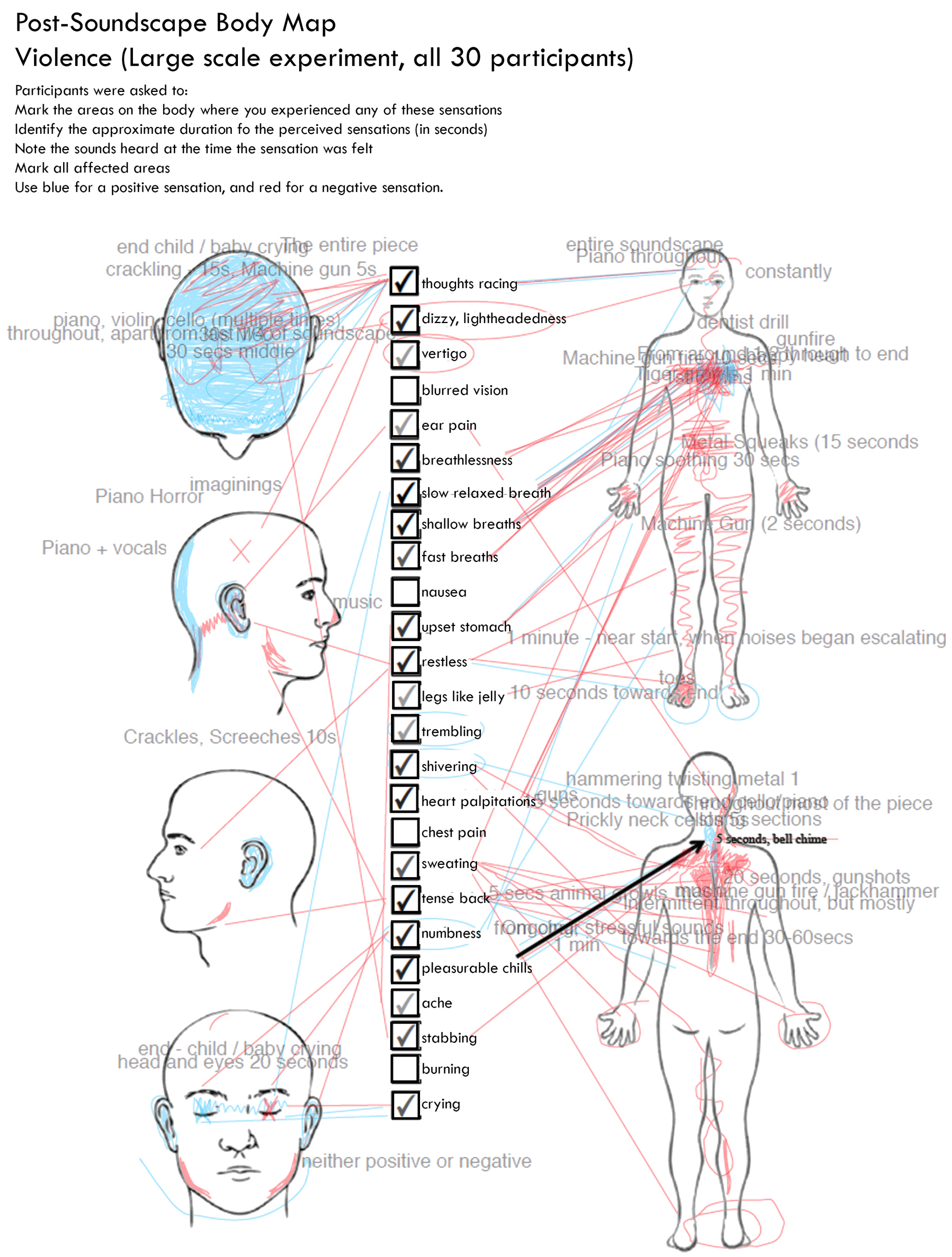


Figure 48: Collated body map for all participants depicting the sensations felt during the *Violence* soundscape

Post-Soundscape Body Map
Situational Phobias (Large scale experiment, all 30 participants)

Participants were asked to:
Mark the areas on the body where you experienced any of these sensations
Identify the approximate duration fo the perceived sensations (in seconds)
Note the sounds heard at the time the sensation was felt
Mark all affected areas
Use blue for a positive sensation, and red for a negative sensation.

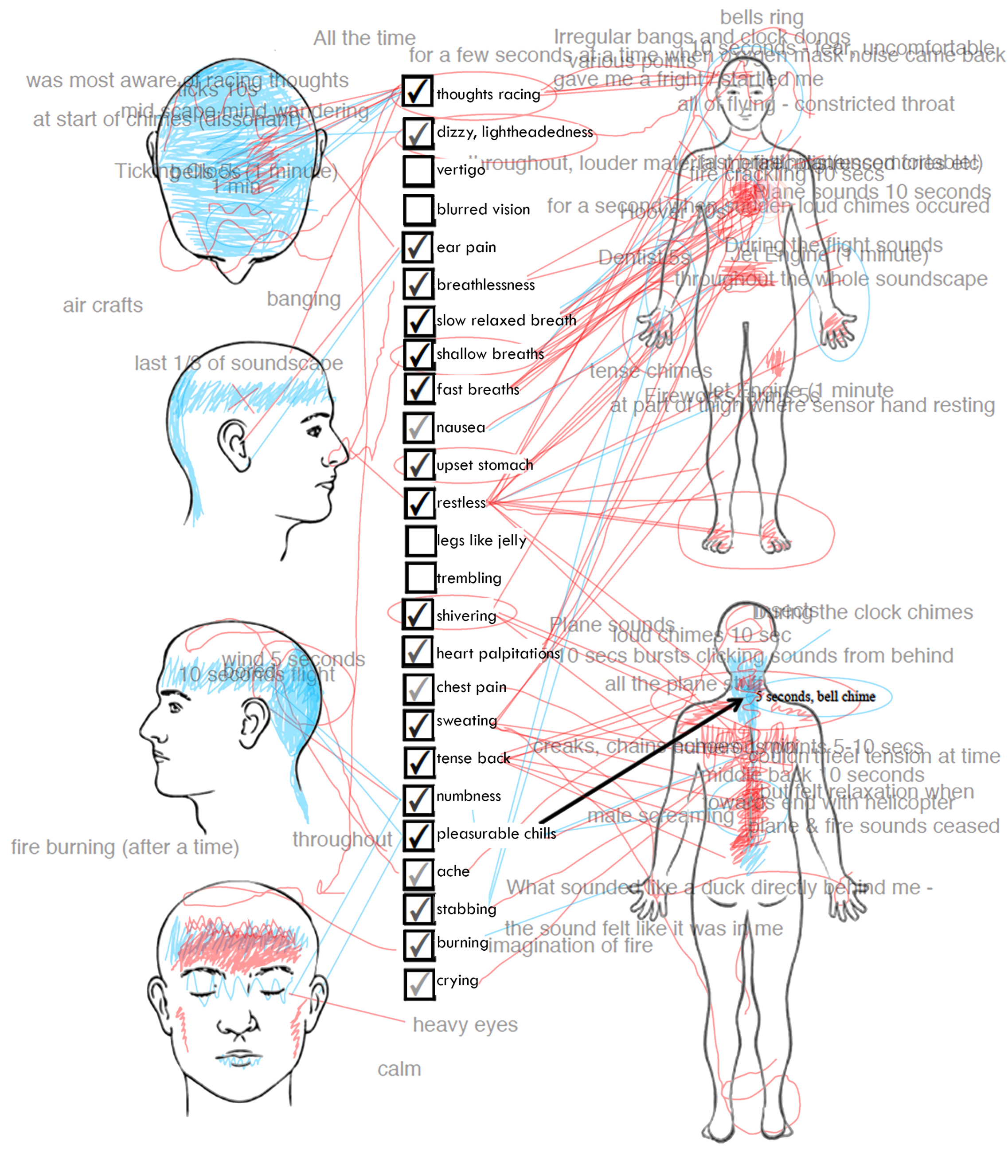


Figure 49: Collated body map for all participants depicting the sensations felt during the *Situational Phobias* soundscape

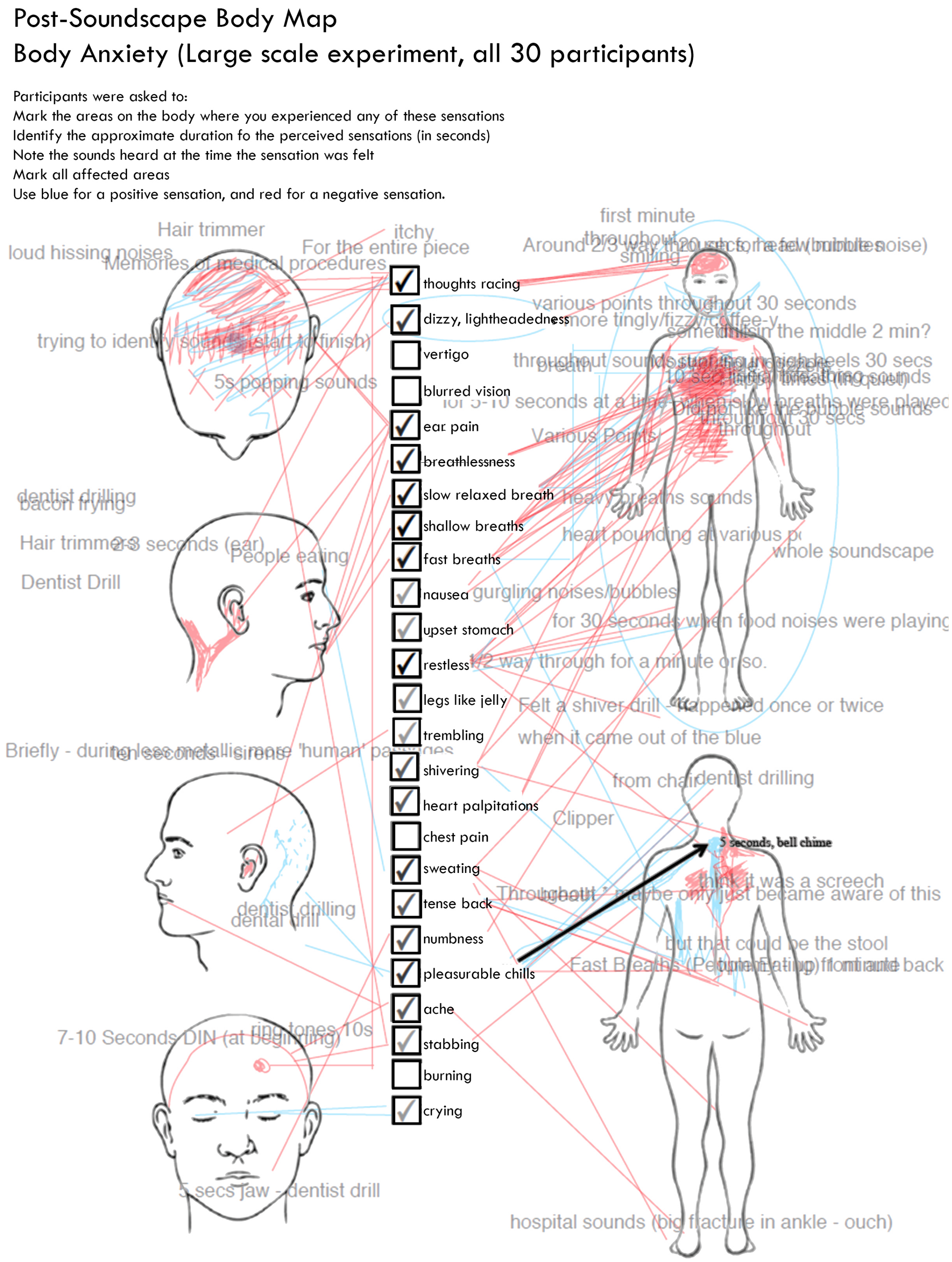


Figure 50: Collated body map for all participants depicting the sensations felt during the *Body Anxiety* soundscape

6.2.3 Subjective Perceptions of each soundscape

The first questions asked of participants following each soundscape, in the *Post-Soundscape Subjective Perceptions* (2.2.1), are designed to gauge immediate reactions, as participants rate the acoustic attributes of the soundscape. The soundscapes' loudness, and the level to which they induced fright, irritation and a sense of immersion are rated using Likert scales, so that these responses are easily quantified. A score of zero is allocated for the opposite of the attribute (for example, "very quiet" is the opposite of loud, "boring" is the opposite of frightening, "blissful" is the opposite of irritating, or the soundscape might be perceived as "not at all" immersive) to three for an "unbearable" degree (except from immersion, where a score of three denotes "constantly"). *Violence* quite consistently elicits the most extreme response ratings, both positive and negative. *Situational Phobias* was often deemed as the most moderate soundscape, although the most personally resonant and strongest trigger of memories.

Participants believed the soundscapes were between "no louder than everyday" (1.5) and "mostly loud" (2) with an overall average score of 1.838 out of a possible 3.000. Intriguingly, although the *Violence* soundscape is objectively the loudest of the soundscapes as measured by a sound pressure level meter, participants actually perceived *Body Anxiety* to be the loudest with an average rating of 1.867, closely followed by *Violence* at 1.858, whereas *Situational Phobias* is perceived to be below average loudness with a score of 1.790. This makes sense, as the *Situational Phobias* soundscape begins with sparse, microscopic close-up sounds of a coin spinning, and many of the sounds are mixed so as to replicate real world situations, at a realistic volume.

When asked to rate how "frightening" the experience was, it was largely deemed as "emotionally neutral" (1.5) with an average overall score of 1.458 for all soundscapes averaged together. *Violence* is deemed the most frightening soundscape, with an average rating of 1.533. This is to be expected given the *Violence* soundscape's overt horror cues, stingers and sounds imbued with physical threats ("machine guns", aggressive animals such as a "leopard growling", and "knife stabs"). The second most "frightening" soundscape is *Body Anxiety*, with an average rating of 1.517 out of three (a rating only 0.016 lower than *Violence*), probably due to the unnatural cacophony of artificial breaths and the perhaps clichéd abrasive hospital beeps and dentist drills. The least "frightening" soundscape is *Situational Phobias* with a significantly lower average rating of 1.325 (a rating 0.216 lower than *Violence*).

Participants rated soundscape exposure as "neither irritating nor pleasant" (1.5) on the whole, with an overall average score of 1.570. *Body Anxiety* is perceived as the most irritating with a score of 1.700, followed by *Situational Phobias* (rated at 1.617), whereas the *Violence* soundscape was significantly less irritating at 1.392, (0.308 less than the score for *Body Anxiety)*. Again, it is imagined that the *Violence* soundscape is the least irritating as it is the only soundscape to feature a constant bed of music, which can at time mask the abrasive acoustic qualities whilst also cohesively gluing the cacophony of disparate sounds together.

Out of all the acoustic attributes which the participants were asked to rate, the highest ratings were for the sense of immersion – overall, participants felt immersed in sound "throughout most of the piece" (2), nearly "constantly" (3) as the overall average rating is 2.216. The most immersive soundscape is perceived to be *Situational Phobias*, with a score of 2.483, followed by *Violence* rated as 2.283 which is still above average, and then *Body Anxiety* is rated as the least immersive with a score of 1.883 – even still, participants felt immersed in sound during *Body Anxiety* at least "2 to 3 times" (1.5) or "throughout most of the soundscape" (2). Thus, this research study's principle aim, designing immersive soundscapes, can be said to have been achieved.

Participants are also asked to rate the levels of enjoyment, revival, perception of vivid emotions, strong sensations or musical bliss, the degree to which they re-experience unpleasant sensations and emotions, and whether they are soothed by a soundscape in the immediate *Post-Soundscape Subjective Perceptions* (2.2.1). A Likert scale also applies for these questions, from zero for a definite "no" to three for "yes". Participants seemed to "enjoy" soundscape exposure a great deal when asked, with average overall enjoyment ratings of 2.26. Rated as the most enjoyable is *Violence* with a score of 2.467, followed by *Body Anxiety* at 2.183, and *Situational Phobias* at 2.130. There also seems to be degree of "revival" provoked by soundscape exposure with the average overall rating falling between as the overall average is 1.633. The soundscape which revived participants most significantly is *Violence* with a score of 1.917, whereas *Situational Phobias* elicited average "revival" ratings of 1.500 and *Body Anxiety* even less, 1.483.

When participants were asked if they felt any "vivid emotions, strong sensations or musical bliss" during soundscape exposure, the overall average response is 2.011. Again, *Violence* triggered the highest "vivid emotions, strong sensations or musical bliss" ratings on average with a score of 2.167, compared to *Situational Phobias* rated at 2.050 whereas *Body Anxiety* trails behind at 1.817. Interestingly, the overall average rating for the soundscapes' triggering "a re-experience of unpleasant sensations and emotions" is 1.533, much lower than the more positive "vivid emotions" rating of 2.011. All the soundscapes elicited similar levels of "unpleasant sensations and emotions", with *Situational Phobias* prompting marginally higher ratings for this question, rated at 1.567, compared to *Violence* at 1.533 and *Body Anxiety* at 1.500.

On the whole participants were relatively "soothed" by the soundscape exposure experience, with an overall average rating of 1.631. Although *Violence* was perceived as being the most frightening soundscape, paradoxically it stands out as being significantly more soothing (with a "soothing" rating of 2.050 out of a possible 3.000), than *Situational Phobias* rated at 1.517, or *Body Anxiety* rated at 1.325. This is quite surprising, as *Body Anxiety* does include a sequence where many waterfall, rainfall, showers and dripping sounds blast through the speakers simultaneously, which many participants are remarked to have enjoyed, and during which the GSR peak rate decreased significantly (as will be demonstrated in Section 6.3). However, even if the *Body Anxiety* soundscape does provide a period of respite, many of the beginning and concluding sounds are very disturbing and abrasive, from mechanized breaths to frightening hospital alarms, which may have negated the relaxation induced by the short period of soothing water sounds. Further, *Violence* ends with a harmonious lilting cello and piano tune, a resolution of the dissonance in the first three quarters of the soundscape – this seemed to have left a lasting impression.

The second page of the *Post-Soundscape Subjective Perceptions* (2.2.1) prompts participants to recall the most emotive sounds while they were still fresh in their minds, asking them to list the most "frightening", "irritating", "panic-inducing" and "memorable" sounds. *Violence* has the most potent sounds overall, as it is consistently provoked the greatest number of reported "frightening", "irritating", "panic-inducing" and "memorable" sounds out of all the soundscapes. (At present, the content of each list is not surveyed, instead the total number of sounds recalled for each category are counted.) Overall, the soundscape experience had more “memorable" sounds, with an average total of 82 sounds listed per soundscape (an average of 2.733 memorable sounds per soundscape, per participant), followed by “irritating” sounds with an average total of 47 sounds listed per soundscape (an average rating of 1.567 “irritating” sounds per soundscape per participant). There is an average of 43 sounds listed as “frightening” in each soundscape, (1.433 per soundscape per participant) and an average of 30 panic-inducing sounds for every soundscape (one per soundscape per participant).

6.2.4 *Post-Soundscape Mood Change Assessment* (questionnaire 2.2.3)

A short multiple choice questionnaire, the *Post-Soundscape Mood Change Assessment* (2.2.3) measures the short-term mood change induced by each soundscape. For each mood (“happiness”, “pleasure”, “relief”, being “in control”, “relaxation”, “contentment”, “tension”, “depression”, and “sadness”), participants either denote a positive state change by circling “+1”, or no change by circling “0”, and a negative state change by circling “-1”. Overall, there was a consensus of positive change as the average rating for “happiness” is +0.239, “pleasure” is also perceived to have increased by +0.306, “relief” increased by +0.101, a sense of being “in control” rose by +0.022, relaxation increased by +0.189, and contentment by +0.178. There are very minor negative changes for tension of -0.001, whereas depression intensified negatively by a degree of -0.078, and sadness deepened further by -0.100.

The *Violence* soundscape garnered the highest average positive mood changes for “happiness” with a score of +0.367, compared to *Body Anxiety’s* +0.217 and *Situational Phobias’* +0.133). An increase of “pleasure” is also greater following the *Violence* soundscape, with a “pleasure” increase of +0.467, much higher than *Body Anxiety’s* +0.283 and nearly three times the +0.167 “pleasure” increase associated with *Situational Phobias*. *Violence* elicited marginally higher rises in “relief”, at a rate of +0.133, compared to +0.100 for *Body Anxiety* and +0.070 for *Situational Phobias*, as well as higher rates of induced “relaxation,” at +0.233, compared to *Body Anxiety’s* +0.200, and *Situational Phobias’* +0.133. Even a rise in “contentment” is greater when listening to *Violence*, increasing by +0.367 compared to *Body Anxiety’s* contentment increase of +0.167 and *Situational Phobias* average score of zero, for “no change”. However, participants felt far less “in control” when listening to the *Violence* soundscape (as a sense of being in control dropped by an average degree of -0.100) than during *Situational*

Phobias (where a sense of being in control rose by +0.067) and *Body Anxiety* (where again, being "in control" increased, by +0.100). Participants are said to have felt positive change in "tension" (that is, they felt less tense) after *Violence* with an average "tension" alleviation score of +0.067, whereas *Situtational Phobias* elicited a negative change, an intensification of tension by -0.070, and *Body Anxiety's* average equated tension score equated to zero, or no change. The highest negative change, or intensification of "depression" appears to have been triggered by *Body Anxiety,* with a worsening of depression by a degree of -0.167, followed by *Violence* which worsened depression by a factor of -0.100 – but participants felt less depressed after listening to *Situational Phobias*, with a positive change of +0.033. The greatest "sadness" was induced by *Violence*, with an average intensification of -0.167, followed by the response to *Body Anxiety*, which worsened sadness by a degree of -0.133 but there was no perceivable change in sadness elicited by *Situational Phobias* as the sadness change rating averaged at zero, for no change.

6.2.5 *Post-Soundscape Memory Record* (questionnaire 2.2.7)

The *Situational Phobias* soundscape induced more memory recall on average than *Body Anxiety* and *Violence* – indeed this makes sense as the situations depicted in *Situational Phobias* are highly relatable, and encountered regularly, as it is split into the sequences *Time Stress, Agoraphobia, Claustrophobia, Fire* and the most relatable phobia of all *Flying*. In contrast, *Body Anxiety* features a microscopic and abstracted view of our bodily functions (composed of *Breath, Visceral, Water, Eating, Exercise,* and *Hospital* sequences) and thus does not locate the listener in a real place as such (even the *Hospital* scene goes beyond a realistic depiction of a literal hospital environment). Perhaps even more removed from the average participants' everyday lived experience were the sounds featured in the *Violence* soundscape, as there were very few participants who previously stated that they had experienced physical abuse or direct involvements in fights or horror scenarios. In fact, quite often the memories induced by the *Violence* soundscape are not so much real-life experiences as much as memories of fearing horror films. The statistics reflect these differences in the soundscape. In the *Post-Soundscape Memory Record* (2.2.7) participants are asked to rate how frequently memories were triggered during the soundscape, from zero for "not at all" to three for "constantly": for the average soundscape, this was closest to "once, very briefly" (1) as the average rating was 1.082. *Situational Phobias* triggers a higher than average rating of 1.267 (between "once, very briefly" (1) and "2-3 times"

(1.5)), whereas *Body Anxiety's* average memory recall rating is slightly lower than average (1.05), and *Violence's* memory recall rating is even lower (0.931). Participants are also asked to list and describe the most vivid memories triggered. The average participant was reminded of 1.433 events when listening to *Situational Phobias*, 1.333 events during *Body Anxiety* and 1.034 events during *Violence*.

Hypothesis 14 has therefore been confirmed, as the participants' immediate subjective perceptions of the soundscape exposure indicate that the soundscapes are perceived to be slightly louder than everyday, and they are highly immersive. The participants' moods are indeed changed from soundscape to soundscape (most dramatically by the *Violence* soundscape), and memory recall is induced regularly in all soundscapes, but especially so during the realistic *Situational Phobias* soundscape. (Section 6.2)

6.3 Detailed review of GSR data

In Section 5.5, broad implications are discerned from the GSR data: by calculating the number of GSR peaks per minute for the average participant for each soundscape (peaks/minute/participant, abbreviated to pk/m/pt), it becomes apparent that the *Violence* soundscape elicits strong sensations (as shown by peak sweat secretions) the most frequently, at an average rate of 0.86 pk/m/pt. The GSR peak rate for the *Situational Phobias* soundscape was slightly less, at 0.73 pk/m/pt, and *Body Anxiety* elicited even less, only 0.69 pk/m/pt. The difference in the physiological response elicited by participants with higher levels of pre-existing anxiety and participants with lower pre-existing anxiety is also evaluated in Section 5.5 – it appears that the participants with higher pre-existing anxiety do demonstrate a higher peak rate, overall, than the lower pre-existing anxiety participants, for the *Violence* and *Situational Phobias* soundscapes, but not for the *Body Anxiety* soundscape. Here, the GSR data will be evaluated in far greater detail, to offer insights as to why the participants with higher pre-exposure anxiety scores, the HPE group, demonstrated a lower GSR peak rate than the participants with lower pre-exposure scores, the LPE group, during the *Body Anxiety* soundscape. Here, the rises and falls in minute by minute average peak rates from both the HPE and the LPE group, are plotted as a colour coded line graph alongside the graphical timeline of sounds (the *Soundmap*) for each soundscape. Further, a *GSR Peak Timeline* shows each instantaneous GSR peak moment from every participant, represented as a thin black line across the whole page (see the key for the Peak Timeline visualisation in Figure 51).

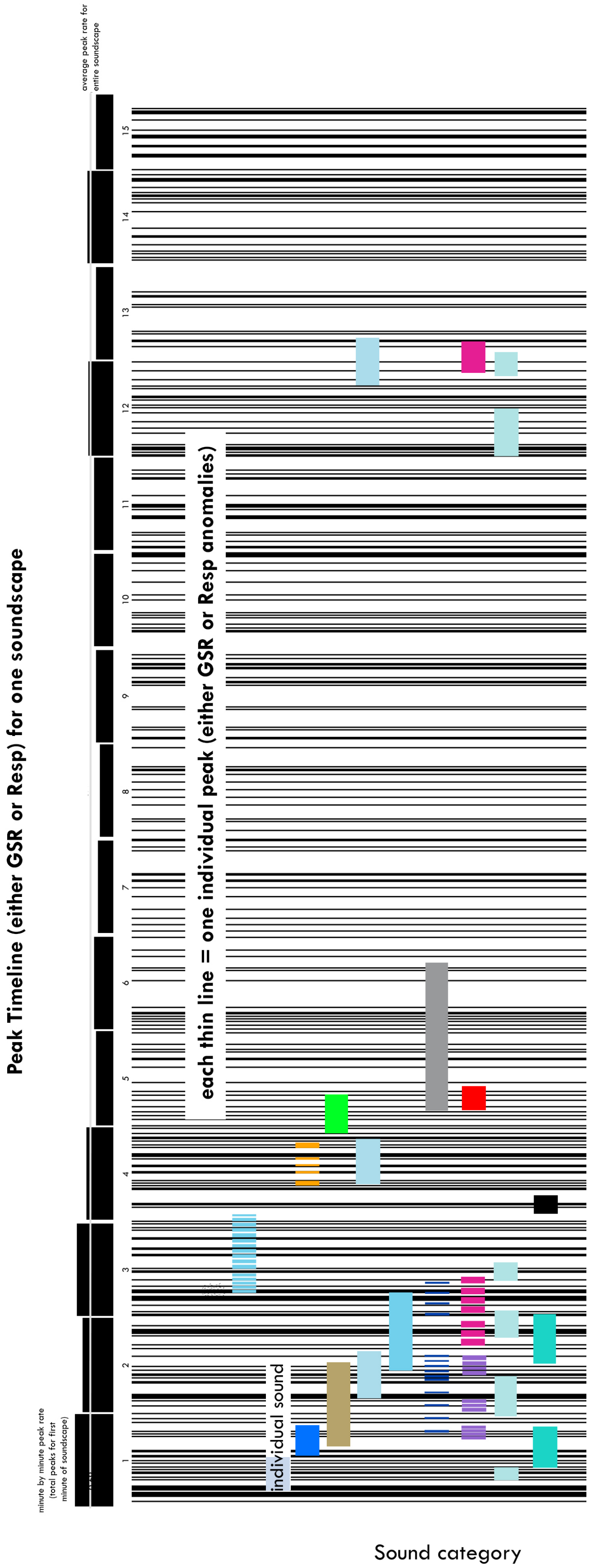


Figure 51: Key for *Peak Timelines* (either GSR or RESP), overlaid onto *soundmap*.

The HPE (higher-pre-existing anxiety) group's minute-by-minute peak rate is represented as a thin red curve at the top of Figure 52, which clearly dips below the green line representing the LPE (lower-pre-existing anxiety) group's minute-by-minute GSR peak rate. The HPE group's peak rate drops far below the 0.65 pk/m/pt average to 0.30 pk/m/pt in minute six, 0.20 pk/m/pt in minute seven, 0.20 pk/m/pt in minute eight, and only rises up to 0.40 pk/m/pt in minute nine (see the central section of Figure 52). Unlike the HPE group, the LPE group does not dramatically deviate from their standard GSR peak rate during this section. Thus, it appears that those individuals who experience higher levels anxiety in everyday life (the HPE group) do not just experience stronger induction of *anxious* sensations than those who are less anxious in everyday life – they are also more receptive towards the *relaxing* sounds. See also the gaps in the bottom GSR peak strip barcode, at the foot of Figure 52, which details all individual peaks over time recorded from the ten participants in the HPE group – minutes six to nine, in the centre, appear to be particularly sparse, with far fewer thin black instantaneous GSR peak lines, compared to the GSR peak strip from the LPE group's peak strip bar code directly above it.

Another intriguing moment of LPE and HPE difference, is that the HPE peak rate is much higher (at 0.90 pk/m/pt) than the LPE group (0.40 pk/m/pt) for minute twelve (to the right of Figure 52), which features stressful "hyperventilation" and an "air slow release sound like cracks in a helmet" alongside a barrage of gymnasium equipment, and frenzied "running in high heels" – all of which when played together certainly seem to tap into memories of panic attacks, or obsessive exercising. Also worth noting, is that the peak rate for the LPE group is substantially higher during minute fourteen (0.80 pk/m/pt) than the peak rate for the HPE group (0.50 pk/m/pt). The sounds featured in minute fourteen are perhaps more universally upsetting, as abrasive "heart monitors beep" erratically, an "FMRI scanner" mechanically churns away, and even a recording of Broadmoor's "psychiatric hospital escape alarm" blares following a tense minute of more innocuous hospital ambiences. It is likely that these sounds resonate with many participant's personal memories of grief or distress in hospitals - pre-existing anxiety is not pre-requisite to show signs of physical arousal induced by these sounds.

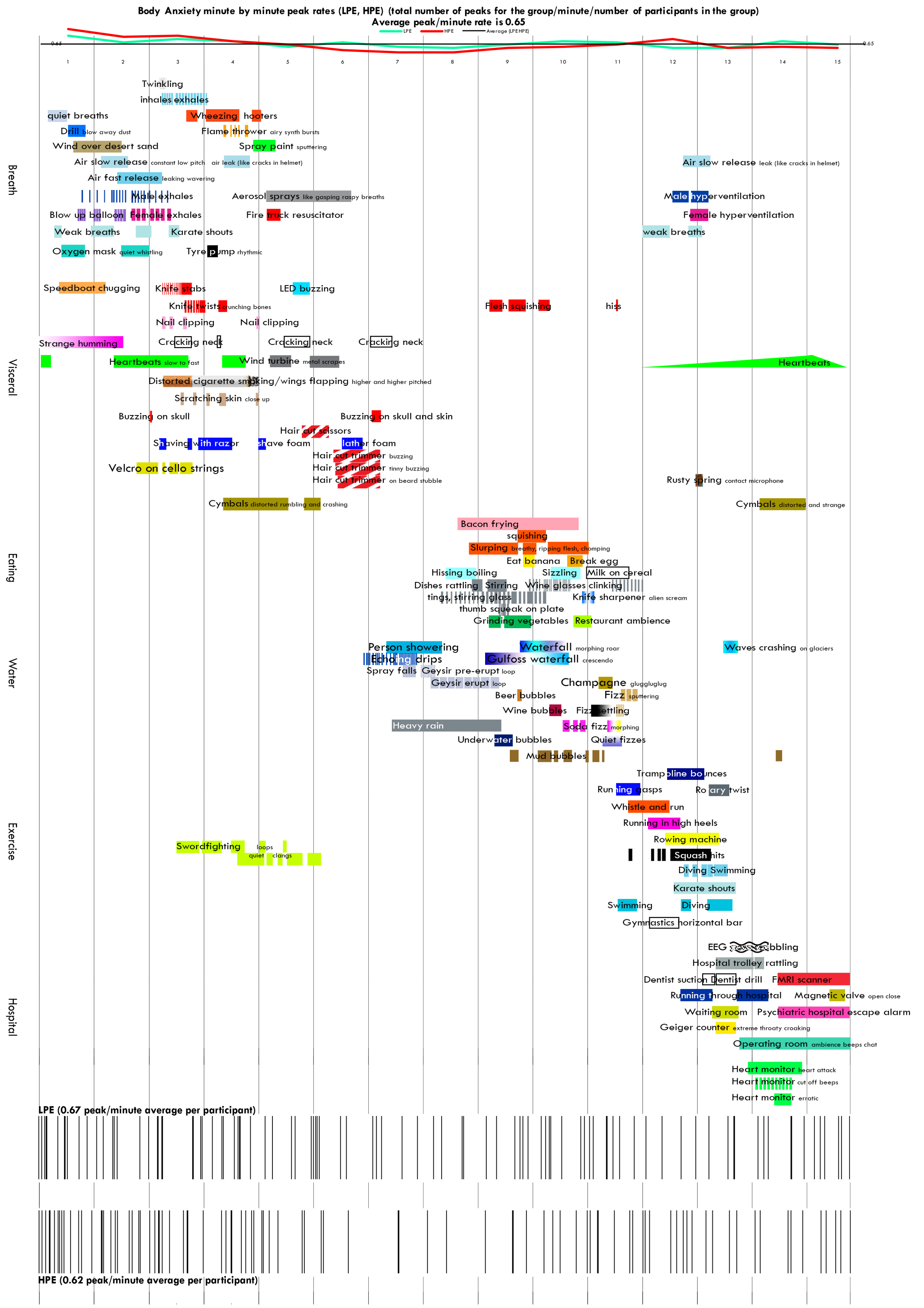


Figure 52: The comparative *GSR Peak Timelines* for the LPE and HPE groups during Body Anxiety.

Overall, it seems the affective state of the HPE group is generally more malleable than that of the LPE group, as the physiology of the participants with higher pre-existing anxiety appears to be more prone to influence by both the aversive, anxiety-inducing sound stimuli and pleasant, relaxing sound stimuli. This heightened physiological response for the participants with higher levels of pre-existing anxiety is also corroborated with their more frequent conscious perception of anxious sensations, as recorded in the *Post-Soundscape Frequency of Perceived Sensations,* questionnaire 2.2.2. The enhanced receptiveness of participants with higher pre-existing anxiety is a fascinating discovery, worthy of further investigation. To recapitulate, those participants who are more anxious in everyday life (the HPE group) became very relaxed at the onset of the soothing water sounds, whereas those who only experience minimal levels of anxiety in everyday life (the LPE group) appeared to be less sensitive to the change in valence of the soundscape. Behavioural observations also corroborate with the quantitative and qualitative measures described above, as those who experience higher anxiety in everyday life became noticeably more anxious during the soundscape exposure session. There are instances recorded in the participants' verbal feedback (which is yet to be transcribed at this stage) where a defensiveness, or irritability is interpreted, which at times is explained by participants to be caused by shock, as they did not expect to be made to feel as anxious as they did (noted particularly by Participant 9).

There are two levels of questioning here: first, which group of participants (out of the lower pre-exposure score group and the higher pre-exposure score group) were the most sensitive to shock or relaxation cues (it appears to be the HPE group); the other question is, what are the specific sounds effective in driving these experiences. Reducing the GSR data to the average number of peaks in each minute of the soundscape, means that the comparisons are quite straightforward. Large-scale differences are apparent in Section 5.5, but a closer look at these *GSR Peak Timelines* is required to identify the salient trigger sounds specific to each group of participants. The sounds which coincide with a surge in GSR peak activity are construed as the most potent, physiologically – usually these are shock sounds, or those construed as physical threats. Intriguing deviations from established trends are also addressed here, such as the HPE's GSR flat-line triggered by the waterfalls section of *Body Anxiety*.

For instance, in the *Violence* soundscape there are a visible cluster of peaks from participants with higher pre-existing anxiety (the HPE group), in minute two (see the second column at the left of Figure 53). However, in the same period there are relatively few peaks from the participants with lower pre-existing anxiety. Minute two of the *Violence* soundscape also happens to elicit the second highest minute-by-minute peak rate for the HPE group of 1.50 pk/m/pt (the highest peak rate is actually found in minute one, 1.60 pk/m/pt as the build-up of ominous sounds becomes saturated with threatening noises, such as sporadic high frequency "removing nail from wood," "tiger growls" circling around the listener, "metal squeaks" and dramatic and repeating "car crashes, head on collisions.") It is significant that the GSR peak rate recorded from the HPE group consistently stays higher than that of the LPE group from minute four until minute twelve of the *Violence* soundscape. The minute with the third highest GSR peak rate for the HPE group is minute four of the soundscape (at 1.30 pk/m/pt, as it begins with alarming "geese shrieking" and concludes with menacing, digitally multi-layered, ascending cello loops, akin to the supra-expressive orchestral scores of horror films.

The minutes with the fourth highest GSR peak rates for the HPE group are minute seven and minute eight, both at 1.00 pk/m/pt – minute seven features the extremely antagonistic, and consistently startling machine guns circling the listener. The LPE group's GSR peak rate for the eighth minute, immediately after the bombardment of gunshots is also particularly high at 1.00 peaks/minute, rising 0.20 peaks/minute above the average for these groups. Following this, peak rates steadily decline for the HPE group staying below average, as the cello and piano melody resolves, the previously dissonant clashing tones become harmonious and elegiac, whilst many of the chaotic sounds fade out leaving a sparser, easily digestible soundscape. Although the GSR peak rate largely declines for the LPE group too, towards the end of the *Violence* soundscape, it appears to rise in conjunction with minute twelve where the listener has only just become used to the gentler, harmonious nature of the soundscape, when "searing, high pitched saws" cruelly burst out of nowhere. This sudden intrusion of an unpleasant sound memory has been purposefully placed to simulate the nature of intrusive thoughts or memories that can plague the consciousness of a highly anxious person, or a Post-Traumatic Stress Disorder sufferer. Thus, it is all the more intriguing that the participants with little anxiety in everyday life are actually more unsettled by this according to the GSR data, than those who have actually experienced mental perturbations – perhaps the low pre-existing anxiety participants (the LPE group) are particularly frightened by these unpleasant disruptions as they have not previously experienced unwanted intrusive thoughts associated with mental ill health, thus they are unprepared.

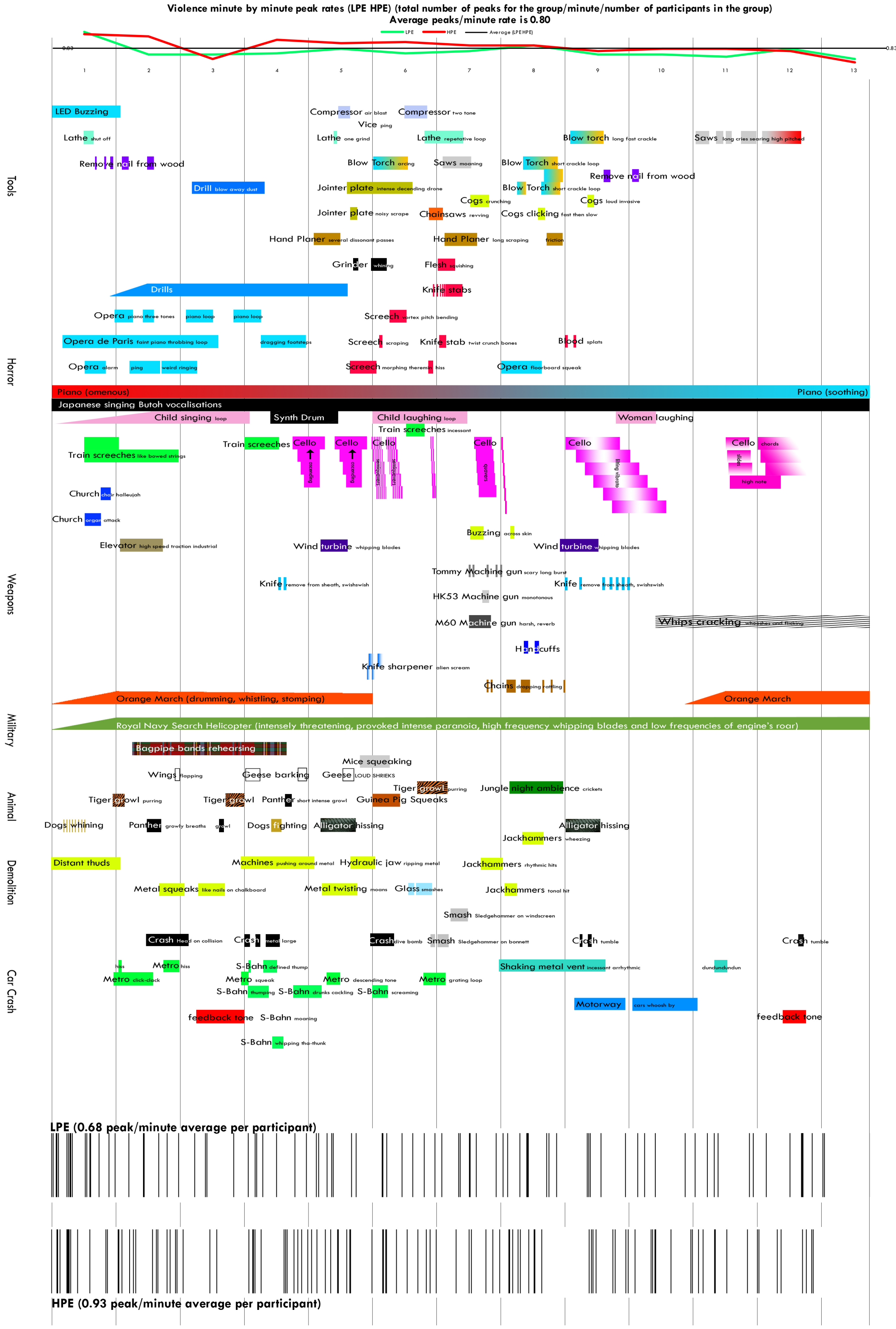


Figure 53: The comparative *GSR Peak Timelines* for the LPE and HPE groups during Violence.

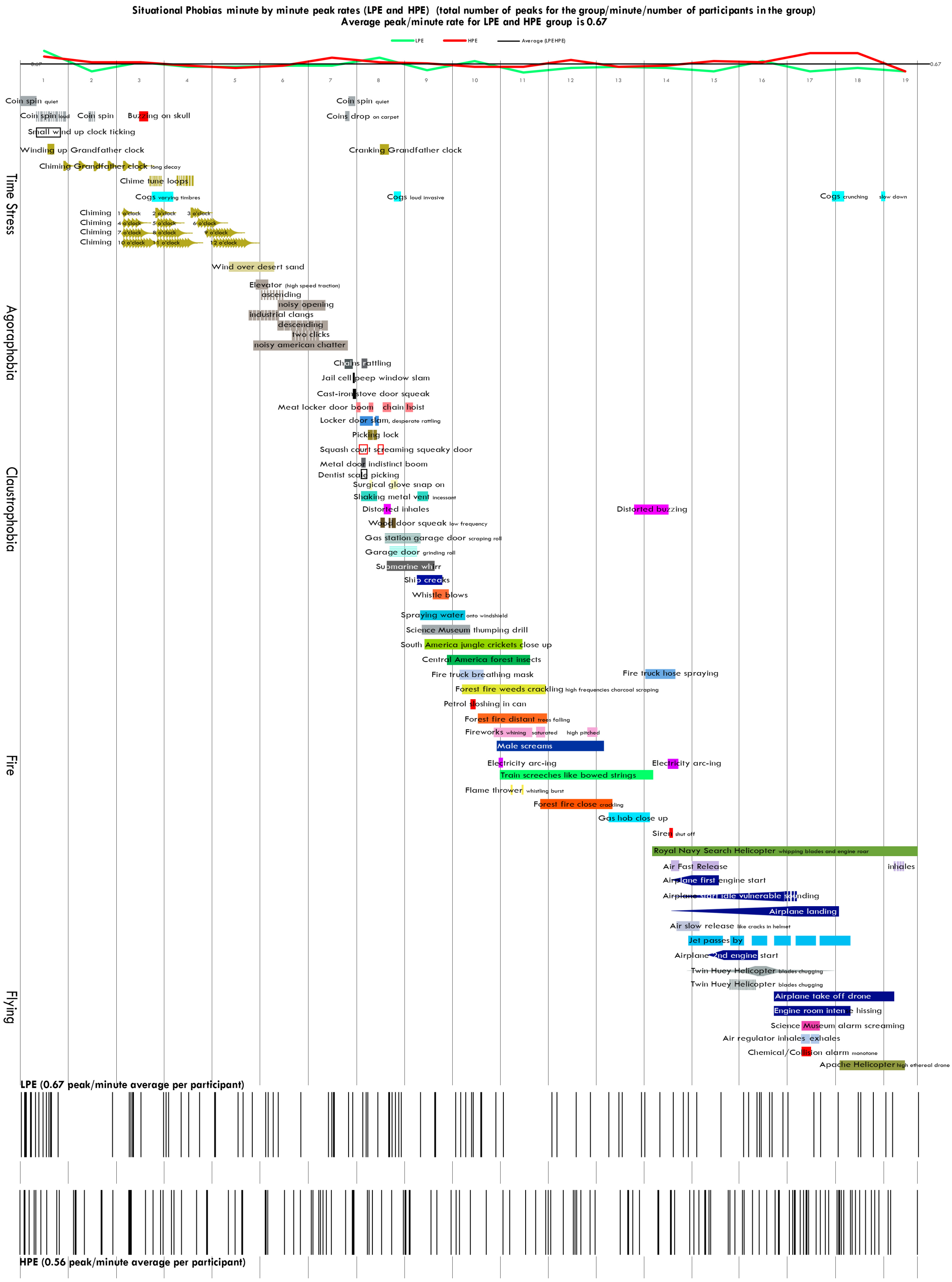


Figure 54: The comparative *GSR Peak Timeline* for the LPE and HPE groups during *Situational Phobias*.

During the *Situational Phobias* soundscape, there are some consistent patterns in rises and attenuation of GSR peak rates that both the LPE group and the HPE group follow, but there are some intriguing splits in response, particularly during minutes seventeen and eighteen, the *Flying* section. Also, it appears that the LPE group's peak rate is much lower during minute two of the *Time Stress* section (see the top left of Figure 54), in which the sound is quite sparse, only featuring a coin spinning and one grandfather clock chiming quite gently. The LPE group's peak rate is at 0.20 pk/m/pt in minute two, compared to the HPE group's peak rate of 0.80 pk/m/pt, which is above the average for these groups (0.67 pk/m/pt). The HPE group's peak rate is also much higher than the LPE group's peak rate for minute seven (the HPE group peak rate is at 1.10 pk/m/pt compared to the LPE's 0.60 pk/m/pt), where, very suddenly, a chain drops from above along with many coins, mixed much louder than they would be in real life, as if they are larger than life. This metallic drop this commences a cacophony of slamming doors to illustrate *Claustrophobia* in minute eight. Whilst the HPE group's peak rate remains above average for minute eight (at 0.80 pk/m/pt), it is notable that the LPE group's peak rate (at 1.10 pk/m/pt) exceeds the HPE group for this din of prison, meat locker, and garage doors all slamming or squeaking on their hinges. As soon as the slamming stops in minute nine, the LPE group's GSR peak rate drops dramatically (down to 0.30 pk/m/pt), far below the average, as a wash of "spraying water on a windshield" saturates the soundscape, along with more organic sounds of "South America jungle crickets".

In minute ten of the *Situational Phobias* soundscape, the LPE group peak rate (0.90 pk/m/pt) rises above that of the HPE group (0.50 pk/m/pt) again – this surge in physiological activity is due to the highly immersive, realistic and quite disorientating multiple "forest fire" ambiences blaring through all the speakers simultaneously. The HPE group actually demonstrate a lower than average peak rate for the beginning of the *Fire* section, but this surges again in minute twelve (doubling up to 1.00 pk/m/pt) as the "forest fire close crackling" is blended with more disturbing human elements that together paint a picture of inherent danger. Short repetitive loops of hauntingly reverberant "male screams" and "train screeches like bowed strings" (both recorded in Grand Central Terminal, New York) seep out from the more intimate fire sounds, which proves to be very disturbing. It is fascinating that the participants with low pre-existing anxiety (the LPE group) demonstrate surges in the GSR peak rate at the immediate onset of the fire sounds, but the higher pre-existing anxiety participants seem to respond more to the fire sound as it becomes imbued with disturbing connotations. It is as if the low anxiety group shows instant elicitation of strong sensation (GSR peaks) in response to the immediate impression of the acoustic features alone, whereas the higher anxiety group needs more substantial psychological cues, such as disturbing sound metaphors to demonstrate signs of anxiety.

Both the LPE group and the HPE group's GSR peak rate remains relatively constant for minute thirteen and fourteen (0.50 and 0.40 pk/m/pt for the LPE group, and 0.50 and 0.60 pk/m/pt for the HPE group), but the LPE group's peak rate drops by half (to 0.20 pk/m/pt) in minute fifteen as the next sound category is introduced, *Flying*. Conversely, the HPE group's peak rate rises above average in minute fifteen (to 0.90 pk/m/pt), and continues to positively surge far beyond the average in minutes seventeen and eighteen, sustaining a rate of 1.40 pk/m/pt (over double the average for these groups, of 0.67 pk/m/pt.). Again, this heightened physiological activity coincides with the introduction of disturbing sound effects to an established base ambience of interior flight sounds, as three sounds are added to the mix which would be terrifying in that context: "Science Museum alarm screaming children," "air regulator inhales exhales," "chemical/collision alarm." Whilst the LPE group's GSR peak rate increases marginally, it does not rise above the average, nor does it approach the HPE group's GSR peak rate in minute eighteen.

Next, the *GSR Peak Timelines* for the participants who heard each soundscape as the first out of the three soundscapes, or the second or the third in the sequence are compared to pinpoint moments of listener fatigue. The *GSR Peak Timelines* are again presented as barcode strips showing every individual peak recorded from each of the three groups at the foot of the page, whereas line graphs show the rise and fall in minute-by-minute peak rates at the top of the page. It is predicted that the first soundscape heard by the participant will be the most anxiety-eliciting (as shown by the most frequent provocation of GSR peaks) as this is quite often the participant's first experience of a soundscape presented in an ambisonic array – it is novel and exciting for many. The participant is also at their most vulnerable during the first soundscape, as they do not know what to expect, as there is little indication of how loud or how abrasive the sounds will be (other than the reassurance that the soundscape exposure experience is ethically safe per the World Health Organisation's standards). However, it can also be argued that by the time that the second soundscape is played, a strong GSR response should still be elicited, as the listener has "warmed up" as it were, and calibrated to this immersive soundscape set up. Participants even tend to enter a flow state by the second soundscape, where they are listening in a very engaged manner, comfortable but constantly tracking the sounds. Upon hearing the third soundscape however, the listener is usually quite exhausted, psychologically and physically, thus usually more habituated to the anxiety trigger sounds, as several are repeated or are similar throughout the soundscapes. Due to the experiment's lengthy duration and the rigorous questionnaire methods used, the participant may also become slightly bored by the third soundscape, thus less sensitive or less reactive to the unpleasant sounds. Nevertheless, for a select few participants, the strongest emotional reaction took place in the second or third soundscape, such as Participant 20's profoundly visceral experience of the *Situational Phobias* soundscape (played as the third soundscape in their sequence), or Participant 29's tears elicited by the *Body Anxiety* soundscape (played as the second soundscape for them). However, many more participants experienced their most intense reactions during the first soundscape they heard, such as Participant 35 who cried towards the end of the *Violence* soundscape as they thought they heard a child crying (their first heard soundscape), and Participant 9, who re-experienced uncomfortable flashbacks to past panic attacks when confronted with the disturbing mechanised *Breath* sequence at the start of *Body Anxiety* (also their first heard soundscape).

Judging from both the length of the written responses and the numerically quantifiable increase in the GSR peak rates elicited, it can be confirmed that the participants' first heard soundscape tended to provoke the most intense experience both emotionally and physically. For instance, the surge in the GSR peak rate is much more pronounced in the group of participants who were exposed to *Violence* as their first soundscape, particularly when many "machine guns" begin to fire in minute seven - the GSR peak rate reaches 1.10 pk/m/pt in minute seven, rising from a rate of 0.90 in minute six (see the dark grey line in top centre of Figure 55). (Participants are nearly always visibly startled at onset of these gunshots which are sent from all directions, usually jumping or at least flinching - again all participants' flinches have been video-recorded, but analysis of this measure is still yet to be undertaken.) However, if the participants had already heard one or two soundscapes prior to being exposed to *Violence*, they are generally more familiar with the set-up and usually lulled or habituated by this point. So, during the gunshots, the jump in GSR peak rate is far less in minute seven for the participants who are listening to *Violence* as the second or the third soundscape. Those who heard *Violence* as their second soundscape demonstrate a GSR peak rate of 0.60 pk/m/pt in minute seven (dropping from a rate of 0.70 in the previous minute), and those who heard *Violence* as their third soundscape show a peak rate of 0.80 pk/m/pt in minute seven, which is the same as the previous minute, and still below the average of 0.86 pk/m/pt.

Differences in GSR peak rates are apparent even in the first two minutes of the *Violence* soundscape. The GSR peak rates of the participants who heard *Violence* as the second or third soundscape in their exposure sequence attenuate from the first to the third minute (the peak rate of the second heard group drops from 2.20 pk/m/pt in minute one, to 0.80 pk/m/pt in minute three, whilst the peak rate of the third heard group drops from 1.30 peaks/minute in minute one, to 0.20 pk/m/pt in minute three). However, the GSR peak rate of the participants who heard the soundscape first rises even further above the average (0.86 pk/m/pt) in the second minute to 1.80 pk/m/pt, as menacing “tiger growls,” high pitched “nails being removed from wood” and dissonant “bagpipe bands rehearsing” all fade in. During minute five, demonic “screeches” and aggressive “cello ascending” loops crescendo, and again the GSR peak rate is the highest in the participants who heard *Violence* as the first soundscape, reaching 1.30 pk/m/pt, compared to only 1.00 peak/minute/participant for those who heard *Violence* as the second or the third soundscape. Although the frequency of individual GSR peaks becomes quite sparse for the participants who are listening to *Violence* as the third soundscape of the exposure sequence (see the bottom peak barcode strip at the foot of the Figure 55), a noticeable cluster of peaks appears midway through minute nine, at the onset of a sudden “car crash tumble,” the beginning of a relentless loop of an arcing “blow torch long fast crackle,” “loud invasive cogs,” along with two “blood splats,” and the re-occurrence of the high pitched “nails being removed from wood” which seems to arouse a high GSR response, as in minute two – other than those sounds there is a relatively pleasant “cello lilting vibrato” sequence. It is strange that the peak rate for the participants who are listening to *Violence* as their last soundscape are particularly receptive to this period – perhaps the gentle cello sequence is encouraging the tired participants to let their guard down by relaxing, only to cruelly blast out abrasive sounds again, and thus the participants have rendered themselves more sensitive to these sounds by this point.

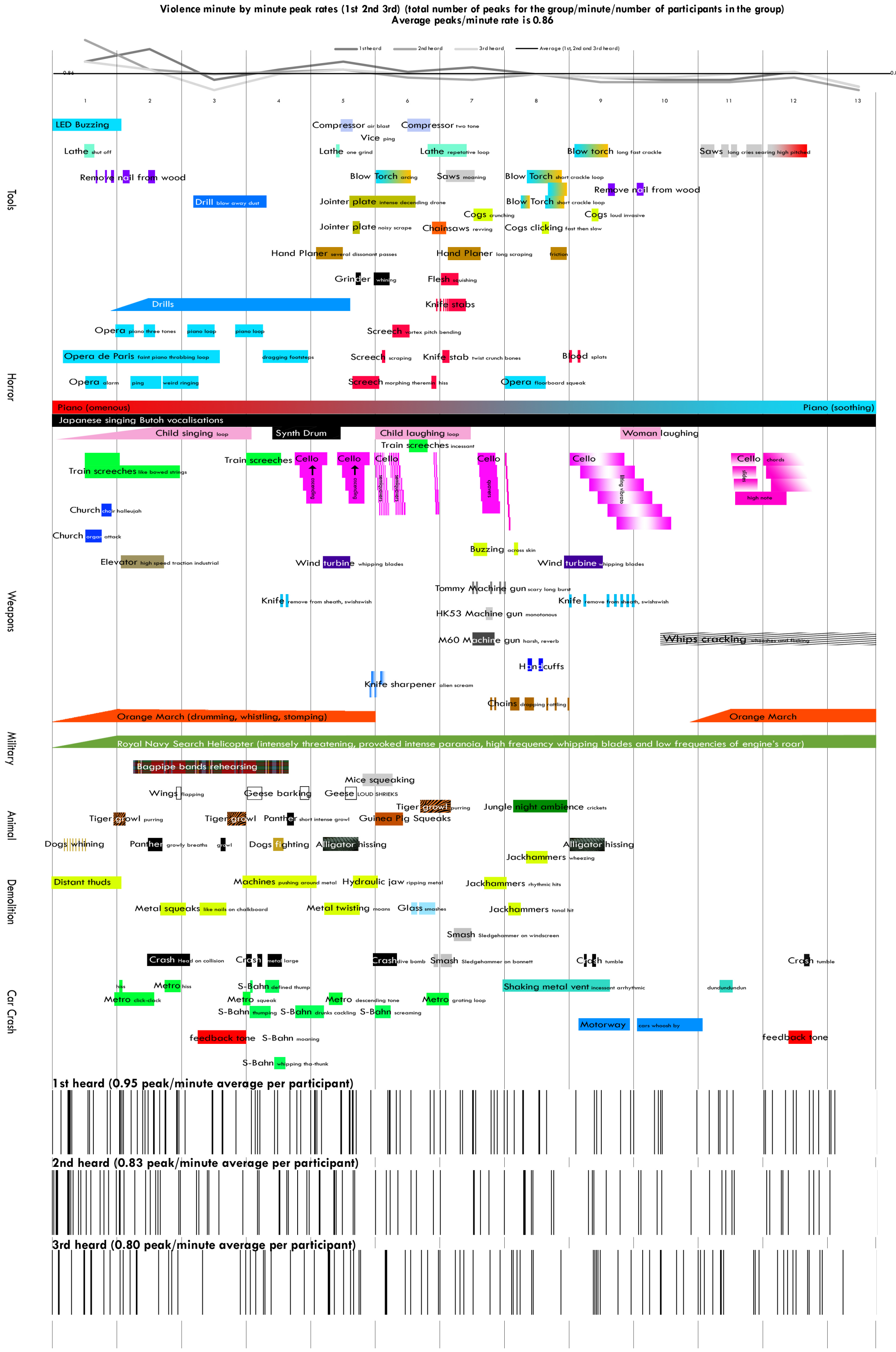


Figure 55: Comparative *GSR Peak Timelines* for the participants who heard *Violence* as the first, second or third in the soundscape.

Overall, there are far more GSR peaks elicited for listeners who heard the *Situational Phobias* soundscape as the first in the sequence, compared to the response of participants who heard the *Situational Phobias* as the second or third in the sequence of soundscapes. This amplified reaction to *Situational Phobias* from those who heard it first is seen in the denser concentration of individual peaks as presented in the top barcode peak strip at the foot of Figure 56, and the rise of darkest grey line far above the lighter grey lines, representing minute by minute GSR peak rates. This dramatic dimming in physiological response for the participants who heard the soundscape as the second or third in the sequence is likely because it is the most realistic of the soundscapes. If the participants have already been exposed to the more perceptually challenging, visceral music concrète of *Body Anxiety*, or the mood-altering music and repeated horror "stingers" within *Violence*, the *Situational Phobias* soundscape seems positively tame in comparison. However, if it is heard first, the participants are more easily impressed or affected by the real-world scenarios depicted across ambisonic spatial array (the immersive audio laboratory experience is a first for many).

Key moments of intensified GSR peak rates for the participants who heard the *Situational Phobias* soundscape as the first in the sequence fall on minutes seven, eight, ten and twelve. The sudden cacophony of slamming doors in the *Claustrophobia* sequence bursts out loudly from a relatively quiet droning of an elevator ascending and falling during the *Agoraphobia* sequence, over minute seven and minute eight: "chains rattle", a "jail cell peep window slams", a "cast iron stove door squeaks", a "meat locker door booms" and a "chain hoists", a "locker door slams", a "lock is picked", the hinges of a "squash court door scream" throughout a reverberant space - even a surgical glove snaps on and signs of struggling sound through the incessant shaking of a metal vent. Both semantically and acoustically, minutes seven and eight are particularly frightening, especially for participants who are experiencing immersive soundscapes for the first time, so it makes sense that the peak rate for these participants is so high: 1.30 pk/m/pt for minute seven, and 1.50 pk/m/pt for minute eight. The participants who heard the *Situational Phobias* soundscape after already hearing the *Violence* soundscape or the *Body Anxiety* soundscape or (both) is considerably lower. The participants who heard it second in the sequence generated an average GSR peak rate of 0.50 pk/m/pt for minute seven, and a rate of 0.70 pk/m/pt for minute eight. The participants who heard *Situational Phobias* as the third soundscape generated a rate of 0.60 pk/m/pt for minute seven, and a rate of 0.50 pk/m/pt for minute eight.

In minute five, the participants who heard the soundscape as the third in the sequence have a much lesser peak rate than both the participants who heard the soundscape as the first in the sequence and the second, at 0.10 pk/m/pt, compared to those who heard the soundscape as the first or second in the sequence who both showed a rate of 0.70 pk/m/pt. This is likely due to intense boredom, as minute five is a deliberately repetitive, almost maddening chiming of a clock tower (marking twelve o'clock, so thus twelve long chimes) only complemented by a subtle "wind over desert sand" at the end of minute two, as well as a gradual fade in of a "high speed traction elevator". The opening theme of the *Situational Phobias* soundscape is *Time Stress,* and the repeated bells chiming are included to elicit a complex reaction, perhaps partly of frustration of its excessive repetition, or boredom at the relative stasis of the soundscape, or of meditative calm in the same way that Indian religions use the sacred Om sound.

Similarly, there are a greater number of peaks in the GSR data for the group that heard *Body Anxiety* first in the exposure sequence, compared to when it was heard second or third. Whilst all three groups generally follow a similar trend of attenuation from minute one to minute ten, followed by a slight rise in signal from minute eleven to minute fourteen, there are several moments of difference between the participant groups. For instance, the participants who heard *Body Anxiety* as the first soundscape in the sequence, sustained a particularly high peak rate from the *Breath* sequence in minute one (see the top left of Figure 57) (1.60 pk/m/pt), minute two (1.40 pk/m/pt) and minute three (1.60 pk/m/pt) only attenuating slightly during the *Visceral* sequence at minutes four (0.90 pk/m/pt), five (0.70 pk/m/pt), six (0.90 pk/m/pt) and seven (0.70 pk/m/pt), only dropping below the average peak rate (0.68 pk/m/pt) at the onset of the relaxing *Water* section at minute eight (dropping to 0.50 pk/m/pt). A faster habituation to abrasive sounds is seen in the GSR response of participants who are listening to *Body Anxiety* as the second or third soundscape in the exposure sequence, as the GSR peak rate attenuates much more rapidly and significantly during the *Breath* and *Visceral* sequences. The GSR peak rate of those who heard *Body Anxiety* as the second soundscape drops from 1.20 pk/m/pt in minute one to 0.30 pk/m/pt at minute six, and the peak rate of the participants who heard *Body Anxiety* as the third in the sequence drops from 0.70 pk/m/pt in minute one to 0.50 pk/m/pts in minute six.

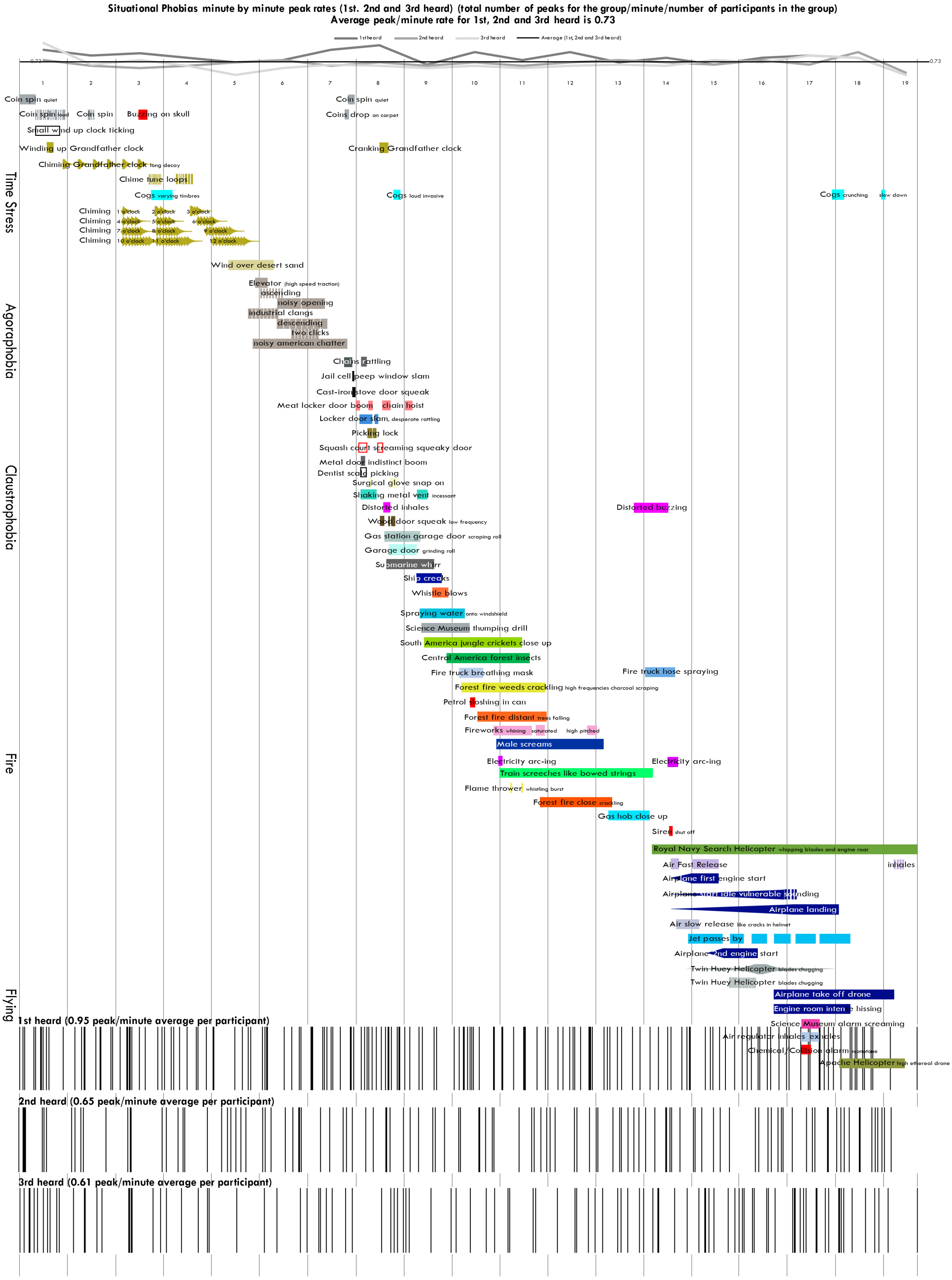


Figure 56: Comparative *GSR Peak Timelines* for the participants who heard *Situational Phobias* as the first, second or third in the soundscape.

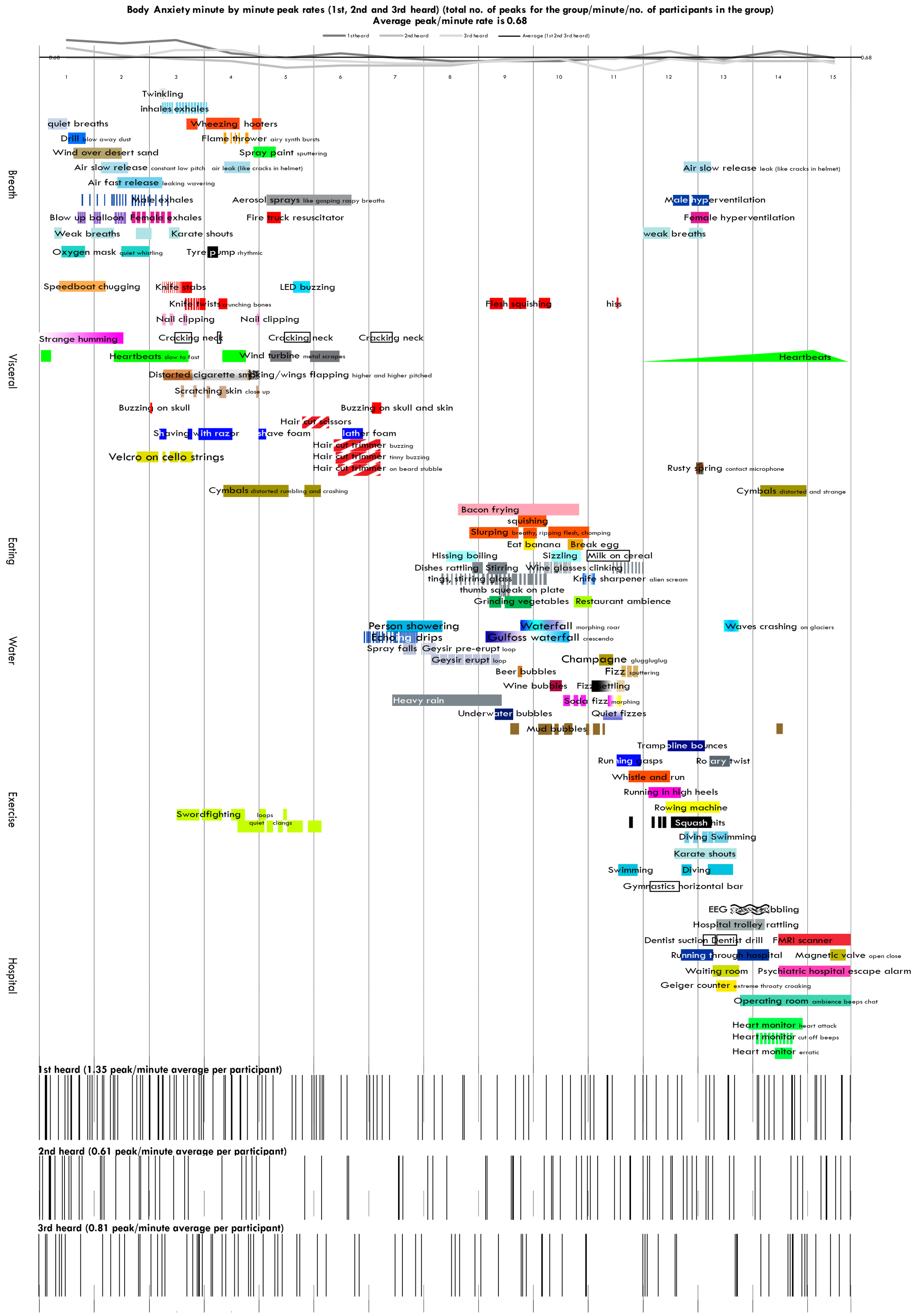


Figure 57: Comparative *GSR Peak Timelines* for the participants who heard *Body Anxiety* as the first, second or third in the soundscape.

Further, during minute eleven, there are no GSR peaks recorded *at all* by any of the participants who are listening to *Body Anxiety* as the third soundscape (a rate of 0.00 pk/m/pt). Minute eleven consists is a relatively gentle collection of “soda fizzing” and “champagne glugging” sounds at the end of the *Eating* sequence – sounds which both acoustically and semantically innocuous, and even quite pleasant, so it is understandable that this relaxation period is reflected as such in the GSR data. (In comparison, the participants who are listening to the *Body Anxiety* soundscape as the first or second in the sequence of soundscapes demonstrate moderate peak rates during minute eleven – a rate of 0.70 pk/m/pt for the first heard group, and a rate of 0.60 pk/m/pt for the second heard group. As expected, the participants who listen to the *Body Anxiety* soundscape as the first in the sequence demonstrate a much higher peak rate in minute fourteen, when the hospital ambiences become saturated with erratic “heart monitor beeps,” an “FMRI scanner” and a psychiatric hospital alarm. The GSR peak rate for the first heard group is 1.00 pk/m/pt during minute fourteen, whereas it is only 0.50 pk/m/pt for the second heard group, and 0.90 pk/m/pt for the third heard group.

Hypothesis 15 has been confirmed, as the sounds that elicited the greatest GSR peak rates are those which are the most antagonistic or those which have negative causal associations. GSR peak eliciting sounds are antagonistic in terms of acoustic abrasiveness, composed of high frequency, chaotically noisy, rhythmically erratic, percussive or dissonant musical forms – these proved to be “saws,” “digitally manipulated cellos,” and “geese shrieking” in the *Violence* soundscape, the sudden onset of “chiming bells,” “chains dropping” and “doors slamming” in the *Situational Phobias* soundscape, and “hyperventilating,” “exercise sounds” and a cacophony of “hospital machinery bleeping” in the *Body Anxiety* soundscape. GSR peak eliciting sounds often have negative causal associations, indicative of physical threats, violent connotations, mechanistic sounds or disgusting taboo sounds – these proved to be “machine guns” and “car crash” in the *Violence* soundscape, “slamming doors,” “male screams in forest fires” and “alarms in jet interior” in the *Situational Phobias* soundscape, and uncannily repeated “exhales” or “hyperventilation and “visceral” sounds in the *Body Anxiety* soundscape.

Hypothesis 16 is also confirmed, as attenuation of GSR peak rates appears to coincide with more pleasant sounds, in terms of acoustic smoothness (lulling repetition, harmonic musical forms, or soothing quality) or positive causal associations (natural sounds, vibrant social atmospheres). The attenuation of GSR peak rates is especially visible during the organic “waterfalls” in the *Body Anxiety* soundscape, as well as the resolution of previously dissonant music to “harmonious piano” and “lilting cello vibrato” in the *Violence* soundscape, and the final repeated “bells chiming” or the vibrant ambience of “South America Jungle crickets” in the *Situational Phobias* soundscape. As predicted in Hypothesis 17, the hypothesized GSR peak rate increases in response to abrasive shock sounds and attenuations in response to relaxing pleasant sounds are more pronounced in in the hyper-sensitive groups, such as the HPE group (higher pre-existing anxiety) and the participants who are listening to a soundscape as the first in the exposure sequence.

6.4 Implications from respiration data (detail)

Respiration data is collected from participants using a respiration belt, tightly placed around the participant’s ribs. An inspiration of breath (an inhale) causes an increase of tension on the belt, which is digitally sampled as a series of increasing numbers, whereas an expiration of breath (an exhale) is recorded as a series of decreasing numbers. The resultant data stream of thousands of numbers for each participant’s experience of a soundscape can be converted to a line graph over time, resembling a saw-tooth wave. Each participant’s respiration line graph is surveyed, and the five deepest inhales (peak breaths) and gaps in the wave form (which are inherently anomalies in respiration rates) are plotted along a collective timeline for all participants. This collective *Respiration Peak/Anomaly Timeline* is then overlaid onto the corresponding soundscape’s *Soundmap,* so it becomes easy to pinpoint the sounds that frequently triggered large gasps or shocked the participants so much that they forgot to breathe. A cohesive collation of all participant’s salient respiration anomalies is plotted on one page for each soundscape, in a similar format to the *GSR Peak Timeline* analysed previously; here the *Respiration Peak/Anomaly Timeline* shows each participant’s instantaneous peak or anomaly as one thin black line running down the entire *Soundmap*, so epochs with many shared anomaly points can be identified. It is possible to count the number of inhales per minute, to generate average respiration rates, but identification of peak inhales and anomalies in breathing patterns (such as pauses, or short stifled breaths) is the most appropriate for this study, whose principal aim is to pinpoint the sounds which instantaneously trigger a strong sensation in the listener, disrupting their resting state. Tracking the minute-by-minute respiration rate is less valuable for this study, as subtle drifts in breathing speed can be somewhat arbitrary.

The limitation of analysing a stand-alone physiological signal, is that whilst these peak or breath anomalies do pinpoint moments of strong emotion during soundscape listening, there is no indication of whether this is a positive or negative sensation induction. The strong sensation peaks and anomalies can only be identified as indications of positive or negative emotion by correlating with the video footage of participant's facial expressions. However, this task is too time-consuming, outwith the scope of this three-year project. Nonetheless, much valuable information can be gathered by taking these peaks and anomalies as a sign of physiological arousal, and thus strong sensation without necessarily discovering if it is a positive or a negative sensation. It is significant that for the *Violence* soundscape, that there are many more peak breaths towards the end of the soundscape, where there is a clear change in tone as the music becomes more soothing and harmonious (noted by numerous participants) and the barrage of sounds gradually disperses. This can be observed as a surge in the respiration anomaly rate to 0.900 anomalies/minute/participant during minute eleven and minute twelve, which is 0.333 anomalies/minute/participant higher than the average rate (see the right of Figure 58). However, it might be construed that the participants generally are merely showing signs of fatigue towards the end of a soundscape, taking deep breaths or letting out sighs.

Another significant increase in anomalies occurs during minute seven of the *Violence* soundscape, where the anomaly rate surges to 0.700 anomalies/minute/participant, as participants are bombarded by the sounds of "knife stabs," frantic electronically manipulated "cello quavers" and the notoriously startling onslaught of multiple "machine guns" firing. This increase in respiration anomalies corroborates with the previous GSR detail appraisals and with the near universal identification of this moment as an anxiety trigger in the *Post-Soundscape Frequency of Perceived Sensations* (2.2.2) as charted in the next section, Section 6.5.

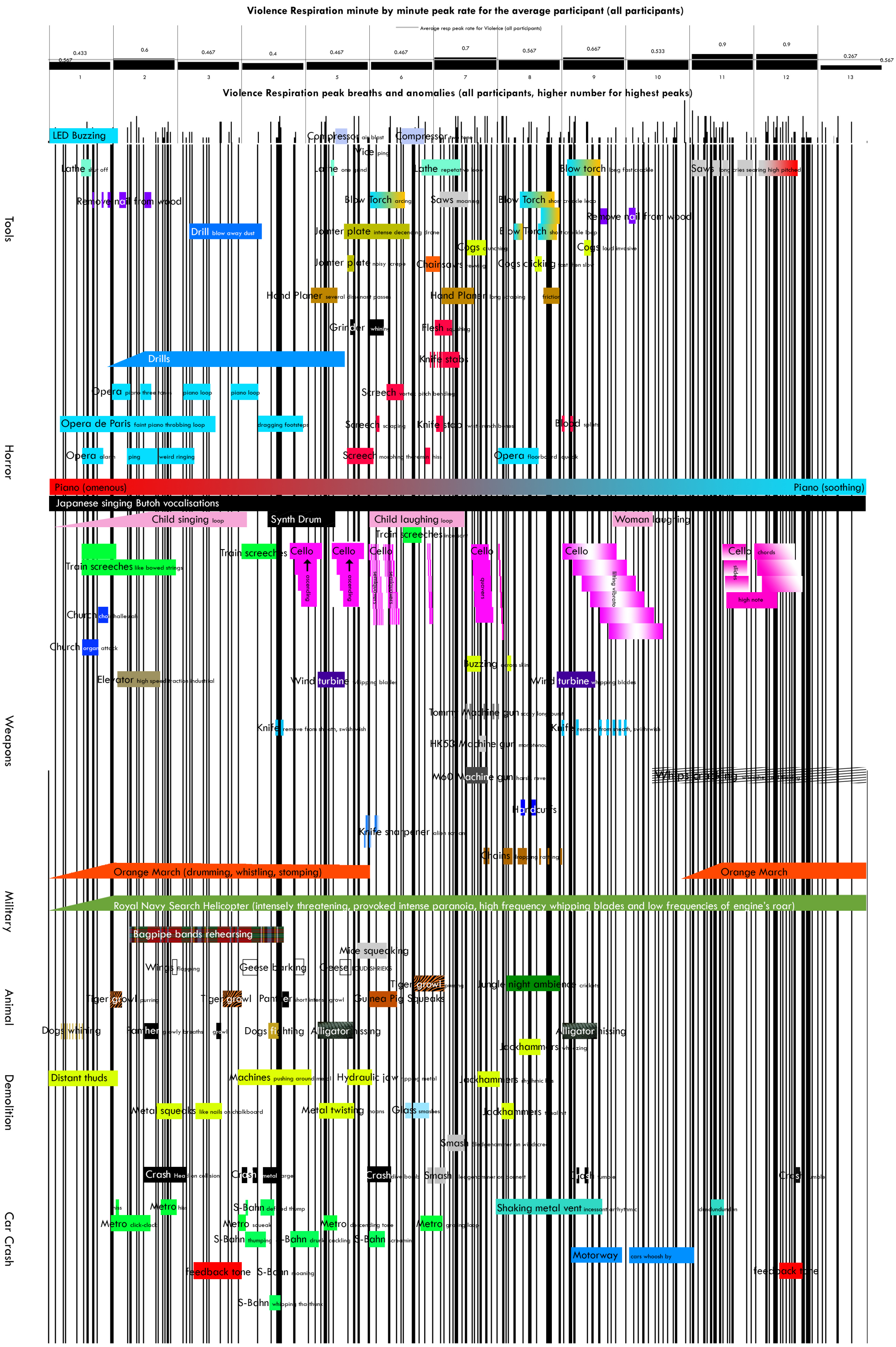


Figure 58: *Respiration Peak Breath/Anomaly Timeline* from all participants for the *Violence* soundscape

The periods that induced many respiration anomalies in the *Situational Phobias* soundscape fall on minute eight (sudden doors slamming in the *Claustrophobia* sequence) minute twelve (the disturbing combination of "male screaming" and "close forest fires"), and overwhelmingly during the *Flying* sequence, minutes sixteen, seventeen and eighteen. These periods where many participants either breathed in very deeply or forgot to breath can be seen clearly in Figure 58, as several clusters of anomalies (appearing as thick black lines running centrally down the image, in minute eight), and as a dense concentrations of thin lines throughout the *Flying* sequence, to the right of Figure 59. The respiration anomaly rate is 0.533 anomalies/minute/participant during minute eight (0.101 anomalies above the average anomaly rate of 0.432 anomalies/minute/participant), 0.600 anomalies/minute/participant during minute nine, and 0.700 anomalies/minute/participant during minute sixteen, 0.733 anomalies/minute/participant during minute seventeen, and 0.667 anomalies/minute/participant during minute eighteen.

Further, during the eighth minute *Body Anxiety* soundscape, a period of high frequency of anomaly breaths among all participants coincides with the *Water* sequence (which is also frequently referred to as a trigger of strong sensation in the *Post-Soundscape Frequency of Perceived Sensation*, questionnaire 2.2.2.). In the *Respiration Peak Breath/Anomaly Timeline* for *Body Anxiety* (Figure 60), there is a distinctly dense cluster of respiration anomalies forming a column slicing through the mid-point of the soundscape timeline. This high concentration of respiration anomalies coincides with the saturation of water sounds; the anomaly rate at its highest during this eighth minute of the soundscape, at 0.667 anomalies/minute/participant (0.191 anomalies higher than the average anomaly rate of 0.476 anomalies/minute/participant). This rules out the possibility that the increase in anomalous breathing activity is only caused by listener fatigue, towards the end of a soundscape - instead there are salient respiration anomaly points throughout the timespans of each the three soundscapes.

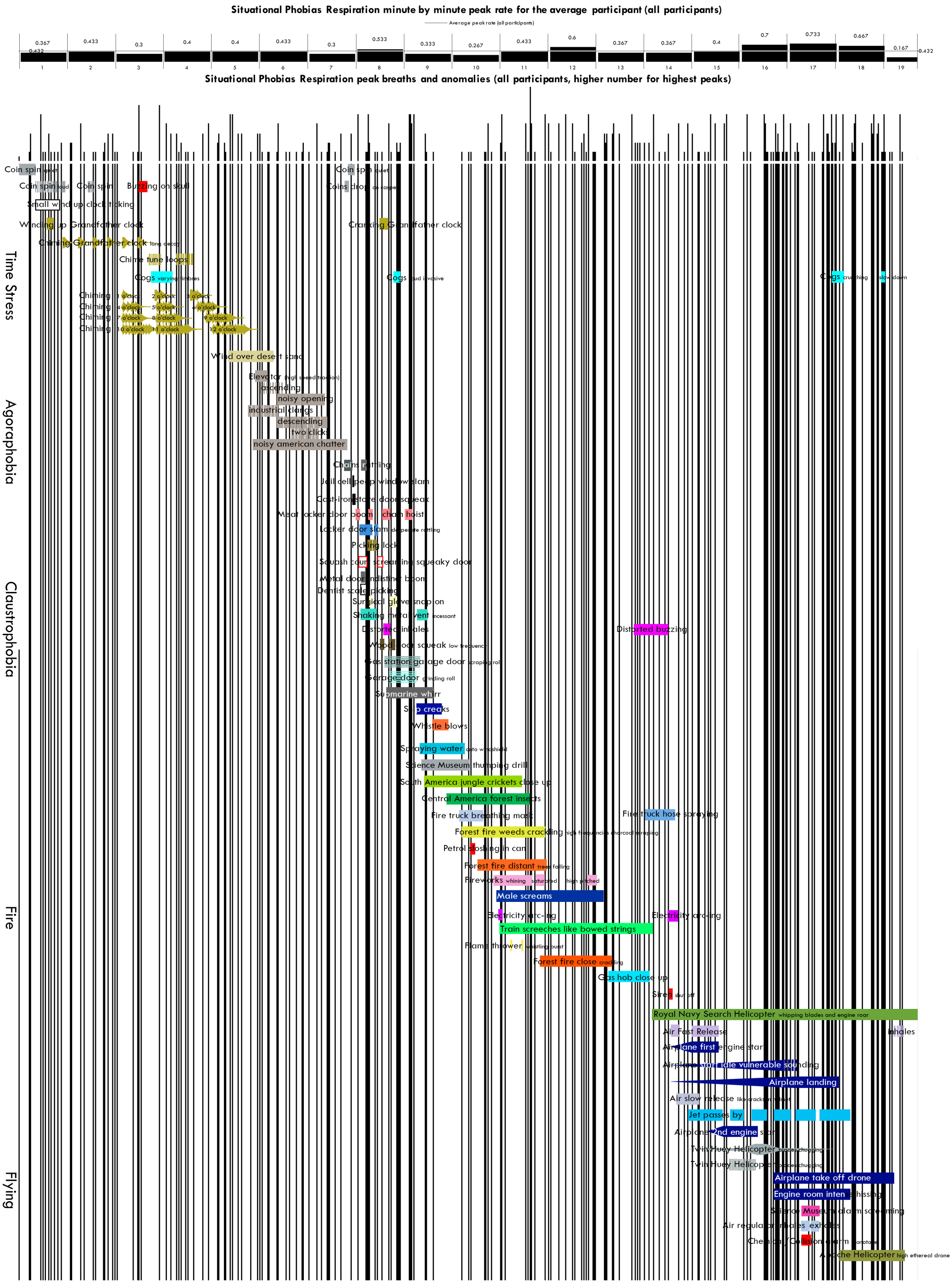


Figure 59: *Respiration Peak Breath/Anomaly Timeline* from all participants for the *Situational Phobias* soundscape

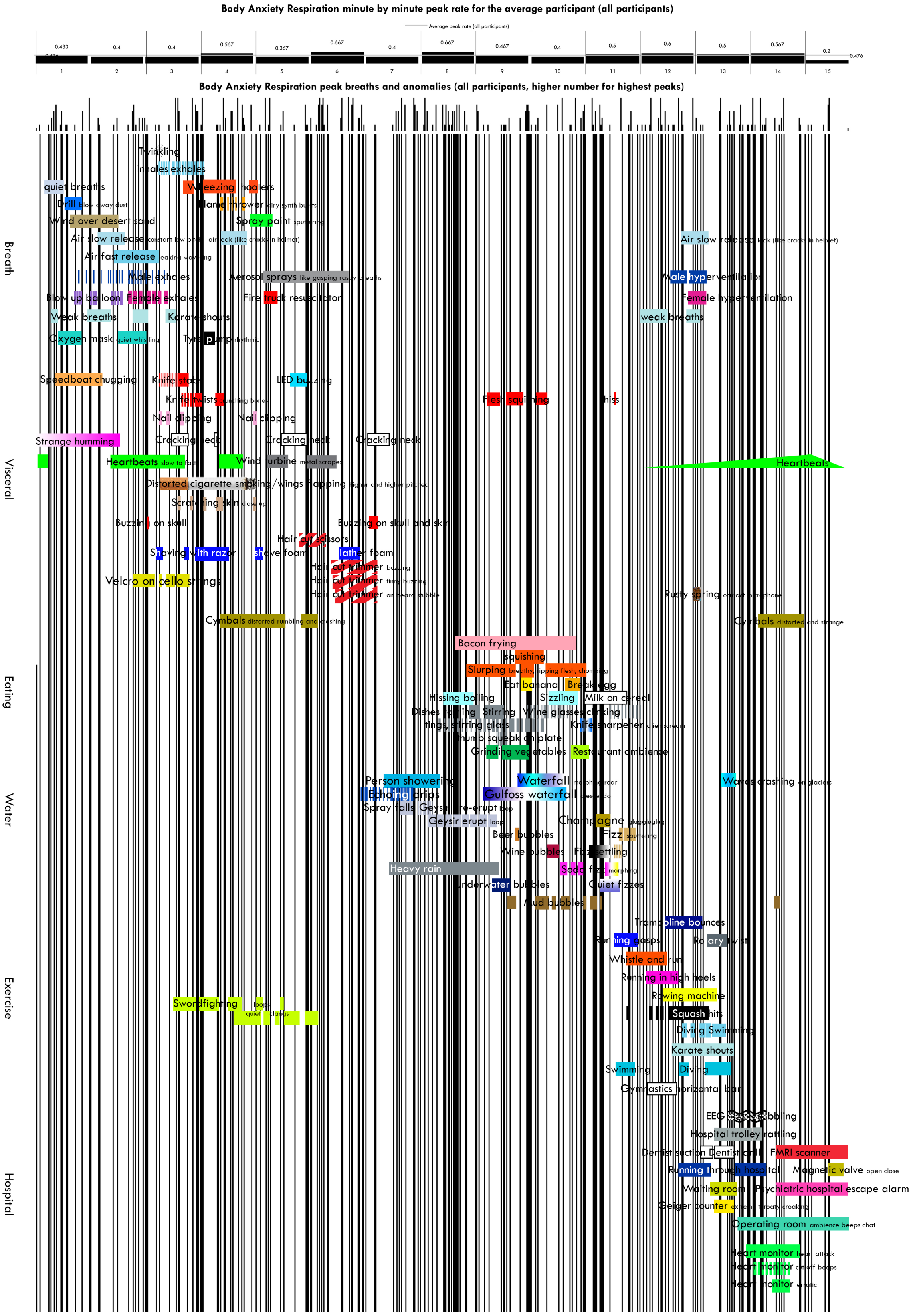


Figure 60: *Respiration Peak Breath/Anomaly Timeline* from all participants for the *Body Anxiety* soundscape

In conclusion, the peak breaths and the anomalies in respiration rates seem to coincide with the sounds which are also consciously perceived as a trigger of strong sensation (according to the *Post-Soundscape Frequency of Perceived Sensation*, questionnaire 2.2.2). These are either particularly fearful sounds (such as the startling "machine guns" in *Violence*, the relentless "doors slamming" or the suspenseful *Flying* sequence in *Situational Phobias*) or the especially relaxing or beautiful sounds (the immersive *Water* sequence in *Body Anxiety,* or the harmonious resolution of previously dissonant cello and piano melodies at the end of the *Violence* soundscape). As outlined in Hypothesis 18, a greater concentration of respiration anomalies occurs during the already established triggers of strong sensation *Post-Soundscape Frequency of Perceived Sensations* (2.2.2), particularly alarming, suspenseful or pleasant sounds.

6.5 Analysis of efficacy of sounds

The soundscape that most frequently that triggered the strong sensations associated with anxiety can be identified by combining data from the questionnaire responses (particularly the *Post-Soundscape Frequency of Perceived Sensations,* questionnaire 2.2.2) along with the physiological data. *Violence* seemed to trigger strong sensations most frequently, as perceived by participants in the *Post-Soundscape Frequency of Perceived Sensations,* questionnaire 2.2.2, as the average decimal percentage for the overall sensation ratings is 0.195 for *Violence* (out of a possible decimal percentage of 1.000), marginally higher than *Situational Phobias* with an overall sensation rating of 0.188, and still higher than *Body Anxiety* which only generated an overall sensation rating of 0.179. Further, the most potent soundscape as indicated by the questionnaire responses can also be corroborated by the Galvanic Skin Response data, notably by establishing the total peak rate from all participants. The average peak rate for *Violence* is 0.86 pk/m/pt, but *Situational Phobias* only elicited an average of 0.73 pk/m/pt, and *Body Anxiety* appears to be even weaker only eliciting 0.69 pk/m/pt (see Section 5.5).

A more detailed investigation to find the most salient trigger sounds is conducted in Section 6.3, as the individual sounds which elicit a universally high rate of GSR peak elicitation are pinpointed. It is also hypothesised that each participant's GSR peaks might align with their individual personal trigger sounds (as reported in the *Pre-Exposure Trigger Diagnosis*, questionnaire 1.2). However, to confirm this hypothesis would be a very time-consuming process, out-with the scope of this three-year project. It would be necessary to generate 30 unique *GSR Peak Timelines* for each individual participant, each mapped onto the participant's personalised *Pre-Exposure Trigger Sound Timeline,* and analyse each of these to then tally the number of GSR-peak/pre-exposure trigger correspondences. This lengthy process would need to be repeated for each soundscape, so 90 unique *GSR Peak Timeline/Pre-Exposure Trigger Sound Timelines* would need to be produced. This is an intriguing hypothesis, which warrants further investigation if time allows, but as of yet, this measurement has not been analysed.

Here, individual sounds are identified which are the most frequently reported triggers of strong sensation in the *Post-Soundscape Frequency of Perceived Sensations* (2.2.2). Discovery of the individual sounds which are the most unanimously reported as sensation-triggering allows the researcher to generate a meaningfully prioritized database of sounds for future use in exposure therapy, where each sound is given a potency rating. Further, whether these particularly potent sounds are triggers of positive or negative sensations can be assessed in Section 6.5.1, as a database of the most frequently liked or disliked sounds is gathered.

In the *Violence* soundscape, "machine guns", "cellos", "violin", and "Japanese singing voices" stand out as the sounds most consistently reported as triggers of strong sensation. For the *Situational Phobias* soundscape, *Time Stress* sounds (very quiet "coins spinning" and then sudden onslaught of "chiming bells") elicit many mixed reactions (generating almost equal numbers of likes and dislikes) followed by *Flying* with 69 mentions. There appears to be less consistency in nomination of the most potent sounds for the *Body Anxiety* soundscape – the sound most commonly reported as sensation-triggering is a "dentist drill," but there are only 42 mentions of it in total. More generally, it can be discerned easily which sound categories were the most frequent elicitors of strong sensation, such as the *Horror* category (which include music and voices), or the *Flying* category.

Unanimously, the sound category most frequently attributed to causing anxiety in the *Post-Soundscape Frequency of Perceived Sensations* (2.2.2) from the *Violence* soundscape is *Horror*, as 322 sounds are identified in total. The next most potent causes of strong sensation are the *Weapons* category (with 103 mentions), the general *acoustic qualities* (with 80 mentions) such as “the entire soundscape”, “loud sudden noises”, “prolonged noises and cacophony”, the *Animal* category (76 mentions), and the *Power Tools* category (56 mentions). The less frequently mentioned causes were sounds associated with *Demolition* (32), *Car Crash* (22), or the *Military* (18). The *soundscape exposure therapy conditions* triggered strong sensations in 15 instances (such as “a general sense of fear,” “listening with attention” and “awareness of own breath”), and the *spatialisation of the sound* inspired six reports as a trigger of strong sensation. The significantly high number of instances that a *Horror* sound acted as an anxiety trigger warrants further explanation. In this soundscape, the horror category includes sounds specifically designed to elicit mortal fears, sounds associated with murder. *Horror* sounds are defined here as those adhering to the generic, conventional tropes associated with horror movies, especially body horror. *Horror* sounds include visceral “knife stabs” and “flesh squishing”, enhanced by hints of the emotional manipulation evoked by horror non-diegetic musical scores (from “ominous piano” to “harmonious airy cello”). There are also allusions to the supernatural – the ethereal shrieks and the expressive, seemingly castrato singing is reminiscent of *Giallo* soundtracks. *Giallo* is a low budget, aesthetically exaggerated, surreal movement of Italian horror, the outstanding example being Dario Argento’s *Suspiria* (1977), which explores a witches’ coven masquerading as a ballet school – the principal enigma set out in *Suspiria* is that the soundscape is saturated with rasping breaths and shrieks, suggesting the hidden witches’ omnipresence, a libidinal score meticulously arranged by progressive rock group, Goblin. Uncanny, slightly dehumanised sounds are also included in the *Horror* sequence in the *Violence* soundscape, such as supra-expressive cello voices, which here are arranged as extremely short extracts from classical music, layered in a very slightly delayed canon. Five copies of the same loop emerge from different speakers, each playing several miliseconds after the other, as if the cello is stuttering – this expands the traditional mode of presenting a cello as one mono sound source, spreading it throughout the spatial array. Western listeners are undoubtedly conditioned to elicit a fear response to these horror cues, as we are familiar with their associations in film, television and games.

For the *Situational Phobias* soundscape, the *Time Stress* section included the most written about individual sound (“chiming bells” which is reported as a trigger of a strong sensation 101 times) also earning the most “like” ticks on the graphic *Soundmap*. However, the *Situational Phobias* sound category that most frequently triggers strong sensations overall is *Flying*, which is mentioned 238 times in total in the *Post-Soundscape Frequency of Perceived Sensations,* questionnaire 2.2.2. As expected, the next most potent sound category is *Time Stress*, which was written about 195 times in total, followed then by the *Fire* section is reported as a trigger of strong sensation 162 times. *Claustrophobia* is reported as sensation-triggering 73 times, and *Agoraphobia* only 26 times – this makes sense, as it is a markedly sparse and subtle interlude consisting of isolated “wind on desert sands” and the clicking of a “high speed traction elevator”. There are also 28 reports of the *acoustic qualities* in general triggering strong sensations: namely, “the entire soundscape”, “high pitched metallic sounds”, “sudden” or “grating noises”. The *Situational Phobias* soundscape also generated 28 reports of the *spatialisation of the sounds* as a trigger of strong sensation. The panning of sounds appears to be much more noticeable (or indeed capable of eliciting strong sensations) in this soundscape, as *Body Anxiety* only inspired twelve comments about spatialisation, and *Violence* only six.

Many of the themes in the *Body Anxiety* soundscape gained nearly equal numbers of responses. The *Breath* sound category is the one that is most frequently reported as a trigger of strong sensations, 135 times, closely followed by the *Water* identified as a cause of strong sensations 124 times. *Hospital* sounds are reported as sensation-triggering 116 times, *Visceral* sounds 95 times, and *Exercise* sounds 79 times. It must be pointed out that a great deal of the strong sensations induced by *Water* sounds are positive. The *spatialisation of the sounds* was mentioned as a cause of a strong sensations in twelve instances, and the *acoustic qualities* in general are reported as sensation-triggering 50 times (mostly the pleasure induced by moments “when unusual sounds became rhythmic” or the “volume” of the soundscape’s playback).

Individual sounds from *Violence* which stand out as being identified the most frequently as the trigger for a strong sensation (in the *Post-Soundscape Frequency of Perceived Sensations,* questionnaire 2.2.2) in descending order are: “machine guns”, mentioned 88 times, “harmonious piano,” mentioned 74 times, as well as “cellos” mentioned 70 times, and “(Japanese) singing voices” with 62 mentions. It is to be expected that these sounds are the most commonly reported as triggers of strong sensation, as these are not only the most acoustically dominant sounds in terms of timespan (the musical sounds are continuous throughout the whole soundscape) but they are often the loudest, at the acoustical forefront of the soundscape. The “machine guns” section is the soundscape’s main climax, specifically engineered to startle the listener, bursting out from a relative dip in volume. This is a classic manipulation of the aural reflex, where a sound will be much more shocking if a period of near-silence precedes it, as the ears are in a sensitive, attentive mode. Other sounds commonly reported as triggers of strong sensation are "music" (reported 26 times), "the entire soundscape" (reported 25 times), sounds "fading out" (reported 24 times, mostly a trigger for relief), "tiger" (reported 20 times), "animal" (reported 16 times), "car crash" (reported 15 times), "saws" (reported 14 times), "piano dischord" (reported 13 times), "crying" (reported 12 times), "screeching" (reported 12 times), "electricity crackling" (reported 11 times), "piano sombre, low, sad, omenous" (reported 10 times), and "bagpipes" (reported 10 times). Many other sounds are only reported sporadically, with the number of reports in single figures (see Figure 61 for a comprehensive list).

The most consistent sensation-triggering sound from the *Situational Phobias* soundscape (and indeed across the board) is the sound of "loud, sudden repeated chiming church bells/gong/dongs", attributed to triggering strong sensations 101 times. *Flying* is also mentioned as a trigger of strong sensation 69 times, as well as a specific reporting of "jet engine noise (increasing in pitch)" 32 times, in addition to the concurrent "alarms/siren/beep" reported 19 times, the "respiratory equipment/ventilator/air regulator/breathing mask" report 18 times, and a "plane take off" reported as a trigger 15 times. *Fire* is reported as a trigger of strong sensation 38 times, as are fireworks, 21 times, and the "accompanying jungle crickets and insects" are reported as sensation-triggering 28 times. The *Claustrophobic* "doors slamming" is reported 16 times (along with numerous mentions of specific types of doors and other bangs totaling to 72 mentions overall). "Ticking clocks" are also identified as a trigger of strong sensation 30 times. All the sounds which are reported as a trigger of strong sensation are listed in Figure 62, including those which trigger sensations less consistently than the sounds just discussed.

Whilst *Body Anxiety* features fewer sounds that are as unanimously reported as a trigger of strong sensation (none which are reported over a hundred times), there are still several which are reported many times. Both "breaths" and "dentist drill" sounds are reported as a trigger of strong sensation 42 times each, and the sound of a "heartbeat pounding" is reported 32 times. Sounds more often construed as a trigger of a pleasant sensation include a "haircut trimmer" reported 30 times, as well as "water" sounds which are reported 18 times, "waves crashing" is reported 22 times, "seashores" are reported 18 times, and "heavy rain" is reported 21 times. Sounds with unpleasant semantic connotations and abrasive acoustic qualities that are frequently reported as a trigger of strong sensation include the sharp scraping sounds of "swordfighting/knives/metallic work," reported 18 times, as well as "psychiatric hospital escape alarm" reported 19 times, general "hospital" sounds reported 18 times, a “ventilator/respirator/oxygen mask” is reported 17 times, along with the chilling swoosh of “aerosol sprays,” reported 16 times, and finally a “heart monitor beep” is also reported 15 times. There are many more sounds which are reported as a trigger of strong sensation fewer than ten times – for a comprehensive overview see Figure 63.

Thus Hypothesis 20 is now confirmed to be true, as the sounds most frequently perceived as a trigger of strong sensation in the *Post-Soundscape Frequency of Perceived Sensations* (2.2.2) are indeed those which are the most antagonistic, in terms of acoustic abrasiveness (high frequency, chaotically noisy, rhythmically erratic, dissonant musical forms, percussive) or negative causal associations (physical threats, violent connotations, mechanistic sounds or disgusting taboo sounds). In the *Body Anxiety* soundscape and the *Violence* soundscape, some of the more pleasant sounds are also the most frequently reported, in terms of acoustic smoothness (lulling repetition, harmonic musical forms, or soothing quality) or positive causal associations (natural sounds, vibrant social atmospheres).

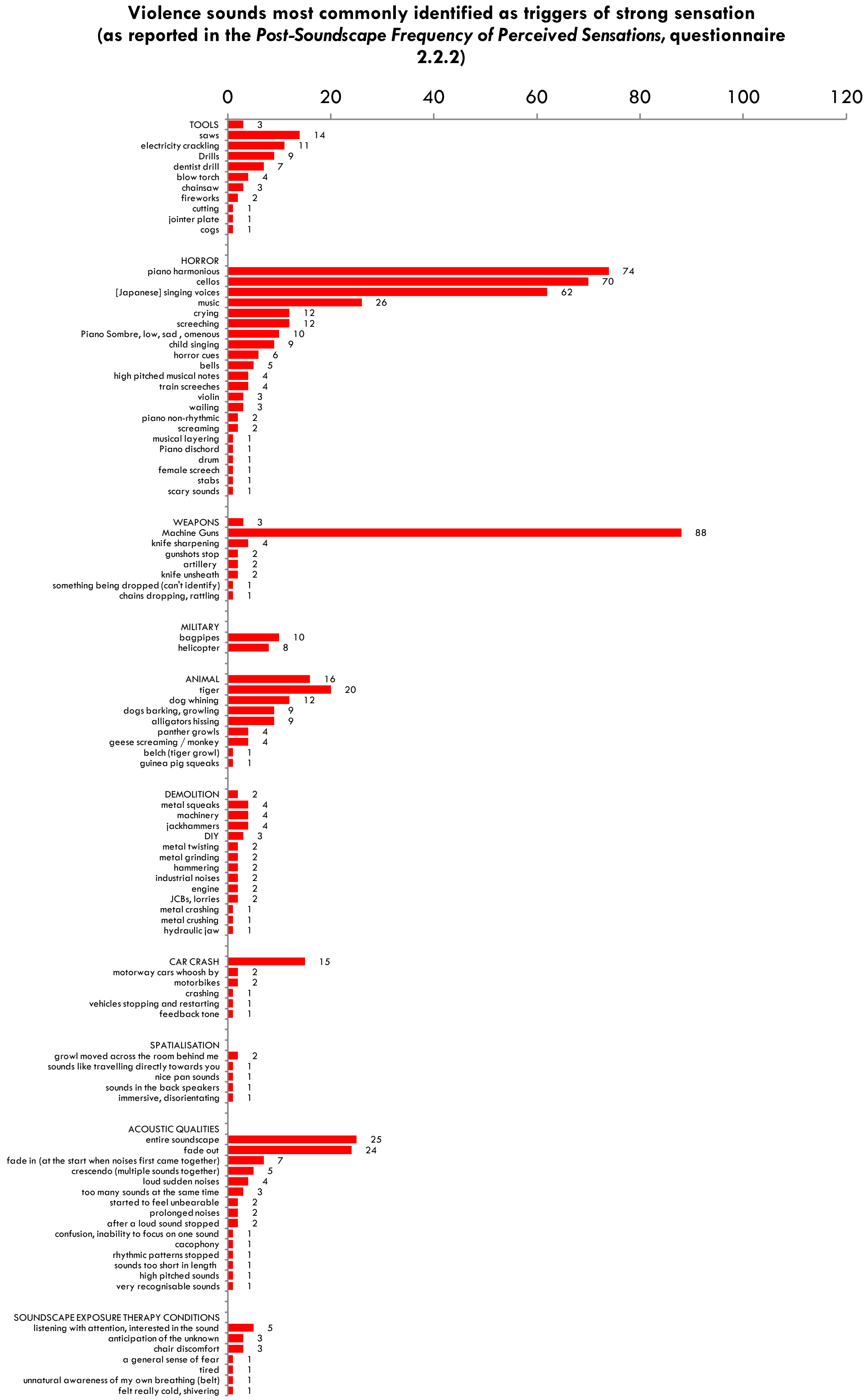


Figure 61: The most frequently reported triggers of sensation during *Violence*

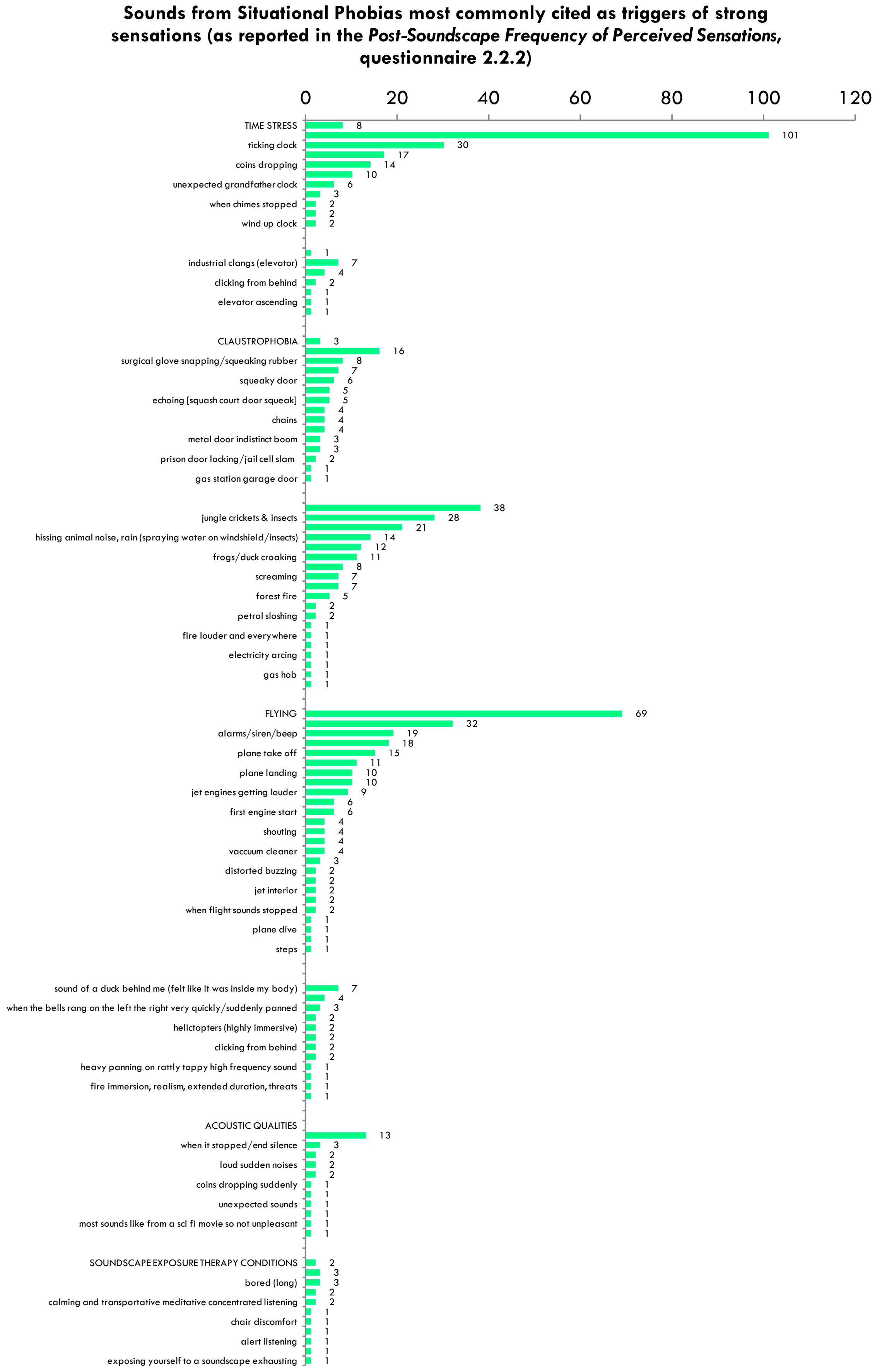


Figure 62: The most frequently reported triggers of sensation during *Situational Phobias*

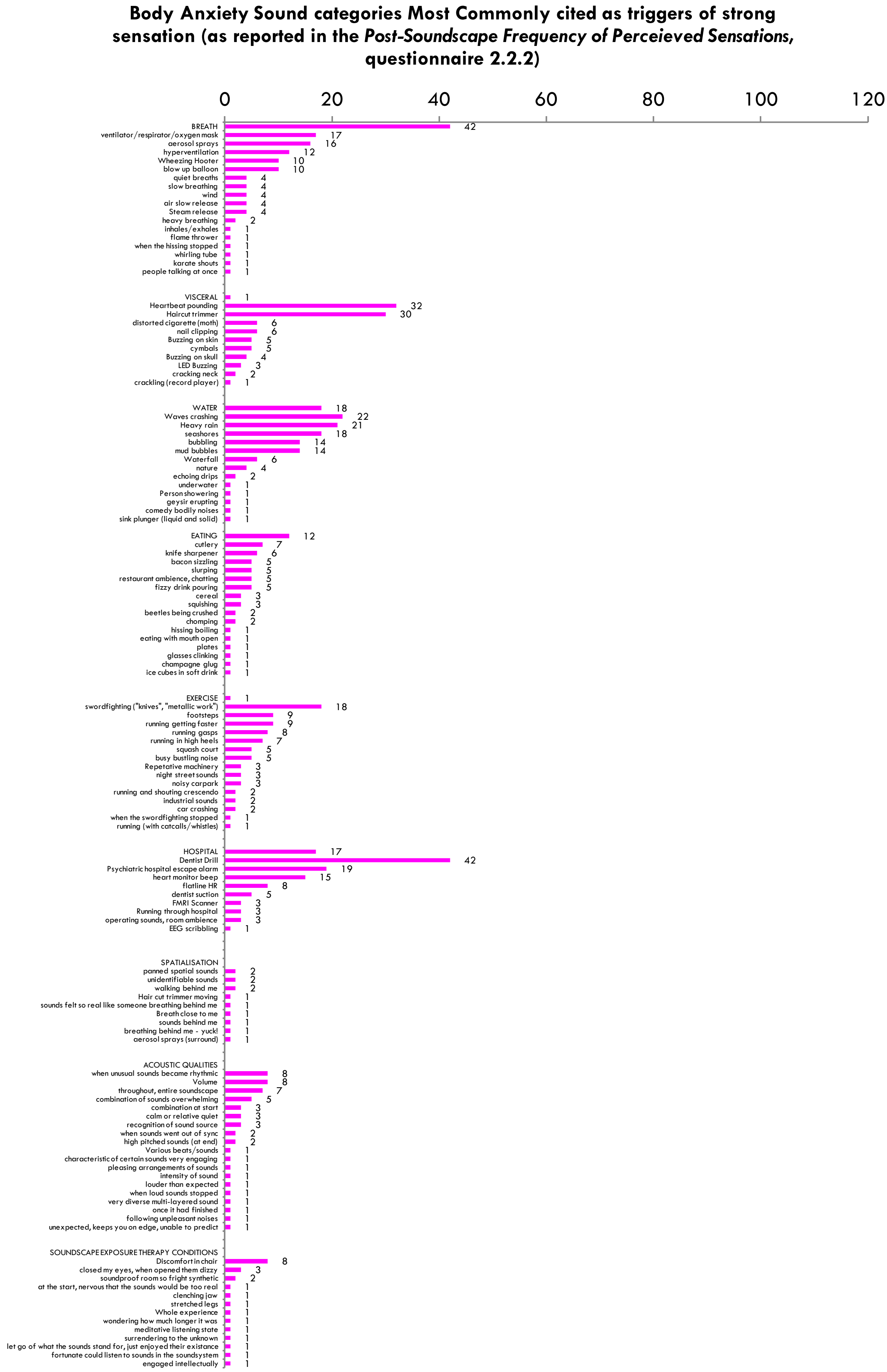


Figure 63: The most frequently reported triggers of sensation during *Body Anxiety*

6.5.1 Evaluation of the popularity of individual sounds within each soundscape

At the end of the *Post-Soundscape Questionnaire* (questionnaire 2) participants given a graphical timeline of sounds (a *Soundmap*) which they are then asked to annotate, placing a tick on every sound that is especially liked, or a cross on every sound that is particularly disliked. A collective *Post-Soundscape Liked and Disliked Sounds*, questionnaire 2.2.9, is generated, to facilitate an at-a-glance data evaluation of the entire data set. For example, a like tick from Participant 1 is represented as a green "1", whereas a dislike cross is shown as a red "1". Thus, clusters of red or green numbers fall on the most salient sounds, which universally elicit likes or dislikes. For instance, there is an abundance of green numbers overlaid on the *Water* sequence mid-way through *Body Anxiety*, due to the near-unanimous marking of these relaxing sounds with a like-tick. It can also be discerned whether the periods with a high concentration of likes or dislikes correspond to the clusters of GSR peaks. Cross-correlation between the two measures (one consciously reported, and the other purely physiological) is achieved by superimposing the collective *Post-Soundscape Liked and Disliked Sounds* datasheet over the *GSR Peak Timeline* for all participants, to pinpoint overlaps of trigger moments. This method of analysis is also significant in that it reveals the complexity of reactions to different salient trigger sounds. For example, "machine guns" are almost unanimously disliked, but there is a mixed reaction to "bells chiming" (as is the case for the *Fire* sequence) and the water sounds are almost consistently liked.

In total, the *Body Anxiety* soundscape features the greatest number of liked sounds, as 234 ticks are found overall, followed by the Situational Phobias soundscape which inspires 213 ticks, and the *Violence* soundscape which trails behind in comparison with only 145 sounds marked as liked. *Situational Phobias* is the soundscape with the greatest number of sounds which are marked as disliked, with a total of 305 crosses marked, followed by *Violence* with 240 crosses, and *Body Anxiety* with 230 crosses. The *Situational Phobias* soundscape seems to have generated the greatest overall response with 518 markings (both crosses and ticks) on the *Soundmap* in total, followed by *Body Anxiety* with 464 markings and Violence with 385. It must be taken into consideration that *Situational Phobias* is a longer soundscape, with more individual distinct sounds - many sounds in the Violence soundscape are continuous.

The sound category which has generated the most likes overall is *Horror*, in the *Violence* soundscape, with 108 ticks drawn onto the *Soundmap*. This makes sense, as the *Horror* category is saturated with cello, piano and musical voices, instruments which consistently engage listeners. The sound category with the second greatest number of liked sounds is the *Water* section in the *Body Anxiety* soundscapes, marked with 105 ticks. Again, this is the intention as this section is engineered as period of sonic respite, enveloping the participants in “waves crashing” and “geysirs whooshing”. *Time Stress* in the *Situational Phobias* soundscape is the third most popular sound category, as there are 85 ticks marked onto the sounds in this section. Fascinatingly, the *Time Stress* section also happens to generate the greatest number of dislikes, as 85 crosses are marked onto these sounds in addition to the 85 ticks. At times, there are even ticks and crosses on these sounds marked from the same participant, indicating a complex reaction to the long and repetitive yet jarring and sudden “bells chiming”. *Fire* is another sound category with an equally mixed response, as there are 57 ticks and 57 crosses marked on these sounds. These sounds which are nearly universally liked are shown as long green bars in Figure 64, whereas the sound categories that inspired a complex mix of both likes and dislikes are shown as clustered red and green bars of equal length.

Predominantly disliked sound categories in the *Situational Phobias* category include: *Fying*, as indicated by 80 crosses, and *Claustrophobia* on which there are 71 crosses indicating disliked sounds. The opening sequence of the *Body Anxiety* soundscape, *Breath*, is the most disliked in this soundscape as 68 crosses are marked onto these sounds. *Hospital* sounds have 50 crosses drawn onto them, and *Visceral* sounds have inspired 43 dislike crosses. In the *Violence* soundscape, *Weapons* sounds (mostly machine guns) elicit 57 crosses and only 2 ticks; *Power Tools* sounds inspire 48 crosses, *Horror* sounds 37 crosses, *Demolition* sounds 35 crosses (and absolutely no ticks) and the *Car Crash* sequence has 28 crosses drawn onto it. Complex reactions are seen in response to *Animal* sounds in the *Violence* soundscape, which are both liked and disliked (with 18 ticks and 19 crosses), and in response to *Agoraphobic* sounds (in the *Situational Phobias* soundscape) as demonstrated by 9 ticks and 12 crosses.

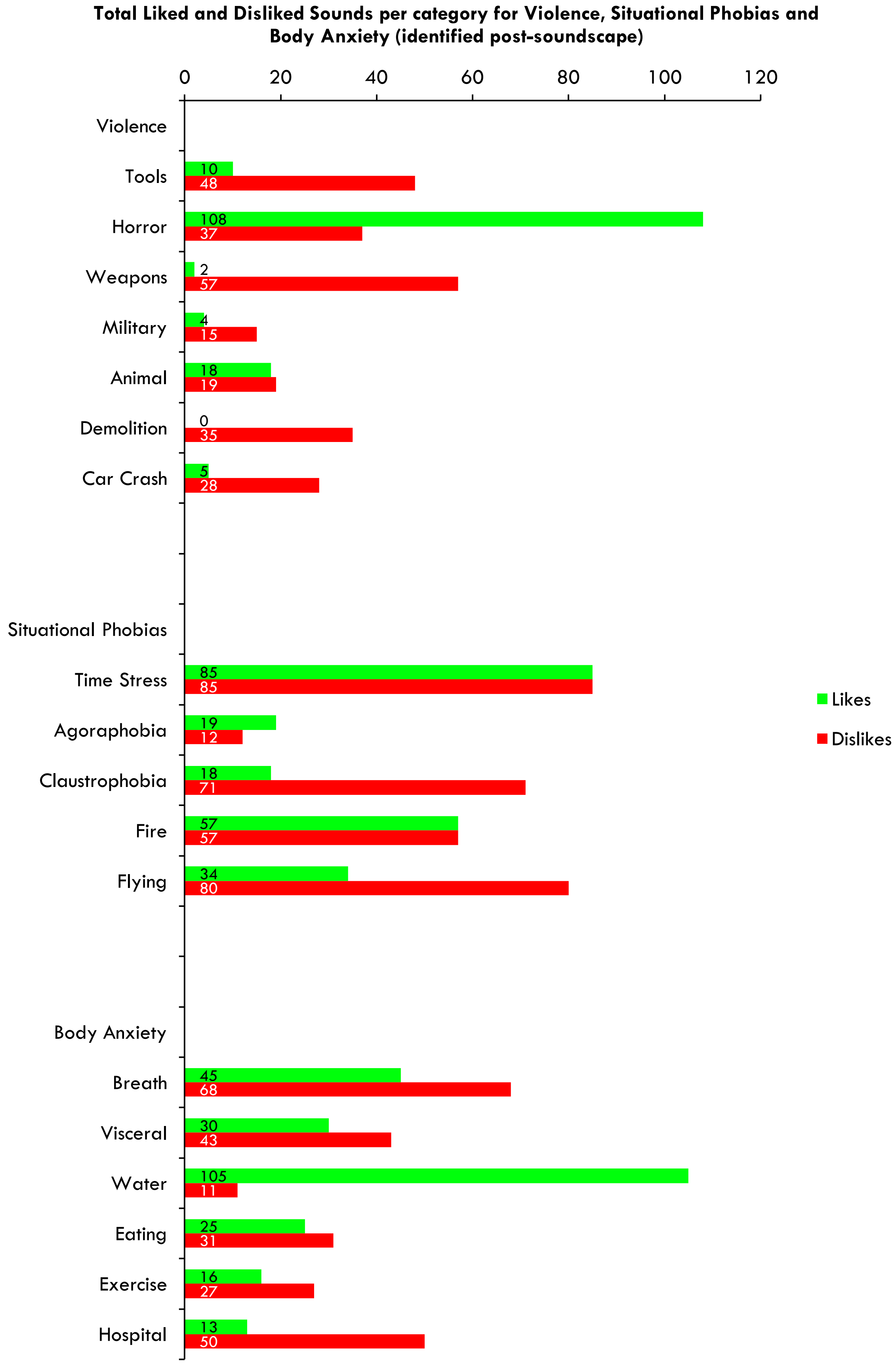


Figure 64: The most liked and disliked sound categories for *Violence*, *Phobias* and *Body Anxiety*

Further, signs of cross-correlation between quantitative and qualitative measures are evident, as the sounds that are most frequently liked or disliked quite often happen to be the sounds that generate the highest GSR peak rates. Figure 65 is a combination of both the collated *Situational Phobias Post-Soundscape Liked and Disliked Sounds* datasheet and the *GSR Peak Timeline* for all participants. All the individual sounds have been removed from this visualisation, for ease of interpretation, only leaving the rough indications of sound categories down the y-axis. The most definitive moment of cross-correlation is seen in minute eight. The eighth minute of the soundscape is part of the *Claustrophobia* sequence, which features an antagonistic bombardment of about ten types of "doors slamming," which has been reported as a trigger of strong sensation many times in the *Post-Soundscape Frequency of Perceived Sensations,* questionnaire 2.2.2. The GSR peak rate for minute eight is exceptionally high, at 0.90 pk/m/pt (0.17 peaks greater than the average GSR peak rate for the entire soundscape, 0.73 pk/m/pt). There are also 61 crosses marked on minute eight, a particularly high concentration of disliked sounds (one fifth of the 305 total dislikes for the entire soundscape), and quite a high concentration of liked sounds, just under a tenth of the total 213 liked sounds for *Situational Phobias*.

It appears that the participants are relieved immediately upon the cessation of the "doors slamming" in minute nine, as the GSR activity attenuates (dropping to a peak rate of 0.50 pk/m/pt), and there are a great many instances that sounds are liked, including the vibrant, organic ambience of "South American jungle crickets" the "Central America forest insects" and the "forest fire weeds crackling". In total, there are 29 likes for the sounds in minute nine, but only 17 dislikes. The liking of this gentler collection of sounds in minute nine is reflected by the relaxation shown in the physiological Galvanic Skin Response. There is slightly less dramatic, but still significant correlation, as the peak rate begins to surge in at the onset of the *Flying* sounds in minutes sixteen, seventeen and eighteen (to 0.80 pk/m/pt, 0.87 pk/m/pt and 1.00 peak/minute/participant respectively). There is another high concentration of 37 dislikes and 17 likes over the course of these three minutes. The GSR peak rate is highest on minute one of the soundscape (at 1.23 pk/m/pt), as it is specially engineered to give the participants a fright, after attuning the listeners' ears to delicate quiet rustling "coins spinning" and "clock ticking" sounds, later interrupted by variations of "grandfather clocks" and "bells chiming." Reassuringly, there are also 20 likes for the sounds playing in minute one, and 11 dislikes.

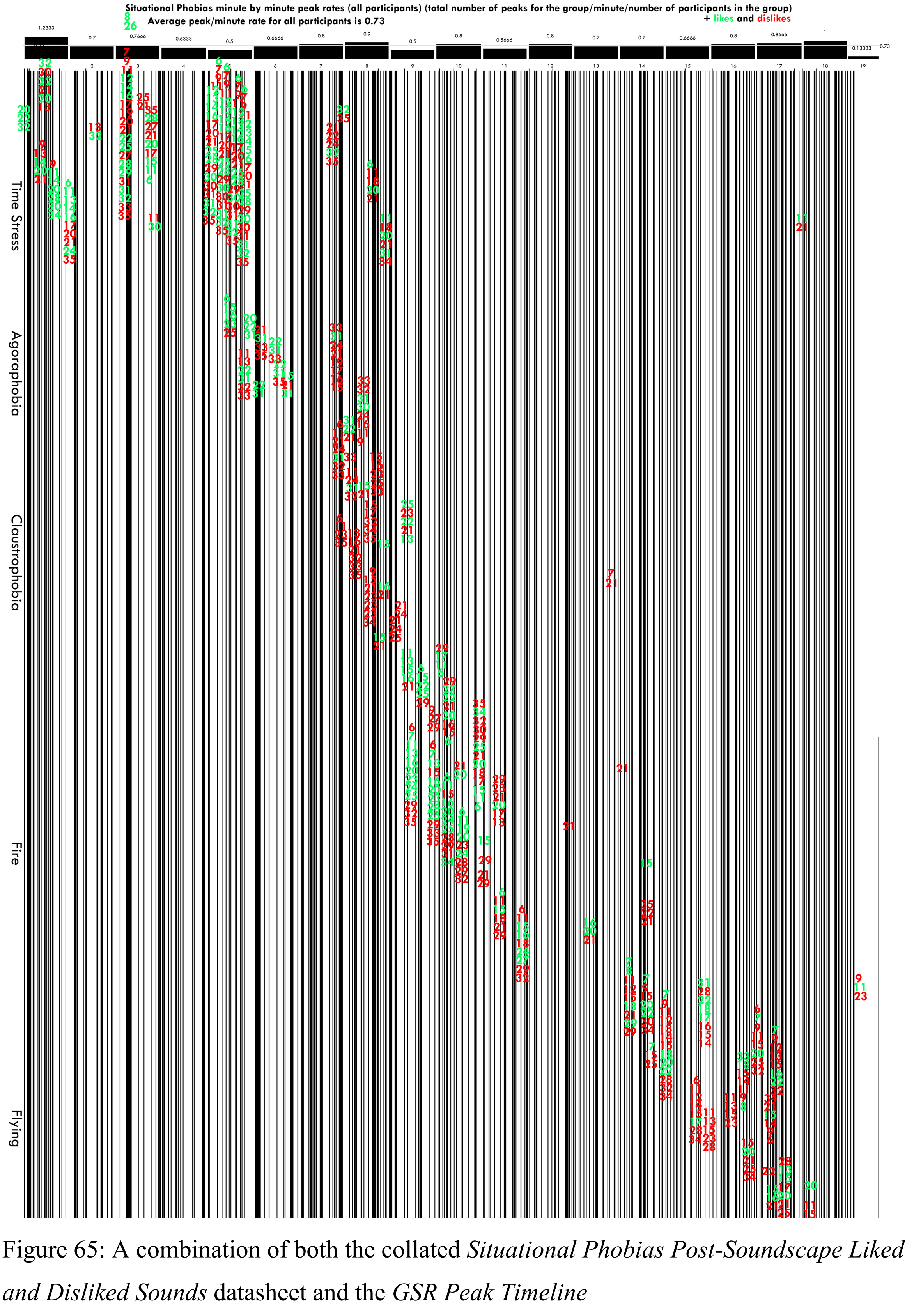


Figure 65: A combination of both the collated *Situational Phobias Post-Soundscape Liked and Disliked Sounds* datasheet and the *GSR Peak Timeline*

In the *Body Anxiety* soundscape, there is another intriguing moment of correlation between the two measures. The GSR peak rate drops far below average for the *Water* sequence during minutes six, seven and eight of *Body Anxiety* (to 0.57 pk/m/pt, 0.47 pk/m/pt and 0.40 pk/m/pt respectively, much lower than the 0.69 peak/minute/participant average). This attenuation of GSR peak rate happens to coincide with 47 instances of sound likes and 26 dislikes (although many of the dislikes are at the end of minute eight and are attributed to *Eating* sounds - all of the water sounds only generated likes). So, it can be construed from this instance that relaxing sounds which are consistently liked, seem to elicit much lower GSR peak rates on the whole. Thus it can be concluded that the sounds which have collected many likes are quite often the ones that have elicited strong positive sensations (according to the *Post-Soundscape Frequency of Perceived Sensations*, questionnaire 2.2.2.), usually during relaxing periods where the GSR peak rate is lower than average. The sounds which are almost universally disliked tend coincide with the minutes where participants demonstrate above average GSR peak rate – to state the obvious, participants dislike the sounds which caused them the most anxiety (as demonstrated by a high frequency of physiological arousals).

6.5.2 Analysis of the impact of relative volume on GSR peak rate

Another hypothesis that may appear to state the obvious, is that participants will be startled by sudden loud sounds – so these shock periods should elicit visibly high GSR minute-by-minute peak rates. Here, proof is sought of a correlation between the heightened loudness of the soundscape and an increase in the number of GSR peaks elicited. The impact of *relative volume* on the GSR peak rate can be discerned by overlaying the waveform image of the soundscape (generated from a binaural recording of the soundscape as it is heard in the soundlab) along the *GSR Peak Timeline.* This method will pinpoint the exact instant where a loud sound, shown as a tall peak in the audio waveform, reliably shocks the average participant, as demonstrated in the physiological data as a cluster of GSR peaks (again, represented by a thin black line for each peak) from several participants. For each of the three soundscapes, the entire waveform graphic is presented along the top of the *GSR Peak Timeline* for all participants, producing what is essentially a high resolution, detailed map of physiological affect caused by sharp increases in volume.

The impact of *overall loudness levels* on the GSR peak rate is evaluated through even more efficient means, as the rise and fall of the average minute-by-minute RMS amplitude of the binaural recording is placed alongside the rise and fall minute-by-minute GSR peak rates, in the form of a stacked line graph for ease of interpretation. To simplify to data, the RMS mean amplitude for each minute is calculated and displayed as a blue line, alongside a black line which represents the average GSR peak rate for each minute (see Figure 66). So, correlations between a rise in longer-term loudness over a given minute and an increase in the GSR peak rate for that minute can be discerned quite easily.

The process for calculating the RMS mean amplitude was as follows:

- each soundscape is played back in the ambisonic array, and recorded by a pair of binaural microphones placed in a dummy head (to record the listening experience of an average participant).
- This binaural recording is opened in Adobe Audition, and the first minute was selected.
- Amplitude Statistics were scanned from this minute, and an Average RMS Amplitude figure for both the left and the right channel was calculated. (The average between these two figures was then calculated to get an overall Average RMS Amplitude across both ears).
- This was repeated for each minute of every soundscape.

RMS Amplitude is a measurement of digital loudness level or electronic level, given in units of Decibels Relative to Full Scale (dBFS). The highest possible loudness level in digital, referred to as "Full Scale," is written as 0dB, and the lowest possible loudness level is written as -60dB to 0dB. So the smaller the number is, the louder the sound signal appears. As decibels run along a logarithmic scale, a digital signal that reaches 50% of the maximum digital loudness level has a level of −6 dBFS (which is 6 dB below full scale. The loudest moments of these soundscapes (as they appear in digital recordings) are approximately -20dBFS, and the quietest sounds are around -50dBFS. To aid the comparison of these two measures along the same axis, the y-axis of the RMS amplitude is inverted, to present the loudest minutes as a taller peak in the line graph. The maximum number on the y-axis of the RMS amplitude is 0dBFS, and the minimum is -80dBFS, whereas the maximum number on the y-axis of the GSR peak rate is 2, and the minimum is

0. This means that the loudest minutes are shown by the highest peaks in the blue line, and the minutes with the greatest GSR peak rate are shown by the highest peaks in the black line. The ideal approach would be to calculate the average loudness levels for each minute in terms of sound pressure level - using a sound pressure level meter might give numbers that are truer to the listener's perception of volume. However, the sound pressure level meter device available at the School of Simulation and Visualisation only works as a real-time read-only gauge, incapable of exporting a data stream for analysis. There have been recent developments in amplitude statistics analysis, as R128 metering conveys the perceived loudness, that is heavily weighted. However, there is a reasonable correlation between average RMS amplitude and perceived loudness, so the Adobe Audition method used here is sufficient in this case.

The loudest minutes of the *Violence* soundscape are minutes five and six, with an average RMS amplitude of -23.42 dBFS (decibels below Full Scale) and -23.31 dbFS respectively. This point is indicated just left of centre in Figure 66. Indeed, for minute five the GSR peak rate is 1.10 pk/m/pt (much higher than the average of 0.86 pk/m/pt), but the GSR peak rate for minute six drops below the average, at 0.80 pk/m/pt. For minute nine, another especially loud minute (at -26.225 dBFS), the GSR peak rate is lower still, at 0.63 pk/m/pt. It appears that the first minute of loudness is the most potent, and after that a habituation comes into effect. This makes sense, as our aural reflex (the body's automatic defence mechanism to protect our hearing) ensures that after a period of listening to loud sounds, the ear tries to shut down, by means of diminished attentiveness.

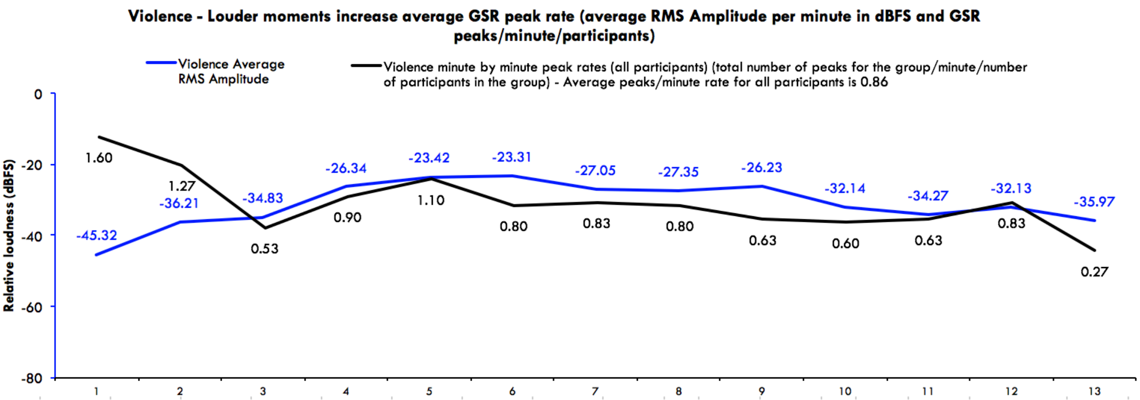


Figure 66: Average RMS Amplitude per minute (in blue) plotted against the GSR minute-by-minute peak rates for *Violence.*

The most dramatic jump in loudness occurs in the *Situational Phobias* soundscape between minute two (at -56.04 dbFS) and minute three (at -37.32 dbFS) (see the left of Figure 67). The impact of this sudden loud shock is reflected to an extent in the rise in GSR peak rate – however the rise is minimal, from 0.70 pk/m/pt in minute two, to 0.77 pk/m/pt in minute three. A similarly dramatic jump in loudness occurs between minute seven (at -53.88 dbFS), to minute eight (at -35.54 dBFS) (see the central points on the blue line in the second line graph of Figure 66). Again, the GSR peak rate matches this jump, rising from 0.80 pk/m/pt to 0.90 pk/m/pt. Although the loud volume is sustained, and it even rises slightly in minute nine, the GSR peak rate drops again (to 0.50 pk/m/pt in minute nine) exhibiting signs of fatigue towards the loud sounds. However, as the volume of the *Fire* sounds relentlessly continues to rise to -31.205dBFS in minute ten, the GSR peak rate jumps dramatically from 0.50 pk/m/pt, to 0.80 pk/m/pt. Nevertheless, as minute eleven crescendos further up towards -31.175dbFS, the GSR peak rate drops again to 0.57 pk/m/pt. So, the impact of loudness on GSR peak rate appears to wears off after the first minute in each of these instances.

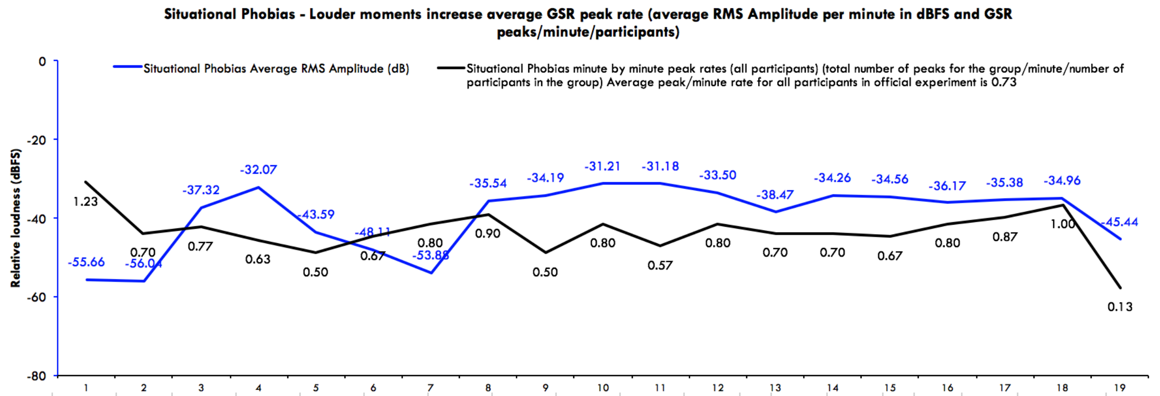


Figure 67: Average RMS Amplitude per minute (in blue) plotted against the GSR minute-by-minute peak rates for *Situational Phobias*.

In the *Body Anxiety* soundscape, minute four and minute thirteen are the loudest overall, with the loudness level of the fourth minute of the recording averaging at -27.08 dbFS and the thirteenth minute averaging at -26.01 dBFS (as seen in Figure 68). Minute four does elicit quite a high GSR peak rate on average (0.83 pk/m/pt, 0.14 peaks more than the average overall peak rate of 0.69 pk/m/pt), but it is actually minute three that elicited the highest peak rate of 1.11 pk/m/pt (see minute three, where the black GSR peak rate line rises above the blue RMS amplitude line). The third minute is still relatively loud (-34.67 dbFS), but it was not the loudest minute of the soundscape. The soundscape reaches -

26.01dBFS in minute thirteen but the peak rate is only 0.50 pk/m/pt at this stage (0.19 peaks lower than the average peak rate for the entire soundscape). This is likely because the loudness rises from -37.35 dBFS in minute ten, to -36.84dBFS in minute eleven, dramatically jumping up to -32.64 dBFS in minute twelve. By the time participants reach minute thirteen, their ears have already experienced the rapid crescendo from minute eleven to minute twelve (with the corresponding jump in GSR peak rate from 0.60 pk/m/pt in minute eleven, to 0.73 pk/m/pt), so the aural reflex has kicked in, and there is little physiological arousal at the loudest part.

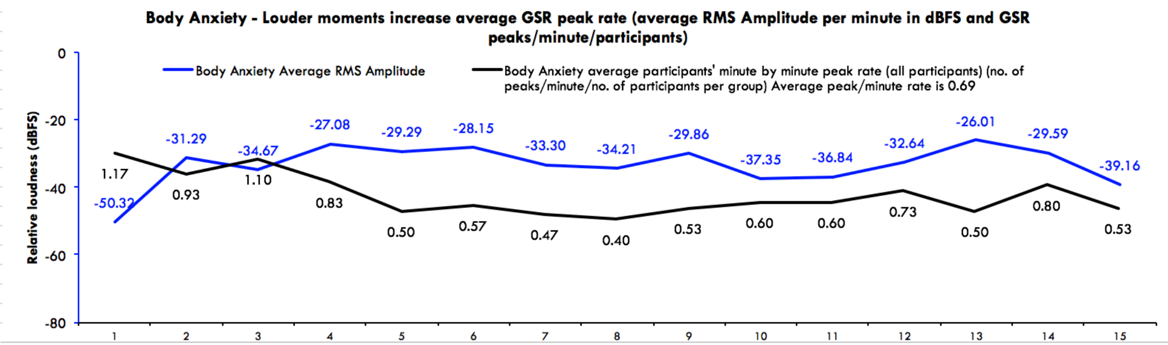


Figure 68: Average RMS Amplitude per minute (in blue) plotted against the GSR minute-by-minute peak rates for *Body Anxiety.*

Next, the impact of relative volume on the GSR peaks is assessed in greater resolution, down to the level of the clusters of individual GSR peaks (represented as a thin black line slicing down the *GSR Peak Timeline*) which appear to directly triggered by the onset of individual sudden loud sounds (represented as tall peaks in the audio waveform running along the top of the *GSR Peak Timeline*), in Figure 69. The *Violence* soundscape crescendos significantly at minute four, as digitally manipulated “cello loops” stutter in ascending canons, also panned in a circle around the listener. The first tall audio peak at precisely half way through minute four does not seem to elicit a particularly dense cluster of individual GSR peaks, in comparison to the average density established throughout the fourth minute. However, exactly halfway through minute five, there are two especially tall audio peaks, caused by ambiguous “loud geese shrieks” that pierce through the already booming second round of “ascending cello loops” coinciding with ethereal “shrieks like a morphing theremin hiss.” These excessively loud audio peaks visibly trigger a dense cluster of peaks during the entirety of the “loud geese shrieks,” over about fifteen seconds of minute five. Indeed, the peak rate for minute five soars up to 1.10 pk/m/pt – this is 0.24 above the overall average 0.86 pk/m/pt for the rest of the soundscape.

The next audio peak is generated at near the start of minute six, at the onset of the next ethereal "scraping shriek" and a disturbing "alien scream (knife sharpener)" – yet again, there is a dense cluster of GSR peaks directly after this excess of loudness, which appears as if a thick black line running down the page. The notorious "machine guns" (often reported as a trigger of strong sensation in the *Post-Soundscape Frequency of Perceived Sensations*, questionnaire 2.2.2) firing half way through minute seven are visible in the audio waveform as the five highest peaks - two peaks are quite brief at the start and so are two at the end, but the peak in between is quite relentless, lasting fifteen seconds. Fascinatingly, the densest concentration of individual GSR peaks is triggered immediately following the first burst of gunfire – whilst there are still a great many peaks triggered during the following gunshots, there is a discernable gap in GSR peak elicitation for the ten seconds immediately following the first gunshot fires. This is likely caused by aural reflex habituation.

Another cluster of GSR peaks is elicited at the onset of a very abrasive sudden loud peak in the wave form, caused by the "blow torch short crackle loop" in minute eight, which is panned to leap from side to side across the Soundlab. The next significant GSR peak cluster is triggered by an intriguing shock sound: the dissonant melody played by the "cellos" finally resolves to a more harmonious "lilting vibrato," and the soundscape becomes sparser in general during minute nine. However, a "car crash tumble" suddenly interrupts the otherwise pleasant lull, a third of the way through minute nine. The soundscape continues to grow gentler, and the listener is lulled into a false sense of security; "high pitched saws" loudly burst through the harmonious music, as does an abrupt "dundundundun of a shaking metal vent," not faded in at all, at the midpoint of minute eleven. The sudden nature of these sounds, indicative of physical threat, visibly trigger a high concentration of GSR peaks for this sound. Finally, another loud audio peak identified as a "car crash tumble" elicits the last dense cluster of GSR peaks, which appears as a thick black line slicing through minute twelve.

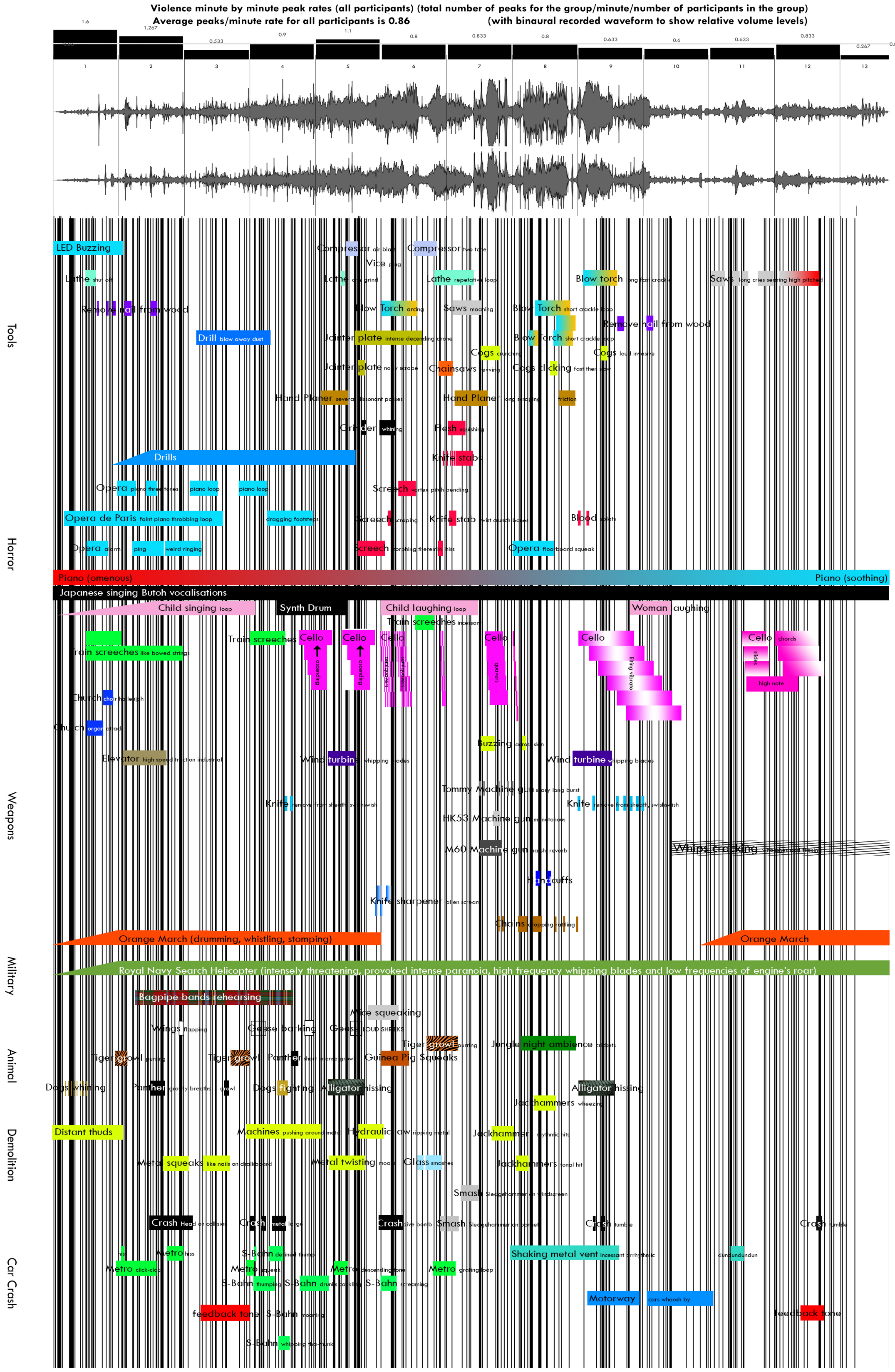


Figure 69: The binaurally recorded waveform of the *Violence* soundscape plotted against the *GSR Peak Timeline*

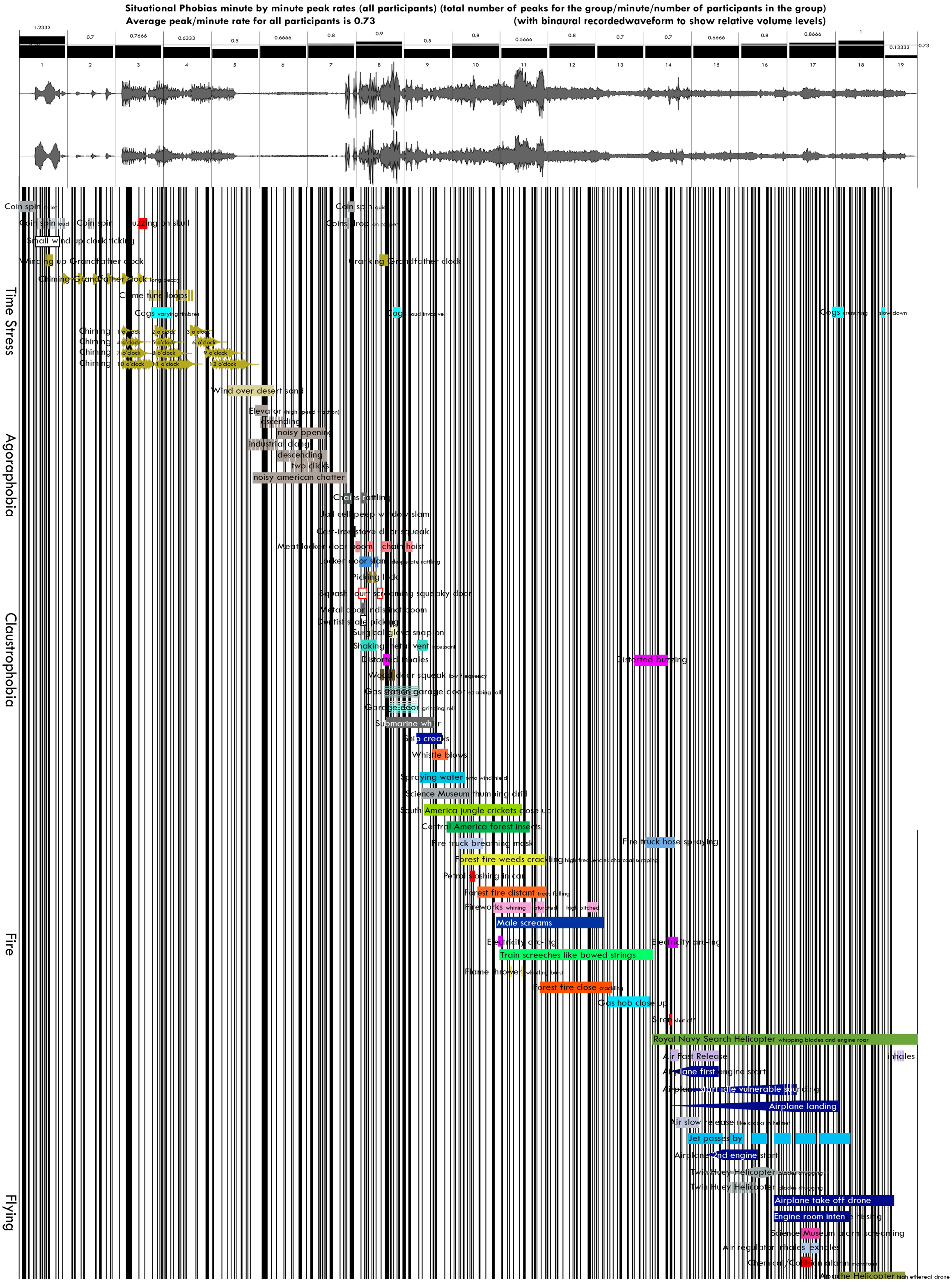


Figure 70: The binaurally recorded waveform of the *Situational Phobias* soundscape plotted against the *GSR Peak Timeline*

Ignoring the first cluster of GSR peaks immediately elicited by the opening seconds of the *Situational Phobias* soundscape (interpreted as a sign of calibration to the soundscape exposure experience, as sound is barely audible at this time), the first significant high concentration of GSR peaks occurs in minute three, immediately at the onset of the excessively loud quadruple layered “chiming one o’clock,” “chiming four o’clock,” “chiming seven o’clock,” “chiming ten o’clock” (see the top left corner of Figure 70). Each of these sounds bursts loudly out of each corner of the array, bouncing up and down with each chiming in a hyperreal manner. Crucially, a skilful manipulation of the aural reflex is utilized here, as there is a false shock in the relatively quiet “grandfather clock chiming” over a minute earlier. This already quiet chime is left to fade out to an almost imperceptible level over twenty seconds, so the listener’s ear is extra attuned to these impossibly quiet sounds. Then, in minute three the multi-layered bells chiming burst out in what is perceived as a deafening audio peak (although, this is still well below the safety thresholds set by the World Health Organisation, it just appears loud due to careful implementation of the silence preceding it). Another period of increased GSR peaks arrives at the second bout of bells chiming, just at the end of minute three, and again at the third set of loud “bells chiming”, at the end of minute four. It appears that this sound is so effective at eliciting shocks (even though it has relatively harmless connotations), that GSR peak rates are still increased even on the third repeat – this sound breaks the otherwise consistent trend previously established, that participants become totally habituated to repeated shocks after the first minute or two of listening.

Then at the start of minute six, the soundscape is still very sparse and very quiet, only featuring the *Agoraphobic* sounds of a “high speed traction elevator” but nevertheless, there are many GSR peaks elicited at that time. This appears to be the first instance of a GSR peak cluster that is not generated by a loud shock sound. Further clusters of GSR peaks are triggered by the instantaneous overly loud “coins dropping” from above, “chains rattling” and “doors slamming” at the end of minute seven, and more GSR peak clusters recur throughout this relentless series of audio peaks. By minute eleven, the soundscape is already loudly saturated by an enveloping collage of fire sounds, but even greater audio peaks emerge at the onset of “fireworks whining” which pierce through an already full frequency spectrum. Consequently, a high concentration of GSR peaks follow, especially so at the burst of “high pitched fireworks at the end of minute twelve. Again, the sudden outburst of “electricity arcing” (as heard also in the *Violence* soundscape) and a brief “siren” shut off marks a transition between the *Fire* sequence and the *Flying* sequence, as audio peaks are visible in the second half of minute fourteen. Two thick black clusters of GSR peaks are seen to line up with the onset of these alarming loud audio peaks in minute fourteen. The high concentration of GSR peaks continues throughout the *Flying* section which largely crescendos very gradually over the concluding minutes of the *Situational Phobias* soundscape.

6.6 Increased efficacy of trigger sounds if matched to pre-existing anxieties, or if they surprise the listener (global)

The main question of the thesis is whether the soundscape exposure elicits anxiety or strong emotional and physical sensations. A tangential question follows: if soundscape exposure does elicit anxiety, is the anxiety-elicitation heightened when the soundscape is tailored to the individual, when the sounds played resonate with a participant's personal history. This question can be answered by isolating remarkable individual participant instances, or even separating participants into groups with pre-exposure to post-soundscape *matched-anxiety-elicitation* or just post-soundscape *surprise-anxiety elicitation* (as in Section 5.6) to discover if the degree to which sensations are perceived is higher for one group, and to assess if the number of physiological peaks is higher for one group, looking primarily at GSR peak rates. The more cohesive approach is to look across the board, by identifying the most commonly cited pre-existing anxiety trigger sounds (as reported in the *Pre-Exposure Trigger Diagnosis*, questionnaire 1.2), and calculating whether these previously predicted trigger sounds did in fact produce higher than average GSR peak rates (across all participants) than sounds which are only identified as a trigger of strong sensation after hearing the soundscape (as reported in the *Post-Soundscape Frequency of Perceived Sensations*, questionnaire 2.2.2).

This global approach collates data from all participants: the average GSR peak rate during a sound category which is recurrently reported as an anxiety trigger in the *Pre-Exposure Trigger Diagnosis* (1.2), is compared to the average GSR peak rate during sound categories which are the most frequently reported as sensation triggers in the *Post-Soundscape Frequency of Perceived Sensations*, questionnaire 2.2.2. In Figure 71, the total number of reports of a sound category in the *Pre-Exposure Trigger Diagnosis* (1.2) appear as black bars, whereas the total number of reports of a sound category in the *Post-Soundscape Frequency of Perceived Sensations*, questionnaire 2.2.2 are shown as grey bars. Thus, several sound categories stand out as both widely identified global *matched-anxiety-elicitor*s, reported widely both in the pre-exposure and post-soundscape questionnaires, such as the *Visceral* category in *Body Anxiety* (see the second bar pair outlined in pink in the third bar cluster in Figure 71). Other sound categories are *surprise-anxiety-elicitors*, only reported as anxiety triggering post-soundscape, with little to no previous awareness of its effect pre-exposure, such as the *Fire* category from the *Situational Phobias* soundscape (see the central bar pair, in the central bar cluster, outlined in green in Figure 71).

Visceral sounds inspired a great number of reports as a pre-existing anxiety trigger in the *Pre-Exposure Trigger Diagnosis* (1.2) (*Visceral* sounds are reported pre-exposure 68 times) and a moderate number of reports as a trigger of strong sensation in the *Post-Soundscape Frequency of Perceived Sensations*, questionnaire 2.2.2 (*Visceral* sounds are reported post-soundscape 95 times). However, *Horror* sounds (from the *Violence* soundscape) inspired both a high number of reports as a pre-existing anxiety trigger, reported 50 times in questionnaire 1.2, and the highest post-soundscape questionnaire response, as *Horror* sounds are reported 322 times as a sensation trigger in questionnaire 2.2.2. The average GSR peak rate elicited during one of these a *matched-anxiety-elicitor* sound categories should be compared to the GSR peak rate elicited during a *surprise-anxiety-elicitor* sound category, one which is not reported as a pre-existing anxiety trigger at all (in the *Pre-Exposure Trigger Diagnosis*, questionnaire 1.2) but nevertheless is reported as a sensation trigger many times in the *Post-Soundscape Frequency of Perceived Sensations*, questionnaire 2.2.2. The most obvious *surprise-anxiety-elicitor* sound category is the *Fire* sequence, in the *Situational Phobias* soundscape. There is absolutely no mention of *Fire* as a pre-existing anxiety trigger in the *Pre-Exposure Trigger Diagnosis*, questionnaire 1.2 (only the accompanying jungle insect sounds were mentioned 24 times), but there are 162 reports of fire sounds as a sensation trigger in the *Post-Soundscape Frequency of Perceived Sensations*, questionnaire 2.2.2. (Even though *Horror* sounds may seem to be the obvious *matched-anxiety-elicitor* sound category to compare with the *surprise-anxiety-elicitor*, these sounds are actually distributed throughout the length of soundscape's timeline, whereas *Visceral* sounds are contained in a discrete five-minute chunk - so the immediate effects of the *Visceral* category can easily compared to the also isolated five-minute *Fire* section.)

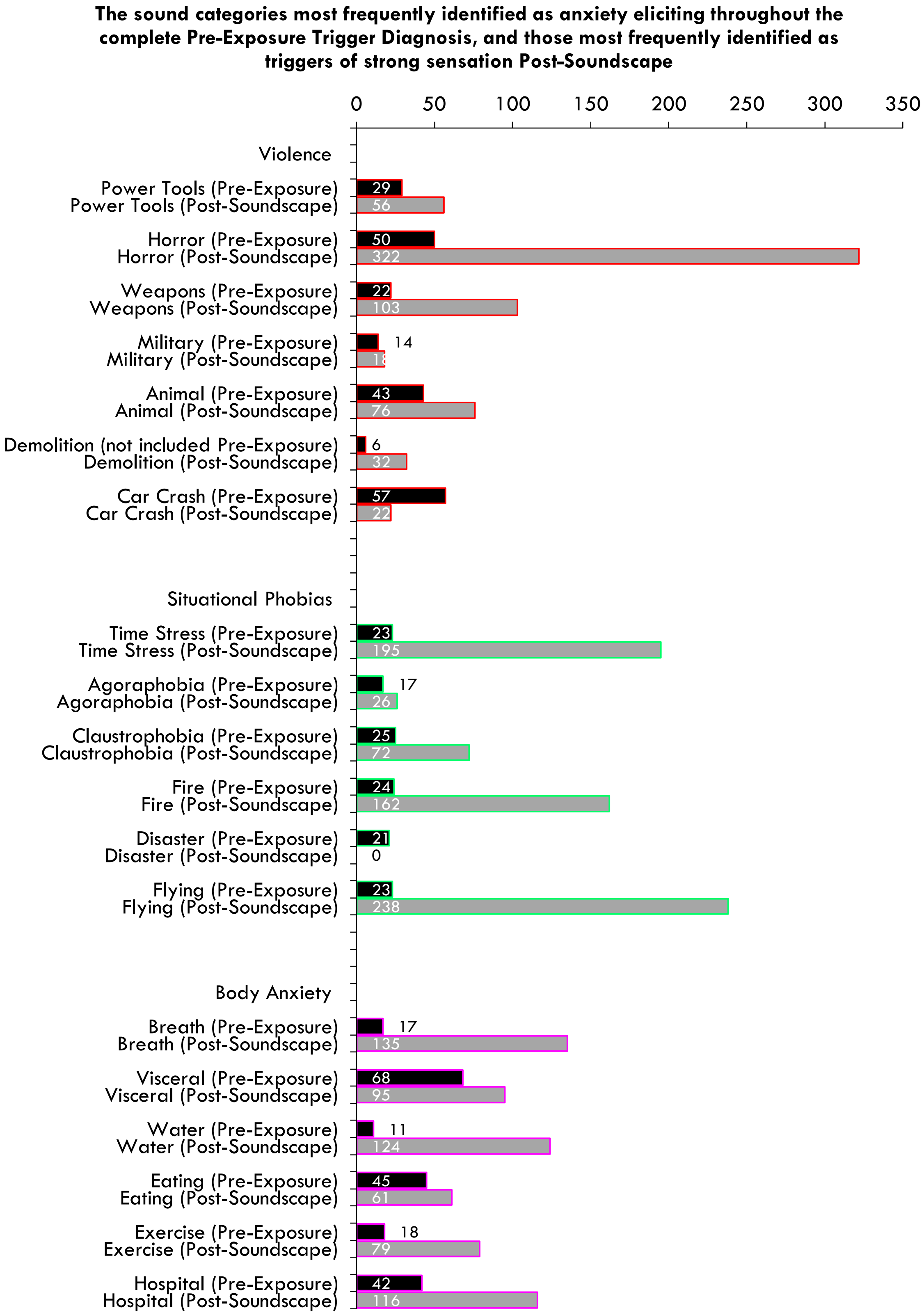
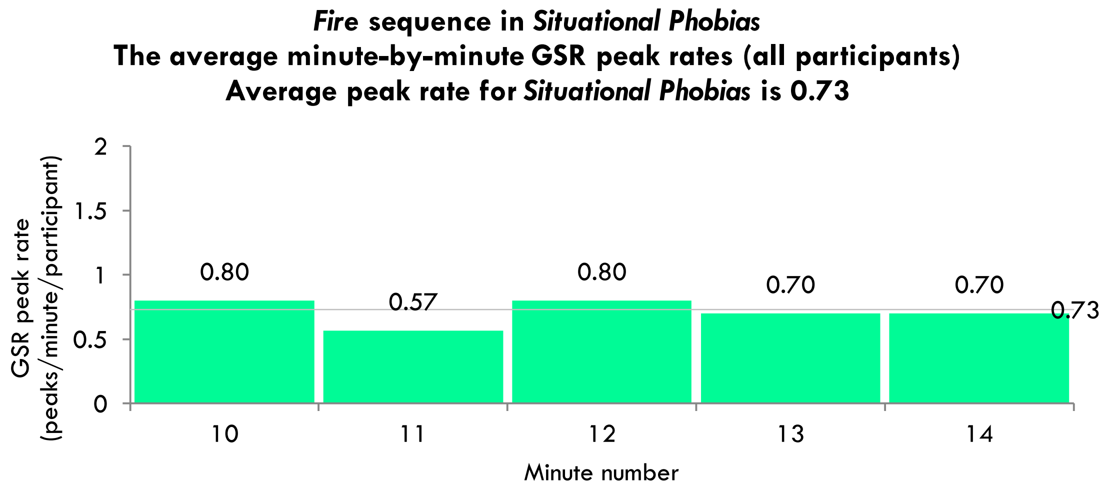


Figure 71: The sounds most frequently identified as anxiety eliciting pre-exposure and the sounds most those most frequently reported as triggers of strong sensation post-soundscape

The soundscape exposure therapy sound libraries are greatly enhanced, if priority high-potency sounds can be separated into two distinct categories: the most commonly reported sounds previously thought to be anxiety triggers (as reported in the *Pre-Exposure Trigger Diagnosis*, questionnaire 1.2), and then the sounds which were actually reported as sensation triggering in the *Post-Soundscape Frequency of Perceived Sensations*, questionnaire 2.2.2. This helps soundscape designers to gauge which sounds stand out in participants' minds pre-exposure, and whether these sounds were really the cause of strong sensation during exposure – it appears that there are sounds that consistently surprised participants. The average GSR peak rates are calculated for each minute of the *surprise-anxiety-elicitor* sound section, the *Fire* sequence in the S*ituational Phobias* soundscape (as no-one previously predicted an aversion to fire sounds, but many reported it as a sensation trigger afterwards), and the average GSR peak rates are also calculated for each minute of a *matched-anxiety-elicitor* sound section, the *Visceral* section from the *Body Anxiety* soundscape (as many people correctly predicted pre-exposure that a strong sensation would be elicited by the fleshy visceral sounds). Both the change in the GSR peak rates over time (from minute to minute) and the average GSR peak rate for each of the sections (in their entirety) are compared. The average GSR peak rate remains high for a sustained period of time during the *Fire* section (the *surprise-anxiety-elicitor*), whereas the average GSR peak rate is very high at the beginning of the *Visceral* section (the *matched-anxiety-elicitor*) but the rate dropped immediately after the first minute. This indicates that participants calmed down after the first minute of the *Visceral* section, whereas the surprisingly frightening *Fire* sounds elicited a long-lasting higher-than average peak rate. It appears that recognition of a pre-existing fears might elicit conscious thought, whereas the hyperreal, immersive and persistent fire sounds appear to be subliminally unsettling over a longer period.

The GSR rate for the average participant during the first minute in the *Fire* section is a high 0.80 pk/m/pt (minute ten of the soundscape), which then drops to 0.56 pk/m/pt in minute eleven, before rising again to 0.80 pk/m/pt in minute twelve, and then settling at 0.70 pk/m/pt for minute thirteen and fourteen (see the two green columns in right of the top chart in Figure 72). The average GSR peak rate for the *Situational Phobias* soundscape is 0.73 pk/m/pt, so it is significant that the immediate GSR peak rate is above average in the first and third minutes, and it remains very close to average in the fourth and fifth minutes of the section. Conversely, the GSR peak rate for the *Visceral* section in *Body Anxiety* starts at a very high 1.10 pk/m/pt for the first minute (see the first pink column of the second chart in Figure 72, minute three of the *Body Anxiety* soundscape) , then drops significantly to 0.83 pk/m/pt in the minute four; it then drops well below average at 0.50 pk/m/pt in minute five, before rising marginally to 0.57 pk/m/pt in minute six, and finally the peak rate drops again to 0.47 pk/m/pt in the final minute of this section, minute seven. The average GSR peak rate for the entire *Body Anxiety* soundscape is 0.69 peaks/minute, so the immediate GSR peak rate rises well above the average on first minute of the *Visceral* sequence, and is still above average in the second minute although it has dropped rapidly, but this initially heightened arousal then dissipates in the third, fourth and fifth minute as the peak rate stays far below the average.



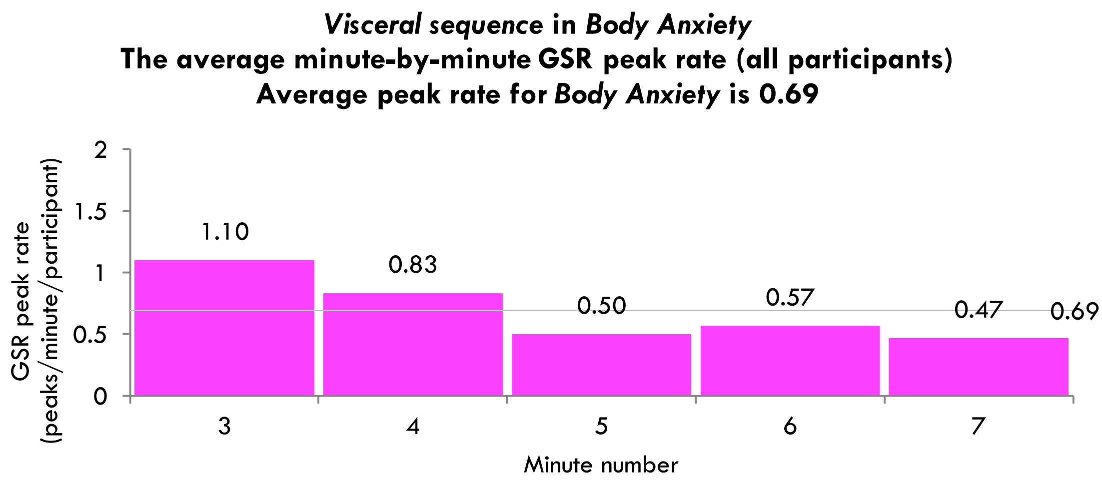


Figure 72: The minute-by-minute GSR peak rate for the *Fire* sequence of the *Situational Phobias* soundscape and during the *Visceral* sequence of the *Body Anxiety* soundscape

Also, the average GSR peak rate for the entirety of the five-minute *Fire* section is 0.71 pk/m/pt, marginally higher than the average peak rate for the whole *Visceral* section at

0.69 pk/m/pt. Thus, the *surprise-anxiety-elicitor* sound category, *Fire*, elicits a slightly higher physiological response than the more predictable pre-exposure-to-post-exposure *matched-anxiety-elicitor* of *Visceral* sounds, with a small difference of 0.02. More notable perhaps is the difference in sustain of the average peak rates. For *Fire* sounds, the minute-by-minute GSR peak rate only diminishes by 0.24, as the *surprise-anxiety-elicitor* sustains a high GSR peak rate over five minutes; whereas the predictably anxiety-eliciting *Visceral* sounds does elicit a very high immediate GSR peak rate in the first minute (1.10 pk/m/pt), but this drops quickly to a very low 0.47 pk/m/pt – a significant drop of 0.63 pk/m/pt. So, the GSR peak rate drops by 0.24 pk/m/pt over the course of the *surprise-anxiety-elicitor Fire* sounds, but the drop in GSR peak rate for the *matched-anxiety-elicitor* is much more dramatic, as the GSR peak rate drops by 0.63 for the *Visceral* sounds. In summary, the average GSR peak rate for all participant rapidly decreases by half during the *Visceral* section from 1.1 pk/m/pt in the first minute to 0.47 pk/m/pts in the second minute. For *Fire* sounds, there is a small drop in the GSR peak rate, whereas during the *Visceral* sounds there is a rapid, more significant drop in the average peak. The meaningful difference appears to be in the sustain pattern of the high peak rate, rather than the difference in average peak rate for the entire section.

There are other variables to take into consideration which might account this difference. The *Fire*[11] sounds are quite consistent in their acoustic make up, and saturate the entire frequency possible frequency spectrum, only growing louder, denser and multi-layered. Conversely, the *Visceral*[12] sounds are each quite short, instantaneous, recognisable and known to be anxiety eliciting. Perhaps the surprise that participants feel is unsettling in itself, as participants seem to experience an intense physiological and conscious reaction to the *Fire* sounds despite a total lack of previous awareness of an aversion to it. Whereas with the clichéd aversive *Visceral* sounds of “knuckles cracking” and “nail clipping” the reaction is instant, recognised and then accepted as the participant moves on to a state of homeostasis. Beyond the differences in acoustic nature, arrangement of the sounds is also quite different between the *Fire* section and the *Visceral* section: *Fire* is a gradually morphing sonic texture whereas the *Visceral* section is a series of distinct sound events.

11Argo, J., 2015. *Fire*,from *Situational Phobias.* Available at <https://soundcloud.com/jessicaevelynargo/situational-phobias-stereo/s-y5u0J#t=9:00 >

12 Argo, J., 2015. *Visceral*, from *Body Anxiety.* Available at <https://soundcloud.com/jessicaevelynargo/body-anxiety/s-69cIy#t=2:00>

Violence features the greatest number of individual types of *matched-anxiety-elicitation* sounds (identified as anxiety-eliciting both pre-exposure and post-soundscape) with 21, closely followed by *Body Anxiety* with 20 - but *Situational Phobias* features only nine *matched-anxiety-elicitor* sounds. *Situational Phobias* and *Violence* both feature 63 individual types of *surprise-anxiety-elicitor* sounds, whereas *Body Anxiety* only features 48. *Violence* also features the greatest number of types of sounds which are reported as anxiety eliciting in the *Pre-Exposure Trigger Diagnosis* (1.2) but fail to be reported as sensation triggering in the *Post-Soundscape Frequency of Perceived Sensations* (2.2.2). There are 38 individual *Violence* sounds only mentioned as a pre-exposure trigger but not a post-soundscape trigger, whereas there are 32 sounds in *Situational Phobias*, and 33 in *Body Anxiety*. However, perhaps more significant than the diversity of the types of sounds mentioned, is the frequency of the reports of sounds which are perceived to directly trigger a strong sensation – that is the number of times that each sound is attributed to causing a sensation. The *Situational Phobias* soundscape elicits 561 more reports of sounds as sensation triggers in the *Post-Soundscape Frequency of Perceived Sensations* (2.2.2) than the initial number of reported anxiety trigger sounds in the *Pre-Exposure Trigger Diagnosis* (1.2) For the *Violence* soundscape, there are only 408 more post-soundscape reports of sounds as triggers in questionnaire 2.2.2 than the initial number of reported trigger sounds in questionnaire 1.2. Similarly, for the *Body Anxiety* soundscape, there are 409 more sounds as triggers reported post-soundscape than the original number of pre-existing triggers reported pre-exposure. Thus, violent and bodily sounds were expected to cause strong sensations to a greater degree than sounds associated with everyday phobias – but these phobic sounds caught participants by surprise. *Situational Phobias* is the soundscape which is the most unexpected to cause high levels of strong sensation.

As well as answering the research question as to whether tailored soundscapes are more anxiety-eliciting, this analytic process also serves as an evaluation of the sound designer's compositional techniques. A critique of the efficacy of the sounds can be given, by calculating the number of sounds which are known as pre-existing anxiety triggers, reported in the *Pre-Exposure Trigger Diagnosis* (1.2), that fail to be reported as a sensation trigger during soundscape exposure (these sounds are not written about in the *Post-Soundscape Frequency of Perceived Sensations*, questionnaire 2.2.2). There are relatively few sounds identified as anxiety eliciting pre-exposure but not mentioned post-soundscape – upon further analysis, it appears that the majority of those sounds are not reported as triggering sensations post-soundscape, because they are not actually present in the soundscape. The few exceptional sounds that are only mentioned pre-exposure but not post-soundscape, even though they happen to feature in the soundscape, are essentially deemed as ineffective, due either to being obscured by other sounds or because they were not anxiety-eliciting enough. *Violence* features 22 sounds identified as a trigger pre-exposure but not post-soundscape which are actually present in the soundscape, thus they might be deemed as ineffective, whereas *Situational Phobias* only has three trigger sounds present but ineffective, and *Body Anxiety* only one. The rest of the sounds that appear in the *Pre-Exposure Trigger Diagnosis* (1.2) but failed to garner reports as a trigger of strong sensation in the *Post-Soundscape Frequency of Perceived Sensations* (2.2.2) are not written about due to the fact they were not actually present in the soundscape, so this explanation is reassuring. Overall, the sounds expected to be anxiety eliciting have largely been implemented in a way that did indeed trigger strong sensations. A list of sounds is devised from the pre-existing anxiety triggers discovered in the *Pre-Exposure Trigger Diagnosis* (1.2) which are missing from the anxiety-eliciting sound library: these sounds will be recorded to expand upon the already comprehensive sound library offered as part of the soundscape exposure therapeutic framework package, aimed at therapists.

Hypothesis 21 has been confirmed to an extent, as the *matched-anxiety-elicitation* sound category (*Visceral* sounds) elicited a fleetingly higher GSR peak rate than the *surprise-anxiety-elicitation* sound category (*Fire* sounds) only for the first minute of the section. However the GSR peak rate dropped dramatically after the first minute of the *matched-anxiety-elicitation* sound category, but the relatively high GSR peak rate for the *surprise-anxiety-elicitation* sound category was sustained over five minutes. Thus, a difference in the speed of attenuation of GSR peak rates is demonstrated, as the surprisingly anxiety-eliciting sounds maintain their power over a longer period, compared to the anxiety eliciting sounds that matched many participants' pre-existing anxieties.

6.7 Conclusion – Confirmation of Secondary Hypotheses and Objectives

There are several hypotheses and objectives for the secondary results which further expand upon those for the primary results. Some of these secondary hypotheses specifically reflect on the detailed analysis offered here in the secondary results.

11. It was hypothesised that the most frequently perceived physical sensations are those widely attributed to auditory and musical processing (such as “pleasurable chills”, “numbness/tingling”, “heart pounding”) or the hyperreal spatial panning of sounds (“dizziness” or “upset stomach”). Indeed, the most frequently perceived positive physical sensations proved to be “pleasurable chills”, “heart pounding”, “numbness/tingling” (commonly triggered by music). The most frequently perceived negative physical sensations “unsteady/shaky” and “upset stomach” (likely induced by the immersive ambisonic panning of sounds across space) are perceived slightly more frequently than the rest of the negative physical sensations between which there are minimal differences in frequency. (Section 6.2.1)
12. It was originally hypothesized that the most frequently perceived psychological sensations are those attributed to memory recall and emotional processing of past traumas (“sad”, “nervous”, “tense”, and “depressed”), followed by those associated with catharsis or habituation (“in control” and “relief”). In actuality, the most frequently perceived psychological positive sensation proved to be “in control,” (related to catharsis or habituation), whilst the others are all mentioned a similar number or times. The most frequently perceived psychological negative sensations proved to be “tension,” followed by “sadness” and “nervousness,” as earlier predicted, in addition to the extreme “complete inability to relax.” “Depression” is reported post-soundscape relatively little. Participants also appeared to be “scared” and “frightened” quite regularly, but the rest of the psychological negative sensations were elicited significantly fewer times. (Section 6.2.1)
13. It was originally imagined that the most frequently affected body parts are likely to be the head (given the psychological nature of the experience), as well as the core (in moments of panic breathing may be altered and sound-induced chills and shivers are usually perceived down the spine). It is thought to be fascinating if the extremities and the limbs are also affected, as these reactions are beyond the usual sensations induced by sound and music or the standard anxiety symptoms – instead

these might be a result of immersion in ambisonic sound, or phantom pain memories. In actuality, the parts of the body that are most frequently affected during soundscape exposure are the head ("thoughts racing," "dizzy/lightheadedness" and an "ache" or "crying"), the core (as "fast breaths" and "pleasurable chills" down the spine or back of the neck, or "nausea" in the stomach) in addition some sensations in the extremities ("restless" or "sweating" hands and feet, or fizzing in arm), which were indeed triggered by memory induction of previous injuries, or "burning" in response to being immersed in fire sounds . There is a mixed perception of these reactions as positive or negative at times (Section 6.2.2).

14. It was hoped that the participants' immediate subjective perceptions of the soundscape exposure should be that the soundscapes are slightly louder than everyday, and that they are highly immersive. The participants' moods should be changed from soundscape to soundscape, and memory recall should be induced by the sounds. From the results of the *Post-Soundscape Subjective Perceptions* (2.2.1), it appears that that the soundscape is loud enough to engage participants but not to an unbearable degree, and importantly the soundscapes are perceived as very immersive. The soundscapes did change participants' moods to an extent, and each participant has at least one memory recall triggered by each soundscape on average (Section 6.2.3).
15. It is hypothesized that the sounds that elicited the greatest GSR peak rates will be those which are the most antagonistic, in terms of acoustic abrasiveness (high frequency, chaotically noisy, rhythmically erratic, dissonant musical forms, percussive) or negative causal associations (physical threats, violent connotations, mechanistic sounds or disgusting taboo sounds). From the results, it is clear that the sounds that elicit the greatest GSR peak rates are indeed like those imagined in the hypothesis: abrasive, high frequency like the "scraping shrieks" in the *Violence* soundscape, and most importantly the sounds that are arranged as a loud shock after a period of quiet, such as the "machine guns." Another observation is that the GSR peak rate tends to attenuate at least ten seconds after loud shock sound as listeners become habituated (Section 6.3 and Section 6.5.2).
16. It is imagined that attenuation of GSR peak rates will coincide with more pleasant sounds, in terms of acoustic smoothness (lulling repetition, harmonic musical forms, or soothing quality) or positive causal associations (natural sounds, vibrant social atmospheres). Indeed, this proved to be the case, especially during the *Water*

sequence of *Body Anxiety* and the “harmonious piano” and “cello lilting vibrato” in the *Violence* soundscape (Section 6.3).

17. Both of the GSR peak rate trends in Hypotheses 15 and 16 are emphasized in the hyper-sensitive groups – both the HPE (higher pre-existing anxiety group) and the participants who are listening to a soundscape as the first in the exposure sequence. For example, The GSR peak rate attenuates during relaxing *Water* sounds much more dramatically in the HPE group than the LPE group, and the GSR peak rate is much higher in the HPE group than the LPE group and during the alarming *Horror* and *Weapons* sounds (such as “geese barking,” “ascending cello loops,” supernatural “ethereal shrieks” and “machine guns” firing). The participants who are listening to a soundscape as the first in the sequence demonstrate much higher GSR peak rates during alarming sounds, than the participants who are listening to the soundscape as the second or third in the soundscape exposure sequence. Those who are listening to a soundscape as their first in the sequence also demonstrate greater attenuation of the GSR peak rate in response to relaxing sounds (Section 6.3).
18. A greater concentration of respiration anomalies occurs during the already established triggers of strong sensation *Post-Soundscape Frequency of Perceived Sensations* (2.2.2), particularly alarming, suspenseful or pleasant sounds (Section 6.4).
19. It was imagined that the sounds most frequently perceived as a trigger of strong sensation in the *Post-Soundscape Frequency of Perceived Sensations* (2.2.2) would be those which were also reported as pre-existing anxiety triggers numerous times in the *Pre-Exposure Trigger Diagnosis* (1.2). This proved to be the case for *Visceral, Eating, Hospital* and *Horror* sounds, but *Fire* sounds are an exception to this rule as many participants were surprised to be made anxious by fire sounds, with no participants reporting previous aversions to the sound. Some of the sound categories most frequently perceived as sensation triggers post soundscape were not actually the most commonly selected pre-existing anxiety triggers, such as *Weapons* and *Flying* (Section 6.5).
20. It was predicted that the sounds most frequently perceived as a trigger of strong sensation in the *Post-Soundscape Frequency of Perceived Sensations* (2.2.2) will be those which are the most antagonistic, in terms of acoustic abrasiveness (high frequency, chaotically noisy, rhythmically erratic, dissonant musical forms, percussive) or negative causal associations (physical threats, violent connotations,

mechanistic sounds or disgusting taboo sounds). They might also be the more pleasant sounds, in terms of acoustic smoothness (lulling repetition, harmonic musical forms, or soothing quality) or positive causal associations (natural sounds, vibrant social atmospheres). According to the results, the unanimously reported post-soundscape sensation triggering sounds are “chiming bells” (not previously reported as a pre-existing anxiety trigger) “machine guns”, both “harmonious” and dissonant musical forms, “flying” sounds, “breath sounds” (particularly the mechanistic, exaggerated forms), and a “dentist drill” (Section 6.5).

21. It was hypothesised that the *matched-anxiety-elicitation* sound category will elicit higher GSR peak rates or a differing speed of attenuation of GSR peak rates than the *surprise-anxiety-elicitation* sound category. Actually, the *surprise-anxiety-elicitation* sound category elicits a slightly higher GSR peak rate on average, and even more telling is the difference in sustain of the peak rate over time. The *surprise-anxiety-elicitation* sound category generates a consistently high peak rate over a sustained period of five minutes, whereas the *matched-anxiety-elicitation* sound category elicits a very high GSR peak rate on upon the first minute, but this drops rapidly for the following four minutes (Section 6.6).

7 Conclusion and Discussion

At the heart of this work, is a truly dedicated motive to contextualise the innovation of three-dimensional sound design within established therapeutic paradigms, drawing on the profound emotional and physical affects elicited by sound. Proposed as a non-invasive, non-pharmaceutical intervention for anxiety sufferers, which fully engages the both senses and the imagination, a soundscape exposure therapy has been meticulously designed, from level of thoughtfully constructed sonic composition, to the implementation of state of the art higher order ambisonics, to the rigour of the extraction of physiological and behavioural recordings, enhanced by the in depth perceptual accounts from the participant.

It has been demonstrated that the soundscape exposure experience had a lasting impact, to diminish the perception of negative sensations. The lasting impact on moods and emotions up to a week following exposure is down to a combination of psychoeducation using methods borrowing from music therapy, cognitive behavioural therapy, interoceptive, imaginal exposure therapy; as well as the provision of a sonic sanctuary in which participants could take time to re-evaluate repressed anxieties. This experience even drew some to tears, a sign that some perceive as visible demonstration of catharsis, and many appreciate as an instinctive return to homeostasis.

It was paramount to this work that painstaking cross-analyses of psychophysical signals and written responses were scrupulously evaluated both to prove that the impact of the experience was beneficial, but also crucially to establish a sound library in which each sound is graded by potency. High-sensation sounds are pinpointed by the consistent arousal of physiological peaks, as well as common consensus in the participants' post-soundscape detailed appraisals of the sounds heard and the sensations elicited.

The soundscape exposure experience is designed to challenge the user to withstand abrasive stimuli, and to delve into at times uncomfortable psychological territory. Thus, it is all the more remarkable that although this intention was executed successfully, there was the experience was largely deemed as a psychologically positive one, which at times outweighed the anxious symptoms induced. Thus, it is hoped that counterconditioning took place, as some participants remarked that the experience gave them a heightened awareness of sensations days after leaving the laboratory, and for most this was deemed helpful. It appears that soundscape exposure can train the user to habituate to the physical symptoms of anxiety, and at times encourage a psychological catharsis. Further to these two primary objectives, the rigorous questioning of the user to rate individual sensations repeatedly over the course of an emotionally diverse range of stimuli, teaches the user that these sensations are merely temporarily drifting through the body as is often the case in everyday anxiety. Thus, soundscape exposure therapy can physically desensitize, trigger a mental catharsis, and even psycho-educate, to interrupt the debilitating fear-of-fear inherent in anxiety.

7.1 Discussion

In this work, a multitude of hypotheses were predicted and many were verified, whereas others warrant further investigation. Crucially, emotionally evocative and physically challenging soundscapes have been exposed to a diverse pool of participants with no adverse long-term effects, even though generally participants reported a slight increase of negative sensations in the short term, as expected in an anxiety exposure session. In fact, there are several measures indicating a significant improvement in wellbeing in over a long-term time frame, which outweigh the short-term discomfort during soundscape exposure. The soundscape exposure experience is largely deemed as more psychologically engaging than physical, and more positive than negative overall. Soundscape exposure, as applied in this research, has been demonstrated to be safe, for both the user's body and mind.

Further, we have learned that participants with greater sensitivity (due to predisposed anxieties) are more receptive to effects of both fearful and relaxing sounds. Participants with higher-pre-existing anxiety (closest to the proposed clientele for soundscape exposure) demonstrated both a more frequent perception of negative sensations and emotions (as reported in questionnaire 2.2.2) in addition to more dramatic fluctuations in GSR activity during the soundscape exposure.

The soundscapes were designed to be perceived as hyperreal rather than realistic representations of everyday, with the thought that the stranger the spatialisation patterns, the greater the unease that would be provoked in the listener. However, it has been learned that hyperreal panning is not exclusively more frightening than realistic panning, and neither is the opposite true. In fact, there is a complex interplay of semantic, causal and reduced listening at play when real world sounds are panned in ambisonics, and whether realism or hyperrealism is the most anxiety eliciting approach appears to be highly context dependent.

Another hypothesis that has been difficult to resolve is the question of whether a soundscape that is tailored to the individual's pre-existing anxieties (such as a fear of flying) is more anxiety eliciting than one which is not personally relevant. Again, it appears that there are many universally anxiety-eliciting sounds, and the manner in which these sounds are presented might be more important than resonance with personal histories. After all, these soundscapes are representative of archetypal anxieties (each including around one hundred individual sound sources), engineered as a series of loud shocks, abrasive frequencies, rendered by complex digital audio manipulation as well as immersive spatialisation methods – they appear to generate anxiety even in response to non-relevant sound scenarios.

It appears that many of the anxious physical sensations elicited are attributed to auditory processing or the disorientation induced by being immersed in a simulated hyperreal sound world. Fascinatingly, participants also recounted unexpected physical sensations in areas of the body which are not usually excited by music listening or intense thinking – in fact, several participants re-experienced localised phantom pains in areas of the body they have injured in the past, triggered by the encounter with a sound that was also present at the time (such as fireworks screeching, or scissors cutting). Further, many of the emotions elicited are indicative of a cognitive re-evaluation of suppressed anxieties, followed by an increase of feeling in control, and at times even an emotional catharsis. Thus, soundscape exposure would be an invaluable method to be integrated in psychotherapy, as the external stimulus of a premixed archetypal anxiety soundscape has reliably elicited a synthetic physical manifestation of anxiety and inspired a deep introspection in many participants, encouraging cognitive re-evaluation of suppressed fears, griefs or traumas, whilst also building self-confidence.

7.2 A simulation of everyday anxiety, but to a lesser degree

A criticism of the efficacy of the soundscape exposure could be that it does not replicate as high an experience of anxiety in everyday life. However, this could also be seen as an advantage, because technically the participants are experiencing anxiety sensations, but they are *not experiencing them to an uncomfortable degree*. This means that the user can practice experiencing the symptoms of anxiety but does not feel overly stressed. Thus. they can re-evaluate the negative association of these anxious sensations – this can break the self-perpetuating anxious cycle of "the fear of fear". Even the exemplar labelling of some physical symptoms as "physical positive sensations" in the questionnaire rather than a blanket term "symptoms of anxiety" suggests that these sensations are not solely markers of illness – they are inherent part of human biology, the instinctual way that we judge and react to environmental stimuli and social situations, so these feelings do not always need to be catastrophized.

7.3 Experiment Design to discern whether tailoring soundscapes is essential

It would be far easier to discern the importance of tailoring soundscapes to personal anxieties, if the experiment is specifically designed with this aim in mind, through targeted recruitment. That is, groups of people would be recruited for their social anxiety and would be played the *Social Anxiety* soundscape first, followed by two less relevant ones. Or the participants primarily recruited for their known aversion to body sounds (such as people with mild eating disorders) would be played *Body Anxiety* first and then two non-relevant sounds. The difference in physiological and written sensation scores would be compared between the personalised and the non-relevant soundscapes. However, due to the time constraints, this foresight and planning was not possible. Also it was deemed more important to get a sense of balance in the order of presentation of soundscapes in a series of permutations, so each soundscape was played first in the sequence the same number of times as it was played second or third, to account for listener fatigue. Also, many neuroscience listener response experiments play one isolated audio stimulus at a time; but these soundscapes are constructed to communicate complex dramaturgies, collaging many associated sounds in a dense orchestration, which indeed elicits stronger emotional and physical responses than the controlled method of playing one sound at a time.

7.4 Reliability of methods and cross correlation

A concern about studies like this one, is the question over reliability. It is essential to discern the reliability of the two independent measures of the physiological data and the behavioural response scores. It has been confirmed that during the trigger sounds which participants identified *post-soundscape* (the sounds that they believed were triggering strong sensations), there was indeed a higher than average GSR response.

Cross referencing strengthens arguments and reveals intriguing contradictions between measures: the most salient are briefly summed up below. Cross correlation of likes and dislikes with feedback from other questions, particularly about subjective perceptions section, for example which were the most irritating sounds. Shock sounds such as the machine guns (which were unanimously disliked) and chiming bells, which had a high but equally mixed response of likes and dislikes were frequently reported as a trigger of strong sensations. The liked and disliked sounds are also correlated with the GSR peak timelines (as well as the minute-by-minute peak rate) to figure out if the physiological peak points match the most frequently liked and disliked sounds. Both the perceived response (likes and disliked sounds) and the unconscious response (GSR peaks) are shown together in the secondary results, to map moments of correlation. It has been fascinating, although frustrating, to attempt to clarify whether the moments which were written about in the *Post-Soundscape questionnaire* where participants believed they had a strong sensation coincide with those reported in the *Pre-Exposure Trigger Diagnoses*. If these moments were clearly one and the same, there is a strong argument for tailoring the soundscape to pre-existing anxieties – however the results for this section are quite opaque.

7.5 Explanation of Anomalies: Verbal Feedback and Facial Expressions

Anomaly participants highlight the problem that comes with implementing ready-made generic soundscapes. For example, most participants found machine-guns a negative sound, but Participant 4 remarked that they liked it in the *Post-Soundscape Soundmap*. Thus, although broad conclusions can be drawn from the results (sounds can be identified as a negative sound for a large percentage of the participant population) there is always the chance that one participant stands out in opposition to the trend, and enjoys an otherwise universally anxiety-triggering sound due to their tastes, personal memories and even cultural upbringing. Another example is, at least two participants thought power tools were a lovely sound because it reminded one of being in their Grandfather's workshop, or power tools are integral to their vocation in life as a sculptor, and that reminds them of exciting moments of creativity. There are always going to be anomalies due to the diversity of personal experience: at times, participants would even explain in conversation how they imagined their experience differed to the perceived normative expectation. For example, Participant 4 is a noise artist, so their personal taste in music is that he enjoys the sound of machine guns and abrasive noises because they numb their mental worries, or indeed encourage a catharsis at times, allowing them to process and evaluate their emotions more effectively. Participant 4 recognises the sound as abrasive, yet enjoys the mental clarity it can induce. The experiment design was extremely rigourous, offering the participant numerous prompts to identify the mood-altering or sensation-provoking positive or negative sounds and any conversational feedback was also recorded. Thus, these archives can be dipped into for further explanation of anomalies. The entire catalogue of verbal feedback has not been fully transcribed, nor the whole bank of videos recording the participants' facial expressions been fully analysed yet - realistically that task might be outwith the scope of the project. Rather than meticulously analysing the entirety of the archive in real-time, it is more useful to treat this archive as a bank of data to dip in to only when necessary, for example for a case-by-case verification of significant anxiety-trigger moments or identifying the reason for stand-out participant anomalies.

It must be acknowledged that some participants' facial expressions might be very mediated in that they are quite performative in their everyday personalities. However, for the majority of participants, their facial expressions might actually be a very revealing and reliable marker of eliciting of subtle emotions, (perhaps more so than the physiological data which might be riddled by artefacts depending on the participant's physiology). For example, if a participant is smiling at the opening of the soundscape, then suddenly frowns as soon as the machine guns kick in, this would evidently be a significant trigger point. However within this work there was insufficient resource with which to explore this avenue.

7.6 Hypno-Exposure or Maximum Anxiety Exposure

For soundscape exposure to be used by psychotherapists, it might be necessary to create two distinct types of soundscapes: a sequence purely for physical desensitization to aversive acoustic qualities, encouraging habituation through repetition and a sequence for maximum anxiety elicitation or targeted memory-recall, evaluation and consolidation. Perhaps even a preparatory-sequence or introduction soundscape that establishes the range of levels and types of sounds used, for people to familiarise themselves with the set-up and ease them into the experience might be helpful. One visitor to the soundscape exposure, who has experienced numerous types of anxiety therapy (including hypnotherapy), proposed two distinct avenues to proceed with.

1. *Hypno-Exposure* (counter-conditioning by pairing negative and positive sounds to re-evaluate negative associations), where the composer should purposefully integrate more soothing timbres, lulling rhythms, or hypnotic loops, ensuring the user is as relaxed as possible whilst also subliminally exposing them gradually to more and more abrasive or emotionally resonant sounds. The user would be guided to be as calm as possible throughout.

2. *Maximum-Anxiety-Exposure*, where the user expects to be completely bombarded by abrasive and emotionally sounds to purge anxious sensations or painful emotions like fear, anger and sadness.

It is useful to outline these two distinct approaches, by establishing two compositional approaches and considerate design of the exposure structure (the time frame that the user will be exposed to sound for, the number of soundscapes and then the time dedicated to introspective reflection by filling out questionnaires). Another important consideration is the time of day recommended for treatment: it might be optimal to invite the user to be attend the exposure session in the evening, when people tend to be relaxed and tired, rather than first thing in the morning when people are often alert and naturally anxious.

7.7 Stereo or Ambisonics

It is hypothesised that participants would be more affected hearing the soundscape in the SoundLab rather than on headphones or in stereo. However, this would be hard to quantify, without doing a straight-up comparison in the form of a randomised controlled trial of 30 participants listening in stereo alongside the 30 participants listening in ambisonics. The only way to legitimately quantify if ambisonic sound is more affective than stereo or headphones, is to additionally conduct a stereo run of tests and compare the two - which realistically is beyond the scope of this project. So, it must be deduced from the participants' responses in the *Post-Exposure Spatialisation Evaluation* (2.3.4) that the sound moving (in ways they would not expect from a normal listening experience) was unsettling or exciting or arousing. an approach to use in the future is to a deliberately delineate a static point in the soundscape, where a 20 second section is rendered in two channel stereo, or the sound is tightly focused from the front speaker. The differences in physiological data readings could be compared between the periods of static sound and those with dynamic panning. The participant might not necessarily be aware of this difference, but the differences in physiology signals between that section and a more dynamic spacing can be compared, to covertly address the issue.

It should be assessed whether non-ambisonic, stereo downmixed or binaural versions of the sounds would have much less physical and emotional impact compared to dynamic panning across the ambisonic array. Part of the soundscapes' power is their mode of presentation, and the other is the semantic meaning of sound sources. It would be useful to figure out to what degree does the acoustic aspect enhance the content of the sound, as there is a large gap in current knowledge. Although ambisonic sound is thought to be optimal, it might actually be that for typical individuals that the effect of the non-ambisonic sound is much bigger, as spherical movement may distract from the sound's contents. Perhaps, for a patient the actual content of the sound (its meaning and connotations) may be affecting enough. If this proposed soundscape exposure is effective, what will be asked next is how can sophisticated ambisonic sounds actually be implemented for clinical use, with limited facilities. Ultimately, the aim of this project is to formulate a toolkit as an ideal scenario for sonic implementation, formulating guidelines and instructions for therapists with the means and motivations to build a sensory room. There are already facilities that employ sophisticated sensory therapy - it does not necessarily have to be a state of the art 16-speaker array like the Arup SoundLab, as the set up can be more basic tailored to lower budgets. For example, The Yard in Edinburgh, a facility for young people with disabilities, have invested in a sensory room with a tactile manipulation of coloured lights and easily altered sounds for either a calming or stimulating effect.

In the perfect scenario, if there is time remaining at the end of the initial write up perhaps a control method can be tested, where new participants complete the soundscape exposure procedure but listening to the sounds panned to two channel stereo. If the first analysis period ended earlier than expected, then this dataset was hoped to be compared to one procured using a sub-optimal stereo soundscape exposure, with different participants, to prove that response is enhanced partly due to ambisonic panning. Realistically, just the first part is substantial: to prove that ambisonics is more effective than stereo would be an added bonus. So soundscapes were tested first in the most optimal situation, the Ambisonic SoundLab, to procure data that will hopefully demonstrate that they are capable of generating a heightened psychophysical and psychological response, thus sound exposure would be a feasible anxiety therapy. It is hypothesized that this arousal is caused by the combination of semantic connotations of the sound which are multiplied and enhanced with the spatial acoustic immersion, as sound sources are animated to move around the listener.

7.8 Translation of immersion into lower budget Soundscape Exposure Therapeutic Frameworks.

It is acknowledged that the soundscape exposure trials were hosted in the optimum advanced soundsystem of Arup Ambisonic Soundlab. Ultimately, soundscape exposure must be adaptable to a diverse range of scenarios, as many facilities would not have the funding required to install a custom-made Soundlab. Spatialisation of sounds has been shown to be of paramount importance in eliciting anxious reactions, and whilst the experiments took place in state of the art sixteen speaker array, the exposure experience can be reproduced with a lower budget, and in for a space that is not purpose built. Soundscapes emitted through loudspeakers in a soundproofed listening space is the ideal to ensure heightened physical immersion and a shared therapist and patient experience (enabling the patient to audibly voice their concerns. Conveniently, first order ambisonic soundscapes can be played back using a minimum of four speakers (whilst a minimum of nine speakers are required for second order ambisonics) so this can keep hardware costs to a minimum.

If a therapist is unable to access even the most rudimentary stereo speaker set up, it must be considered how soundscape exposure therapy could be applied to headphones. A means of delivery more cost effective than installing even a basic ambisonic array is to binaurally mix down the ambisonic soundscapes played from headphones. Binaural soundscapes can retain a sense of the animation of sounds moving, but are obviously perceived as moving closely around the listener’s head. However, this mode of playback will not vibrate the listeners body in the same way that ambisonic immersion will. Also problematic, is that the patient might be isolated from the therapist using standard headphones – ideally the therapist should be perceiving the sounds simultaneous to the patient, through linked headphones. Even if the experience is shared by means of linked headphones, the patient will be less able voice concerns or emotions as both they and the therapists have blocked their ears. The ideal means of translating ambisonic to binaural is through a downmixing software (such as BlueRipple's $200 plugin). The hardware approach is placing a binaural dummy head in the centre of the ambisonic spatial array. All the soundscapes used in this research (as well as the isolated sounds from the spatialisation evaluation) have been binaurally recorded in the soundlab, using a dummy head with binaural microphones embedded in the ears. Impressively, a sense of the ambisonic panning is retained, and is especially effective during sparser periods of the soundscape. Moreover, binaural sound has its limitations, as frontal imaging is often not ideal – but there have recently been dramatic technological innovations in high end headphones. For example, in *Ossic X* 3D audio headphones (retailing at $300), eight individual drivers work in tandem, and the weighting of sounds is calibrated to the individual's anatomy. There is also capability for head tracking if used alongside Virtual Reality Visualisation goggles. There are also software applications developed so that 3D audio can be played back on any headphones, such as the Waves NX app, primarily used for iTunes music.

One reassuring measure to ease the facilitation of soundscape exposure therapy in the real-world, is that if the healthcare environment does build a multichannel sound studio (either stereo, quad, 5.1 or indeed the minimum of 4 speakers required for first order ambisonics), it might not be necessary for them to employ an in-house sound designer. An automatic soundscape generator software is proposed (yet to be developed) which can randomly assign the sounds in space, and thus the listener would be enveloped in sound in a relatively hassle-free method. It is envisaged that at least ten personal trigger sounds would be identified for each user; then these are randomly mixed in time with a battery of other sounds that have pre-defined positions in space, and the software could randomly shuffle those together and play it - sounds would each have pre-assigned spatial arrangements, randomly aligned in time. Even better, would be to embed each sound with an appropriate space or path assignment: for instance, the sound of helicopter blades would always sound from the ceiling, or creaky elevator doors would emerge from the front speaker and open into wide stereo.

The element of surprise is important in generating anxiety, a combination of the dread of the unknown and the triggering of the startle mechanism to activate the pre-historic "fight-or-flight" reflex. Thus, the ideal scenario is that the participant will not be able to predict the timing of each sound. Computer generated random-timeline-assortment would create some very jarring arrivals of sound. In truth, these might be even more effective than a sound designer composed soundscape, as a human sound designer instinctively creates sound matches, linking periods and slow-building crescendos and diminuendos. However, the clarity of the sounds might become muddled at times with some unusual overlaps. If the software kept changing and reshuffling the sounds, the user would effectively be exposed to sounds that are linked to their anxiety, in an unexpected arrangement that would be intriguing and spatially immersive. The essential requirements for soundscape exposure therapy are met, even if it means eschewing the role of the sound designer.

However, the precise plotting of each individual sound through its own appropriate ambisonic path is the ideal, as the panning action of some sounds can be especially meaningful. For instance, the sound of footsteps approaching the listener from behind would simulate the panic induced when they are followed in real-life. Naturally, this will rouse much more fear than if the footsteps were played in static mono from the front – the footsteps would lose their menacing quality, representing only the sound itself rather than acting as a "sound-character" to bring a past-experience to life.

These soundscapes can also be played in communal events, such as Mental Health Week, acting as an "empathy machine" in much the same way that film critic Roger Ebert said movies do. (Ebert 2005). Public playback of these anxiety simulation soundscapes not only spreads awareness of both the adversity perceived by sufferers of mood disorders, but also serves to publicising the new therapeutic framework of soundscape exposure to mental health professionals. Using a first order B-format four channel recording (or downmix) and the plugin SurroundZone, the soundscape can be converted to a 5.1, appropriate for cinema spaces. Indicative data analysis deemed *Violence* as the most potent anxiety elicitor, so the soundscape has been showcased publicly in two different 5.1 surround sound arrays, first at a small sound art event with an audience of about 30, INTER- 5 at Stereo in December, then at the Sound Thought Conference in the large Center for Contemporary Arts Theatre venue with an audience of up to 300. The responses of participants who experienced the Soundscape Exposure in the collective environment will be compared with the averages from participants who listened individually in the laboratory setting. Next, funding must be sought to make the final proof of concept prototype pack which would be developed once the doctorate is completed. Funded fellowships with medical research councils, the NHS, mental health organisations will advance this further and place soundscape exposure in the realm of healthcare.

7.9 Listener Fatigue

The soundscape exposure is difficult listening, with rapid movements and dense complex layering, so participants may become tired and irritable: assuming they will hopefully be affected by the sounds, it will be even more exhausting and more demanding than standard experiment fatigue. The participants may answer in the questionnaire that the experience was irritating, but not because of the sound - instead because of the scenario and the duration. When participants get tired, they will become less sensitive to the sounds they hear: if they do not listen very carefully anymore, they will not be so immersed by the sound. Whilst this might dampen the participant's potential arousal towards the end of the experiment, ultimately habituation is the aim of soundscape exposure. Essentially, the aim of the project is habituate users to aversive stimuli, to purge anxiety through mental exercise, as fatigue will diminish shock – so the listener should be exposed to the soundscape for enough time that they become used to the soundscape exposure, but not so long that they begin to feel much worse, or are made angry. Whilst it is necessary to test many different sounds to evoke reactions, presenting an excessively long soundscape programme will inevitably make people tired and less likely to show signs of arousal by the end of the experiment. To counter the effects of listener fatigue on the data, the order of presentation is shuffled for each participant.

So, if the soundscape exposure therapeutic framework for healthcare practitioners features more than one soundscape, then it can be assumed that the first played soundscape is usually going to be the one that triggers the most anxiety. Thus, the first soundscape should contain features that are the main focus of the user's treatment, e.g. *Body Anxiety* for an anorexic patient. Indeed, soundscape exposure may be most consistently effective when the participant is only exposed to one soundscape. It must be taken into consideration that the soundscapes the participant hears second or third are most likely to be perceived as the ones they have habituated themselves to, as their anxious symptoms are going to be numbed somewhat. So after the initial "shock period", the participant is still being exposed to anxiety-eliciting sounds, but their body is now trained to be more comfortable with it, as "tiredness" can be equated with "habituation" - both are essentially a dulling of reactions. Thus it would be reassuring to the user that they can confront the sounds of their anxiety, whilst simultaneously experiencing a dimming of anxious symptoms. It is desirable that the exposure session produces a concave downwards arc of affect, with the first soundscape inducing high anxiety and that this anxiety dissipates during the second and third soundscape, so the participant leaves the session feeling tired and habituated.

Crucially, although participants may have started to become physically habituated during the second and third soundscapes as can be gathered from the attenuation of GSR peak, participants nevertheless kept rating their *Frequency of Perceived Sensations* quite highly in their self-reports. The ratings on the Likert scales for anxious sensations did not automatically become a series of 0s. Therefore, it can be inferred that the participants were still psychologically engaged, and personal anxious memories can still be recalled and evaluated, even though they are physically habituated. This is beneficial as users can confront painful memories (to encourage a healthy processing of the emotions to enable a resolution or catharsis) without necessarily being overcome by a physical panic attack. Further, this soundscape exposure is a scenario that *externalises* the participant's anxiety: they are being guided through the process of emotional induction triggered by external stimuli, rather than the everyday experience of anxiety spontaneously occurring through their own volition of obsessive rumination, or by intrusive, unwanted thoughts. This act *separates the trigger from the anxiety sufferer*, externalising their fear. So, users feel like it is not their fault that they are re-experiencing challenging emotions - their anxiety source is externalised, separated from them. This is a process that should remind anxiety sufferers that their symptoms do not define them. Soundscape exposure instead teaches the user that anxious sensations can spontaneously drift in and out of the body, temporarily provoking effect but leaving them relatively unscathed. The more that the user practices this fleeting anxious memory induction, the stronger the affirmation that they can overcome anxious symptoms, and they themselves are not the root of the problem. They are not the anxiety, they are a person who at times experiences anxious sensations – and in time, hopefully the frequency of these symptoms would subside, or at least they will become more resilient towards them.

7.10 Limitations

Although this research has been executed with a high level of rigour, there are of course limitations. These are either relating to the veracity in discerning the enhancement of emotional and physiological impact when sounds are spatialized (or indeed personalised), or there are also some limitations regarding closeness of the experiment procedure to the intended complex medical intervention. The latter will be evaluated first. Regarding the healthy participant sample, it would have been unethical to initially recruit the intended clientele: anxiety sufferers who have sought and are perhaps already receiving psychotherapeutic treatment (either from the National Health Service or through other community outreach services). Therefore, it was essential first to conduct a large-scale experiment recruiting relatively healthy participants from the general population to assess the intensity of the anxiety elicited, prior to recruitment of vulnerable participants. Further, the ideal experiment procedure would more accurately mimic the real-world implementation of exposure therapies, where a client returns to the Soundlab for repeated exposures over several weeks or months. However, logistically this would have been very challenging in terms of the sheer volume of data to be analysed, and the diminished likelihood of participant recruitment and retention (without reflective increase in budget to fairly remunerate participants). Other ideal procedures would be to conduct a randomised controlled trial, assigning one group of participants a control condition (either no treatment at all, or a standard psychotherapeutic treatment such as counselling alone, or a psychiatric pharmaceutical prescription alone) and assigning one group of participants the soundscape exposure, to identify differences in impact between the various treatments. Again, this would not have been possible as a doctoral experiment, due to the short timescale, and the necessity of testing the procedure on healthy participants first prior to recruitment of vulnerable participants. Also, it is unethical to intentionally delay or totally deprive one group an already established beneficial treatment (Craig et al 2006).

Similarly, a control group of participants could have been exposed to the a stereo mixdown of these soundscapes in the same experiment conditions, to clearly demarcate the impact of ambisonic panning on participants, compared to static stereo playback. Unfortunately, it was outwith the scope of this project to assign a further thirty participants to the experimental control, in terms of budget, and time constraints. Also, to clearly discern whether personally relevant soundscapes (that match participants' pre-existing anxieties) more frequently trigger strong sensations and emotions than non-relevant soundscapes, a specialist experimental design is required, where participants are recruited into target groups according to their strongest personal anxiety. For example, thirty participants who suffer from social anxiety would be exposed to the *Social Anxiety* soundscape, and thirty more participants who have social anxiety would be exposed to the *Situational Phobias* soundscape instead. To conduct randomised controlled trials for each of the five archetypal soundscapes would require 300 participants. An experiment of this kind would be near to impossible to conduct within the timeframe and budget allowed in this research. Overall, after conferral with Glasgow School of Art's Research Developer, and the diverse specialist knowledge of the supervisory team, a counter-balanced measure design was chosen, to investigate several of the most crucial hypotheses in an efficient manner. This proof of concept would also benefit from a full economic evaluation, assessing the cost-effectiveness of a soundscape exposure intervention, ideally working in tandem with counselling and cognitive behavioural therapies, in comparison to either a placebo or counselling alone or a pharmaceutical intervention alone.

7.11 Summary

The original contribution to knowledge is two fold: primarily, a suite of five archetypal anxiety-eliciting soundscapes have been created and panned in an immersive ambisonics loudspeaker array; secondly, a proof of concept for a new form of psychotherapeutic soundscape exposure, which uses these soundscapes as temporary anxiety stimuli. The aim is to synthetically induce anxious sensations in the user, to physically desensitize and encourage a psychological catharsis. According to the Medical Research Council's new guidance for complex interventions (Craig et al. 2006), the experimental research serves as a feasibility study. A small-scale version of soundscape exposure therapy is piloted, where the short-term and long-term impact on the well-being of a healthy participant is analysed, following a singular exposure to the sounds, on only one occasion. In established exposure therapies , the user would undergo a series of exposures over a number of weeks or months. To establish that the procedure does not have adverse effects on participants with everyday levels of anxiety, as sample of 30 healthy participants was recruited. The results of this feasibility study will be disseminated to both sound studies innovators and healthcare practitioners through publication of articles in peer-reviewed journals and paper presentations at conferences, with a view to further testing, implementation and development.

This research contributes to the established therapeutic paradigms, by amalgamating elements of music and arts therapies and exposure therapies to invent an approach to anxiety treatment using a medium much more suited to the affliction, sound – the use of which is underemployed in exposure therapy. The fight-or-flight response has been triggered by alarming sounds for millennia – in more primitive ancient civilisations, humans' survival and procreation depended on an attentive listening to environmental threats or to emotionally communicative vocalisations and music. Unfortunately, this instinctual auditory hypersensitivity is vestigial in the present day, and the flight-or-fight response can be triggered by a multitude of seemingly innocuous everyday stimuli, or even in response to a new host of socio-economic stresses. The researcher has identified that a blend of real-world sounds and emotionally manipulative music can be arranged in a manner that significantly engages the listener, so they can re-evaluate their own anxieties whilst learning coping strategies and boosting their confidence, increasing their ability to withstand fleeting anxious sensations.

In this experiment, the soundscapes elicited a complex timeline of physical and emotional affect, in a seemingly consistent manner. The sudden loud sounds reliably shocked participants, whilst immersion in an oceanic collage of waterfall sounds relaxed participants, and sounds that resonated with a participant's personal memories even triggered tears in several instances – these effects were both objectively recorded by the physiological monitoring equipment and consciously reported by the participant. On the whole, participants largely perceived a short-term rise in negative sensations and emotions immediately following the soundscape exposure, as intended. However, this temporary induction of negative sensations and emotions served to trigger a deep cognitive re-evaluation of unresolved fears, traumas or grieving in many, or at least served as an empowering psycho-educative endurance test. In turn, this re-experience of anxieties reassured the participants, so that there was a notable increase of their perception of being in control (both in the short term and the long term). Importantly the re-evaluation of psychological issues generated a long term positive impact, both emotional and physical, which far outweighed the short-term negativity perceived during the soundscape exposure.

In short, this research provided a unique opportunity to implement innovative sound technologies in a psychological experiment, whose methods consisted of meticulous psychophysical monitoring and conscious evaluations of the sounds heard, as well as the sensations and emotions elicited by these sounds. The experiment confirmed most of the hypotheses outlined, and when deviations were encountered even these are very instructive. For example, it was expected that the more hyperreal and exaggerated the spatialisation imposed on a sound is, the greater the anxiety or fear elicited would be, it appears that this is not always the case - sometimes a greater sense of realism is required to immerse the listener in a recreation of real-world scenario. The detailed accounts and data analysis provides a wealth of insights into the nature of anxiety-elicitation whilst demonstrating the myriad benefits of soundscape exposure. In addition to this data, the five archetypal soundscapes and experimental procedure produced in this research provide a model that can be used in healthcare, as a bespoke therapeutic framework which goes beyond the established therapeutic paradigms.

References

Abramowitz, J.S., Deacon, B. J. and Whiteside, S. P. H eds. 2011. *Exposure Therapy for Anxiety: Principles and Practice.* New York: The Guildford Press.

Altenmuller, E., Kopiez, R. and Grewe, O., 2013. Strong Emotions in Music: Are they an Evolutionary Adaptation? In: R. Bader, ed., 2013. *Sound Perception Performance*, [e-book]. Switzerland: Springer International Publishing. pp. 131-156. Available at < http://link.springer.com/chapter/10.1007%2F978-3-319-00107-4_5 > [Accessed 19 January 2017]

Altenmuller, E. and Schlaug, G., 2013. Neurologic music therapy: The beneficial effects of music making on neurorehabilitation. *Acoustical Science and Technology*, [e-journal] 34 (1), pp.5–12. Available at: <https://www.jstage.jst.go.jp/article/ast/34/1/34_E131002/_pdf > [Accessed 16 January 2017]

Argo, J., 2013. *From Phrase to Phase: Evolving Musical Affect by Transformative Visceral Catharsis*. Masters Thesis, MDes Sound for Moving Image at Glasgow School of Art.

Avid., 2017. *ProTools: New Features.* Available at: < http://www.avid.com/pro-tools/features#Edit-tracks > [Accessed 2 February 2017]

Austin, D., 2006. Songs of the Self: Vocal Psychotherapy for Adults Traumatized as Children. In: L. Carey, ed. 2006. *Expressive and Creative Arts Methods for Trauma Survivors*. London: Jessica Kingsley. Ch.7.

Ashton, P.W., 2010. Music Mind and Psyche. In: P. W Ashton, and S. Bloch, eds. *Music and Psyche*. New Orleans: Spring Journal Books. Ch. 8.

Aziz-Zadeh, L., Iacoboni, M., Zaidel E., Wilson, S. and Mazziotta, J., 2004. Left hemisphere motor facilitation in response to manual action sounds. *European Journal of Neuroscience*, [e-journal] 19(9) pp. 2609-2612. Available at < http://onlinelibrary.wiley.com/doi/10.1111/j.0953-816X.2004.03348.x/epdf > Accessed 19 January 2017.

Bartel, L., University of Toronto, 2012. *Good vibrations: using sound to treat disease*. [online] Available at <. https://www.utoronto.ca/news/good-vibrations-using-sound-treat-disease > [Accessed 19 January 2017]

Beck, A. T., Epstein, N., Brown, G., & Steer, R. A., 1988. An inventory for measuring clinical anxiety: psychometric properties. *Journal of Consulting and Clinical Psychology*, 56(6), pp. 893–897.

Becht, M. C., & Vingerhoets, A. J. J. M., 2002. Crying and Mood Change: a Cross-Cultural Study. *Cognition and Emotion*, [e-journal] 16(1), pp. 87-101. Available at: < https://pure.uvt.nl/ws/files/492469/crymoodchange.PDF >

Benveniste, S., Jouvelot, P., Lecourt, E., and Michel, R., 2009. Designing Wiimprovisation for Mediation in Group Music Therapy with Children Suffering from Behavioural Disorders. IDC 2009 (Interaction Design and Children) *International Conference on Interaction Design and Children*, [e-book] pp. 18-26. Como, Italy 3-5 June 2009 (2009). http://dx.doi.org/10.1145/1551788.1551793

Berlyne, D. E., 1970. Novelty, complexity, and hedonic value. *Perception and Psychophysics*, [e-journal] 8(5), pp. 279-86. Available at: < http://link.springer.com/article/10.3758/BF03212593 > [Accessed 19 January 2017]

Biddle, I. and Thompson, M. eds., 2013. *Sound, Music, Affect: Theorizing Sonic Experience*. London: Bloomsbury.

Bourke, P., 1996. *Möbius (Möbius) strip.* [online] Available at: < http://paulbourke.net/geometry/mobius/ > [Accessed 25 May 2017]

Bradley, M. M. & Lang, P. J. 2007. *International Affective Digtized Sounds.* Center for the Study of Emotion and Attention, University of Florida. [online] Available at: http://csea.phhp.ufl.edu/media.html [Accessed 16 January 2017]

Breton-Lopez, J., Quero, S., Botella, C., Garcia-Palacios, A., Banos, R.M. & Alcaniz, M., 2010. An augmented reality system validation for the treatment of cockroach phobia.

Cyberpsychology, Behavior and Social Networking, 1-16. [photograph] Available at < https://ispr.info/2010/10/20/treating-cockroach-phobia-with-augmented-reality/> [Accessed 16 January 2017]

Brezinka, V and Hovestadt, L., 2007. Serious Games Can Support Psychotherapy of Children and Adolescents. In A. Holzinger, ed., 2007. USAB 2007, *Symposium of the Austrian HCI and Usability Engineering Group*, [e-book] Graz, Austria 22nd November 2007. Berlin: Springer-Verlag Heidelberg. http://dx.doi.org/10.1007/978-3-540-76805-0_30

Brodsky, W., 2000. Post-Exposure Effects of Music-Generated Vibration and Whole Body Acoustic Stimulation Among Symphony Orchestra Musicians. *Psychology of Music,* [e-journal] 28, pp.98-115. Available at <http://journals.sagepub.com/doi/pdf/10.1177/0305735600281007 > [Accessed 19 January 2017]

Bylsma, L. M., Vingerhoets, A. J. J. M., and Rottenberg, J., 2008. When is Crying Cathartic? An International Study. *Journal of Social and Clinical Psychology*, [e-journal] 27 (10). pp.1165-1187. Available at <http://uweb.cas.usf.edu/mood/docs/Bylsma_2008_jscp.pdf > [Accessed 16 January 2017]

Callaghan, K., 1997. Torture – the body in conflict. The Role of Movement Psychotherapy. In: M. Liebmann, ed. 1997. *Arts approaches to conflict*. London: Jessica Kingsley.

Champion, E., 2011. *Playing with the Past, Human-Computer Interaction Series*. [e-book] London: Springer Verlag. Ch. 7. Available at Google Books < http://booksgoogle.com > [Accessed January 16 2017]

Cheng, W., 2014. Monstrous Noise: Silent Hill and the Aesthetic Economies of Fear. In: C. Vernallis, A. Herzog, J. Richardson, 2014. *The Oxford Handbook of Sound and Image in Digital Media*. Oxford: Oxford University Press.

Chion, M., 1994. *Audio-Vision: Sound on Screen*. New York: Columbia University press. P.66

Cohen, A. J., 2011. Music as a Source of Emotion in Film. In: P. Juslin & J. Sloboda, eds. 2011. *Handbook of Music and Emotion: Theory Research and Applications*. Oxford: Oxford University Press. Ch.31.

Concord Health Supply, 2014. *Nonin Ear Pulse Oximeter Sensor* [photograph] Available at <http://www.concordhealthsupply.com/Nonin-Ear-Clip-Sensor-3ft-p/non-8000q2.htm> [Accessed 16 January 2017]

Cooking Hacks, 2014. *Galvanic Skin Response sensor* [photograph] Available at: <https://www.cooking-hacks.com/documentation/tutorials/ehealth-v1-biometric-sensor-platform-arduino-raspberry-pi-medical/> [Accessed 16 January 2017]

Cox, T. J., 2008. Scraping Sounds and Disgusting Noises. *Applied Acoustics* [e-journal] 69(12) pp.1195-1204. Available at < http://usir.salford.ac.uk/12958/ > [Accessed 19 January 2017]

Craig, P., Dieppe, P., Macintyre, S., Michie, S., Nazareth, I., Petticrew, M., 2006. *Developing and evaluating complex interventions: new guidance.* Medical Research Council. Available at: < www.mrc.ac.uk/complexinterventionsguidance > [Accessed 29 May 2017]

Csikszentmihalyi, M., 1990. *Flow: The Psychology of Optimal Experience*. New York: Harper Perennial.

Dack, J., 2013. Collage, montage and the composer Pierre Henry: The real the concrete and the abstract in sound art and music. *Journal of Music Technology & Education*, [e-journal] 6(3) pp.275-284. Available at < http://www.ingentaconnect.com/content/intellect/jmte/2013/00000006/00000003/art00003?crawler=true > [Accessed 19 January 2017]

Davies, W.J., Adams, M. D., Bruce, N. S., Cain, R., Carlyle, A., Cusack, P., Hall, D. A., Hume, K.I., Irwin, A., Jennings, P., Marselle, M. R., Plack., C.J., and Poxon, J., 2013. Perception of Soundscapes: An Interdisciplinary approach. *Applied Acoustics*, [e-journal] 74 (2) pp.224-231. http://dx.doi.org/10.1016/j.apacoust.2012.05.010

Deacon, B., 2012. The Ethics of Exposure Therapy for Anxiety Disorders. In P. Neudeck and H. U. Wittchen, eds. 2012. *Exposure Therapy: Rethinking the Model – Refining the Method*, [e-book]. New York: Springer. pp. 9-22. Available at < http://link.springer.com/chapter/10.1007%2F978-1-4614-3342-2_2 > [Accessed 19 January 2017]

Deacon, B. J., Abramowitz, J. S. (2004) Cognitive and behavioral treatment for anxiety disorders: A review of meta-analytic findings. *Journal of Clinical Psychology*, [e-journal] 60(4), pp. 429-441. Available at <http://onlinelibrary.wiley.com/doi/10.1002/jclp.10255/epdf > [Accessed 19 January 2017]

Deacon, B. J., Farrell, N. R., 2013. Therapist Barriers to the Dissemination of Exposure Therapy. In: E. A. Storch, and D. McKay, eds. 2013. *Handbook of Treating Variants and Complications in Anxiety Disorders,* [e-book] New York: Springer Science and Business Media. Pp. 363-373. Available at < http://link.springer.com/chapter/10.1007%2F978-1-4614-6458-7_23 > [Accessed 19 January 2017]

Donnelly, K., 2005. *The Spectre of Sound: music in Film and Television.* London: British Film Institute.

Dugas, M. J. Robichaud, M. J., 2007. *Cognitive-behavioral treatment for generalized anxiety disorder: from science to practice*. New York: Routledge.

Eckman, I., 2014. A Cognitive Approach to the Emotional Function of Game Sound. In: K. Collins, B. Kaprolos, B and H. Tessler, eds. *The Oxford Handbook of Interactive Audio*. Oxford: Oxford University Press.

Ebert, R., 2005. Ebert's Walk of Fame Remarks, [website]. Available at: < http://www.rogerebert.com/rogers-journal/eberts-walk-of-fame-remarks > [Accessed 31 January 2017]

Ellis, R. J., Koenig, J. and Thayer, J. F., 2012. Getting to the Heart: Autonomic Nervous system function in the Context of Evidence Based Music Therapy. *Music and Medicine* [e-journal] 4 (2) pp. 90-99. Available at <

https://mmd.iammonline.com/index.php/musmed/article/view/MMD-2012-4-2-5 > Accessed 19 January 2017.

Evans, I. M., 1972. Conditioning model of a common neurotic pattern: Fear of fear. *Psychotherapy: Theory Research and Practice,* 9 (3), pp. 238–241.

Fachner, J. and Stegemann, T., 2013. Electroencephalography and Music Therapy: On the Same Wavelength. *Music and Medicine,* [e-journal] 5(4) pp. 217-222. Available at <https://www.researchgate.net/publication/261323672_Electroencephalography_EEG_and_music_therapy_On_the_same_wavelength > [Accessed 19 January 2017]

Falsetti, S. A., Resnick, H. S. and Davis, J., 2005. Multiple Channel Exposure Therapy: Combining Cognitive-Behavioral Therapies for the Treatment of Posttraumatic Stress Disorder with Panic Attacks. *Behavior Modification*, [e-journal] 29(1), pp. 70-94. Available at < http://journals.sagepub.com/doi/pdf/10.1177/0145445504270874 > Accessed 19 January 2017.

Fassbender, E., and Martyn Jones, C., 2014. The importance and creation of high-quality sounds in healthcare applications. In M. Ma, L. C. Jain, P. Anderson, eds. 2014. *Virtual, Augmented Reality and Serious Games for Healthcare 1.* Berlin: Springer Berlin Heidelberg. Ch. 26.

Field, T., Martinez, A., Nawrocki, T., Pickens, J., Fox, N. A.. and Schanberg, S., 1998. Music shifts frontal EEG in depressed adolescents. *Adolescence,* [online] 33 (129) pp. 109-116. Available at <https://www.thefreelibrary.com/Music+shifts+frontal+EEG+in+depressed+adolescents.-a020740163 > Accessed 19 January 2017.

Foa, E., Hembree, E. and Rothbaum, B. O., 2007. *Prolonged Exposure Therapy for PTSD: Emotional Processing of Traumatic experiences: Therapist Guide.* Oxford: Oxford University Press.

Foa, E. B., Huppert, J.D. and Cahill, S.P., 2006.Emotional processing theory: An update. In: B. O. Rothbaum, ed. *Pathological anxiety: emotional processing in etiology and* *treatment*, [e-book] pp.3-24. New York: Guilford Press. Available at < http://www.guilford.com/excerpts/rothbaum.pdf > [Accessed 19 January 2017]

Frankenhaeuser, M., 1980. Psychoendocrine approaches to the study of personal-environment transactions. In: H. Selye, ed. (1980) *Selye's Guide to Stress Research*. New York: Van Nostrand Reinhold.
Vickhoff, B., Astrom, R., Theorell, T., von Scheele, B., Nilsson, M., 2012. Musical Piloerection. *Music and Medicine*, 4(2) pp. 82-89.

Freeman, J. and Lessiter, J., 2001. Here, There and Everywhere: The Effects of Multichannel Audio on Presence. In: *Proceedings of the 2001 International Conference on Auditory Display*, [e-book] Available at:< http://hdl.handle.net/1853/50621 > [Accessed 16 January 2017]

Freud, S., 1919. Das Unheimliche. In S. Freud, ed. 1959. *Collected Papers, Volume IV*. New York: Basic Books. pp.372-95.

Fox, S., 2010. *Noise Level Chart* and *Noise Dose Chart.* [online] Available at: < http://www.noisehelp.com/noise-level-chart.html > < http://www.noisehelp.com/noise-dose.html > [Accessed 19 January 2017]

Gabrielsson, A., 2001: Emotions in Strong Experiences in Music. In P, Juslin & J. A. Sloboda, eds. 2001. Music and Emotion: Theory and Research. Oxford: Oxford University Press. Ch.19.

Gamito, P., Oliveira, J., Morais, D., Rosa, P., Saraiva, T., 2010. Serious Games for Serious Problems: from Ludicus to Therapeuticus. In J, Kim, ed. 2010. *Virtual Reality*, [e-book] Rijeka: InTech. http://dx.doi.org/10.5772/12870

Gendolla, G. and Krusken, J., 2002. Mood state, task demand, and effort-related cardiovascular response. *Cognition and Emotion*, [e-journal] 16(5), pp. 577-603. Available at < http://www.tandfonline.com/doi/abs/10.1080/02699930143000446 > Accessed 19 January 2017.

Gerlach, A. L., and Neudeck, P., 2012. Interoceptive Exposure. In P. Neudeck and H. Wittchen, eds. *Exposure Therapy: Rethinking the Model – Refining the Method*, [e-book] 2012. New York: Springer Science & Business Media. Available at: Google Books < http://booksgoogle.com > Accessed 16 January 2017)

Gerra, G., Zaimovic A, Franchini D., Palladino, M., Giucastro, G., Reali, N., Maestri, D., Caccavari, R., Delsignore, R., and Brambilla, F., 1998. Neuroendocrine responses of healthy volunteers to 'techno-music': relationships with personality traits and emotional state. *International Journal of Psychophysiology*, [e-journal] 28(1) pp. 99-111. Available at <http://www.sciencedirect.com/science/article/pii/S0167876097000718 > [Accessed 19 January 2017]

Goncalves, R., Pedrozo, A. L., Coutinho, E. S. F., Figueira, I., Ventura, P., 2012. Efficacy of Virtual Reality Exposure Therapy in the Treatment of PTSD: A Systematic Review. In *Plos One*, [e-journal] December 2012, 7(12). Available at < http://dx.doi.org/10.1371/journal.pone.0048469 > [Accessed 16 January 2017]

Goodman, S. 2010. *Sonic Warfare: Sound, Affect, and the Ecology of Fear.* Massachusetts: MIT Press.

Graham, R. A., 2010. Cognitive attentional perspective on the psychological benefits of listening. *Music and Medicine*, [e-journal] 2 (3), pp. 167. Available at < https://mmd.iammonline.com/index.php/musmed/article/view/MMD-2010-2-3-6 > [Accessed 19 January 2017]

Greenman, D., Meulenberg, F., White, M., 2008. The Power of Music. In G. Bolton, ed. 2008. *Dying, bereavement and the healing arts*. London: Jessica Kingsley. Ch.12.

Grewe, O., Katzure, B. Kopiez, R. Altenmuller, E., 2010. Chills in different sensory domains: Frisson elicited by acoustical, visual, tactile and gustatory stimuli. *Psychology of Music*, [e-journal] 39 (2) pp. 220-239. Available at < http://musicweb.hmt-hannover.de/kopiez/Grewe-etal(2011)ChillsDifferentDomains.pdf > [Accessed 19 January 2017]

Grillon, C., Franco-Chaves, J. A., Mateus, C. F., Ionescu, D. F., and Zarate, C. A., 2013. Major Depression is Not Associated with Blunting of Aversive Responses; Evidence for Enhanced Anxious Anticipation. *Plos One*, [e-journal] August 2013, 8 (8). http://dx.doi.org/10.1371/journal.pone.0070969.

Hanser, S. B., 2009. From Ancient to Integrative Medicine: Models for Music Therapy. *Music and Medicine* [e-journal] 1(2) pp.87-96. Available at < https://mmd.iammonline.com/index.php/musmed/article/view/MMD-2009-1-2-2 > [Accessed January 19 2017]

Have, I., 2008. Background Music and Background Feelings - Background Music in Audio-Visual Media. *The Journal of Music and Meaning*, 6, Spring 2008. [online] Available at: < http://www.musicandmeaning.net/issues/pdf/JMMart_6_5.pdf > [Accessed 16 January 2017]

Hegarty, P., 2013. Brace and Embrace: Masochism in Noise Performance. In: I. Biddle and M. Thompson, eds. *Sound, Music, Affect: Theorizing Sonic Experience*. London: Bloomsbury. Ch. 8.

Herbelin, B., Riquier, F., Vexo, F., and Thalmann, D., 2002. Virtual Reality in Cognitive Behavioural Therapy: a Study on Social Anxiety Disorder. *ResearchGate* Available at <https://www.researchgate.net/publication/2478918_Virtual_Reality_in_Cognitive_Behavioral_Therapy_Study_on_Social_Anxiety_Disorder > [Accessed January 16 2017]

Herbert, R., 2011. An empirical study of normative dissociation in musical and non-musical everyday life experiences. *Psychology of Music* , [e-journal] 41(3) pp. 372 – 394. Available at < http://journals.sagepub.com/doi/pdf/10.1177/0305735611430080 > [Accessed 19 January 2017].

Hoffman, H. G., Chambers, G. T., Meyer III, W. J., Arceneaux, L. L., Russell, W. J., Seibel, E. J., Richards, T. L., Sharar, S. R. and Patterson, D. R. 2011. Virtual Reality as an Adjunctive Non-pharmacologic Analgesic for Acute Burn Pain During Medical Procedures. *The Society of Behavioral Medicine*, [e-journal] 41, pp. 183-191. http://dx.doi.org/10.1007/s12160-010-9248-7

Hoffman, H. S., 1995. Attentional Factors in the Elicitation and Modification of the Startle Reaction. In: P. J. Lang, R. F. Simons, and M. Balaban, eds. 1997. *Attention and Orienting: Sensory and Motivational Processes*, [e-book]. New York: Routledge. Ch. 8. Available at: Google Books < http://booksgoogle.com > [Accessed January 19 2017]

Hofmann, S. G., Gutner C. A. and Asnaani, A., 2012. Cognitive Enhancers in Exposure Therapy for Anxiety and Related Disorders. In P. Neudeck and H. U. Wittchen, eds. *Exposure Therapy: Rethinking the Model – Refining the Method,* [e-book] New York: Springer. pp. 89-110. Available at < http://www.springer.com/us/book/9781461433415# > Accessed 19 January 2017.

Holman, T., 2008. *Surround Sound: Up and Running*. 2nd ed. Burlington: Focal Press. p.109

Hoyer, J. and Beesdo-Baum, K., 2012. Prolonged Imaginal Exposure Based on Worry Scenarios. In P. Neudeck and H. U. Wittchen, eds. *Exposure Therapy: Rethinking the Model – Refining the Method,* [e-book] New York: Springer. pp. 245-260. Available at < http://link.springer.com/chapter/10.1007%2F978-1-4614-3342-2_14 > [Accessed 19 January 2017]

Huron, D., 2006. *Sweet Anticipation: Music and the Psychology of Expectation.* Cambridge, Massachusetts: MIT Press.

Hwang, E. and Oh, S., 2013. A Comparison of the Effects of Music Therapy Interventions on Depression, Anxiety, Anger, and Stress on Alcohol-Dependent Clients: A Pilot Study. *Music and Medicine* [e-journal], 5(3), pp.136. Available at < https://mmd.iammonline.com/index.php/musmed/article/view/MMD-2013-5-3-2 > Accessed 19 January 2017.

Ihde, D., 2007. *Listening and Voice: Phenomenologies of Sound*. Albany: State University of New York Press. p.212

Inglis, C. (1977) Directional Sound Reproduction: Stereo, Quad and Beyond, *Sound for the Moving Image 2 – Lectures – Surround Sound and Spatial Sound – Ambisonics* [online via internal VLE] Glasgow School of Art. Available at:

<https://vle.gsa.ac.uk/webapps/blackboard/content/listContentEditable.jsp?content_id=_234159_1&course_id=_2777_1 > Accessed 3 February 2017]

Jonsson, A., Breslin, R., and Ma, M. 2013. The Ambience Table — A Serious Gaming Interface for Aiding Sound Design. In: M. Ma, M., M. F. Oliveira, S. Petersen, J. Baalsrud Hauge eds. 2013. *Serious Games Development and Applications, Lecture Notes in Computer Science, LNCS 8101*. [e-book] 151-164, Berlin: Springer-Verlag Berlin Heidelberg. Available at: Google Books < http://booksgoogle.com > [Accessed January 16 2017]

Juslin, P. N. and Vastfjall, D., 2008. Emotional responses to music: the need to consider underlying mechanisms. *Behavioral and Brain Sciences* [e-journal] (2008) 31 pp. 559-621. Available at < http://nemcog.smusic.nyu.edu/docs/JuslinBBSTargetArticle.pdf > Accessed 19 January 2017.

Kerins, M, 2010. *Beyond Dolby (Stereo): Cinema Sound in the Digital Age.* Indiana: Indiana University Press.

Kim, S., Andre, E., 2004. Composing Affective Music with a Generate and Sense Approach. In V. Barr and Z. Markov, eds. 2004. *FLAIRS, Proceedings of the Seventeenth International Florida Artificial Intelligence research Society Conference*, [e-book] Miami Beach, Florida, 12-14 May 2004. Miami: American Association for Artificial Intelligence Press. Available at < https://ww.aaai.org/Papers/FLAIRS/2004/Flairs04-011.pdf > [Accessed 16 January 2017]

Knox, M., Lentini, J., Cummings, T. S., McGrady, A., Whearty, K. and Sancrant, L., 2011. Game-based biofeedback for pediatric anxiety and depression. *Mental Health and Family Medicine*, [online] 8, pp. 195-203. Available at: < https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3314276/pdf/MHFM-08-195.pdf > [Accessed 16 January 2017]

Koerner, N. and Francalanza, K., 2012. The Role of Anxiety Control Strategies in Imaginal Exposure. In: P. Neudeck and H. U. Wittchen, eds. *Exposure Therapy: Rethinking the Model – Refining the Method,* [e-book] New York: Springer. pp. 245-260.

Available at < http://link.springer.com/chapter/10.1007%2F978-1-4614-3342-2_12 > [Accessed 19 January 2017]

Kumar, S., von Kriegstein, K., Friston, K. J., and Griffiths, T. D., 2013. Dynamic System for the Analysis of Acoustic Features and Valence of Aversive Sounds in the Human Brain. In: B. C. J. Moore, R. D. Patterson, I. M. Winter, R. P. Carlyon, and H. E. Gockel, eds. 2013. *Basic Aspects of Hearing, Advances in Experimental Medicine and Biology*, [e-book] New York: Springer Science + Business Media. pp.463-472. http://dx.doi.org/10.1007/978-1-4614-1590-9_51

Kryter, K. D., 1970. The Effects of Noise on Man. New York and London: Academic Press.

Kzenon at Shutterstock, 2014. *Woman in wellness and spa setting having a singing bowl massage therapy, the therapist is waking her up with cymbals.* [photograph] Available at <https://www.shutterstock.com/image-photo/woman-wellness-spa-setting-having-singing-113069137?src=qMfzHwCAClAcNI6C93LcJA-1-19> [Accessed 16 January 2017]

Lahav, A., Saltzman. E., and Schlaug., G., 2007. Action Representation of Sound: Audiomotor Recognition Network While Listening to Newly Acquired Actions. *Journal of Neuroscience*, [e-journal] 27(2): pp. 308-314. Available at < http://www.jneurosci.org/content/27/2/308.full > [Accessed 19 January 2017]

Laird, I., Murphy, D. T. and Chapman, P., 2014. Comparison of Spatial Audio Techniques for use in Stage Acoustic Laboratory Experiments. In*: Proceedings of EAA Joint Symposium on Auralization and Ambisonics*. Berlin, Germany, 3-5 April 2014. pp. 140-146. Available at < http://dx.doi.org/10.14279/depositonce-23 > https://www.dolby.com/us/en/technologies/cinema/dolby-atmos.html

Landy, L., 2007. Understanding the art of sound organization. Massachusetts: MIT Press.

Lang, P.J., Cuthbert, B. N., 1984. Affective information processing and the assessment of anxiety. *Journal of Behavioral Assessment*, 6(4), pp. 369-395.

Latham, C., 2013. Listening to the talking cure: Sprechstimme, hypnosis, and the sonic organization of affect. In: I. Biddle and M. Thompson, eds. *Sound, Music, Affect: Theorizing Sonic Experience*. London: Bloomsbury. Ch. 6.

Leadley, M., 2011. Soundscape and perception: reconfiguring the acoustic environment for experimental purpose. *SoundEffects*, [e-journal] 1 (1) Available at <www.soundeffects.dk/article/download/4082/5005> [Accessed 16 January 2017]

Liljjedahl, M., 2011. Sound for Fantasy and Freedom. In M. Grimshaw, ed., 2011. *Game Sound Technology and Player Interaction: Concepts and Developments*. [e-book] Hershey New York: IGI Global. Ch. 2. Available at < http://soda.swedish-ict.se/4048/1/Game_Sound_Experience.pdf > [Accessed 16 January 2017]

Liljjedahl, M., 2011. Sound for Fantasy and Freedom. In M. Grimshaw, ed., 2011. *Game Sound Technology and Player Interaction: Concepts and Developments*. [e-book] Hershey New York: IGI Global. Ch. 2. http://dx.doi.org/10.4018/978-1-61692-828-5.ch002

Loui, P., Bachorik, J. P., Li, H.C. and Schlaug, G., 2013. Effects of Voice on Emotional Arousal. *Frontiers in Psychology*, [e-journal] 4 (675). http://dx.doi.org/10.3389/fpsyg.2013.00675.

Magee, W, Bertolami, M., Kubicek, L, LaJoie, M., Martino, L., Sankowski, A., Townsend, J., Whitehead-Pleaux, A. M., and Zigo, J. B., 2011. Using Music Technology in Music Therapy with Populations across the Life Span in Medical and Educational Programs. *Music and Medicine*. 3 (3) pp. 146-153. Available at <http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.907.9113&rep=rep1&type=pdf > [Accessed 16 January 2017]

Manucia G. K., Baumann, D. J., Cialdini, R. B., 1984. Mood influences on helping: Direct effects or side effects? *Journal of Personality and Social Psychology*, 46(2), pp. 357-364. Available at <http://www.communicationcache.com/uploads/1/0/8/8/10887248/mood_influences_on_helping-_direct_effects_or_side_effects.pdf> [Accessed 19 January 2017]

McGeoch, C. 2013. *Equalization lecture*, Sound for Moving Image. Glasgow School of Art, unpublished.

McKendrick, R. P., 2007. *A Conductor's Analysis of Gabriel Faure's Requiem, Op. 48*. MMu. Georgia State University. Available at: < http://scholarworks.gsu.edu/music_theses/2 > [Accessed 19 January 2017]

Memory, B., 2012. *Music Therapy active performance.*[photograph] Available at <http://blog.ecu.edu/sites/ecunow/blog/2012/01/20/interest-rising-in-music-therapy/> [Accessed 16 January 2017].

Meyer, L. B., 1956. *Emotion and Meaning in Music*. Chicago: University of Chicago Press.

Michelsen, M., 2012. Michael Jackson's sound stages. *SoundEffects – An Interdisciplinary Journal of Sound Experience*, [e-journal] 2(1). Available at < http://www.soundeffects.dk/article/view/5163/5449 > [Accessed 19 January 2017]

Mitchell, D. J., McNaughton, N., Flanagan, D. and Kirk, I. J., 2008. Frontal-midline theta from the perspective of hippocampal "theta". Progress in Neurobiology [e-journal] 86 (3) pp. 156-185. Available at < http://www.sciencedirect.com/science/article/pii/S0301008208001007 > Accessed 19 January 2017.

Moorefield, V., 2005. The Producer as Composer: Shaping the Sounds of Popular Music, Cambridge, MA.

Mueller, W., 1995. *EASe Listening Therapy.* [online] Available at: <http://www.easecd.com/EASe1.html > [Accesssed 16 January 2017]

Schafer, R. Murray (1994) *The Soundscape: Our Sonic Environment and The Tuning Of the World*. Rochester, VT: Destiny Books.

Olatunji, B. O., Cisler, J., Deacon, B. J., 2010. Efficacy of cognitive behavioral therapy for anxiety disorders: A review of meta-analytic findings. *Psychiatric Clinics of North America*, 33(3), pp. 557-577. Available at

<http://www.sciencedirect.com/science/article/pii/S0193953X10000444 > [Accessed 19 January 2017]

Olatunji, B. O., Deacon, B. K., Abramowitz, J. S., 2009. The cruelest cure? Ethical issues in the implementation of exposure-based treatments. *Cognitive and Behavioral Practice* [e-journal] 16(2), pp. 172-180. Available at <http://www.sciencedirect.com/science/article/pii/S1077722909000066> [Accessed 19 January 2017]

Oohashi, T., Nishina, E., Honda, M., et al., 2000: Inaudible High Frequency Sounds Affect Brain Activity: Hypersonic Effect. *Journal of Neurophysiology, The American Physiological Society*, [online] 83, pp. 3548-3558. Available at: < http://jn.physiology.org/content/83/6/3548.long > [Accessed 16 January 2017]

Otto, M. W., McHugh, R. K. and Kantak, K. M., 2010. Combined pharmacotherapy and cognitive-behavioral therapy for anxiety disorders: Medication effects, glucocorticoids, and attenuated outcomes. *Clinical Psychology: Science and Practice* [e-journal] 17(2), pp. 91-103. Available at < https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4743901/pdf/nihms-725579.pdf > Accessed 19 January.

Panksepp, J. and Bernatzky, G., 2002. Emotional sounds and the brain: the neuroaffective foundations of musical appreciation. *Behavioral Processes*, [e-journal] 60, pp. 133-155. http://dx.doi.org/10.1016/S0376-6357(02)00080-3

Panksepp, J., 1995. The emotional sources of chills induced by music. *Music Perception: An Interdisciplinary Journal*, [e-journal] 13(2), pp. 171-207. Available at < https://www.jstor.org/stable/40285693?seq=1#page_scan_tab_contents > Accessed 19 January 2017.

Pereira, C., Teixeira, J., Figueiredo, P., Xavier, J., Castro, S. L., and Brattico, E., 2011. Music and emotions in the brain: Familiarity matters. *PLoS ONE,* [e-journal] 6 (11) e27241. Available at < http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0027241 > [Accessed 19 January 2017]

Psychcentral, 2010. *Noises Triggering Anxiety Psych Central Forum.* [online] Available at: < https://forums.psychcentral.com/anxiety-panic-phobias/156400-noises-triggering-anxiety.html > [Accessed 16 January 2017]

Ready, T., 2011. Containment and Communication through Musical Preference. *Music and Medicine* [e-journal] 3(4) pp.246. Available at < https://mmd.iammonline.com/index.php/musmed/article/view/MMD-2011-3-4-6 > [Accessed 19 January 2017]

Rickard, N. S., 2004. Intense emotional responses to music physiological arousal hypothesis. *Psychology of Music*, [e-journal] 32 (4) pp. 371-388. Available at: <http://journals.sagepub.com/doi/pdf/10.1177/0305735604046096 > [Accessed 19 January 2017]

Ross, A., 2007. *The Rest is Noise: Listening to the Twentieth Century*. London: Harper Perennial.

Roy, M. J., Francis J, Friedlander J, Banks-Williams L, Lande R. G., Taylor, P., Blair, J., McLellan, J., Law, W., Tarpley, V., Patt, I., Yu, H., Mallinger, A., Difede, J., Rizzo, A. and Rothbaum, R., 2010. Improvement in cerebral function with treatment of posttraumatic stress disorder. *Annals of the New York Academy of Sciences*, [e-journal] 1208, pp.142–149. http://dx.doi.org/10.1111/j.1749-6632.2010.05689.x

Rigby Hanssen, T., 2012. Please, do not turn up the volume. *SoundEffects - An Interdisciplinary Journal of Sound Experience*, [e-journal] 2 (2) Available at < http://www.soundeffects.dk/article/view/6299/6637 > [Accessed 16 January 2017]

Rizzo, A., Pair, J., Graap, K., Manson, B., McNerney, P. J., Wiederhold, B., Wiederhold, M., Spira., J., 2006. A Virtual Reality Exposure Therapy Application for Iraq War Military Personnel with Post Traumatic Stress Disorder: From Training to Toy to Treatment. In: M. Roy, ed. 2006. *NATO Advanced Research Workshop on Novel Approaches to the Diagnosis and Treatment of Posttraumatic Stress Disorder,* [e-book]. pp. 235-250. Washington DC: IOS Press. Available at: < http://ict.usc.edu/pubs/A%20Virtual%20Reality%20Exposure%20Therapy%20Application

%20for%20Iraq%20War%20Military%20Personnel%20with%20Post%20Traumatic%20Stress%20Disorder-%20From%20Training%20to%20Toy%20to%20Treatment.pdf > [Accessed 16 January 2017]

Sangild, T., 2002. *The Aesthetics of Noise* [e-book] Copenhagen: Datanom, Available at < http://www.ubu.com/papers/noise.html > [Accessed 19 January 2017]

Sanglid, T., 2004. Noise - Three Musical Gestures: Expressionist, Introvert and Minimal Noise. *Journal of Music and Meaning* [e-journal], 2(4), Available at < http://www.musicandmeaning.net/issues/showArticle.php?artID=2.4 > [Accessed 19 January 2017]

Saarakallio, S., 2008. Music in mood regulation: Initial scale development. Musicae Scientae, 12(2), pp. 291-309. Available at <http://journals.sagepub.com/doi/pdf/10.1177/102986490801200206 > Accessed 19 January 2017.

Schaeffer, P., 1966. *Traité des objets musicaux*. Paris: Le Seuil.

Schmidt, N. B., Woolaway-Bickel, K., Trakowski, J., Santiago, H., Storey, J., Koselka, M., and Cook, J., 2000. Dismantling cognitive-behavioral treatment for panic disorder: Questioning the utility of breathing retraining. *Journal of Consulting and Clinical Psychology,* [e-journal] 68(3), pp.417-424. Available at <http://psycnet.apa.org/journals/ccp/68/3/417/> [Accessed 19 January 2017]

Schnall, S., Hedge, C. and Weaver, R., 2012. The Immersive Virtual Environment of the digital fulldome: Considerations of relevant psychological processes. *International Journal of Human Computer Studies,* [e-journal] 70 (8). http://dx.doi.org/10.1016/j.ijhcs.2012.04.001

Shepard, R. N., 1964. Circularity in judgments of relative pitch. *Journal of Acoustical Society of America.* 36(12), pp. 2346-2353.

Skille, O., Wigram T., 1995. The effect of music, vocalization and vibration on brain and muscle tissue: studies in vibroacoustic therapy. In T. Wigram, B. Saperston and R. West, eds. *The Art & Science of Music Therapy: A Handbook*. Amsterdam: Harwood Academic publishers, pp. 23-57.

Smith, C. S., 2008. Welcome to 'the disco'. *The Guardian* [online]. Available at: < https://www.theguardian.com/world/2008/jun/19/usa.guantanamo > Accessed 19 January 2017.

Smith, J., 2005. The Frenzy of the Audible: Pleasure, Authenticity and Recorded laughter. *Television & New Media* 6(1), pp.23-47. Available at: < http://journals.sagepub.com/doi/abs/10.1177/1527476404268114 > [Accessed 29 May 2017]

Soravia, L. M., Heinrichs, M., Aerni, A. Maroni, C., Schelling, G., Ehlert, U., Roozendaal, B. and de Quervain, D. J. F., 2006. Glucocorticoids reduce phobic fear in humans. *Proceedings of the National Academy of Sciences of the United States of America*.[e-journal] 103(14), pp.5585-5590. Available at < http://www.pnas.org/content/103/14/5585.full.pdf > [Accessed 19 January 2017]

Steinberg, M., 2005. *Choral Masterworks: A Listeners Guide*. New York: Oxford University Press. p. 132)

Stiegler, L. N., Davis, R., 2010. Understanding Sound Sensitivity in Individuals with Autism Spectrum Disorder. *Focus on Autism and Other Developmental Disabilities* 25(2), pp. 67-75. Available at <http://journals.sagepub.com/doi/pdf/10.1177/1088357610364530> [Accessed 19 January 2017]

Stein D. J., van Honk, J., Isper, J., Solms, M., and Panksepp, J., 2007. Opioids from physical pain to the pain of social isolation. *CNS Spectrums: The International Journal of Neuropsychiatric Medicine*, [e-journal] 12(9) pp. 669-670. Available at < https://pdfs.semanticscholar.org/433d/d30303c9fc473aefe0f95f72cbeae4869e6a.pdf?_ga=1.84842777.147436755.1484838295 > Accessed 19 January 2017.

Stens Corporation, 2014. *Respiration Sensor* [photograph] Available at <https://stens-biofeedback.com/collections/sensors/products/nx-rsp1a-respiration-sensor-for-the-nexus-4-10-and-16> [Accessed 16 January 2017]

Tahlier, M., Miron, A. M. and Rauscher, F. H., 2012. Music choice as a sadness regulation strategy for resolved versus unresolved sad events. *Psychology of Music*, [e-journal] 41(6), pp. 729-748. 2012. Available at < http://journals.sagepub.com/doi/pdf/10.1177/0305735612446537 > [Accessed 19 January 2017]

Tervaniemi, M. and Hugdahl K., 2003. Lateralization of auditory-cortex functions. *Brain Research Reviews*, [e-journal] 43 (3), pp. 231-146. Available at < http://www.sciencedirect.com/science/article/pii/S0165017303002236 > Accessed 19 January 2017.

The Sound of Fear, 2011. [Radio broadcast] BBC Radio 4, 18 Oct 2011, 21:00. Available at < http://www.bbc.co.uk/programmes/b015zpf5 > [Accessed 19 January 2017]

Toprac, P. and Abdel-Meguid, A., 2011. Causing Fear, Suspense and Anxiety Using Sound Design in Computer Games. In M. Grimshaw, ed., 2011. *Game Sound Technology and Player Interaction: Concepts and Developments*. [e-book] Hershey New York: IGI Global. Ch. 9. http://dx.doi.org/10.4018/978-1-61692-828-5.ch009

Trappe, H. J., 2012. The Effect of Music on Human Physiology and Pathophysiology. *Music and Medicine* [e-journal] 4 (100) Available at < https://mmd.iammonline.com/index.php/musmed/article/view/MMD-2012-4-2-6 > [Accessed 19 January 2017]

Trapnell, P. D., Campbell, J. D., 1999. Private self-consciousness and the five factor model of personality: distinguishing rumination from reflection. *Journal of Personality and Social Psychology*, [e-journal] 76(2), pp. 284-304. Available at < http://psycnet.apa.org/journals/psp/76/2/284/ > Accessed 19 January 2017.

Tsunetsugu, Y., Park, B. J., Ishii, H., Hirano, H., Kagawa, T., and Miyazaki, Y. 2007. Physiological effects of Shinrin-yoku (taking in the atmosphere of the forest) in an old-growth broadleaf forest in Yamagata Prefecture, Japan. *Journal of Physiological Anthropology*, [e-journal] (26), pp. 135-142. http://doi.org/10.2114/jpa2.26.135

Van der Zwaag, M.D., Fairclough, S. Spiridon, E., and Westerink, J. H. D. M., 2011. The impact of music on affect during anger inducing drives. ACII 2011, *International Conference on Affective Computing and Intelligent Interaction*, [e-book] Memphis, Tenessee, 9-12 October 2011. Berlin: Springer Heidelberg. http://dx.doi.org/10.1007/978-3-642-24600-5_44

Van der Zwaag, M. D., Westerink, J. H. D. M. and van den Broek, E. L., 2011. Emotional and psychophysiological responses to tempo, mode, and percussiveness. *Musicae Scientiae*, [e-journal] 15(2) pp. 250-269. Available at <http://eprints.eemcs.utwente.nl/19893/01/vanderZwaag-Emotional_and_psychophysiological_responses_to_tempo_mode_and_percussiveness2.pdf > Accessed 19 January 2017.

Wegerer, M., Blechert, J., Kerschbaum, H., and Wilhelm, F. H., 2013. Relationship between Fear Conditionability and Aversive Memories: Evidence from a Novel Conditioned-Intrusion Paradigm. *Plos One*, November 2013, 8 (11). http://dx.doi.org/10.1371/journal.pone.0079025.

Weisser, S., 2011. Emotion and music: The Ethiopian lyre bagana. *Musicae Scientiae*, [e-journal] 16(3), pp.3-18. Available at < http://journals.sagepub.com/doi/pdf/10.1177/1029864911416493 > Accessed 19 January 2007.

Wells, A., 2007. The Attention Training Technique: Theory, Effects and a Metacognitive Hypothesis on Auditory Hallucinations. *Cognitive and Behavioral Practice*, 14 (2), pp. 134-38.

Wilhelm, K., Gillis, I., Schubert, E., Whittle, E. L., 2013. On a Blue Note: Depressed People's Reasons for Listening to Music. *Music and Medicine* [e-journal] 5 (76) Available at < https://mmd.iammonline.com/index.php/musmed/article/view/MMD-2013-5-1-3r > [Accessed 16 January 2017]

Winnicott, D.W., 1968. Playing: its theoretical status in the clinical situation. International Journal of Psychoanalysis, 49(4) pp. 591-599.

Yelena Kozlova, 2013. *Introducing O.zen, a gamified stress management tool from Ubisoft.* [video online] Available at: < www.youtube.com/watch?v=oUFiWYAXL0A > [Accessed 16 January 2017]

Young, A., 2007. Images in the Aftermath of Trauma. *Crime, Media, Culture,* [e-journal] 3 (30). http://dx.doi.org/10.1177/1741659007074444

8 Appendix

8.1 Information Sheet, Consent Form and Questionnaires

Information Sheet

Immersive Soundscapes to elicit Anxiety in Exposure Therapy: Physical Desensitization and Emotional Catharsis

Invitation

Exposure Therapy is designed to strengthen Anxiety sufferers, by gradually exposing the user to the sources of their fear – whether that is physically boarding a plane, or seeing a Virtual Reality visualization of a spider running over their hand, or even just describing a traumatic experience to a therapist. Disappointingly, sound has not been used in Exposure Therapy – even though it is known to be able to consistently startle, anger, or even induce bliss in a listener. Exposure Therapy might become more effective if therapists use **sonic anxiety triggers** instead of visual, verbal or real-world ones. Sudden loud sounds can startle the listener, or high frequencies can send a shiver down the spine. If listeners recognize a sound that was heard during a past experience, they can feel launched back in time; or sad melodies can move the listener to tears. Sounds will repeat again and again so that the listener will become used to them – to remind them that it is just a noise, thus encouraging them to focus on how it sounds rather than what it means. Soundscape Exposure fuses **physical desensitisation** with **emotional catharsis**: when listeners repeatedly confront the sounds associated with their discomfort, their bodies will automatically become better equipped to cope with everyday anxiety symptoms, and their mind can work to resolve underlying psychological traumas.

We invite you to listen to soundscapes that have been arranged across the 16 speakers of the Soundlab ambisonic array, whilst wearing a heart-rate, breathing and sweat secretion monitoring system - so we can find out if these sounds do actually trigger anxiety.

Purpose of Study

We are testing to see if you become anxious when exposed to ambisonic soundscapes (recording your heart rate, sweat secretion and breathing rate lets us pinpoint exact moments you were anxious, depressed, relaxed or happy). Questionnaires you answer will show whether you perceived the exposure as a positive or negative experience, and to what extent.
If sound can synthetically induce signs of panic, then therapists should offer Soundscape Exposure Therapy to anxiety sufferers: this would improve upon on the limited existing practices of talking, real- life or Virtual Reality Exposure Therapies.

Do I have to participate?

Your participation is voluntary. We would be grateful for your consent to take part, as we require listener feedback and physical data from healthy participants to fine-tune this new form of therapy, before therapists can proceed to treat anxiety sufferers with it. You are free to walk out of the experiment at any point, without having to give a reason. You can easily stop the playback of sounds at any time, simply with the touch of a button.

What will I do if I participate?

If you consent to take part in the study, we ask you to read this **Information Sheet** in full and sign the Consent Form, which you can **email** back to us.
You will first complete a **Pre-Exposure Participant Screening Questionnaire**, to ensure your eligibility for the soundscape exposure (this can also be sent via **email**).
Then, you are invited to The Arup Ambisonic Soundlab, The Hub at Pacific Quay, to **listen** to five soundscapes, and complete individual evaluation **questionnaires** for each. You will wear a Pulse- Logger either clipped onto your little fingernail or your earlobe; a Respiration-Belt around your ribcage; and a Galvanic-Skin-Response-Logger strapped around the base of two of your fingers. (Please ensure you remove nail polish, and use hand moisturiser prior to connection). These devices will record your heart-rate, breathing rate and sweat secretion, only for the time that the soundscapes are playing. Your facial expressions will be **video-recorded** throughout the soundscape exposures, for analysis only by the research team. They will be converted into a graphical code (emoticons) for the

published results – your photographic image will not be published without your consent (which will be asked for in due course if necessary). Following your listening experience, you will complete the **Post Exposure Evaluation questionnaire.** There is an optional follow up questionnaire also, to be completed one week later

Time Commitment
The maximum time you will spend at the Soundlab will likely be 2 hours, and all testing will be completed within a single visit.

Stage 1 = 15 minutes

(Pre-Exposure Participant Eligibility Screening Questionnaire (at home): 7 to 10 minutes

Information Sheet and Consent Form Reading: 5 minutes)

Stage 2 = 2 hours maximum.

(Information Sheet Re-Reading and Consent Form Signing: 5 minutes

Pre-Exposure Evaluation of Anxiety Levels Questionnaire: 1 to 2 minutes

Set-Up of Physiological Monitoring Equipment: 3-5 minutes

3 x Soundscape playback time: minimum 38 min 18 sec – maximum 46 min 32 sec.

3 x Post-Soundscape Questionnaire time: 8-15 minutes

Post-Exposure Questionnaire time: 10 minutes

Stage 3 = 15 minutes

Long-Term Catharsis Questionnaire (at home one week after Stage 2, optional): 10 minutes

What are the possible disadvantages/risks of participating?
You will hear occasionally hear mildly threatening and fear-inducing sounds; however sound- pressure-levels have been tested according to World Health Organisation standards to ensure your safety and comfort. Whilst care has been taken to ensure you will not be in pain, you may feel tired following a long listening test: thus, refreshments will be provided to boost energy levels upon your departure.

You may be mildly upset if you are sensitive to certain anxiety trigger sounds – but you will have the opportunity to identify featured sound categories prior to the exposure. You are entitled to stop the playback of the soundscape at any time, using a clearly indicated button. After the experiment, you are welcome to then immerse yourself in a soothing soundscape in the SoundLab, or sit in a comfy armchair with headphones if preferred.

What are the possible benefits of participating?
You will provide an invaluable contribution to the advancement of non-pharmaceutical Anxiety treatment: if Soundscape Exposure can be used as therapy, this could improve the quality of life for as many as 1 in 6 of the population afflicted with the disorder. You may even have a strong emotional experience yourself and learn more about what affects you psychologically and physically. This is an exciting chance to experience innovative artwork from the Glasgow School of Art in the most state-of- the-art sound technology.

You will receive a small gift of thanks and you will be reimbursed for travel to the Digital Design Studio. (McGills 23, 26, or Stagecoach F1, X1 buses stop outside the front door, or it is a 10 minute walk from Ibrox Subway station.)

Will my participation in the study be kept confidential?
All personal information provided (both questionnaire responses and physiological data) will be kept confidential: only members of the research team (Jessica Argo, Prof. Christoph Kayser, Dr. Daniel Livingstone, and Ronan Breslin) will have access to it. Results will be averaged, and any individual results necessary for thesis publication will be 299herapeuti as participants will be allocated a number (e.g.

Participant 1, *Participant 2*) to ensure no participant can be identified. Data will be kept until the completion of the study (expected to be January 2017).
However, if you reveal any information that indicates the risk of harm to yourself or anyone else, we may have to inform the appropriate authorities – we will discuss all possible options before deciding whether or not to take action.

What will happen to the results of the research study?
All of your information will be stored anonymously in encrypted files on a password-protected computer. The computer is stored in a secure, locked office space, only in proximity to authorized staff. Any hard copy questionnaires will be locked away in a filing cabinet. This is in accordance with the Glasgow School of Art Data Protection Policy 2012.

The results from the analysis of the tests will be available in a Doctoral Thesis, accessible upon request from research-network websites and stored in Glasgow School of Art's library. It may also be disseminated in scientific papers for peer-reviewed academic journals, and used for presentations in international conferences or educational seminars.

Who is conducting the research?
The research is funded by the Scottish Government's Global Excellence Initiative, and is situated at the Glasgow School of Art's Digital Design Studio.

Health and Safety
In the unlikely event of a fire or evacuation of the building, please vacate the Soundlab through the doors that you entered (the second door requires a press of a switch to the left of the door-handle). Exit the building using the main entrance, 10 metres directly in front of the Soundlab.
Toilets are located to about 15 metres to the left of the SoundLab, as is a sink with drinking water. Precautions have been taken to ensure the sounds are at a comfortable listening level, and in accordance with the World Health Organisation's stipulations: excessively loud sounds will not exceed more than a few seconds duration.

If you have been affected by the sounds, or the exposure experience in general, the following organisations may provide help and advice:

The Samaritans: T: 08457 909090 (24/7) E: jo@samaritans.org
Anxiety UK: T: 08444 775 774 (Mon-Fri, 9.30am-5.30pm) E:support@anxiety.org.uk

Consent Form

Immersive Soundscapes to elicit Anxiety in Exposure Therapy: Physical Desensitization and Emotional Catharsis

(You are being invited to participate in a research project. Before you decide to take part, you must be informed of the experiment procedure and the motivations for the research. Please take your time (you have **three days** to decide whether or not you participate) and read the **Information Sheet** in detail: feel free to discuss with others if you like. Please ask for further clarification if you have any queries.)

All details about the procedure and justification for what will happen has been explained to me. I have been given time to ask questions. I understand that I give my consent for the following to take place:

	Initials
I will be immersed in a mid-loud volume sound presentation lasting up to 50 minutes in total. The entire procedure will take up to **2 hours.**	☐
Questionnaires are to be completed prior to, during and following the test	☐
A non-invasive physical monitoring system will be worn throughout the test – heart-rate, breathing and sweat-secretion will be recorded during soundscape playback	☐
Video of my facial expressions will recorded throughout during soundscape playback	☐
I understand and have had explained to me the appropriate **health and safety** procedures for my part in this research.	☐
I understand and have had explained to me any **risks** associated with the experiment activity.	☐
I understand that my involvement in the research will remain strictly **confidential**. I have approved that my questionnaire response hard copies will be locked in a filing cabinet and my physiological data will be stored in encrypted documents in a password protected computer, only for the duration of the research. I have approved that results from the analysis of this data will be published in the Doctoral Thesis (available upon request online or at the Glasgow School of Art library) and the results may be disseminated in academic journals, conferences and seminars. Only the research team involved with this study will have access to the data. It has been explained to me what will happen to my data once the research is complete.	☐
I have read the **Information Sheet** about the research project I have been invited to participate in, and I have kept a personal copy.	☐
Although I have given this consent, I understand that I am entitled to **withdraw** from the research at any time, and without having to give a reason. Even if I withdraw from the experiment before it is complete, I will still be reimbursed for travel and I understand there to be a token of thanks offered for participation.	☐
I hereby give my free and total consent to participate in this study, which has been completely explained to me, in detail.	☐

Partincipant's Name/Initials: ____________________ Signature:___________________Date:
Investigator's Name:_______________ Investigator's Signature:___________________Date:

Contact: Jessica Argo, Digital Design Studio, The Hub, Pacific Quay, Glasgow, G51 1EA. E: j.argo1@student.gsa.ac.uk. / Dr Daniel Livingstone E: D.Livingstone@gsa.ac.uk

Questionnaire 1: Pre-Exposure Participant Eligibility Screening
1.1 Pre-Exposure Evaluation of Anxiety Levels (long-term)

1.1.1 Stress Thermometer

Please circle on the Stress Thermometer scale how you have felt over the past month (on average).

10 **MAXIMUM ANXIETY**, **muscles so tense** you cannot sit still, **worries racing** through mind, **unable to breathe or speak**.

9 **EXTREMELY** unpleasant distress, physical tension, worry, fear or anxiety, intolerable sensations (**sweating, faint, dizzy**). **Impossible to concentrate** or think clearly.

8 **HIGHLY** unpleasant distress, physical tension, worry, fear or anxiety, intolerable sensations (**trembling, nausea**). It is **difficult to concentrate** or think clearly

7 **QUITE HIGHLY** unpleasant distress, physical tension, worry, fear or anxiety. Very unpleasant sensations (**heart pounding, headache**). Can still concentrate.

6 **MODERATE** physical tension, worry, fear or anxiety. Unpleasant sensations (**nausea, headache**) Can still concentrate.

5 **MILD-MODERATE** unpleasant physical tension, worry, fear or anxiety

4 **MILD** physical tension, mild worry, fear or anxiety

3 **ALERT**, concentrating, sitting up straight

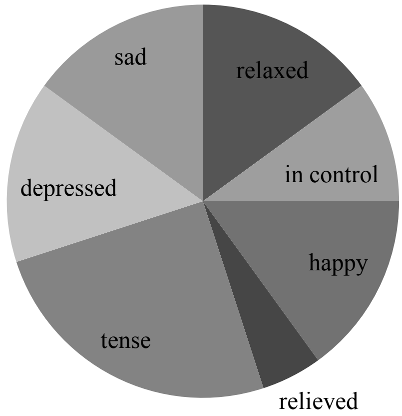
2 **CONTENT**, as if relaxing on a beach

1 **DOZING** off to sleep, mind drifting

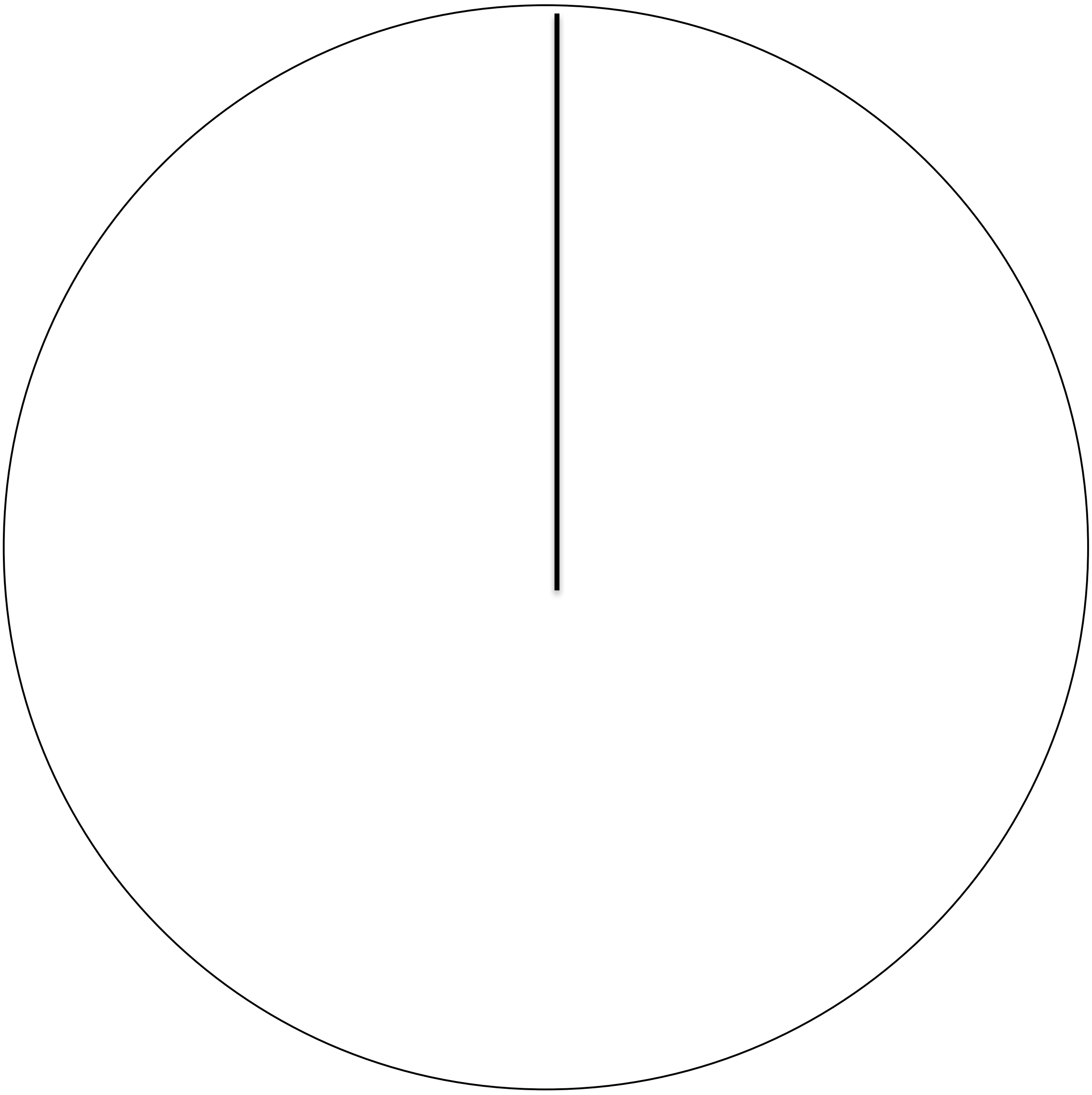
0 **TOTAL RELAXATION**, deep sleep

1.1.2 Pre-Exposure Emotion-Time Distribution

Please allocate a section of the pie chart to represent the **time** spent feeling each emotion, over the past month, as shown in the example below.



(Example)



1.1.3 Pre-Exposure Intensity of Perceived Sensations

Please circle the **intensity** of sensations felt over the past month (on average). Please indicate if there have been any particular situations or stimuli that triggered a sensation.

Physical Positive (Ph +)

Did you feel **numbness or tingling?**

Not at all mild noticeable chronic unpleasant severe distress and inability to function

Trigger: ____

Did you **blush?**

Not at all mild noticeable chronic unpleasant severe distress and inability to function

Trigger: ____

Did you feel **hot?**

Not at all mild noticeable chronic unpleasant severe distress and inability to function

Trigger: ____

Did you feel your **heart pounding?**

Not at all mild noticeable chronic unpleasant severe distress and inability to function

Trigger: ____

Physical Negative (Ph -)

Did your **legs feel wobbly?**

Not at all mild noticeable chronic unpleasant severe distress and inability to function

Trigger: ____

Did your **hands tremble?**

Not at all mild noticeable chronic unpleasant severe distress and inability to function

Trigger: ____

Did you feel **unsteady or shaky?**

Not at all mild noticeable chronic unpleasant severe distress and inability to function

Trigger: ____

Did you break out in a **hot or cold sweat?**

Not at all mild noticeable chronic unpleasant severe distress and inability to function

Trigger: ____

Did you feel **dizzy?**

Not at all mild noticeable chronic unpleasant severe distress and inability to function

Trigger: ____

Did you feel **faint?**

Not at all mild noticeable chronic unpleasant severe distress and inability to function

Trigger: ____

Did you get **an upset stomach?**

Not at all mild noticeable chronic unpleasant severe distress and inability to function

Trigger: ____

Psychological Negative (Ps -)

Did you **feel completely unable to relax?**

Not at all mild noticeable chronic unpleasant severe distress and inability to function

Trigger: ____

Did you **fear the worst happening?**

Not at all mild noticeable chronic unpleasant severe distress and inability to function

Trigger: ____________________

Did you **fear you were going to die?**

Not at all mild noticeable chronic unpleasant severe distress and inability to function

Trigger: ____________________

Did you **fear losing control?**

Not at all mild noticeable chronic unpleasant severe distress and inability to function

Trigger: ____________________

Did you feel **terrified?**

Not at all mild noticeable chronic unpleasant severe distress and inability to function

Trigger: ____________________

Did you feel **depressed?**

Not at all mild noticeable chronic unpleasant severe distress and inability to function

Trigger: ____________________

Did you **feel nervous?**

Not at all mild noticeable chronic unpleasant severe distress and inability to function

Trigger: ____________________

Did you feel **frightened?**

Not at all mild noticeable chronic unpleasant severe distress and inability to function

Trigger: ____________________

Did you feel **scared?**

Not at all mild noticeable chronic unpleasant severe distress and inability to function

Trigger: ____________________

Did you feel **tense?**

Not at all mild noticeable chronic unpleasant severe distress and inability to function

Trigger: ______________________________

How **sad** did do you feel**?**

Completely very neither sad nor happy quite not at all

Trigger: ______________________________

Psychological Positive (Ps +)

How **content** did you feel?

Completely very neither content nor discontent quite not at all

Trigger: ______________________________

How **relaxed** did you feel**?**

Completely very neither relaxed nor tense quite not at all

Trigger: ______________________________

How **in control** did you feel**?**

Completely very neither in control nor out of control quite not at all

Trigger: ______________________________

How **relieved** did you feel**?**

Completely very neither relieved nor worried quite not at all

Trigger: ______________________________

How much **pleasure** did you feel?

Constant a lot a moderate amount very little none at all

Trigger: ______________________________

How **happy** did you feel**?**

Completely very neither happy nor unhappy quite not at all

Trigger: ______________________________

1.2 Pre-Exposure Trigger Diagnosis

Please circle any stimuli which make you anxious, and please list any personal triggers below, in each of the categories.

sounds
(e.g. screeching, sloshing, banging, hissing whistling)

____

____

____

scenarios
(e.g. job interview, argument, shopping, studying)

____

____

____

people
(e.g. football fans, teenagers, police officers, strangers)

____

____

____

Anxiety Triggers

spaces
(e.g. library, museum, train, boat, shopping centre)

____

____

____

animals
(e.g. tigers, spiders, sharks, dogs, mice)

____

____

____

sensations
(e.g. heart pounding, dizziness, upset stomach, muscle tension)

____

____

____

Which sounds make you anxious? Please circle any sounds which affect you.
Feel free to expand in the spaces provided with your own personal triggers for anxiety., or any sounds you particularly dislike.

military
(e.g. Apache helicopter, marching band, bagpipes)

power tools
(e.g. vice, saw, drill, planer)

car crash
(e.g. skid, collision, explosion)

Violence

horror
(e.g. blood splats, organs squishing, screeching)

animal
(e.g. alligator hissing, geese screaming, mice squeaking)

weapons
(e.g. M60 machine gun, knife)

Which sounds make you anxious? Please circle any sounds which affect you.
Feel free to expand in the spaces provided with your own personal triggers for anxiety., or any sounds you particularly dislike.

flying
(e.g. engines starting, jet passing by)

____

____

____

fire
(e.g. fire extinguisher, flamethrower, gas hob)

____

____

____

claustrophobia
(e.g. jail door slam, picking lock)

____

____

____

Phobias

agoraphobia
(e.g. desert winds, jungle insects)

____

____

____

time
(e.g. clock chiming, ticking, coins spinning)

____

____

____

disaster
(e.g. sirens, nuclear bomb, eathquake rumbling)

____

____

____

Which sounds make you anxious? Please circle any sounds which affect you.
Feel free to expand in the spaces provided with your own personal triggers for anxiety., or any sounds you particularly dislike.

crowds
(e.g. Times Square New York, Museums, Opera House, sports arena booing)

speech
(e.g. yelps, whispering, shouts, catcalls)

music
(e.g. tango, techno, piano)

People

clothes
(e.g. leather jacket, zippers)

footsteps
(e.g. combat boots, stiletto heels, running, stomping, approaching)

laughter
(e.g. sniggering, hysterics, nervous laughter)

Which sounds make you anxious? Please circle any sounds which affect you.
Feel free to expand in the spaces provided with your own personal triggers for anxiety., or any sounds you particularly dislike.

visceral
(e.g. nail clipping, skin scratching, knuckles cracking)

____
____
____

breath
(e.g. sighs, air pump)

____
____
____

exercise
(e.g. running on treadmill, gymnastics creaking)

____
____
____

Body

hospital
(e.g. heart monitor beeping, dentist drill)

____
____
____

eating
(e.g. bacon frying, munching crisps, fruit squelching)

____
____
____

water
(e.g. drips, bubbling, waterfall, geysir erupt)

____
____
____

Which sounds make you anxious? Please circle any sounds which affect you.
Feel free to expand in the spaces provided with your own personal triggers for anxiety., or any sounds you particularly dislike.

environment
(e.g. lawn mower, hedgetrimmer. garbage truck)

construction
(e.g. bulldozer, jackhammers, ripping metal)

office
(e.g. printer, scissors, pages turning)

Sensory Irritation

factory
(e.g. yarn weaver, forklift truck, printing press)

traffic
(e.g. beeps, revs, trains rumbling)

domestic
(e.g. air conditioner, vaccuum, washing machine)

Which sounds make you anxious? Please circle any sounds which affect you.
Feel free to expand in the spaces provided with your own personal triggers for anxiety, or any sounds you particularly dislike.

mechanical
(e.g. lawn mower, hedgetrimmer. vaccum cleaner, train)

____

____

____

irregular rhythms
(e.g. doors slamming, dogs barking, hammering)

____

____

____

loud, abrasive frequency
(e.g. squeaky door hinges, rustling crisp wrappers)

____

____

____

Acoustic Qualities

repulsive visceral
(e.g. cracking bones, nail picking, slurping, crunching)

____

____

____

vocal
(e.g. toddlers screaming, whistling, football crowds)

____

____

____

1.3 Pre-Exposure Hypothesised Worry Scenario

What is **the worst** that could happen to you?
Please describe in vivid detail the **environment**, the **situation**, and the **sensations** and **emotions** felt in your most **catastrophic** worry scenario.

What is your **most regular** anxiety-inducing source.
Please describe in vivid detail the **environment**, the **situation**, and the **sensations** and **emotions** felt in your **most regular** worry scenario.

If you have completed this form within Adobe Acrobat, please save it and attach it in an email to j.argo1@student.gsa.ac.uk.

If you have printed this out and completed this form manually, please scan or photograph it, and email to j.argo1@student.gsa.ac.uk.

If you would prefer to post it, please post to:
Jessica Argo,
Digital Design Studio,
The Hub,
Pacific Quay,
Glasgow,
G51 1EA.

Questionnaire 2: SoundLab

2.1 Pre-Exposure Evaluation of Anxiety (short-term)
2.1.1 Pre-Exposure Stress Thermometer

Please circle on the Stress Thermometer scale how you feel today.

10 **MAXIMUM ANXIETY**, **muscles so tense** you cannot sit still, **worries racing** through mind, **unable to breathe or speak**.

9 **EXTREMELY** unpleasant distress, physical tension, worry, fear or anxiety, intolerable sensations (**sweating, faint, dizzy**). **Impossible to concentrate** or think clearly.

8 **HIGHLY** unpleasant distress, physical tension, worry, fear or anxiety, intolerable sensations (**trembling, nausea**). It is **difficult to concentrate** or think clearly

7 **QUITE HIGHLY** unpleasant distress, physical tension, worry, fear or anxiety. Very unpleasant sensations (**heart pounding, headache**). Can still concentrate.

6 **MODERATE** physical tension, worry, fear or anxiety. Unpleasant sensations (**nausea, headache**) Can still concentrate.

5 **MILD-MODERATE** unpleasant physical tension, worry, fear or anxiety

4 **MILD** physical tension, mild worry, fear or anxiety

3 **ALERT**, concentrating, sitting up straight

2 **CONTENT**, as if relaxing on a beach

1 **DOZING** off to sleep, mind drifting

TOTAL RELAXATION, deep sleep

0

2.1.2 Intensity of Perceived Moods

Please circle the answer most representative of how you feel today.

How **happy** do you feel?

Completely	very	neither happy nor unhappy	quite	not at all

How **relieved** do you feel?

Completely	very	neither relieved nor worried	quite	not at all

How much **pleasure** do you feel?

Constant	a lot	a moderate amount	very little	none at all

How **in control** do you feel?

Completely	very	neither in control nor out of control	quite	not at all

How **relaxed** do you feel?

Completely	very	neither relaxed nor tense	quite	not at all

How **content** do you feel?

Completely	very	neither content nor discontent	quite	not at all

How **sad** do you feel?

Completely	very	neither sad nor happy	quite	not at all

How **tense** do you feel?

Completely	very	neither tense nor relaxed	quite	not at all

How **depressed** do you feel?

Completely	very	neither depressed nor cheerful	quite	not at all

Questionnaire 2.2: Post-Soundscape Questionnaire (repeated after each Soundscape)

2.2.1 Post-Soundscape Subjective Perceptions (acoustic and emotive attributes)

How **loud** was the soundscape?

Very quiet mostly quiet no louder than everyday mostly loud unbearably loud

How **frightening** was the soundscape?

Boring comforting emotionally neutral mostly frightening unbearably frightening

How **irritating** was the soundscape?

Blissful pleasant neither irritating nor pleasant mostly irritating unbearably irritating

Did you feel **immersed** in sound?

Not at all once, very briefly 2-3 times throughout most of the piece constantly

Please circle *Yes* or *No*, or the less definitive answers.

Did you **enjoy** listening to the soundscape?

Yes a little neither **Yes** nor **No** not really **No**

Did you feel **revived** during and after listening to the soundscape?

Yes a little neither **Yes** nor **No** not really **No**

Did you feel any **vivid emotions**, **strong sensations** or **musical bliss** listening to the soundscape?

Yes a little neither **Yes** nor **No** not really **No**

Please elaborate:

Did you **re-experience unpleasant sensations** and **emotions** during listening to the soundscape?

Yes a little neither **Yes** nor **No** not really **No**

Please elaborate:

Were you **soothed** by the sounds?

Yes a little neither **Yes** nor **No** not really **No**

Please list the sounds you found the most **frightening**

Please list the sounds you found the most **irritating**

Please list the sounds you found the most **panic-inducing**

Please list the sounds you found the most **memorable**

2.2.2 Post-Soundscape Frequency of Perceived Sensations

Please **circle** the correct frequency of each sensation felt during listening.
If you can, please state which **sound** you remember hearing when you felt each sensation.

Physical Positive (Ph +)

Did you feel **pleasurable chills?**

Not at all once, very briefly 2-3 times throughout most of the piece constantly

Trigger sound: ______________________________

Did you feel **numbness or tingling?**

Not at all once, very briefly 2-3 times throughout most of the piece constantly

Trigger sound: ______________________________

Did you **blush?**

Not at all once, very briefly 2-3 times throughout most of the piece constantly

Trigger sound: ______________________________

Did you feel **hot?**

Not at all once, very briefly 2-3 times throughout most of the piece constantly

Trigger sound: ______________________________

Did you **feel your heart pounding?**

Not at all once, very briefly 2-3 times throughout most of the piece constantly

Trigger sound: ______________________________

Physical Negative (Ph -)

Did you **legs feel wobbly?**

Not at all once, very briefly 2-3 times throughout most of the piece constantly

Trigger sound: ______________________________

Did you feel **trembling hands?**

Not at all once, very briefly 2-3 times throughout most of the piece constantly

Trigger sound: ______________________________

Did you feel **unsteady or shaky?**

Not at all once, very briefly 2-3 times throughout most of the piece constantly

Trigger sound: ______________________________

Did you **break out in a hot or cold sweat?**

Not at all once, very briefly 2-3 times throughout most of the piece constantly

Trigger sound: ______________________________

Did you feel **dizzy?**

Not at all once, very briefly 2-3 times throughout most of the piece constantly

Trigger sound: ______________________________

Did you **feel faint?**

Not at all once, very briefly 2-3 times throughout most of the piece constantly

Trigger sound: ______________________________

Did you get **an upset stomach?**

Not at all once, very briefly 2-3 times throughout most of the piece constantly

Trigger sound: ______________________________

Psychological Negative (Ps -)

Did you feel **sad?**

Not at all once, very briefly 2-3 times throughout most of the piece constantly

Trigger sound: ______________________________

Did you feel **tense?**

Not at all once, very briefly 2-3 times throughout most of the piece constantly

Trigger sound: ______________________________

Did you feel **scared?**

Not at all once, very briefly 2-3 times throughout most of the piece constantly

Trigger sound: ______________________________

Did you feel f**rightened?**

Not at all once, very briefly 2-3 times throughout most of the piece constantly

Trigger sound: ______________________________

Did you feel **nervous?**

Not at all once, very briefly 2-3 times throughout most of the piece constantly

Trigger sound: ______________________________

Did you feel **depressed?**

Not at all once, very briefly 2-3 times throughout most of the piece constantly

Trigger sound: ______________________________

Did you **fear losing control?**

Not at all once, very briefly 2-3 times throughout most of the piece constantly

Trigger sound: ______________________________

Did you **fear you were going to die?**

Not at all once, very briefly 2-3 times throughout most of the piece constantly

Trigger sound: ______________________________

Did you **fear the worst happening?**

Not at all once, very briefly 2-3 times throughout most of the piece constantly

Trigger sound: ______________________________

Did you feel **terrified?**

Not at all once, very briefly 2-3 times throughout most of the piece constantly

Trigger sound: ______________________________

Did you feel **completely unable to relax?**

Not at all once, very briefly 2-3 times throughout most of the piece constantly

Trigger sound: ______________________________

Psychological Positive (Ps +)

Did you feel **content?**

Not at all once, very briefly 2-3 times throughout most of the piece constantly

Trigger sound: ______________________________

Did you feel **relaxed?**

Not at all once, very briefly 2-3 times throughout most of the piece constantly

Trigger sound: ______________________________

Did you feel **in control?**

Not at all once, very briefly 2-3 times throughout most of the piece constantly

Trigger sound: ______________________________

Did you feel **relieved?**

Not at all once, very briefly 2-3 times throughout most of the piece constantly

Trigger sound: ______________________________

Did you feel **pleasure?**

Not at all once, very briefly 2-3 times throughout most of the piece constantly

Trigger sound: ______________________________

Did you feel **happy?**

Not at all once, very briefly 2-3 times throughout most of the piece constantly

Trigger sound: ______________________________

2.2.3 Post-Soundscape Mood Change Assessment

Did your original mood states negatively change (-1), remain the same (0) or positively change (+1) after listening to the soundscape.

Happiness	-1	0	+1
Pleasure	-1	0	+1
Relief	-1	0	+1
In control	-1	0	+1
Relaxation	-1	0	+1
Contentment	-1	0	+1
Tension	-1	0	+1
Depression	-1	0	+1
Sadness	-1	0	+1

2.2.4 Post-Soundscape Breathing Assesment

How would you best describe your breathing when listening to the soundscape.

Breathless ☐
Slow relaxed breath ☐
Shallow breaths ☐
Fast breaths ☐

2.2.5 Post-Soundscape Affect Dichotomy

Please circle which emotion you felt most predominantly, either the black or the white box.

Excitement	depression
pleasure	displeasure
arousal	sleepiness
distress	contentment
alarmed	sleepy
afraid	at ease
bored	astonished
frustrated	satisfied

2.2.6 Post-Soundscape **Better or Worse**

Please mark on the scale whether you feel **better** or **worse** than when you walked in to the SoundLab.

Worse	**Exactly the same**	**Better**

2.2.7 Post-Soundscape Memory

Were any memories triggered? Were you reminded of any past real-life experiences?

Not at all once, very briefly 2-3 times throughout most of the piece constantly

If so, please elaborate on the nature of these memories:

Please describe in vivid detail the **environment**, the **situation**, and the **sensations** and **emotions** of the memories.

Memory 1

Environment: ______________________________

Situation: ______________________________

Sensations: ______________________________

Trigger sound: ______________________________

Memory 2

Environment: ______________________________

Situation: ______________________________

Sensations: ______________________________

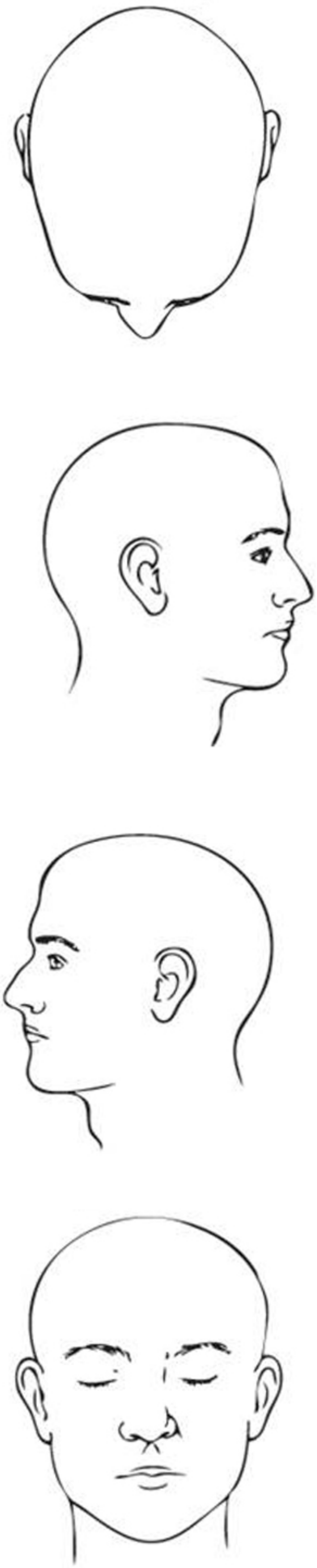
Trigger sound: ______________________________

Please estimate at which point in the soundscape each memory was triggered.
If you can recall the sound playing at the time, please note this as well.

start end

2.2.8 Post-Soundscape Body Map

Mark the areas on your body where you experienced any of these sensations.
Identify the approximate duration of the perceived sensation in seconds.
If you can remember, please note the sound that you heard at the time that you felt the sensation.
Please marke all affected areas



Thoughts racing

Dizzy, lightheadedness

Vertigo

Blurred vision

ear pain

Breathlessness

Slow relaxed breath

Shallow breaths

Fast breaths

Nausea

upset stomach

Restless

Legs like jelly

trembling

shivering

heart palpitations

chest pain

sweating

tense back

numbness

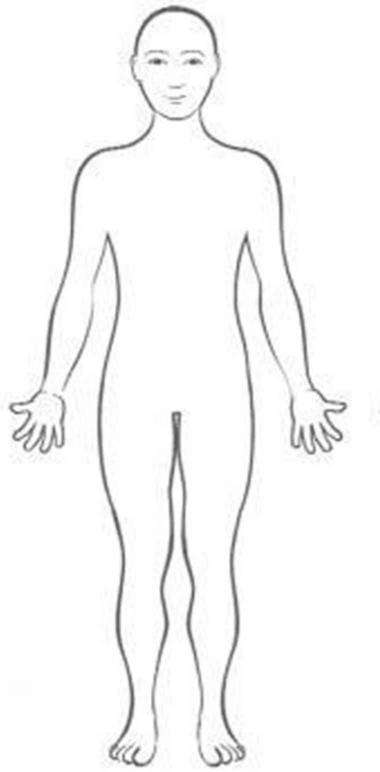
pleasurable chills

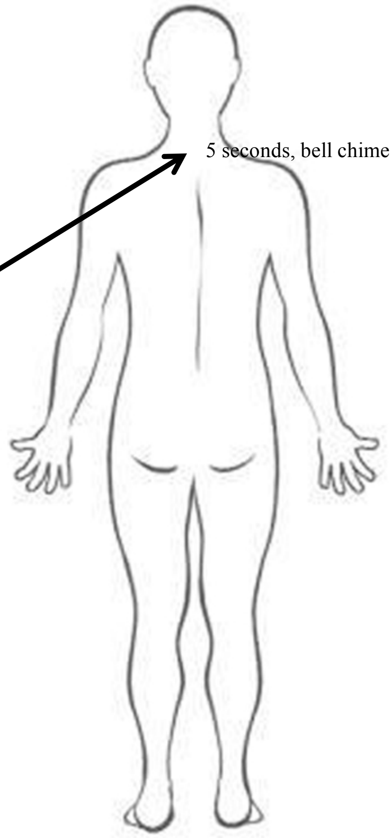
ache

stabbing

burning

crying





2.3 Post-Exposure Evaluation of Anxiety Levels (short-term)
(to be completed after complete soundscape exposure experience)

2.3.1 Post-Exposure Stress Thermometer

Please circle on the Stress Thermometer scale how you feel now, following the Soundscape Exposure.

10 **MAXIMUM ANXIETY**, **muscles so tense** you cannot sit still, **worries racing** through mind, **unable to breathe or speak**.

9 **EXTREMELY** unpleasant distress, physical tension, worry, fear or anxiety, intolerable sensations (**sweating, faint, dizzy**). **Impossible to concentrate** or think clearly.

8 **HIGHLY** unpleasant distress, physical tension, worry, fear or anxiety, intolerable sensations (**trembling, nausea**). It is **difficult to concentrate** or think clearly

7 **QUITE HIGHLY** unpleasant distress, physical tension, worry, fear or anxiety. Very unpleasant sensations (**heart pounding, headache**). Can still concentrate.

6 **MODERATE** physical tension, worry, fear or anxiety. Unpleasant sensations (**nausea, headache**) Can still concentrate.

5 **MILD-MODERATE** unpleasant physical tension, worry, fear or anxiety

4 **MILD** physical tension, mild worry, fear or anxiety

3 **ALERT**, concentrating, sitting up straight

2 **CONTENT**, as if relaxing on a beach

1 **DOZING** off to sleep, mind drifting

TOTAL RELAXATION, deep sleep

0

2.3.2 Post-Exposure Intensity of Perceived Moods

Please circle the answer most representative of how you feel now, following the Soundscape Exposure.

How **happy** do you feel?

Completely	very	neither happy nor unhappy	quite	not at all

How much **pleasure** do you feel?

Constant	a lot	a moderate amount	very little	none at all

How **relieved** do you feel?

Completely	very	neither relieved nor worried	quite	not at all

How **in control** do you feel?

Completely	very	neither in control nor out of control	quite	not at all

How **relaxed** do you feel?

Completely	very	neither relaxed nor tense	quite	not at all

How **content** do you feel?

Completely	very	neither content nor discontent	quite	not at all

How **sad** do you feel?

Completely	very	neither sad nor happy	quite	not at all

How **tense** do you feel?

Completely	very	neither tense nor relaxed	quite	not at all

How **depressed** do you feel?

Completely	very	neither depressed nor cheerful	quite	not at all

2.3.3 Post-Exposure Better or Worse

Please mark on the scale whether you feel **better** or **worse** than when you walked in to the SoundLab.

Worse	**Exactly the same**	**Better**

2.3.4 Post Exposure Spatialisation Evaluation

Which motion pattern of sound did you notice the most in the soundscapes?

- Horizontal spinning ☐
- Vertical dropping ☐
- Random darting around the room ☐
- Slow rise from floor to ceiling ☐
- Drop from ceiling to floor ☐
- circling from below ☐
- rear to front ☐
- front to rear ☐
- stereo image widening like a jaw ☐

Listen to Sound 1 and Sound 2.

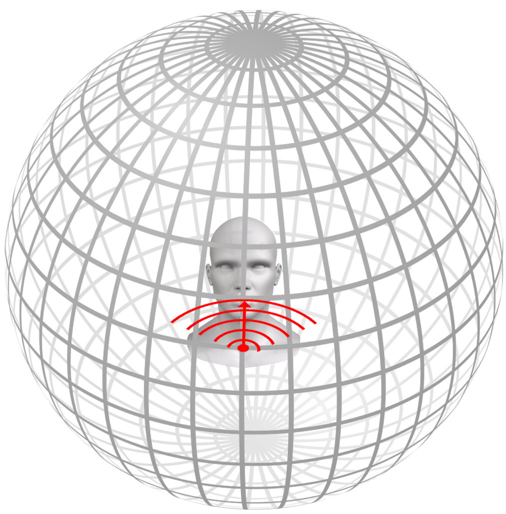
Which sound was the most **realistic**?
- Sound 1 (chains, static mono) ☐
- Sound 2 (chains, slow drop from top to bottom) ☐

Which sound was the most **unnerving**?
- Sound 1 (chains, static mono) ☐
- Sound 2 (chains, slow drop from top to bottom) ☐

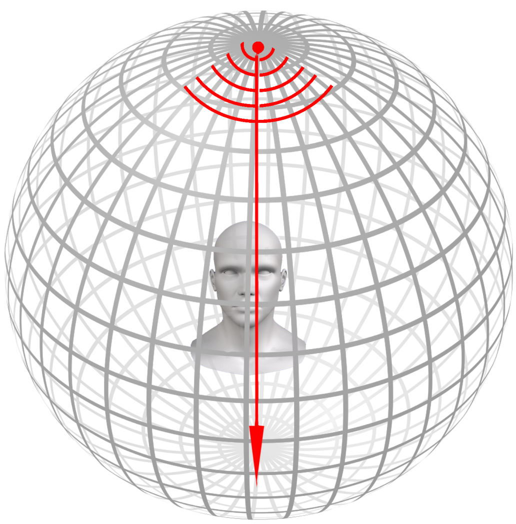
Which sound was the most **frightening**?
- Sound 1 (chains, static mono) ☐
- Sound 2 (chains, slow drop from top to bottom) ☐

Which sound was the most **irritating**?
- Sound 1 (chains, static mono) ☐
- Sound 2 (chains, slow drop from top to bottom) ☐

Which sound was the most **panic-inducing**?
- Sound 1 (chains, static mono) ☐
- Sound 2 (chains, slow drop from top to bottom) ☐



Sound 1 (chains, static mono from front speaker)



Sound 2 (chains, slow drop from top to bottom)

Listen to Sound 3 and Sound 4.

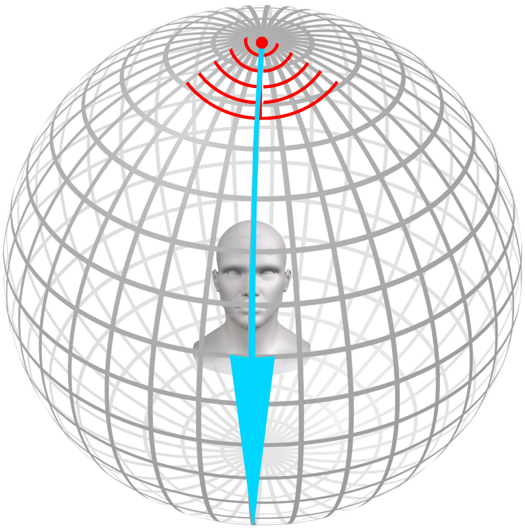
Which sound was the most **realistic**?
Sound 3 (jet pass by, fast drop from top to bottom) ☐
Sound 4 (jet pass by, slow drop from top to bottom) ☐

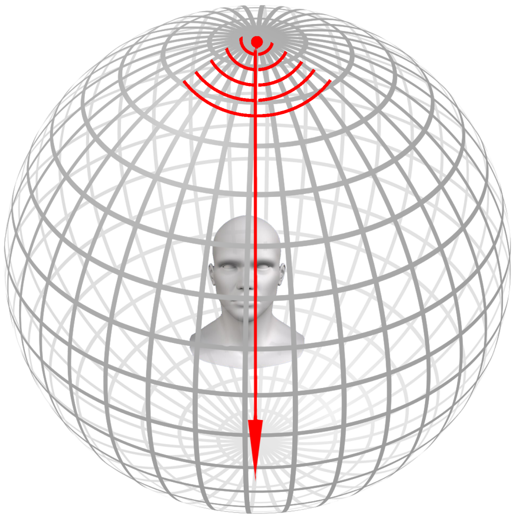
Which sound was the most **unnerving**?
Sound 3 (jet pass by, fast drop from top to bottom) ☐
Sound 4 (jet pass by, slow drop from top to bottom) ☐

Which sound was the most **frightening**?
Sound 3 (jet pass by, fast drop from top to bottom) ☐
Sound 4 (jet pass by, slow drop from top to bottom) ☐

Which sound was the most **irritating?**
Sound 3 (jet pass by, fast drop from top to bottom) ☐
Sound 4 (jet pass by, slow drop from top to bottom) ☐

Which sound was the most **panic-inducing?**
Sound 3 (jet pass by, fast drop from top to bottom) ☐
Sound 4 (jet pass by, slow drop from top to bottom) ☐





Sound 3 (jet pass by, fast drop from top to bottom) Sound 4 (jet pass by, slow drop from top to bottom)

Listen to Sound 5, 6 and 7.

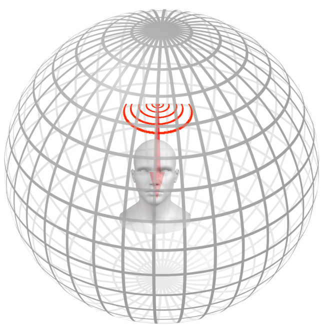
Which sound was the **most realistic?**
Sound 5 (footsteps, rear to front) ☐
Sound 6 (footsteps front to rear) ☐
Sound 7 (footsteps circling) ☐

Which sound was the **most unnerving?**
Sound 5 (footsteps, rear to front) ☐
Sound 6 (footsteps front to rear) ☐
Sound 7 (footsteps circling) ☐

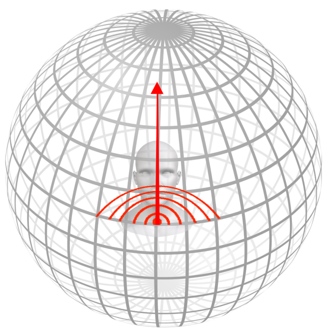
Which sound was the most **frightening?**
Sound 5 (footsteps, rear to front) ☐
Sound 6 (footsteps front to rear) ☐
Sound 7 (footsteps circling) ☐

Which sound was the most **irritating?**
Sound 5 (footsteps, rear to front) ☐
Sound 6 (footsteps front to rear) ☐
Sound 7 (footsteps circling) ☐

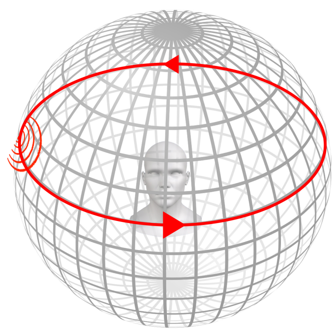
Which sound was the most **panic-inducing?**
Sound 5 (footsteps, rear to front) ☐
Sound 6 (footsteps front to rear) ☐
Sound 7 (footsteps circling) ☐



Sound 5 (footsteps, rear to front)



Sound 6 (footsteps front to rear)



Sound 7 (footsteps circling)

Listen to Sound 8 and Sound 9.

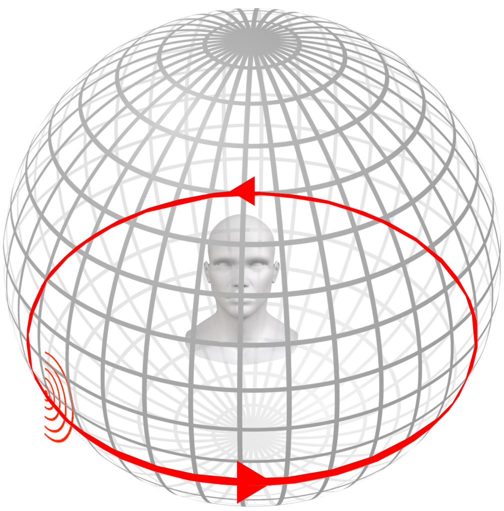
Which sound was the most **realistic?**
Sound 8 (leopard growling, circling from below) ☐
Sound 9 (leopard growling, circling at ear height) ☐

Which sound was the most **unnerving?**
Sound 8 (leopard growling, circling from below) ☐
Sound 9 (leopard growling, circling at ear height) ☐

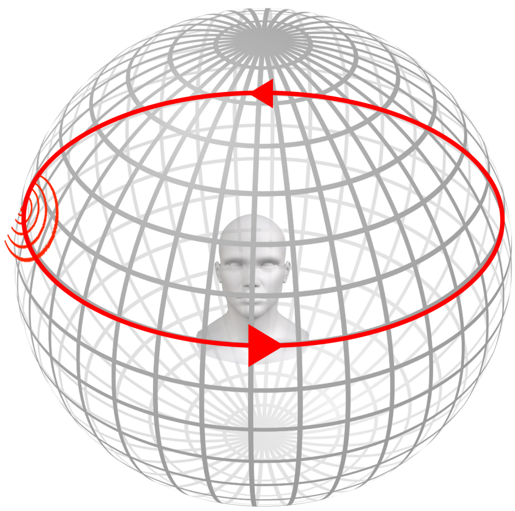
Which sound was the most **frightening?**
Sound 8 (leopard growling, circling from below) ☐
Sound 9 (leopard growling, circling at ear height) ☐

Which sound was the most **irritating?**
Sound 8 (leopard growling, circling from below) ☐
Sound 9 (leopard growling, circling at ear height) ☐

Which sound was the most **panic-inducing?**
Sound 8 (leopard growling, circling from below) ☐
Sound 9 (leopard growling, circling at ear height) ☐



Sound 8 (leopard growling, circling from below)



Sound 9 (leopard growling, circling at ear height)

Post-Exposure Debrief Script

Immersive Soundscapes to elicit Anxiety in Exposure Therapy: Physical Desensitization and Emotional Catharsis

Following the Sound Exposure, the participant is asked:

"How are you feeling? Are you ok?"
[If the participant is **dizzy** – "Would you like something to drink or a snack?]
[If the participant is **upset** – "Would you like to chat about any issues that were raised by the sounds?"]
[If the participant is still very **tense** – "Would you like to listen to a relaxation soundscape in the Soundlab or on headphones in a comfortable chair?"]

"The main aim of the experiment was to test how anxious you became when exposed to ambisonic soundscapes. Your heart rate, sweat secretion and breathing rate can all reveal whether you are emotionally aroused – I was particularly looking to see when your vital signs speeded up (indicating anxiety, panic or excitement), or if they slowed down (suggesting relaxation or depression). I also wanted to find out how strong you perceived your emotional involvement to be, and whether you perceived the exposure as a positive or negative experience. If the soundscapes did provoke strong emotional and physical reactions, then there are 334herapeutic applications. Tailored soundscapes could be administered to anxiety sufferers who wish to habituate themselves the physical symptoms of anxiety and to resolve underlying psychological trauma. When users confront the sounds associated with their discomfort, they can become better equipped to cope with everyday anxiety."

"Do you have any comments or questions about the experiment? "[allow the participant to ask comment or ask questions].

"Please take a note of my contact details and the email addresses of the research team, and please let us know if you have any further questions about this experiment [give contact details, and encourage further comments]."

Thank you very much for your participation."

Contact: Jessica Argo, Digital Design Studio, The Hub, Pacific Quay, Glasgow, G51 1EA. T: 07783681564 E: j.argo1@student.gsa.ac.uk. / Dr Daniel Livingstone E: D.Livingstone@gsa.ac.uk

Questionnaire 3: Long-Term Catharsis Evaluation
(to be completed one week after Exposure)

3.1 Long-Term Stress Thermometer

Please circle on the Stress Thermometer scale how you have felt during the week immediately following the Soundscape Exposure.

10 **MAXIMUM ANXIETY**, **muscles so tense** you cannot sit still, **worries racing** through mind, **unable to breathe or speak**.

9 **EXTREMELY** unpleasant distress, physical tension, worry, fear or anxiety, intolerable sensations (**sweating, faint, dizzy**). **Impossible to concentrate** or think clearly.

8 **HIGHLY** unpleasant distress, physical tension, worry, fear or anxiety, intolerable sensations (**trembling, nausea**). It is **difficult to concentrate** or think clearly

7 **QUITE HIGHLY** unpleasant distress, physical tension, worry, fear or anxiety. Very unpleasant sensations (**heart pounding, headache**). Can still concentrate.

6 **MODERATE** physical tension, worry, fear or anxiety. Unpleasant sensations (**nausea, headache**) Can still concentrate.

5 **MILD-MODERATE** unpleasant physical tension, worry, fear or anxiety

4 **MILD** physical tension, mild worry, fear or anxiety

3 **ALERT**, concentrating, sitting up straight

2 **CONTENT**, as if relaxing on a beach

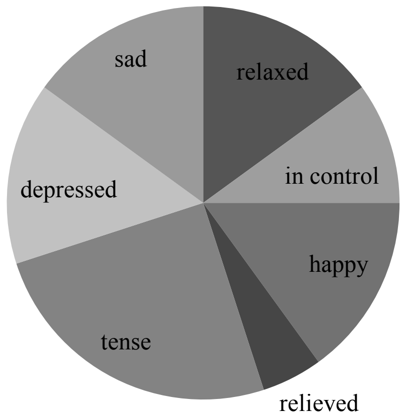
1 **DOZING** off to sleep, mind drifting

TOTAL RELAXATION, deep sleep

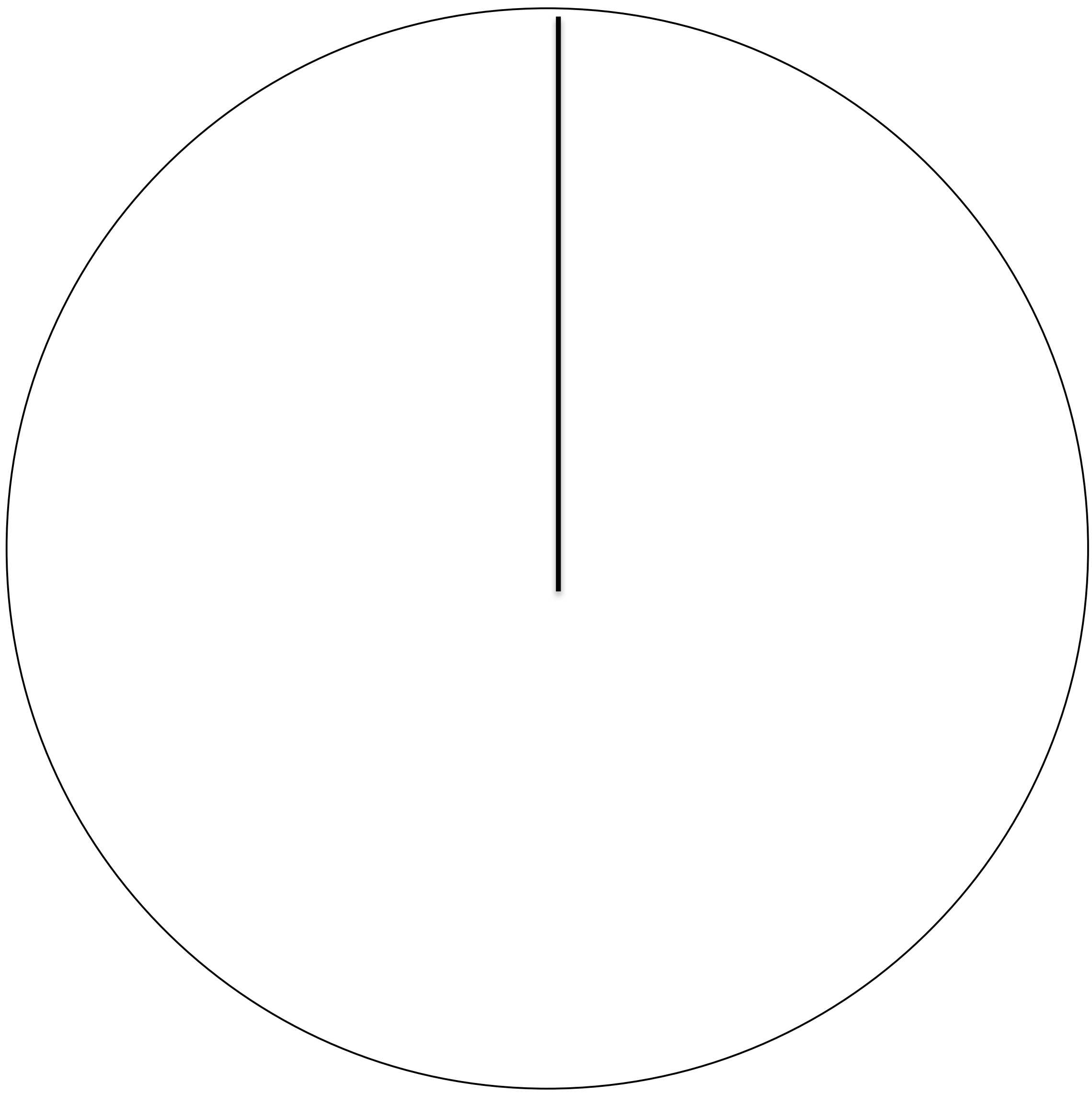
0

3.2 Long-Term Emotion-Time Distribution

Please allocate a section of the pie chart to represent the **time** spent feeling each emotion, over the week immediately following the Soundscape Exposure, as shown in the example below.



(Example)



3.3. Long-Term Intensity of Perceived Sensations

Please circle the **intensity** of sensations felt during the week immediately following the Soundscape Exposure. Please indicate if there have been any particular situations or stimuli that triggered a sensation.

Physical Positive (Ph +)

Did you feel **numbness or tingling?**

Not at all mild noticeable chronic unpleasant severe distress and inability to function

Trigger: ____

Did you **blush?**

Not at all mild noticeable chronic unpleasant severe distress and inability to function

Trigger: ____

Did you feel **hot?**

Not at all mild noticeable chronic unpleasant severe distress and inability to function

Trigger: ____

Did you feel your **heart pounding?**

Not at all mild noticeable chronic unpleasant severe distress and inability to function

Trigger: ____

Physical Negative (Ph -)

Did your **legs feel wobbly?**

Not at all mild noticeable chronic unpleasant severe distress and inability to function

Trigger: ____

Did your **hands tremble?**

Not at all mild noticeable chronic unpleasant severe distress and inability to function

Trigger: ____

Did you feel **unsteady or shaky?**

Not at all mild noticeable chronic unpleasant severe distress and inability to function

Trigger: ____________________

Did you break out in a **hot or cold sweat?**

Not at all mild noticeable chronic unpleasant severe distress and inability to function

Trigger: ____________________

Did you feel **dizzy?**

Not at all mild noticeable chronic unpleasant severe distress and inability to function

Trigger: ____________________

Did you feel **faint?**

Not at all mild noticeable chronic unpleasant severe distress and inability to function

Trigger: ____________________

Did you get **an upset stomach?**

Not at all mild noticeable chronic unpleasant severe distress and inability to function

Trigger: ____________________

Psychological Negative (Ps -)

Did you **feel completely unable to relax?**

Not at all mild noticeable chronic unpleasant severe distress and inability to function

Trigger: ____________________

Did you **fear the worst happening?**

Not at all mild noticeable chronic unpleasant severe distress and inability to function

Trigger: ____________________

Did you **fear you were going to die?**

Not at all mild noticeable chronic unpleasant severe distress and inability to function

Trigger: ____________________

Did you **fear losing control?**

Not at all mild noticeable chronic unpleasant severe distress and inability to function

Trigger: ____________________

Did you feel **terrified?**

Not at all mild noticeable chronic unpleasant severe distress and inability to function

Trigger: ____________________

Did you feel **depressed?**

Not at all mild noticeable chronic unpleasant severe distress and inability to function

Trigger: ____________________

Did you **feel nervous?**

Not at all mild noticeable chronic unpleasant severe distress and inability to function

Trigger: ____________________

Did you feel **frightened?**

Not at all mild noticeable chronic unpleasant severe distress and inability to function

Trigger: ____________________

Did you feel **scared?**

Not at all mild noticeable chronic unpleasant severe distress and inability to function

Trigger: ____________________

Did you feel **tense?**

Not at all mild noticeable chronic unpleasant severe distress and inability to function

Trigger: ____________________

How **sad** did do you feel?

Completely very neither sad nor happy quite not at all

Trigger: ____

Psychological Positive (Ps +)

How **content** did you feel?

Completely very neither content nor discontent quite not at all

Trigger: ____

How **relaxed** did you feel?

Completely very neither relaxed nor tense quite not at all

Trigger: ____

How **in control** did you feel?

Completely very neither in control nor out of control quite not at all

Trigger: ____

How **relieved** did you feel?

Completely very neither relieved nor worried quite not at all

Trigger: ____

How much **pleasure** did you feel?

Constant a lot a moderate amount very little none at all

Trigger: ____

How **happy** did you feel?

Completely very neither happy nor unhappy quite not at all

Trigger ____

3.4 Long-Term Emotional Impact of Soundscape Exposure

Were you initially **upset** by the soundscape exposure? (either during the experiment or later that day)

Yes a little neither **Yes** nor **No** not really **No**

Did you **cry** in the days following the Soundscape Exposure?

Yes a little neither **Yes** nor **No** not really **No**

Have you gained **confidence** in your ability to withstand anxious sensations, as a result of the Soundscape Exposure?

Yes a little neither **Yes** nor **No** not really **No**

Did you excessively **ruminate on negative issues (more than usual)** in the week following the Soundscape Exposure?

Yes a little neither **Yes** nor **No** not really **No**

Please elaborate:

Did the effects of the soundscape exposure **last beyond** the visit to the SoundLab?

Yes a little neither **Yes** nor **No** not really **No**

Please elaborate:

Did you **resolve any underlying fear, trauma or grief** either during the Soundscape Exposure, or in the days following it?

Yes a little neither **Yes** nor **No** not really **No**

Please elaborate:

Have you **become more aware of the fluidity of your moods, and mindful of your physical sensations** since the Soundscape Exposure?

Yes a little neither **Yes** nor **No** not really **No**

Has this heightened awareness been **helpful** or **distressing** ?

Did you **re-hear** any of the sounds heard during the Soundscape Exposure, as a form of ear-worm?

Yes a little neither **Yes** nor **No** not really **No**

Please elaborate:

3.5 Long-Term Mood Change

Did your original mood states negatively change (-1), remain the same (0) or positively change (+1) after listening to the soundscape.

Happiness	-1	0	+1
Pleasure	-1	0	+1
Relief	-1	0	+1
In control	-1	0	+1
Relaxation	-1	0	+1
Contentment	-1	0	+1
Tension	-1	0	+1
Depression	-1	0	+1
Sadness	-1	0	+1

3.6 Long-Term Better or Worse

Please mark on the scale whether you feel better or worse than when you walked in to the SoundLab.

Worse Exactly the same Better

3.7 Long-Term Soundscape Exposure Affects

Which of these do you feel the Soundscape Exposure did to you (please tick one or more options)

Entertained you

Energized you

Relaxed you

Vibrated throughout your entire body

Induced strong sensations

Distracted you from other worries

Intensified anger and frustration

Saddened you

Helped you to understand your emotions

Comforted you

8.2 Full ethical approval form: Participants in non clinical setting

Please complete all sections unless instructed otherwise by your Research Developer. Questions highlighted in **bold** and *italicised* are particularly important and answers must be detailed or there will be a delay in obtaining ethical approval.

Upon completion, please email or send in internal mail for the attention of the Research Developer (a.hay@gsa.ac.uk). Your application will then be discussed at the next meeting of the GSA Research Ethics Committee and a decision will be communicated back to the applicant.

1. APPLICANT DETAILS

Name of researcher (Applicant):	Jessica Argo
School:	Digital Design Studio
Project Title:	*Immersive Soundscapes to elicit Anxiety in Exposure Therapy: Physical Desensitization and Emotional Catharsis*
Funder:	Global Excellence Initiative Fund
Project Reference Code:	

2. RECRUITMENT

a)

Number of participants required:	30
Will recruitment be direct (led by the researcher) or indirect (led by an organisation / third party)?	DIRECT

b) If your study involves INDIRECT recruitment, please detail the recruitment plan covering: i) organisation / institution / individual in charge of identifying possible participants; ii) how they will recruit individuals (letters, phone calls etc); iii) any individual who has direct contact with participants; iv) any ethical protocols the third party has in place; v) level of permission that third party has to disseminate information on behalf of the participants (append any documents if necessary)

N/A

c) If your study involves DIRECT recruitment (i.e led by the applicant / research team):

Who is in charge of recruitment:

I will identify possible participants, as the principal researcher.

What is the method of identifying participants:

I will identify participants from two groups.
For **Stage 1**, self-referred, non-vulnerable anxiety sufferers identified from a database of support-groups will complete a ***Pre-Exposure Screening Questionnaire*** and ***Trigger Diagnosis*** (see attached).
For **Stage 2,** healthy participants (most likely university students) will be invited to the SoundLab at the Digital Design Studio, for the more emotionally and physically challenging **Soundscape Exposure**.

Support Groups
I used *Google*, the *Breathing Space Scotland Support Groups Directory* and *Patient.co.uk* to search for self-help support groups in Glasgow, specifically those that address Anxiety and Depression. The Glasgow groups would be ideal

participants for **Stage 1** (questionnaires to identify sounds and situations that trigger anxiety), with the opportunity to continue to **Stage 2** (the Soundscape Exposure) if they are eligible. (I also located support-groups in Renfrewshire, the rest of Scotland, and UK-wide**,** where I can identify participants able to remotely complete the **Stage 1** questionnaires online, but obviously they would be much less likely to take part in **Stage 2** exposure which will be housed in the Arup Ambisonics SoundLab in the Digital Design Studio, Pacific Quay, Glasgow.) Only community initiatives independent of the NHS will be contacted initially, as NHS initiative run groups need NHS ethical clearance.

Student Population

The ideal situation is that at least 30 non-vulnerable individuals from the support groups complete **Stage 1** questionnaires and continue to **Stage 2**, so we find all the participants for the Sound Exposure from this sensitive pool. However, realistically, I do not believe we would have such a large positive response, and I would likely need to supplement this recruitment from elsewhere, primarily Undergraduate Psychology students from the University of Glasgow. There is also a local student body from Post-Graduate courses based at the Digital Design Studio, although they are limited in number and availability. If we recruited the Sound for the Moving Image, Serious Games and Heritage Visualisation students already on-site, there are only approximately 40 students, so we would need almost every single student to take part. This would be difficult given the multiple deadlines the students have all through the year due to the condensed nature of the one-year Masters course. The Digital Design Studio students would be familiar with the environment and conveniently on-site, but sound students may have a cultural bias, with advanced listening techniques taught on the course, which might distort results. I will also submit an ethics form to the University of Glasgow School of Psychology so I can recruit their students. Undergraduate student participants are less available in the exam seasons of May and June, or December, and will be most keen to take part in **September** or **October** (or early Spring) when the workload is at a minimum.

I will conduct a small pilot of five participants (mainly students and artists) in July 2015.

How will participants be invited to take part: (e.g. letters, phonecalls, door to door):

Support Groups

I will contact support group co-ordinators (who will act as gate-keepers) once ethical clearance is granted, to advertise recruitment for the **Stage 1**. To prime first, rather than overload, I will email each group leader asking if they are happy to receive information. (Email will appear more inviting and visible than sending a large ominous envelope in the post.) If they approve of their support group members' participation in a research study, I will then follow up with more detailed information. This will include the recruitment advertisement **poster** for display within the community centre, a copy of the ***Information Sheet, Consent form, Pre-Exposure Participant Screening Questionnaire*** and ***Trigger Diagnosis***. As the project aim is to develop a new, non-medicinal Anxiety therapy that might one day be beneficial to the group, hopefully the group leader would be motivated to invite group members to participate. An email with the ***Pre-Exposure Participant Eligibility Screening Questionnaire*** attached can be forwarded from the group leader to all members, upon which the participants can register with me anonymously (by saving their document as a pseudonym or abbreviation of their name) and provide either a contact email and/or phone number when they email the completed document to me.

Following the survey, I will invite them to participate in **Stage 2,** the Soundscape Exposure. It will be made clear that they are in no way obliged to participate: it is only if they believe they are capable of withstanding a sound exposure aimed to test and strengthen their susceptibility to aversive sounds, and if it is convenient for them to attend the experiment at Pacific Quay.

Student and General Public Population

I hope that participants from the Support Groups will be encouraged to continue to **Stage 2** as they will provide an invaluable contribution to the advancement of non-pharmaceutical Anxiety treatment: if Soundscape Exposure can be used as therapy, this could improve the quality of life for as many as **1 in 6** of the population afflicted with the disorder. They may even see an opportunity for self-improvement, to diminish their anxiety in the long run. However, I think many anxiety sufferers will be cautious, assuming the exposure will be an unpleasant experience they are not willing to endure. Thus, to attract a significant base of people, at least 30 will be recruited from the student population.

I will advertise on www.callforparticipants.com, Student and Graduate Employment sites (http://employer.glas.prospects.ac.uk), and Gumtree. Professor Christoph Kayser (my external supervisor for University of Glasgow) will advertise on the School of Psychology participant recruitment website, which has a large pool also reaching other members of the public interested in participating in studies, and on which we can also screen by particular age and gender.

	Stage 1 (Trigger Diagnosis)	Stage 2 (Sound Exposure)
IDEAL / LOGICAL	Self-referred Anxiety sufferers	Self-referred Anxiety sufferers
USEFUL richer source from which to identify trigger sounds	Self-referred Anxiety sufferers & Healthy non-vulnerable public	Healthy non-vulnerable public
SUFFICIENT	Healthy non-vulnerable public	Healthy non-vulnerable public

The decision to give questionnaires to non-vulnerable anxiety sufferers (even if I may not be able test the soundscapes on them) may seem quite illogical, but I must acknowledge that the nature of the experiment will be off-putting to anxiety sufferers. The ideal scenario is that I receive a plethora of responses to the questionnaires just from the support groups and at least 30 of these contributors continue to take part in the exposure test, but this will probably not happen so to supplement the support groups, I would then reach out to the student body as well.

d) Regardless of method of recruitment, what is your exclusion / inclusion criteria for this study:

I will gather data from healthy, non-vulnerable people, who are fully able to consent (ideally those prone to anxiety from time to time) using questionnaires. It would not be appropriate or safe to ask potentially upsetting questions to vulnerable, hospitalized acute anxiety sufferers, but perhaps relatively psychologically stable members of self-help groups may be motivated to contribute to research that aims to diminish their affliction. Therefore, I must screen to identify participants who are at an ideal point on the spectrum of anxious symptoms - not completely anxiety-free but not in the midst of an acutely nervous episode. (Whilst there is not a strictly defined line between patients and non-patients, as soon as someone is clinically diagnosed they are then labeled as vulnerable.) **Stage 1** is a ***Pre-Exposure Participant Eligibility Screening***, using an adaptation of the *Beck Anxiety Inventory* and the *Subjective Units of Distress Scale*. I will assess whether it is safe to then expose the questionnaire respondent to soundscapes, or if the anxiety they experience is too acute at that moment in time (identifiable by crossing threshold scores of 43 (Beck) and 8 (SUDS) respectively), rendering them unable to take part in **Stage 2**. So, I would exclude those who are acutely experiencing a nervous episode, indicated by a score exceeding 43 on the ***Pre-Exposure Intensity of Perceived Sensations*** scale reflecting on the participant's past month (an adaptation of the *Beck Anxiety inventory*). I would also exclude those who marked a score of 8 or above on the ***Pre-Exposure Evaluation of Anxiety Levels*** (an adaptation of the Subjective Units of Distress Scale), marking that their past month mostly comprised of "HIGHLY unpleasant distress, physical tension, worry, fear or anxiety, intolerable sensations (trembling, nausea), with difficulty concentrating or thinking clearly." The ***Emotion-Time Distribution*** is a graphical pie-chart evaluation of anxiety over the past month; I will exclude those who dedicate over 75% of the chart's area to negative emotions (sad, depressed, tense) with only 25% of the chart's are allocated to positive emotions (relaxed, in control, happy, relieved). So if a participant generated a collective score of **51.75** (43 Beck + 8 SUDs + 0.75 EMT) from the ***Pre-Exposure Participant Eligibility Screening,*** then they would be excluded from the **Stage 2 Soundscape Exposure**. I would instead provide a database of support groups and helplines such as the Samaritans and Anxiety UK. I will also provide basic take-home psycho-education in the form of the NHS booklet, *Coping with Anxiety* (see attached). If they are a student I can even point them in the direction of internal Student Support counseling, which is free of charge and would be the most effective treatment for them at this point in time.

Age

I will only include adults (over 18 years of age) who can give fully informed consent, and who are non-hospitalized, fully functioning members of the public. I can include those who are recovering from past experience of anxiety, but are not at their most critically vulnerable. There will be no upper limit age restriction.

Critically, recruiting mostly from the student body ensures the population sample is at an average age of 18-30, thus they share a similar level of life experience. This will likely prevent extraneous variables such as the participants' experience of hard-hitting adult trauma (e.g. divorce, family deaths or inter-personal ordeals) that younger generations are usually yet to suffer. However, I acknowledge that widening the spectrum of ages might actually be beneficial, as it gives a research study a balanced demographic - there are myriad advantages and disadvantages of screening for age. I will screen the respondents first of all, and take it from there rather than impose too many limits at this stage. If within the cohort there are sub-groups, then I can form conclusions and correspondences in the analysis.

Remarkably, a consideration idiosyncratic to this study (which uses **sound** as an experimental stimulus), is that aging onsets a hearing loss, specifically the ability to perceive high frequencies or subtler sounds. Those under 22 actually have much more sensitive perception of high frequencies than myself now, so the younger participants may hear sounds unintentionally placed within the soundscape, or frequencies implemented to be purely visceral. Obviously, a soundscape being tested on deafened, aging ears is not going to be as effective as it would be if tested on the younger age group.

Support Group Leader's subjective selection?

I would acknowledge advice from the support-group leaders as to who to recruit, but I would rather ask them to offer the ***Pre-Exposure Participant Eligibility Screening*** questionnaire unilaterally to all the group members. If a prospective participant's *Beck Anxiety Inventory* adaptation score breached the threshold of 43, and their *Subjective Units of Distress Scale (SUDs)* is 8 or above, and their **Emotion-Time Distribution (EMT)** Pie Chart is over 75% negative, this indicates that they are in the midst of acutely nervous episode, so that will be quantified vulnerability criteria. I would exclude those who are acutely experiencing a nervous episode, indicated by a collective score of **51.75** (43 Beck + 8 SUDs + 0.75 EMT) on the ***Pre-Exposure Participant Eligibility Screening,*** reflecting upon the past month's sensations and emotions**.** This is fairer than the group leader choosing on their behalf, deeming a group member too weak. Obviously, they are well acquainted and the group leaders are often trained mental health professionals, but it their choices would be too subjective, as their personal relationship may interfere.

In all cases, append a copy of i) information sheet for participants; ii) consent form; iii) copies of any other documents distributed to participants

3. CONSENT

a) Give a detailed account of the steps taken by the researcher to obtain informed consent from the participants (regardless of method of recruitment):

I will ask to attend and observe one of the support group meetings to assess if the group would be suitable for the research study. The group leader may or may not endorse the group members' participation in the study.

I have assembled a concise ***Information Sheet*** that outlines the project, with a ***Consent Form*** for the participant to sign (and their own copy to retain). These both clarify the purpose of all data that will be recorded: from the initial questionnaire, to the full spectrum of quantitative and qualitative data monitored during the entirety of the participant's exposure to the soundscapes. I have included multiple consents, such as, is the participant willing to expose themselves to this loud sound pressure level, potentially upsetting subject matter, and also to be monitored (both psychophysically and through video). The supplementary forms all include the DDS and GSA's logo, my contact details so prospective participants can follow up with me, plus a third party contact (my Primary Supervisor, Dr. Daniel Livingstone) so they can check with an external reference if they have any additional questions.

It will be made clear that prospective participants are in no way obliged to participate: it is only if they believe they are capable of withstanding a challenging sound exposure, and if it is convenient for them to attend the experiment at Pacific Quay.

b) How will researchers ensure the participant has capacity to consent:

I will only **include** adults (over 18 years of age) capable of giving fully informed consent: I will be cautious if prospective elderly participants have deteriorating understanding or age-related afflictions such as dementia, as they may be less able to give informed consent.

Prior to participation in the Sound Exposure, the participant will undergo a rigorous screening process composed of 5 questionnaires. I would exclude those who are acutely experiencing a nervous episode, indicated by a score exceeding 43 on the ***Pre-Exposure Intensity of Perceived Sensations*** scale reflecting on the participant's past month (an adaptation of the *Beck Anxiety inventory*). I would also exclude those who marked a score of 8 or above on the ***Pre-Exposure Evaluation of Anxiety Levels*** (an adaptation of the Subjective Units of Distress Scale), marking that their past month mostly comprised of "HIGHLY unpleasant distress, physical tension, worry, fear or anxiety, intolerable sensations (trembling, nausea), with difficulty concentrating or thinking clearly." The ***Emotion-Time Distribution*** is a graphical pie-chart evaluation of anxiety over the past month; I will exclude those who dedicate over 75% of the chart's area to negative emotions (sad, depressed, tense) with only 25% of the chart's are allocated to positive emotions (relaxed, in control, happy, relieved).
So, if a participant generated a collective score of **51.75** (43 Beck + 8 SUDs + 0.75 EMT) from the ***Pre-Exposure Participant Eligibility Screening,*** then they would be excluded from the **Stage 2 Soundscape Exposure**. I would instead provide a database of support groups and helplines such as the Samaritans and Anxiety UK. I will also provide basic take-home psycho-education in the form of the NHS booklet, *Coping with Anxiety* (see attached).

c) If your work requires participants belonging to vulnerable groups (children under 16, adults unable to give consent, prisoners, individuals in dual relationships), what additional steps will be taken to gain consent:

I will not be working with vulnerable groups.

If I recruit self-referred support group members to complete questionnaires (to identify the sonic anxiety triggers), this means we can gather rich data from a whole pool of autonomous non-vulnerable sufferers; I will not need to question hospitalized patients. Thus NHS clearance is not necessary. Ideally, it is safest to go through NHS clearance, but for that we need proof that Sound Exposure doesn't harm healthy people first, which is not possible within the short 3-year PhD timescale. Exposing sound to healthy students who experience stress from time to time will be sufficient to prove that Soundscape Exposure has an effect that does not cause lasting or significant harm, and that careful implementation of sound may even be beneficial when used as Exposure Therapy.

Ethical approval for working with support group members can be granted internally, as long as I do not use the NHS self-help groups. Further down the line, if I find that I do need to consult the NHS initiatives, I will then go through the NHS ethics procedure. I will consult the independent self-help groups first so I can evaluate the quality and rate of response. If these respondents do not provide suitable results, I might then have to request NHS ethical approval to interact with the NHS initiatives. The ideal is that I should always conduct research with healthy volunteers first, and then only if it would be helpful recruit people who are self-referred to a support group, and only then if completely necessary proceed with NHS groups. I will build it up in stages, to limit the exposure of vulnerable people. I will be refining the experimental techniques as I go along, so I can predict the responses I will get, and build up professional experience as a researcher. I would not even send the ***Pre-Exposure Participant Eligibility Screening Questionnaire*** to those who are vulnerable, because subject matter of the questionnaire alone may be upsetting.

I will be recruiting students, but I have no dual relationships with them, as I am not a tutor for any of these students. There is no unequal relationship, thus hopefully no skewing of their responses to please an authority figure. I am not a member of staff and the participants will not know me - I may occasionally offer technical support to the students in Digital Design Studio, but this is not equivalent to the skew on the results that would be caused by a student wishing to please their professor.

d) If your work requires the consent of a gatekeeper, please detail the steps you will take to ensure participants are not coerced by their gatekeeper. State also whether you plan to obtain additional signatures from participants and if not, why

Support Group Leader's subjective selection and coercion?

The gatekeeper will be a support group leader, who is contractually bound to care for the wellbeing of group members. I would acknowledge advice from the support-group leaders as to who to recruit, but I will ask them to offer the **Participant Eligibility Screening** questionnaire unilaterally to all the group members. If a prospective participant's *Beck Anxiety Inventory* adaptation score breached the threshold of 43, this indicates that they are in the midst of acutely nervous episode, so that will be quantified vulnerability exclusion criteria. I would also exclude those who marked a score of 8 or above on the ***Pre-Exposure Evaluation of Anxiety Levels*** (an adaptation of the Subjective Units of Distress Scale), marking that their past month mostly comprised of "HIGHLY unpleasant distress, physical tension, worry, fear or anxiety, intolerable sensations (trembling, nausea), with difficulty concentrating or thinking clearly." The ***Emotion-Time Distribution*** is a graphical pie-chart evaluation of anxiety over the past month; I will exclude those who dedicate over 75% of the chart's area to negative emotions (sad, depressed, tense) with only 25% of the chart's are allocated to positive emotions (relaxed, in control, happy, relieved). So if a participant generated a collective score of **51.75** (43 + 8 + 0.75) from the ***Pre-Exposure Participant Eligibility Screening,*** then they would be excluded from the **Stage 2 Soundscape Exposure**. I would instead recommend that they continue to attend support groups and direct the participant to helplines such as the Samaritans and Anxiety UK. I will also provide basic take-home psycho-education in the form of the NHS booklet, *Coping with Anxiety* (see attached). This is fairer than the group leader choosing on their behalf, deeming a group member too weak. Obviously, they are well acquainted and the group leaders are often trained mental health professionals, but their choices would be too subjective as their personal relationship may interfere.

Signatures I will administer ***Consent Forms*** and ***Information Sheets*** to each individual participant, so they are fully informed of the purposes and methods of the study. They will have a personal copy to keep for their records. I will require only the individual participant's signature on the ***Consent Form*** - a gatekeeper's signature is not necessary. The support group leader is not responsible for the participant, as they will be aged 18 or over with no cognitive impairments or learning difficulties. **Financial Incentive** Neither the gatekeepers, nor the participants will be offered any monetary incentives, other than reasonable compensation for their time and travel expenses. Participants will be reimbursed for travel to the Digital Design Studio (they have been informed that the McGills **23, 26, or Stagecoach F1, X1**, buses stop outside the front door / it is a 10 minute walk from **Ibrox** Subway station.) For the student participants, I cannot offer course credit, as this would give unfair academic advantage to the eligible students: those too vulnerable to partake in exposure will be excluded and miss out on the extra credit. Instead I will offer token gestures of thanks, such as Amazon or IMAX vouchers, or monetary compensation for their time at £6.50 per hour.

e)

How much time will be given for the participant to decide whether or not to take part:	3 days
By what method will you seek to obtain consent (written, oral, video etc) and why: NB: please be aware of any Data Protection issues here	Written (as it is most convenient for the participants and myself, and easy to store) The participants can register with me anonymously (by saving their ***Consent Form*** as a pseudonym or abbreviation of their

	name) and provide either a contact email and/or phone number when they email the completed document to me. Their original email will be deleted. All personal information provided will be stored in a private password-protected user account, on a computer only in proximity to authorized Digital Design Studio Staff, in encrypted documents. Any hard copies of questionnaires and consent forms, plus a digital back up of the project on an external hard drive will be stored in a fireproof, lockable cabinet.
Will copies of consent be given to participants:	YES
For how long will the copies of consent be retained by the researcher and where will the consent form be stored:	Copies of consent will be kept for the duration of the study, until final graduation from the PhD course. The paper consent forms will be stored in a personal locker, and digitized and securely stored in encrypted documents on a password protected computer, only in proximity to authorized Digital Design Studio Staff.

4. LOCATION

a) If the research activities take place in a third party location (i.e. not on GSA premises), please explain the choice with reference to the study. Append confirmation of permission to use location given by the owner and confirm that all researchers have been made aware of any local rules and regulations (append if necessary).

For **Stage 1**, The ***Information Sheet*** and ***Consent Form*** will be emailed directly to prospective participants (or the gatekeeper to distribute to members of their support group) – they are welcome to email scans of these or post them back to me, whichever is most convenient for them. Upon receipt of a signed ***Consent Form***, The ***Pre-Exposure Participant Eligibility Screening*** questionnaires will be sent and completed via email or post. If distributed in hard copy by a support group leader, these will be completed in the respective location of each support group. I would supervise the completion of questionnaires and collect in person if accessible (in the Renfrewshire/Central Belt Area). If the support group is out-with reasonable travel distance, the questionnaires will be completed on site and posted back to the me, as a Signed For recorded delivery or the support group leader can email scans of the documents to me.

For **Stage 2**, the **Sound Exposure** will take place in the Arup Ambisonic Sound Lab, part of the Digital Design Studio, in The Hub at Pacific Quay. The Ambisonics lab is the most immersive sound array in the Glasgow School of Art, with a spherical 16-speaker formation. It is an ideal controlled environment: a private, soundproofed, windowless room. The speaker array offers adaptable playback - we are even able to carry out a control test in stereo if required.

I will explain the Health and Safety regulations of the The Hub and the Ambisonics Lab in the **Consent Form** to the participants, and re-iterate on arrival.

(There is also a contingency **Soundscape Exposure** location, in case we cannot recruit enough participants due to the psychological distance of a taxi or bus-ride to the Digital Design Studio. It will be easier to recruit University of Glasgow School of Psychology students if there is a way of testing in their own labs in the West end, although the quality of the ambisonics set-up will be dramatically compromised. As we must compensate participants both for their time and travel, if they go to DDS we have to pay more money, to reimburse for travel costs. (Professor Christoph Kayser' s Psychology department could contribute some money to pay the participants.) I will emphasise in the recruitment advert that both the participants' time and travel will be compensated for. However, I am only keeping this option in mind as a possibility, and I have weighed up which option will be more cost-effective.

We will most likely not use the University of Glasgow laboratory: as we would need to check that the equipment will be available to transport for a week, source a van and require the support of Ronan Breslin (my co-supervisor) to help me set up the array – which might prove more difficult than transporting participants to the Digital Design Studio. Although a 16-speaker array like the Arup ambisonics sound lab is not strictly necessary, even setting up a minimum of 8 speakers, with stands, and a computer with ambisonic panning interfaces will be a great undertaking. I will complete ethics for both locations as a precaution.

I will first try to transport participants to the optimal 16-speaker ambisonic array ready-made at the DDS, but I have planned for the event that the psychological distance is too far for participants to travel.

Reimbursing travel costs to DDS = £90 - £300.

(£3 return subway ticket x 30 = £90, or £3.50 return bus ticket x 30 = £105, or £10 per taxi x 30 - £300)

Cost of van to transport equipment (to University of Glasgow and back to DDS) - < £70 - 90

∴ The costs saved are not worth the upheaval, the University of Glasgow option will only be used if recruitment is proving impossible.

If we do need to set up a laboratory at the University of Glasgow, I will make myself aware of the local health and safety regulations and fully inform the participants.)

b) If the research activities take place in the participants' home, please CLEARLY explain the choice with reference to the study and why no other location is possible. Detail all measures taken to minimise the risk to both participants and researchers entering the home.

N/A

5. INCENTIVES

a) Reasonable reimbursements for time and travel compensation are acceptable as incentives to participate in a research study. An acceptable level of reimbursement would be no more than £50 (approximately).

Do you plan any of the following:

Travel reimbursement only	NO
Small incentive only (e.g. gift voucher)	NO
Travel and small incentive	YES

b) If the incentive exceeds £50, please state the reasons why (note a large financial incentive, whilst appearing generous, could be deemed unethical on the grounds of coercion. See also, the Bribery Act 2010):

N/A

6. METHODOLOGY AND ACTIVITIES

a) Please state the methodology employed within the study and give references (literature or any previous work by the researcher) to support their use:

The methodology consisted firstly of a survey of academic literature and online forums to identify existing therapeutic frameworks and sonic anxiety triggers, (to be later supplemented with trigger questionnaires sent to anxiety sufferers). I then produced five anxiety-eliciting soundscapes, which have been panned across the ambisonic array. I will expose these to healthy participants so I can monitor their psychophysical arousal, with rigorous questioning to qualitatively assess emotional catharsis.

Identify sonic triggers

↓△

Compose Soundscapes → Soundscape Exposure

(Physiological Monitoring & Catharsis Assemsent)

Exposure Therapy is an established psycho-therapeutic technique designed to diminish the intensity of Anxiety symptoms, by gradually exposing the user to their fear triggers, either directly (*in vivo*) or through simulation (such as Virtual Reality visualization) [1]. However, out of all of the senses, humans have evolved to have the deepest immediate fear response to **sound** [2] - so Exposure Therapy might be more effective if therapists implement sonic anxiety triggers instead of only visual stimuli.

Acoustic features can reliably elicit physical sensations: sudden loud sounds can startle the listener [3], or abrasive high frequencies send a shiver down the spine [4]. A soundscape can evoke memory, as indicative sound sources can locate the listener in a past situation [5], and melody can induce emotions [6]. Individual anxiety trigger sounds will repeat to habituate the listener - to remind them that it is just a noise, and encourage them to focus on how it sounds rather than what it means [7]. Soundscape Exposure fuses **physical desensitisation** with **emotional catharsis,** as the user confronts repressed traumatic memories and develops coping strategies.

I will invite participants to listen to soundscapes that have been arranged across the 16 speakers of the SoundLab ambisonic array, whilst they wear a non-invasive heart-rate, breathing and sweat secretion monitoring system - so I can deduce if these sounds could be effective anxiety stimuli.

Personalized trigger sounds are essential, as tears (and thus catharsis) are more reliably caused by stimuli that resonates with the listener's own experience [8]. For instance, a hostage victim was conditioned to intensely fear footsteps and knocking, as those were the warning signs of his captor's approach during his captivity [7]. An obvious approach would be to habituate him through gradually exposing these sounds - at first only exposing him subliminally to certain frequencies, then over time the footsteps would become clearer, then be placed in a percussive rhythm, extending the sound beyond its property as a signifier, repetition rendering it meaningless – reminding him it is **just a sound**.

There are myriad sounds which universally induce fear: ominous sound effects indicative of physical threat or violence, or stabbing string instrumentation orchestrated to frighten the listener in sforzando horror stingers. Online forums such as Psychnet provide useful insights from a diverse demographic of sufferers, revealing that the anxious hypersensitivity renders banal domestic, environmental, social and visceral disturbances agonizing. Through questionnaires I can identify both sonic triggers, but also situational triggers to be symbolised by sound – the scenarios, spaces and bodily symptoms that provoke anxiety along with a vivid description of the participant's ultimate "worry scenario" [9].

I have produced the sound primarily using established anxiety triggers and matching synthesized instruments, tracklaying the base elements of field recordings, foley, sound effects and instrumentation. I manipulate listener affect using: repetitive loops to fluctuate between irritation, menacing onslaught and eventually trancelike hypnosis; equalization, the ducking or boosting of frequencies of the sound to mimic sensory distortion induced by panic; excessive reverb or indeed lack of, to simulate large agoraphobic spaces or recreate an inner-subjective auditory hallucination; visceral, inaudible frequencies (predominantly emitted by low-frequency sub-bass) shake the listener or high frequency's minute vibrations can entrain alpha brainwaves, subliminally inducing relaxation [10]. The novel ambisonic spatial array allows me to construct soundscapes as haunting bombardments to invoke paranoia with disembodied sound objects assaulting the listener from all sides.

I will employ physiological monitoring to pinpoint arousal during exposure. Heart-rate will identify moments of shock or waves of relaxation – particularly, a surge and then a consequent attenuation of heart-rate-reactivity is indicative of *emotional processing*, showing an arousal and then adaptation of the fear response [11, 12]. I also detect signatures of acoustic processing from the skin, as a Galvanic Skin Response logger will measure instantaneous sweat secretion and piloerection from fear or musical frisson. Respiration will trace shock patterns and identify gasps. Electroencephalography (EEG) will measure real-time brainwave patterns, distinguishing mental states across a broad spectrum: from when the listener engages with the sensory environment (Alpha brainwaves at 8-12 Hz); stressed, anxious states due to the expectation of changes (Beta brainwaves at 12-38 Hz); to active processing of acoustic sensations (Gamma brainwaves 30-70 Hz). The exposure soundscape should provoke stressed Beta waves, then lead to a sensory-euphoric Gamma state, showing an energetic leap out of a depressive state.

During the exposure video-recording will be employed to track facial expression. A questionnaire following each soundscape will discern which resonant sounds triggered emotional memories and positive or negative physical sensations.

1. Roy, M. J., Francis J, Friedlander J, Banks-Williams L, Lande RG, et al.: et al. (2010) Improvement in cerebral function with treatment of posttraumatic stress disorder. Annals of the New York Academy of Sciences, 1208, pp.142–149 (2010).
2. Panksepp, J., Bernatzky, G.: Emotional sounds and the brain: the neuroaffective foundations of musical appreciation. In: Behavioral Processes, Issue 60, pp. 133-155 (2001)
3. Hoffman, H. S. Attentional Factors in the Elicitation and Modification of the Startle Reaction. In Lang, P. J, Simons, R. F, Balaban, M. Attention and Orienting: Sensory and Motivational Processes. Psychology Press, 2013
4. Grewe et al. Chills in different sensory domains: Frisson elicited by acoustical, visual, tactile and gustatory stimuli. Psychology of Music, 39, 220-239, 2010 in Altenmuller et al. Strong Emotions in Music: Are they an Evolutionary Adaptation? In Bader (ed.) Sound Perception Performance, Springer International Publishing Switzerland. 2013.
5. Liljjedahl, M. Sound for Fantasy and Freedom. In Grimshaw (Ed.) Game Sound Technology and Player Interaction: Concepts and Developments. Information Science Reference (2011)
6. Juslin, P. N., Vastfjall, D. Emotional responses to music: the need to consider underlying mechanisms. Behavioral and Brain Sciences (2008) 31 559-621.
7. Wegerer, M., Blechert, J., Kerschbaum, H., Wilhelm, F. H.: Relationship between Fear Conditionability and Aversive Memories: Evidence from a Novel Conditioned-Intrusion Paradigm. In Plos One, November 2013, Vol. 8, Issue 11. (2013)
8. Bylsma, L. M. When is Crying Cathartic? An International Study In Journal of Social
and Clinical Psychology, Vol. 27, No. 10, pp.1165-118 (2008)
9. Hoyer, J. Beesdo-Baum, K. Prolonged Imaginal Exposure Based on Worry

Scenarios.
In Neudeck, P., Wittchen, H.U. (eds.) Exposure Therapy: Rethinking the Model – Refining
the Method. Springer Science and Business Media (2011).
10. Oohashi, T., Nishina, E., Honda, M., et al.: Inaudible High Frequency Sounds Affect Brain Activity: Hypersonic Effect. In: Journal of Neurophysiology, The American Physiological Society, Vol. 83, pp. 3548-3558 (2000)
11. Lang, P.J., Cuthbert, B. N. Affective information processing and the assessment of
anxiety. Journal of Behavioral Assessment, 6, 369-395 (1984)
12. Foa, E. B., Huppert, J.D., Cahill, S.P. Emotional processing theory: An update. In Rothbaum, B. (Ed.) Pathological anxiety: emotional processing in etiology and treatment
(pp.3-24) Guilford Press, New York. (2006)

b) For each activity employed please detail: i) its purpose; ii) direct correlation to the research outcomes; iii) how any analysis will be performed. **Copies of all material given to participants must be appended to this form wherever possible.**

ACTIVITY 1: **Pre-Exposure Participant Eligibility Screening Questionnaire**

If the participant wishes to take part in the study, I will ask them to read the ***Information Sheet*** in full and sign the ***Consent Form***, which they can **email** back to us.

They will then complete a ***Pre-Exposure Participant Eligibility Screening Questionnaire***, to ensure their capability to endure the soundscape exposure (this can also be sent via **email**).

So before the participant's invitation to Soundlab, the ***Participant Eligibility Screening*** includes:

1. ***Pre-Exposure Evaluation of Anxiety Levels*** (long-term, for the previous month)

2. ***Pre-Exposure Emotion-Time Distribution***

3. ***Pre-Exposure Trigger Diagnosis*** (to quantify the efficacy of tailoring soundscapes

to individuals, by mapping moments of peak anxiety during exposure onto to each participant's pre-informed individual anxieties)

4. ***Pre-Exposure Hypothesised Worry Scenario***

5. ***Pre-Exposure Intensity of Perceived Sensations*** (long-term, for the previous month)

I adapted the established anxiety evaluation inventories to tailor-make questionnaires to be more suited to evaluating sound-provoked anxiety, and to ensure I did not merely copy them verbatim. It is legal to include questions from established questionnaires if they are reworded, as they do not have a patent just a copyright. These pre-exposure questionnaires will ultimately be used to:

i) discern participant eligibility

ii) identify the trigger sounds

iii) tailor the soundscapes

iv) discover if there are anomaly individuals with unusual triggers, or subgroups

v) prove that heightened arousal can be induced by soundscapes matched to idiosyncratic triggers

I simplified the *Beck Anxiety Inventory* and the *Subjective Units of Distress Scale,* as they are standardized and previously evaluated, most commonly used in Cognitive Behavioural Therapy. Thus, I have ensured that I am not burdening people with poorly constructed research or unnecessary questions, yet I will still gain a deep insight in to the eligibility of the prospective participant, with relevant exclusion criteria. I have implemented a variation of a Lickert scale for most, to offer multiple-choice answers. All the anxiety attributes from the ***Pre-Exposure Screening*** appear in the ***Post-Soundscape Frequency of Perceived Sensations*** and ***Post-Exposure Evaluation of Anxiety Levels*** questionnaires, to enable **pre- to post-test mapped analysis**.

The ***Pre-Exposure Evaluation of Anxiety Levels*** shows where the participant lies on average on *Subjective Units of Distress Scale*, over the past month. I offer a distress thermometer (as seen in Cognitive Behavioural Therapy handouts) with a single-line summary of varying degrees of anxiety symptom intensity, as a quick mode of reference.

The ***Pre-Exposure Intensity of Perceived Sensations*** is essentially the *Beck Anxiety Inventory* presented in different words and a different style, so I can convert a prospective participant's responses into a score. On the Beck Anxiety Inventory it offers 0, 1, 2, 3, 4 to choose from, whereas I have chosen to replace this with verbal degrees for each symptom:

0 = not at all
1 = mild
2 = noticeable
3 = chronic unpleasant
4 = severe distress and inability to function

If an individual's score for The Beck Anxiety Inventory (which has 21 symptoms) is over 36 this is a cause for concern, and they should be referred to counseling, definitely excluded from testing (0-21 is very low anxiety, 22-35 is moderate anxiety). The anxiety attributes listed in the **Pre-Exposure Intensity of Perceived Sensations** (long-term, for the previous month) are combined both those found in the *Beck Anxiety Inventory* and Becht and Vingerhoets' (2002) *Crying and Mood Change* study. So if a prospective participant's score for the **Pre-Exposure Intensity of Perceived Sensations** exceeds the threshold of 43 then that is cause for them to be excluded (as per the Beck Anxiety Inventory, plus 7 additional questions adapted from the *Crying and Mood Change* study). It is unethical to present the soundscapes to someone who is not well, who is firstly in need of conventional talk-therapy and medical guidance.

The **Emotion-Time Distribution** is a graphical pie-chart evaluation of anxiety over the past month, where the participant can allocate percentages to negative emotions (sad, depressed, tense) and positive emotions (relaxed, in control, happy, relieved).

This **Pre-Exposure Screening** has a dual function: to use as **exclusion criteria**, but it also collects interesting **baseline data**, for creating different **subgroups** to comparatively analyse. After the first pass of general analysis, I will follow with analysis among subgroups differentiating by the participant's initial scores in the screening. I could compare the result for someone with occasional mild anxiety with someone who never experiences anxiety.

So primarily, I will use the evaluations of the past month's anxiety to exclude people who are in too much pain to participate; whereas the **Trigger Diagnosis** is more informative, as I can use the results as predictive data, e.g. "I expected Participant A to have stronger arousal when exposed to mechanical noises, given their original trigger diagnosis". I have these expectations, but I will also take note if there are anomalies – those prone to anxiety everyday may even feel **less stressed** by the sounds, as they may be desensitized to the stress that they experience every day. Or those who have stated that they dislike mechanical noises may not react as obviously to mechanical sound events, as they are used to hating these in everyday life (their body may not be as surprised anymore, although they still cognitively dislike it). The **Trigger Diagnosis** can also be used to best **allocate** soundscapes to the participant – if they list people sounds as their main anxiety trigger I will play them *Social Anxiety* first. I will be able to tailor the whole Soundscape Exposure experience, assigning the most relevant soundscapes to each participant depending on their **Trigger Diagnosis**. Post-Experiment period I will use the test results analysis to optimize exposure by modifying the soundscape compositions, prioritizing the most powerful sounds in the sound library compiled for the Soundscape Exposure Therapeutic Framework, using these new revelations. I will assemble all retrieved questionnaire responses as appendices to my thesis.

I will present sound categories to select as multiple-choice answers that map directly onto the categories that I have used to compose the soundscapes (essentially, a streamlined version of my full library of sounds). Participants will be asked circle a category, a sub-category, plus one example, with space to expand upon this to identify their own triggers e.g. "Violence - weapons, e.g. M60 machine gun". If I offer multiple-choice checkboxes mapping to categories I can later efficiently **link** one participant's dislike of door sounds with their behavioural measurements recorded during exposure to the soundscapes. I know where in time the door sound comes, so I can check if that is when the physiological arousal increases.

Stage 1 is the pre-exposure survey to identify common anxiety triggers, so I can optimize the composition of the soundscapes, and certify that the sounds used are indeed universally relevant. I have identified obvious scenarios, but these questionnaire responses will certify that my choices of triggers are relevant and perhaps identify triggers I am unaware of. If many people identify a new sound I will include it, and also if a situational trigger lends itself easily to be converted into sound then I will also use it. These perfected soundscapes, post experiment will be optimized exemplars for the Soundscape Exposure Therapy Framework. So I will compile a library of certified anxiety triggers, from a large pool of people. For now, I have designed five soundscapes based on the most common universal fear-inducing sounds (*Social Anxiety, Body Anxiety, Violence, Situational Phobias* and *Sensory Irritation*), and the responses from questionnaires will hopefully corroborate with these designs. I have already analyzed context data that was easily graspable, without me being invasive, as I retrieved sonic anxiety triggers from online forums.

The ***Hypothesised Worry Scenario*** **[4]** asks the participant to describe in vivid detail the **environment**, the **situation**, and the **sensations** and **emotions** felt in their most **catastrophic** worry scenario (the worst that could happen) and to do the same for their **most regular** worry scenario.

I acknowledge that interviews may actually inspire richer, more in depth responses than questionnaires, as questions can be expanded upon and personalized to the interviewee; each method has its advantages and disadvantages. However, due to logistics and sensitivity reasons, I will proceed with only questionnaires. The advantage of using a questionnaire is that responses can be more honest and revealing, as participants feel less inhibited than if they spoke out loud to an unfamiliar interviewer, as electronic or paper based questioning can be rendered completely anonymous. If I only recruited participants from local support groups or universities in Glasgow this would allow interviews in person; but if I only use questionnaires, we may open up the pool to be nationwide or even worldwide. Logistically, online electronic forms are easier, as the participants do not need to post back a paper form.

I will invite all participants who are deemed eligble from the questionnaires in **Stage**

1 to participate in **Stage 2**, the **Sound Exposure**.

1. Beck, A. T., Epstein, N., Brown, G., & Steer, R. A. (1988). An inventory for measuring clinical anxiety: psychometric properties. Journal of Consulting and Clinical Psychology, 56, 893–897.
2. Foa, E., Hembree, E., Rothbaum, B. O. (2007Prolonged Exposure Therapy for PTSD: Emotional Processing of Traumatic experiences: Therapist Guide
3. Becht, M. C., & Vingerhoets, A. J. J. M. (2002). Crying and Mood Change: a Cross-Cultural Study. Cognition and Emotion, 16(1), 87-101.
4. Hoyer, J. Beesdo-Baum, K. Prolonged Imaginal Exposure Based on Worry Scenarios. In Neudeck, P., Wittchen, H.U. (eds.) Exposure Therapy: Rethinking the Model – Refining the Method. Springer Science and Business Media 201104.

ACTIVITY 2: **Sound Exposure**

Following successful completion of the **Consent Form** and of the **Pre-Exposure Participant Eligibility Screening Questionnaire**, the participant is invited to The Arup Ambisonic Soundlab, in The Hub at Pacific Quay, to **listen** to ambisonic soundscapes, and complete individual evaluation **questionnaires** following each soundscape.

On arrival at Soundlab, the participant will complete the following questionnaires:

1. ***Pre-Exposure Evaluation of Anxiety Levels*** (short-term, for that day)
2. ***Post-Soundscape Subjective Perceptions***
3. ***Post-Soundscape Frequency of Perceived Sensations***
4. ***Post-Soundscape Mood Change Assessment*** 2-7 completed
5. ***Post-Soundscape Breathing Assessment*** after every soundscape
6. ***Post-Soundscape Memory Record***
7. ***Post-Soundscape Body Map***
8. ***Post-Exposure Spatialisation Assessment***
9. ***Post-Exposure Evaluation of Anxiety Levels***

Pre-Exposure Evaluation of Anxiety Levels

This will be the same format as the adapted *Crying and Mood Change* and *Subjective Units of Distress* Scales featured in **Pre-Exposure Participant Eligibility Screening Questionnaire**, but with the questions adapted to a short-term timescale – the participant will evaluate their anxiety felt on the day of testing (rather than the previous month), to evaluate a baseline rating of anxiety.

Post-Soundscape Subjective Perceptions

I want to discern the impact of the soundscape: mainly how frightened, irritated, and immersed the participant was. Later on, I will want to discover how these reactions map onto each participant's pre-disposed personal anxieties or personal trigger sounds. I will summarise the responses in various ways. At the end of the experiment run, I will be able to conclude that "80% of participants thought the soundscape was "very loud"" for example, so I could be satisfied I had a majority that thought the sounds were played at optimum volume. For questions such as "Did you enjoy listening to the soundscape?" I have offered a verbal Lickert scale from 1 to 5, with **Yes** or **No** absolutes at either end for the participant to choose from, to increase the sensitivity of the questionnaire (some participants may feel indifferent or think yes, to a certain degree but not definitively a yes). For a first pass of analysis, I can read it in a binary way (rounding up to yes, or rounding down to no, or neither yes nor no). For each question, I will find the percentage of people that answered yes, no or neither. For example, "the majority of people were scared by the soundscape", or "the majority of people were bored by the soundscape", and draw general impact conclusions from that. I could also draw sub-group conclusions, such as "the people who are highly anxious in their everyday lives were highly antagonized by the soundscape", or "surprisingly, those who experience anxiety everyday enjoyed the soundscape much more than those who never do, possibly because it matches their emotional state". I must find out how **emotionally disrupted** participants are by the soundscape (and whether it is in a **positive** or **negative** sense). Some questions directly answer my research questions, e.g. "How irritating was the soundscape?" which could be summarised later on into one score. In the experiment write-up, it would make sense to emphasize results from questions that elicited the most extreme answer on the scale, or those which nearly all 30 participants responded the same. So I can deal with each question individually first, to figure out which are the most interesting, clear or definitive answers. I have offered verbal Lickert scales of 1 to 5, so it is easy for participants to give their answers and easy for me to summarize numerically: a streamlined experience for the participant, and simplifying the analysis for me.

Asking participants to rate the **loudness** of the soundscape is pure curiosity. Personally, I do not think the sounds need to be deafeningly loud to elicit anxiety, if the sound source itself is quite scary and there is a long exposure time – in fact, some sounds should be quieter and harder to grasp, to be even more unsettling. If the exposure has an extended duration it should not be excessively loud. So ideally, the pilot results should indicate that the soundscape is *mostly loud*, but not *unbearable*. If respondents think it is too quiet I will re-mix to increase the volume (even if just for the peak loudest parts.)

Post-Soundscape Frequency of Perceived Sensations

The original *Beck Anxiety Inventory* asks the participant to rate how **intensely** they felt each of a list of anxiety symptoms, on average over the past month. However, I have tailored the ***Frequency of Perceived Sensations*** questionnaire to evaluate a short soundscape: so I ask the participant to assess the **frequency** rather than the intensity of the symptoms. That is, I ask: “how often did you feel <this sensation>”? Either “not at all”, “once very briefly”, “2 or 3 times”, “throughout most of the piece”, or “constantly”? Although the rating is a bit different than the original test, if you think about it, **frequency** is almost the same as **intensity** when it comes to sensation - it is just another way of approaching it. Asking a participant how **often** they perceived a sensation means they think of it more objectively or empirically rather than emotionally. It can be seen as a neutral question, rather than “how deeply affected were you?” or “how upset were you?” It is a way of removing the sensation away from the participant’s psyche, emphasizing the power of the external stimulus, rather than blaming the participant for becoming upset, for example. It may be easier for the participant to answer if delivered in terms of frequency rather than intensity.

All the anxiety attributes from the ***Pre-Exposure Participant Eligibility Screening*** (Beck Anxiety Inventory redraft) appear in the ***Post-Soundscape Frequency of Perceived Sensations*** test, to enable **pre- to post-test mapped analysis**. I combine the Beck attributes with those listed in Becht and Vingerhoets' (2008) *Crying and Mood Change* study. In Becht and Vingerhoets' study, Mood Change was assessed as follows:

"....using a scale including the following seven mood states: (1) relaxed, (2) in control, (3) happy, (4) relieved, (5) tense, (6) depressed, and (7) sad. The respondents indicated whether they generally experienced more, the same, or less of the specified mood after a crying episode, as compared to before. For each mood indicator, a positive change was scored with +1 ("more" for mood states 1 to 4, "less" for mood states 5 to 7), no change was scored as 0, and a negative change was scored as –1. The scale yields a total score (Mood Change Score: MCS) ranging between –7 and +7, with –7 indicating a maximum deterioration of one's mood after crying, and +7 a maximum positive mood change."

One type of response is about the **efficacy of specific sounds** (quantifiable by participants identifying certain categories pre- and post-test); the other type is **about the emotional involvement** of the participants, to what degree they felt specific sensations. I will group the responses according to much more general questions, to average the responses: overall, how **physical** the Soundscape Exposure experience was compared to how **psychological**. So each participant would have a few scores indicating that they were either very emotionally involved or not so emotionally involved, and either very physically aroused or not so physically aroused.

These attributes do seem to be over-arousal, or anxiety traits, but if you reframe them, they could be markers of the sound's power to stir up emotion, full stop. Whilst painful sensations are generally negative, tingling can be positive, in a way. For depressed people, who may be struggling to feel anything, the fact that they can be triggered to feel an emotion or sensation could be seen as a positive.

I must extract the right type of information, so I have developed a score system to reduce the complexity of the questionnaires. I have assembled the ***Post-Soundscape***

Frequency of Perceived Sensations so that I can map the ratings of Anxiety attributes onto axes. I can group answers to these questions: there are many examples of negative physical symptoms ("dizzy", "upset stomach") whereas some physical affects may be more positive or exciting ("pleasurable chills", "tingling"); psychologically, there are many negative feelings ("sad", "frightened") and some which are positive ("in control", "relieved"). The severity of the symptom, or strength of affect can also be evaluated (from the most psychologically positive "happy" to the most psychologically negative "completely unable to relax", or the most physically positive "pleasurable chills" to the most physically negative "upset stomach"), as well as generating an average score for each valence branch of affect. The participants have space to expand upon any strong sensations or musical bliss, and even note the sound trigger they associated with it (if remembered).

Using the categories of **Physical Positive** (Ph +), **Physical Negative (Ph -), Psychological Negative (Ps -)** and **Psychological Positive (Ps +)**, I will average the responses, in degrees from 0 to 5 within these 4 categories, then I would have 4 scores per participant for each soundscape (360 scores total (4 scores, 30 participants, 3 sounsdcapes)). If I average these then I have a way of qualitatively assessing how **physically involved** (possibly negative) they were - whether they had mostly sad or terrified feelings or if they felt more positively. I can easily do a comparison across soundscapes or participants. (See example score set below).

Physical positive (Score: 5/15 = 0.333)	Physical negative (Score: 4/18 = 0.22)
Pleasurable chills (1/3) Numbness/tingling (1/3) Blush (0/3) Hot (2/3) Heart pounding (1/3)	Legs wobbly (2/3) Shaking hands (0/3) Unsteady/shaky (1/3) Sweat (0/3) Faint (0/3) Upset stomach (1/3)
Psychological positive (Score: 7/18 = 0.167)	Pychological negative (Score: 6/30 = 0.2)
Happy (2/3) Pleasure (1/3) Relieved (0/3) In control (1/3) Relaxed (1/3) Content (2/3)	Sad (1/3) Tense (2/3) Scared (0/3) Frightened (0/3) Nervous (1/3) Depressed (1/3) Fear losing control (0/3) Fear you were going to die (0/3) Fear the worst happening (1/3) Completely unable to relax (0/3)

This framework is partly inspired by Russell's *Circumplex Model of Affect*, which spaces all the states from two spectrum dimensions around a circle (from Positive to Negative and from Aroused to Relaxed).

I will average the responses for each question in isolation, highlighting those that are scored as "constantly," emphasise them, use as focus of discussion. It's hard to predict which ones will be until tested on a pool of participants – I can only know once tested. If I conduct a trial run of 4 or 5 people for the pilot, then I can tweak the questionnaires if needs be. I will get a sense of the data and methods of summarising, to see how easy this would be to analyse.

(Some anxiety symptoms are more obviously associated with a musical stimulus (**sound-provoked**) where others are co-morbid or **mentally-generated** (the participant is winding themselves up). I could also separate the evaluated symptom into those groups, to understand how much the sounds may be the cause of affect rather than the experiment scenario or baseline participant sensitivity. Heart-rate changing speed is specifically tied to accelerandos in music, as the body trying to match beats heard (**sound-provoked** group), whereas feeling nervous is more of a **situational** attribute, that they are nervous about undergoing a test. This may change over time though, the participant may have felt nervous at the start because they did not know what to expect, so a “once very briefly” response could be quite common.)

Sound Identification

The main goal of the research is to discover whether the **soundscape elicits anxiety reliably in everyone** (although the ideal is in people that need therapy). Does the soundscape trigger feelings of anxiety in general, and if we play the sound triggers that particularly distress the participant in everyday life, will this elicit strong psycho-physical reactions during playback? Can I match the peaks in physiological signals to their predicted sound trigger? This can be clarified in the ***Body Map***, where the participant is asked to say **what** they felt, **where** on the body, and **which sound** was playing at the time. This is also emulated in the ***Memory Record***, where I ask if any memories were triggered and what sound was playing at the time. I also have some crucial questions about the nature of the sounds (e.g. “please list the sounds you found most frightening”) which ideally should map onto whichever sounds they have indicated on the pre-screening. I hope to discover that the peak sensations and emotions that the soundscape elicits do actually link to categories the participant is usually very sensitive to. I will map the participant’s list of sounds identified as “most frightening” in the ***Post-Soundscape Subjective Perceptions, Body Map*** and ***Memory Record*** questionnaires, onto responses on ***the Pre-Exposure Triggers Diagnosis*** questionnaire, to see if the sounds that made participant feel anxious in the soundscape are the same as the ones they previously indicated they are sensitive to in everyday life.

Strangely enough, in the process of composing and panning the soundscapes, the sounds I find the scariest are the most **unfamiliar or unidentifiable** to me. Thus, what might happen is that the participants are **more scared by sounds that they were not expecting to be scared o**f, or those that they could not even recognize the source of. This does complicate matters, as we cannot ask participants to take a note of sounds that they could not even identify in the first place! If I find that the effective trigger sounds are different from what they previously listed in the ***Pre-Exposure Trigger Diagnosis*** that would be very interesting. If that was the case I need a strong way of quantifying this.

If the participant rates the sounds they heard on the same category dimensions as in the ***Pre-Exposure Trigger Diagnosis*** and they essentially report which sounds triggered the emotion, then I will either find a good overlap or dissociation. Of course if they cannot pinpoint or name the sounds from memory, there needs to be a way for them to indicate the correct sounds – e.g a **sound event timeline**, so they can write something about the sound, when it comes or what kind of memories it triggered. I will present them with a long, comprehensive timeline of sounds, similar to a Digital Audio Workstation (Reaper or ProTools) timeline with every single sound presented in isolation or clusters placed in time: essentially, an understandable form of a musical score. I will print these out for people to see, so they can circle or annotate their trigger sounds. They might know their anxiety trigger was near the beginning, then figure out it was the busy part where lots of sounds were playing, and eventually decide it was specifically *Horror Screech,* for example. If they could not remember or identify a sound source unprompted, perhaps having the sounds mapped out graphically may jog their memory – rather than just offering a blank line. I will print each composition on an A3 sheet, so the participant could see it all on a large scale and then isolate thematic sections or differentiate between denser and sparser sections, then zoom in and see each sound's name. A print-out sheet for each participant means that they can mark and annotate it, which is best for data collection. (The advantage of presenting it on an iPad would be that they could click on the individual sound to hear it and verify it is correct. The simplest way to do it would be to display the Reaper session on the Monitor, scroll up and down and solo a track to let them hear it – however that would take up too much time.) A physical handout is quicker and ensures a good record of their notes is kept. If the participant could actually name the sounds from the timeline that's an easy way of mapping them against the ***Pre-Exposure Trigger Diagnosis***. The ***Memory Record*** will be more effective if the participant can pinpoint on the timeline, although it may not be that easy to understand for someone who has never seen such a graph. I can use silhouette symbols for different sound sources, e.g. a plane, or a bird, or a fan, vague category symbols, and a colour-coded (alarming, soothing, neutral, vocal) bar of a length representative of the exact duration of each sound sample.

Body Map

Although I will have hopefully have a digital record of Physiological Responses (pulse rate, breathing, sweating), it is still necessary that I ask the participants to note how they perceived their physiology to change. It will be interesting to compare participant's perceptions of their breathing or heart rate to the reality: they may not have actually been breathing fast the whole time but if they think they were then that means they were in fact psychologically affected.

The ***Body Map*** is an accessible way to identify the symptoms felt, as the participant joins up the sensation with the location on the body they felt them, and can then identify the sound they thought caused the sensation. This method is more commonly used by doctors to diagnose illness as patients use symbols for different types of pain: for example, lines for stabbing pain and dots for tingling. Similarly, the participant could indicate a negative sensation through using a red pencil or a positive sensation with a blue pencil, but this will be too time consuming. (If they did use colour, I could digitally scan all the responses, overlaying them in photoshop and have a pictorial average of 30 responses. The result could be that there is most dense colour is blue around the neck area (probably musical chills) and red around the forehead (tension headache from frowning), so can I could quantify an average visually.) It may also indicate that even though the participant is immersed in an Ambisonic sound array the affect is still largely concentrated around the ears, or that the sound vibrations are distributed evenly across the whole body – emphasizing that its not just the acoustic quality of the sounds that causes affect, it is the loudness and the immersivity of the Ambisonic mode of presentation. However this is a supplementary research question, "how does it work?" or "which areas of the body does it directly affect?" which is a tangent secondary to the fundamental "does soundscape exposure elicit anxiety?" First I have to know that it works, showing that either the trigger sounds that make it work relate to the specific kinds of anxiety people report before, which means that therapists can actually use a tailored soundscape. Or I could find that participants are emotionally immersed and feel anxious, but due to sound that might not be what they indicate in the ***Pre-Exposure Trigger Diagnosis***, which would make it more difficult for therapists to tailor soundscapes, but they would still work. In the ***Body Map***, I will just ask the participant to circle body parts, and give list of symptoms to choose from (to aid the participants in case their mind goes blank).

Post-Exposure Spatialisation Assessment

The compositions are so dense that it will be difficult for participants to directly pinpoint or recall individual pans - especially if they are new to ambisonic sound. Sometimes the panning is only really perceivable if a sound is solo-d or many sounds are moving in the same direction. The effects can be subliminal: if a sound source rises very slowly this might make the listener feel like they are melting (which I thought to be close to sensations I have experienced during severe anxiety attacks). It will be difficult for people to identify which spatialisation pattern affected them because I don't think they will be able to identify at the time, let alone remember! The participant will not be able to hear spatialisation as clearly as they might be able to identify the sound source or the acoustic quality. The graphical sonic timeline handout will have spatialisation symbols (such as horizontal spin) assigned to each sound as well, so both participants and myself can better track all instances of different panning styles.

The advantage of using the Ambisonic array over stereo or headphones is the composer can induce nightmarish distortions:

- displacing the height of a sound event to induce vertigo
- making the listener feel small, by enlarging sound sources usually lower to the ground, e.g. a dog barking could emerge from above
- making a listener feel crept up on, by sending footsteps from the rear
- simulating the feeling that the listener is actually standing in a hot frying pan, by placing the sound of oil bubbling at the listener's feet

Much of the panning is tailored to either replicate close to real-life spatial behaviours of original sound sources, or exaggerate and twist the sound to seem slightly strange or wrong:

- helicopter sounds are either static above, or synthetically circling above, or transformed into a more threatening vertical spinning from floor to ceiling, or thrashing indiscriminately around the room

- a waterfall sound at first pans from ceiling to floor, but then slowly rises - this would in fact be impossible, breaking the laws of physics. Rather than reversing the impact sounds in time, I invert the sound's spatial pattern - as if the floor itself is rising.

Following the soundscape exposure I will play a several isolated sound paors, asking for example if fast or slow movement is scarier, is rear to front scarier, or is fast circling scarier than slow circling, asking the participant to compare as follows:

"Listen to Sound 1 and Sound 2.

Which sound was the most **realistic**?

Sound 1 (chains, static mono) ☐

Sound 2 (chains, slow drop from above to below) ☐

Which sound was the most **unnerving**?

Sound 1 (chains, static mono) ☐

Sound 2 (chains, slow drop from above to below) ☐

Which sound was the most **frightening**?

Sound 1 (chains, static mono) ☐

Sound 2 (chains, slow drop from above to below) ☐

Which sound was the most **irritating**?

Sound 1 (chains, static mono) ☐

Sound 2 (chains, slow drop from to above to below) ☐

Which sound was the most **panic-inducing**?

Sound 1 (chains, static mono) ☐

Sound 2 (chains, slow drop from above to below) ☐"

The use of the ambisonic array is justified as the research team and I are aware of how much more affecting immersion in spatialised sound is (compared to stereo), and the SoundLab is a professional test environment. I contextualise the research among the larger scope of public entertainment venues: if people want to feel stimulated they go to theme parks, or IMAX - the success of the IMAX despite the extra cost is testament to how much extra people are willing to pay to be immersed as possible. With a tightly placed 16-speaker array with a personalized single-person sweet spot, I can argue that we are using a framework that even exceeds current cinema's sound technology. So given the context of sound production, it makes sense to use this space, as sound exposure should be tested in the optimum condition.

I hypothesise people would be more affected hearing the soundscape in the SoundLab rather than on headphones or in stereo. This would be hard to quantify, without doing a straight-up comparison of stereo to ambisonics. The only way to legitimately quantify if ambisonic sound is more affective than stereo or headphones, is to additionally conduct a stereo run of tests and compare the two - which we won't have time for. So, I must elicit from the participants that the sound moving (in ways they would not expect from a normal listening experience) was unsettling or exciting or arousing. It will be difficult to tell if it was just the sound per se, or whether it was the way the sound was emerging or moving that caused distress, but I could get some kind of subjective rating on that whether they thought that the ambisonic nature further enhanced impact the sound would have had. if it was presented in stereo. I will place some static points in the soundscape, isolating a 20 second section that is completely stereo, or tightly focus the sound from the front speaker, and then spread the sounds out into the space. I would know which points they are, and I can compare the physiological data between the static sound and the dynamic panning. The participant would not necessarily be aware of this, but I can compare the physiology between that section and a more dynamic spacing, to covertly address the issue.

Would non-ambisonic, stereo downmixed versions of the sounds have much less physical and emotional impact compared to dynamic panning across the ambisonic array? Part of the soundscapes' affect is the acoustic presentation, and the other is the semantic meaning of sound sources. To what degree does the **acoustic** aspect enhance the **content** of the sound? This is a question we should be testing, as there is a large gap in current knowledge, and the ambisonic array one of the main reasons I conduct the project at the DDS. Hopefully the sound itself would still be evocative in stereo, but in my experience with even just panning to 5.1, sound can be transformed into a hauntingly disembodied entity, bombarding the listener from all sides, rather than merely a stationary stimulus. Although ambisonic sound is more optimal, it might be that for typical individuals that the effect of the non-ambisonic sound is much bigger, as spherical movement may distract from the sound's contents. Maybe, for a patient, the actual content of the sound (its meaning and connotations) is already affecting enough. If this proposed Soundscape Exposure Therapeutic Framework is effective, what will be asked next is: "how can we actually implement sophisticated ambisonic sounds for clinical use, with limited facilities?" To that I say that the aim of this project is to formulate a toolkit, an ideal scenario for sonic implementation, as an exemplar, formulating guidelines and instructions for therapists with the means and motivations to build a sensory room. There are already facilities that employ sophisticated sensory therapy - it doesn't have to be a state of the art 16-speaker array like the Arup SoundLab, as the set up can be more basic tailored to lower budgets. For example, The Yard, Edinburgh, is a facility for young people with disabilities. They have invested in a sensory room, with a tactile manipulation of coloured lights and easily altered sounds for either a calming or stimulating effect.

"Does immersion in ambisonic sound provoke higher arousal than stereo listening*?*" is a crucial question to ask - if there is not a lot of literature on it, then it is a worthwhile experiment/hypothesis to test, to try the soundscapes in stereo on a few additional subjects, to discover the effectiveness of stereo compared to an ambisonic mix. Rather than extending the exposure time for all participants by repeating the same content in a stereo format, I can embed this difference within the soundscape – one phrase can play first in stereo, and then it can pan around the room, and I can compare physiology at those precise times. (Usually researchers would randomly assign some participants to the stereo condition and the others to the ambisonic condition, but that would require a much greater sample size. Testing that question by itself is a huge study, needing a decent number of participants in both conditions. In the perfect scenario, if there is time, I will conduct the experiment in optimized Ambisonics Sound Lab, then test a different sample in a basic stereo set up, to compare the two conditions (randomly assigning participants to either condition). If the experiment to quantify ambisonic-sound-provoked arousal ends earlier than expected, then I can compare this dataset to one procured using a sub-optimal stereo soundscape exposure, with different participants, so that I can point out amplification of response is partly due to ambisonic panning. Realistically just the first part is substantial: to prove that ambisonics is more effective than stereo would be an added bonus.) This is a project in Glasgow School of Art, so the focus of the work is on the creative output: part of what I do is create a technically good soundscape, and the other part is develop a framework of how I can use them, discerning whether the soundscapes are actually useful for future clinical application. So I will test the soundscapes first in the most optimal situation, the ambisonic lab, to procure data that will hopefully prove that they are capable of generating a marked psychophysical response, thus Sound Exposure would be a feasible Anxiety Therapy. I hypothesize that this arousal is caused by the combination of semantic connotations of the sound with the spatial acoustic immersion, with sound sources moving around the listener.

Post-Exposure Evaluation of Anxiety Levels

This will be the same format as the adapted *Crying and Mood Change* and *Subjective Units of Distress* Scales featured in **Pre-Exposure *Evaluation of Anxiety Levels***, but with the questions adapted. The participant will evaluate their anxiety felt in the period **immediately following the soundscape exposure experience**, so I can compare this to their baseline ratings of anxiety (on the **day**, and the previous **month**).

Then, the participant must decide overall (at the end of the experience) whether they feel **better**, **worse** or **exactly** the same as when they walked in. Evaluation of this basic scale is vital to discern overall wellness after exposure - even though it seems general, and one could argue that there are nuances of emotions (no-one would just feel either completely better or completely worse). The participant can perceive the question as “has your general well-being improved?”, or “have you achieved catharsis?” If they have been upset by certain sounds, they may feel better after they have thought about an upsetting issue and resolved it.

Please mark on the scale whether you feel **better** or **worse** than when you walked in to the SoundLab.

Worse **Exactly the same** **Better**

Physiological Monitoring

For the 1hour 15 minute duration, the participant will wear Edu-Lab Scientific Resources Edu-Logger devices: a Heart-Rate and Pulse Logger either clipped onto the little fingernail or the earlobe; a Respiration-Belt around the ribcage; and a Galvanic-Skin-Response-Logger strapped around the bases of two of their fingers. These devices will record the participant's heart-rate, breathing rate and sweat secretion, only for the time that the soundscapes are playing (plus 20 seconds before and after for baseline measurements). These vital signs are strong indicators for emotional arousal – that is, amplified signals or accelerated speeds indicate anxiety, panic or excitement, whereas attenuating signals suggest relaxation or depression.

The devices are less distracting and run more smoothly in *Offline-mode* (they are not connected to a computer, instead they record the experiment data on each sensor's internal memory). I can ensure that the devices are still recording from the LED light flashing at the sample rate of data capture. Ideally, I would just switch on once, for a one or two hour run, but the longer I make the recording, the lower the resolution becomes. A one-hour experiment recording is only 1Hz, whereas 15 or 20 minute recording can have a 5Hz sample rate (a resolution of 5-10 samples per second is ideal). I can store five 20-minute experiments on each sensor's internal memory. *Online-mode* might cause a computer crash (which means that the data is lost), so *Offline-mode* independent of a computer is safest. First, I check the online visualisation when the devices are connected to my MacBook, to confirm the monitors on the finger or ear lobe are connected properly, and then I can unplug the devices from computer and record *Offline*. (The pulse monitor uses a Light-Dependent Resistor to capture rate of blood flow, so its LED needs to be placed over a blood vessel to recognise a pulse.) So once I have checked *Online* that the measurements are there, the participant must keep their hand **completely** still (for GSR and Pulse) to avoid artefacts, so I will ask them to place their hand on their lap or on the other chair, whichever is most comfortable. I can place all electrodes on one hand, to leave the other free to move. I can press all record buttons at the same time to synchronise the recording, and count 20 seconds on a stopwatch before I start the soundscape playback (to record baseline data). One worry is that the participant may become alarmed at a sudden noise and accidentally move their hand, causing a massive artefact: but that would still be an indicator of a jump or startle event. (However, this may also occur if they involuntarily raise their hand when they yawn if they are bored, or fidgeting). Some people's skin might be quite dry, so I must ask participants to wash and moisturise their hands prior to the experiment to enhance the Galvanic Skin Response reading, and remove nail polish on their little finger for optimized pulse monitor reading. I will ensure the Soundlab as little to no lighting, as stray light from other sources interferes with the Pulse logger's infrared phototransistor receiver (light detector). Darkness will also encourage greater immersion in the soundscape, as the participant will be less distracted by their visual environment. The pulse rate will be recorded in BPM (beats-per-minute) numbers rather than ARB wave function, as numbers are easier to interpret.

Polina Zioga is using the Digital Design Studio's single-electrode Electroencephalography (EEG) headband device, constantly until August. It is the main focus of her PhD, so I do not want to tamper with it (plus it is not available) until after her Performance on the 30th and 31st July. So I will not be able to implement it in the Pilot experiment, but I will use it in the official experiment in September to October.

The participant's facial expressions will be **video-recorded** (albeit in low-light) throughout the soundscape exposures. Monitoring the participant's fluctuating facial expressions during sound exposure will pinpoint notable emotions, enabling identification of fast-acting catharsis (crying or frowning followed by calm relief). I will use a Canon EOS 500D on a tripod (although an unobtrusive web-cam or monitor-embedded style camera might make the participant more comfortable). The video-recording will be analysed only by the research team; to anonymise the participant for the published results, I will translate their facial expressions into an info-graphic timeline, a graph denoting either flat-line straight faces, a smile, a frown, or tears, aligning it with the sound event playing at the time. The participant's photographic image will not be published without their consent (which will be asked for in due course if necessary). It might be enlightening illustration to include a notable facial expression (such as a grimace caused by screeching high frequencies) in the thesis or a conference paper, but this is not completely essential.

If there are any further activities, please continue and append to this form.

c) State how harm, distress or anxiety to the participants will be minimised during the study

Listener Fatigue

The Soundscape Exposure will be difficult listening, with rapid movements and dense complex layering, so participants may become tired and irritable: assuming they will hopefully be affected by the sounds, it will be even more exhausting and more demanding than standard experiment fatigue. The participants may answer in the questionnaire that the experience was **irritating**, but not because of the sound - instead because of the **scenario** and it's **duration**. When participants get tired, they will become less sensitive to the sounds they hear: if they do not listen very carefully anymore, they will not be so immersed by the sound. Whilst this might dampen the participant's potential arousal towards the end of the experiment, ultimately **habituation** is what I want to achieve from Soundscape Exposure! Essentially, the aim of the project is habituate users to aversive stimuli, to purge anxiety through mental exercise, as fatigue will diminish shock – so I must expose the listener for enough time that they become used to the soundscape exposure, but not so long that they begin to feel much worse, or are made angry. Whilst it is necessary to test many different sounds to evoke reactions, presenting an excessively long soundscape programme will inevitably make people tired and less likely to show signs of arousal by the end of the experiment. To counter the effects of listener fatigue on the data, I will shuffle the order of presentation (see below).

Participant no.	**Violence**	**Sensory Irritation**	**Body Anxiety**	**Social Anxiety**	**Situational Phobias**
1	✓ 1st	✓ 2nd	✓ 3rd		
2		✓ 1st	✓ 2nd	✓ 3rd	
3			✓ 1st	✓ 2nd	✓ 3rd
4	✓ 3rd			✓ 1st	✓ 2nd
5	✓ 2nd	✓ 3rd			✓ 1st
6	✓ 1st		✓ 2nd		✓ 3rd
7	✓ 3rd	✓ 1st		✓ 2nd	
8		✓ 3rd	✓ 1st		✓ 2nd
9	✓ 2nd		✓ 3rd	✓ 1st	
10		✓ 2nd		✓ 3rd	✓ 1st
11	✓ 3rd	✓ 1st	✓ 2nd		
12		✓ 3rd	✓ 1st	✓ 2nd	
13			✓ 3rd	✓ 1st	✓ 2nd
14	✓ 2nd			✓ 3rd	✓ 1st
15	✓ 1st	✓ 2nd			✓ 3rd
16	✓ 3rd		✓ 1st		✓ 2nd
17	✓ 2nd	✓ 3rd		✓ 1st	
18		✓ 2nd	✓ 3rd		✓ 1st
19	✓ 1st		✓ 2nd	✓ 3rd	
20		✓ 1st		✓ 2nd	✓ 3rd
21	✓ 2nd	✓ 3rd	✓ 1st		
22		✓ 2nd	✓ 3rd	✓ 1st	
23			✓ 2nd	✓ 3rd	✓ 1st
24	✓ 1st			✓ 2nd	✓ 3rd
25	✓ 3rd	✓ 1st			✓ 2nd
26	✓ 2nd		✓ 3rd		✓ 1st

27	✓ 1st	✓ 2nd		✓ 3rd	
28		✓ 1st	✓ 2nd		✓ 3rd
29	✓ 3rd		✓ 1st	✓ 2nd	
30		✓ 3rd		✓ 1st	✓ 2nd

Ideally, exposing all five soundscapes to each participant would allow us to calibrate for individual differences in sensitivity, and each participant may have varying musical preferences and emotional biases from diverse life circumstances. Also, it would be an effective use of travel expenses to maximise the data produced by each participant. Whilst I want to ensure I have covered all sound subjects with each participant, realistically this is probably not possible - whilst they will have been exposed to all soundscapes, this may only yield results that indicate boredom or tiredness. The experiment may not work if everyone has to listen to all the soundscapes. There are different ways of reducing exposure time: either trimming the duration of each soundscape, or reducing the number, which is the most sensible. There are similarities between the soundscapes, so it will not be too detrimental to the data to only present 3 soundscapes of the 5 available to the participants in the official experiment. For every participant, I can choose 3 and use the soundscapes at their original length, untrimmed: the most sensible soundscapes, preferably tailored to suit the anxieties participants I invite. For 30 participants, I can have 30 different combinations of 3 soundscapes, so all soundscapes will be distributed evenly across the participants. There could be 60 different combinations, with different orders (5 x 4 x 3 = 60). A minimum of 10 exposure sessions ensures that each soundscape played an equal number of times. So for 30 participants, each soundscape will be played 18 times, and each will be framed by a different preceding or following soundscape.

Participant no.	Played 1st	Played 2nd	Played 3rd
6, 12, 18, 24, 30	*Violence*	*Phobias*	*Body Anxiety*
7, 13, 19, 25, 31	*Phobias*	*Body Anxiety*	*Violence*
8, 14. 20, 26, 32	*Body Anxiety*	*Violence*	*Phobias*
9, 15. 21, 27, 33	*Body Anxiety*	*Phobias*	*Violence*
10, 16. 22, 28, 34	*Phobias*	*Violence*	*Body Anxiety*
11, 17. 23, 29. 35	*Violence*	*Body Anxiety*	*Phobias*

(An alternative to omitting two soundscapes per participant, may be to trim down the duration of each soundscape. Rather than trying to fit all of the same sounds in and compress each section (which would be possible, but it may take a lot of work and yield unsatisfactory results, changing the piece to a point that the sound relationships do not work any more), what might be more effective is to remove chunks or clusters of sounds, cut out a section from each. For example, the *Time Stress* section of *Situational Phobias* is intentionally repetitive, sparse, and intended to make the participant think that listening to that part of the composition is a waste of their time. This was more of an artistic concept rather than being rather than the most crucial test stimuli central to the research.)

Participants should not know the theme of the soundscape before hearing it, as this may skew reactions or spoil surprises, if they have preconceived notions of how they think they will feel. I could offer that they choose their own soundscapes, but then lots of people might choose the same one, and some may not be picked. So instead I will prescribe the soundscapes for each participant.

One argument is that the long duration is a necessary part of the Soundscape Exposure Therapeutic Framework. When anxiety sufferers go to counseling or talk therapy they are usually allocated a 40mins or 1hr session. Even if the client feels uncomfortable or upset, all parties have agreed to dedicate the set amount of time, and they should speak or sit with the therapist for the duration. The clients are free to leave before their time is up, but they are not completing treatment. Sometimes when I explain the concept to people they ask, "is it like in *A Clockwork Orange*?" as they imagine the user would be strapped in and forced to endure torturous sounds for an extended period. Whilst the user is not restrained as in the barbaric fictional Ludivico treatment, it is an essential part of the treatment that the user perseveres for a length of time so they build up resistance to aversive stimuli. There will be a panic button available, which will stop the sound whenever the participant chooses. I acknowledge that soundscape exposure will be a tiring process, but it is an endurance test and the participant **should become desensitized** (i.e. bored) by the end. The novelty should wear off, and in fact it will be valuable if we have data that shows the last 10 minutes of exposure the physiological signals are less dramatic, more reflective of calm or boredom.

The thrust of the project is “can soundscape exposure be therapeutic?” If soundscape exposure is ever actually implemented in treatment, the therapist would first diagnose the specific type of anxiety and tailor a soundscape. So from the collection, only one might be necessary. First, I will test to see if the collection of soundscapes work, and discover whatever makes people engage with the soundscapes: is it something to do with the correspondence between the sounds played and to their pre-disposed anxiety triggers?

I know five people who are keen to hear the soundscapes as soon as possible. They are enthusiastic and would like to hear all of the sounds. So I will shuffle the order as below:

Participant	Played 1st	Played 2nd	Played 3rd	Played 4th	Played 5th
1	*Violence*	*Body Anxiety*	*Situational Phobias*	*Sensory Irritation*	*Social Anxiety*
2	*Body Anxiety*	*Situational Phobias*	*Social Anxiety*	*Violence*	*Sensory Irritation*
3	*Sensory Irritation*	*Social Anxiety*	*Situational Phobias*	*Body Anxiety*	*Violence*
4	*Social Anxiety*	*Violence*	*Body Anxiety*	*Sensory Irritation*	*Situational Phobias*
5	*Situational Phobias*	*Sensory Irritation*	*Violence*	*Social Anxiety*	*Body Anxiety*

Total Soundscape Exposure = 71 minutes 49 seconds

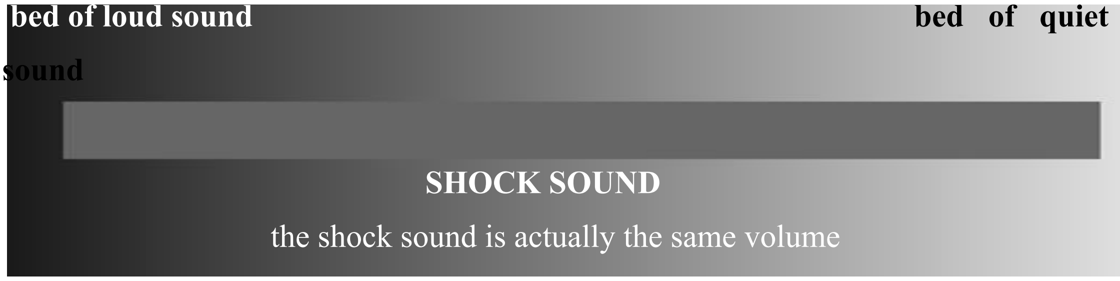
I will ask the pilot participants a few additional questions elaborating on the participant’s tiredness or boredom - it is a trial, so I can probe them a little further afterwards, and record feedback conversations about the endurance level.

Loudness

How loud I can play the soundscapes brings ethical concerns. I will clarify the **Information Sheet** that the exposure will not be any louder than the legal threshold which people are willing to expose themselves to in the ever-increasing loudness of cinema. There is a strict World Health Organisation guideline, starting at 8dBA for 8 hours, 90dBA for 4 hours, 94dBA for 2 hours, 1 hour at 98 dBA – the exposure soundscape can become quite loud as long as it is for a short exposure time. Nonetheless, I will impose limits on what might just be too unpleasant (even if it is legally safe) – the exposure should not necessarily be just at the threshold of pain throughout.

Noise level (dBA)	Example	Maximum Exposure / 24hr
85	passing diesel truck	8 hours
91	squeeze toy, lawn mower, arc welder	2 hours
94	inside subway car	1 hour
100	riding a motorcycle	15 minutes
103	sporting event	7.5 minutes
112	rock band	56 seconds
115	emergency siren	28 seconds
121	thunderclap	7 seconds
124	balloon popping	3 seconds
130-140	peak stadium crowd noise	less than 1 second
140	air raid siren	NO EXPOSURE
150	fireworks	NO EXPOSURE
160	fighter jet take off	NO EXPOSURE
165	shotgun	NO EXPOSURE
170	.357 magnum revolver	NO EXPOSURE
180	safety airbag	NO EXPOSURE
194	rocket launch	NO EXPOSURE
	soundwaves become shockwaves	

Whilst part of what makes up a shock sound is the *actual* volume, an important characteristic of a shock is the *perceived* volume. That is, whether listener is prepared for a loud bang as it follows a warning build up creascendo, or if the bang is completely unexpected, bursting through a period of quiet. Like the *simultaneous brightness* illusion below, even if the shock sound is at the same volume in both situations, the unexpected shock from a quiet base will always seem louder and thus more jarring.



A shock is also more potent with a powerful attack, with an action attached such as a strike, rather than just loudness. If a sound is extremely transient it can be disturbing as we have insufficient time identify the sound source; or conversely it is an extended stinger it can be unbearable, as the loud sound continues much longer than expected. The entire exposure time should not be consistently high volume, to best manipulate humans' instinctual volume-diminishing aural reflex (as our ears automatically clam up after a period of loud sounds); most should actually be a quiet-moderate base, or even a meditative aural *mandala* of repeating patterns (which may provoke dreamlike cognitive dissociation) from which the shocks should leap out unexpectedly.

Upset

The participant might become mildly upset if they are sensitive to certain anxiety trigger sounds – but they should be somewhat prepared, as they have identified featured sound categories prior to the exposure. They are entitled to stop the playback of the soundscape at any time, using a clearly indicated button.

The **Post-Exposure Evaluation of Anxiety Levels** questionnaire will assess the participant's lasting distress - if anyone shows a high score on the adapted *Subjective Units of Distress Scale* or the *Crying And Mood Change* Lickert scales, then I will offer them a database of self-help groups (find attached), in addition to professional helplines indicated on the **Information Sheet**, as below:

"If you have been affected by the sounds, or the exposure experience in general, the following organisations may provide help and advice:

The Samaritans: T: 08457 909090 (24/7) E: jo@samaritans.org

Anxiety UK: T: 08444 775 774 (Mon-Fri, 9.30am-5.30pm) E: support@anxiety.org.uk"

If a participant becomes very upset, I will personally offer comfort, asking if they'd like to chat about it. (They can use the helplines provided for counselling and advice, if preferred). Refreshments such as tea, coffee, juice and snacks will also be provided to all participants, to boost energy levels upon their departure.

I have consciously engineered the soundscapes so that they gradually build in intensity towards the abrasive sounds and then morph back to a more pleasant frequency range and sound density. This should naturally calm people down during the experiment, but I will also offer an extra **respite composition** post exposure, including nature sounds and soothingly bare cello melodies. Whilst I do not want to unnecessarily extend the time that people are in the DDS, an upset participant is welcome to immerse themselves in soothing sounds in the SoundLab, or to sit in a comfy armchair with headphones if preferred.

Comfort

The Soundlab needs a more comfortable chair - ideally one that will not absorb or deflect too much of the sound, as we must let the sound resonate in muscles as well just ensuring it reaches the ears. The chair cannot be on wheels, so participant does not roll out of the sweet spot.

d) Please state the time commitment of the participants and whether you plan repetitive testing as part of the study

Official Experiment (September-October 2015)

Stage 1 = 15 minutes

(Pre-Exposure Participant Eligibility Screening Questionnaire (at home): 7 to 10 minutes

Information Sheet and **Consent Form** Reading: 5 minutes)

Stage 2 = 1 hour 15 minutes maximum.

(Information Sheet Re-Reading and **Consent Form** Signing: 5 minutes

Pre-Exposure Evaluation of Anxiety Levels Questionnaire: 1 to 2 minutes

Set-Up of **Physiological Monitoring** Equipment: 3-5 minutes

3 x **Soundscape playback** time: minimum 38 min 18 sec - maximum 46 min 32 sec.

3 x **Post-Soundscape Questionnaire** time: 5 to 8 minutes

Post-Exposure Questionnaire time: 3 to 5 minutes)

The **Pre-Exposure Participant Eligibility Screening Questionnaire** should take up to 10 minutes to complete, and can be filled in remotely, via email. The total duration of the official Soundscape Exposure at Digital Design Studio should be 1 hour and 15 minutes at most: including **pre- and post-exposure questionnaires**, playing 3 soundscapes to each participant. Each soundscape lasts 12 to 18 minutes, and 5 to 8 minutes is allotted in between to fill in **Post-Soundscape questionnaires** and rest the ears. Although it will be a long test, a great wealth of data will be procured per participant, so it makes the trip to DDS worthwhile. It will be a prolonged exposure to sound, but the testing is not repetitive, as all soundscapes exposed will be different.

Pilot Experiment (July 2015)

Stage 1 = 15 minutes

(Pre-Exposure Participant Eligibility Screening Questionnaire (at home): 7 to 10 minutes

Information Sheet and **Consent Form** Reading: 5 minutes)

Stage 2 = 2 hour 9 minutes maximum.

(Information Sheet Re-Reading and **Consent Form** Signing: 5 minutes

Pre-Exposure Evaluation of Anxiety Levels Questionnaire: 1 to 2 minutes

Set-Up of **Physiological Monitoring** Equipment: 3-5 minutes

5 x soundscape playback time: 71 minutes 49 seconds.

5 x **Post-Soundscape Questionnaire** time: 5 to 8 minutes

Post-Exposure Questionnaire time: 3 to 5 minutes)

I know five people who are keen to hear it as soon as possible. They are enthusiastic and would like to hear all of the sounds. This will add 25 minutes extra sound presentation and up to 16 minutes extra Post-Soundscape Questionnaire time to the ideal proposed procedure for the Official Experiment. I will ask a few additional questions elaborating on the participant's tiredness or boredom, because it is a trial, so I can probe them a little further afterwards, and record feedback conversations about the endurance level.

e) What is the statistical power of the study:

I have allowed for a reasonable number of participants to test the soundscapes on, who will be probed with a rich set of qualitative questionnaires, with quantitative physiological data to corroborate. With this combination data, I will be able to pinpoint concrete moments of emotional and physiological affect, and causally link them to discrete, identifiable sound events within the stimulus.

If you plan to leave participants with information at the close of the study (e.g. leaflets with further information, details of support groups etc), please append to this form.

7. PARTICIPANT DATA

All researchers must abide by the Data Protection Act 1998 and the GSA Data Protection Policy – it is the responsibility of the researcher to familiarise themselves with each.

Who is the custodian of the data:	The researcher, Jessica Argo
Where will the data be stored:	All personal information provided (both questionnaire responses and physiological data) will be stored in encrypted documents, in a private password-protected user account, on a computer that is only in proximity to authorized Digital Design Studio Staff. Any hard copies of questionnaires and consent forms will be stored in a fireproof, lockable cabinet (along with a digital back up of the project on an external hard drive).
Who has access to the data:	The researcher, Jessica Argo, and members of the research team (Prof. Christoph Kayser, Dr. Daniel Livingstone, and Ronan Breslin) will have access to the data.
Will permission to identify the participants be sought as part of informed consent	NO
What methods will be undertaken to guarantee anonymity (e.g. coding, ID numbers, use of pseudonyms)	**For Stage 1**, I will email the **Pre-Exposure Participant Eligibility Screening questionnaire** in a word document or an editable PDF, which they can Save As with their initials (rather than putting their whole name and contact details). I would only require their email address or a phone number to invite the participant to the SoundLab for Stage 2. Results will be averaged, as I will tabulate the

	responses: for example, “20 people said that the sound of airplane engines starting caused anxiety.” Thus I would not need to include names and addresses in the published results. Any individual results necessary for thesis publication will be anonymised as participants will be allocated a number (e.g. Participant 1, Participant 2) to ensure no participant can be identified. I will separate contact details from the questionnaire responses once each participant has been assigned an ID number eg. Participant 1. I will black out contact details before publishing participant’s questionnaires in the appendix. To track people through the research, I will keep a key to the ID number coding in a standalone password protected document only accessible by myself. People do not even need to offer me their real names, as a pseudonym with their contact telephone number or email address will suffice.
How will the link be broken between participant details and information given as part of study?	Any documents that include detailed data with the original name will become anonymised, replacing the participants’ real names with numerical identification instead (Participant 1, Participant 2 ..)
How long will the data be stored for? (Participants must be made aware of this at point of consent).	The data will be stored for the duration of the study, until the final thesis submission in January 2017 (approximately).
How will the security of the dataset in its entirety be secured?	The security of the dataset will be secured by password protection of the entire user account on the desktop computer (which is locked in the Digital Design Studio, which is only in proximity with authorized staff). All documents will be individually

	encrypted, and any hard copies and a digital back up on an external hard drive will be securely stored in a fireproof locker.
How will the data generated be analysed and used?	Raw psychophysical data will be stored as time graphed waveforms and .CSV files, retained in the appendix, with tabulated identification, eg. "Participant 23 showed heightened arousal in response to this sound." Questionnaire responses will be converted into scores. For example, I have assembled the ***Post-Soundscape Frequency of Perceived Sensations*** so that I can map the ratings of Anxiety attributes onto axes. There are many examples of negative physical symptoms ("dizzy", "upset stomach") whereas some physical affects may be more positive or exciting ("pleasurable chills", "tingling"); psychologically, there are many negative ("sad", "frightened") and some which are positive ("in control", "relieved"). (See example score set in 6.b) ACTIVITY 2). Using the categories of **Physical Positive** (Ph +), **Physical Negative (Ph -), Psychological Negative (Ps -)** and **Psychological Positive (Ps +)**, I will average the responses, in degrees from 0 to 1 for these 4 categories. I will have 4 scores per participant for each soundscape (360 scores total (4 scores, 30 participants, 3 sounsdcapes)). If I average these then I have a way of qualitatively assessing how **physically involved** (possibly negative) participants were - whether they had mostly sad or terrified feelings or if they felt more positively. I can easily do a comparison across soundscapes or

	participants. Contact details from the questionnaires will be blacked out once the participants' involvement with the project has ceased.
Who will have access to the data beyond the project (if the data is being retained, not destroyed)	Any essential data to be retained beyond the project, will only be accessible by the primary researcher, Jessica Argo, stored in an encrypted external hard-drive stored in a fireproof locker.
Does the research funder require the participant data generated be lodged with them upon conclusion? If yes, give details	No

8. SAFETY

All researchers must abide by the GSA Health and Safety Policy – it is the responsibility of the researcher to familiarise themselves with this.

a) How will the safety of the participants be ensured during this study?

The **Information Sheet** provides Health and Safety advice for the Digital Design Studio, The Hub Pacific Quay:

"In the unlikely event of a fire or evacuation of the building, please vacate the Soundlab through the doors that you entered (the second door requires a press of a switch to the left of the door-handle). Exit the building using the main entrance approx. 10 metres directly in front of the Soundlab.

Toilets are located to about 15 metres to the left of the SoundLab, as is a sink with drinking water.

Precautions have been taken to ensure the sounds are at a comfortable listening level, and in accordance with the World Health Organisation's stipulations: excessively loud sounds will not exceed more than a few seconds duration.”

b) If your work requires participants belonging to vulnerable groups (children under 16, adults unable to give consent, prisoners, individuals in dual relationships), what additional steps will be taken to ensure their safety:

N/A

c) If the study involves work on non-GSA premises, how will the safety of researchers working off site be ensured?

If I move the Soundscape Exposure to the University of Glasgow (for ease of participant recruitment) then I will make myself and the participants aware of the local health and safety regulations; I will identify the fastest escape route in case of a fire, as well as the nearest toilets and drinking water.

9. DECLARATION

Please ensure you have answered all the questions herein and have appended the following documents:

Consent form ✔

Participant Information Sheet ✔

Follow up information ✔

Any other relevant documentation: Database of Support Groups ✔

Questionnaires ✔

I certify that the information contained in this application is accurate. I understand that should I commence research work in absence of ethical approval, such behaviour may be subject to disciplinary procedures.	
Name of Principal Investigator:	Jessica Argo
Signed:	
Date:	22/06/15

Please email the completed form and associated documents to the Research Developer (a.hay@gsa.ac.uk).

Ethics form revision 1: 27th August 2015

Eligibility Criteria revision: Pre-Exposure Intensity of Perceived Sensations

I have conducted a small Pilot study where 5 participants took part in both Stage 1 and Stage 2 of the experiment. All participants safely passed the Eligibility Screening questionnaires, and they were each comfortably exposed to 5 soundscapes in the Ambisonic Soundlab. The Eligibility Screening test was devised to protect vulnerable individuals in the midst of acute anxiety from being exposed to aversive soundscapes. However, upon recruiting new participants for the official experiment due to take place in October 2015, I realise now that the exclusion threshold for one component of the screening is set disproportionally lower than those for the first two tests, which is proving problematic.

The first test, the ***Pre-Exposure Evaluation of Anxiety Levels is*** a simple one-to-ten thermometer with an exclusion threshold of 8/10 (80%) which means the Participant has felt mostly "HIGHLY unpleasant distress, physical tension, worry, fear or anxiety, intolerable sensations (trembling, nausea), and difficulty in concentrating or thinking clearly" over the past month. The cut-off for ***Emotion-Time Distribution*** test is if the participant felt negative emotions 75% of the time, and positive 25%. However, I originally set ***Pre-Exposure Intensity of Perceived Sensations*** to have an exclusion threshold of 43, out of a possible maximum score of 112 - which makes it a very low cut off of 38%. Thus, participants might be excluded if they have even felt a middling intensity of anxious symptoms.

I have 3 modifications to make to the ***Pre-Exposure Intensity of Perceived Sensations*** section of the screening:

1. Change the **allocation of scores** on the Lickert scale answer options, from "0, 1, 2, 3, 4" to "0, 1, 1.5, 2, 3", to account for my addition of one extra option to circle to the original model.
2. Increase the **exclusion threshold** to reflect a realistic amount of everyday anxiety, whilst excluding participants who feel anxiety symptoms to a predominantly "noticeable" and "chronic unpleasant" degree (which would be 58%)
3. Omit the additional 7 questions assessing **mood levels** from the exclusion criteria, as they do not focus specifically on anxiety symptoms, and have a different weighting

of scores (due to the adjusted Lickert scale options to choose from).

1. I modelled the ***Pre-Exposure Intensity of Perceived Sensations*** as an adaptation of the *Beck Anxiety Inventory*. The original purpose for the *BAI* is to assess the levels of cognitive and somatic anxiety symptoms for people who are undergoing Cognitive Behavioural Therapy, to mark progress over the course of treatment. If a user feels "SEVERE ANXIETY that means simply that it is an unpleasant amount and more than the average person. They feel enough anxiety for it to be negatively affecting their lives, but are able to function in their everyday tasks.

The original *BAI* lists 21 anxiety symptoms and the user has to select from **four** options on a Lickert scale to best represent the the degree that they felt each symptom over the previous week:

- NOT AT ALL (0 points)
- MILDLY: It did not bother me much. (1 point)
- MODERATELY: It was very unpleasant, but I could stand it. (2 points)
- SEVERELY: I could barely stand it. (3 points)

So, the original *Beck Anxiety Inventory* has 21 questions, and a maximum score of 63.

- 0-21: minimal level of anxiety (0-33%)
- 22-35: moderate anxiety (34-55%)
- 36 - 63 SEVERE ANXIETY - (56 - 100%).

So a user could have SEVERE ANXIETY, even if they answered mostly "MILDLY" and "MODERATELY" on the Lickert scale. I originally planned to exclude all prospective participants that showed scored the equivalent of 36 and above, under the blanket diagnosis of SEVERE ANXIETY.

When devising the ***Pre-Exposure Intensity of Perceived Sensations,*** I added one more option to make the scale even more sensitive:

- not at all (0 points)
- mild (1 point)
- **noticeable (2 points)**
- chronic unpleasant (3 points)
- severe distress and inability to function (4 points)

So the ***Pre-Exposure Intensity of Perceived Sensations*** adaptation test has 21 anxiety-focused questions, and with a maximum score of 84.

- 0-28: minimal level of anxiety (0-33%)
- 29-46.2: moderate anxiety (34-55%)
- 47-63: SEVERE ANXIETY - (56 - 100%).

Perhaps I should not have added one more option in the Lickert Scale, as it means that participants might be more likely to score higher, than if they were only offered the original four to choose from. Reviewing the semantics of this scale now, "mild" and "noticeable" are really similar levels of distress, so I should adapt the scoring system thus:

- not at all (0 points)
- mild (1 point)
- noticeable (1.5 points)
- chronic unpleasant (2 points)
- severe distress and inability to function (3 points)

So then, the test would have a maximum score of 63, as per the original, and the participant could be said to have "SEVERE ANXIETY" if they score 36 and above. Hopefully this should be more forgiving for those participants who experience "noticeable" anxiety from time to time.

2. If the prospective participant feels an average amount of anxiety due to work or travel related stress and encounters with everyday phobias, they might be likely to score up to say 60-70%. To use this evaluation as a pragmatic screening tool for the experiment, the exclusion threshold should perhaps be closer to the other ***Pre-Exposure Evaluation of Anxiety Levels*** and ***Emotion-Time Distribution*** measures, which are set at 80% and 75%. This means that we are using common sense and intuitive judgment, so we will exclude people who are currently crippled by acutely high anxiety, who are feeling mostly "chronic unpleasant" symptoms. This would give a score of **42,** which is **66%**. To be even more cautious, I could instead exclude those participants who rated 11 symptoms as "noticeable" and 10 as "chronic unpleasant", which would give a score of **36.5**, which is **58%**. (Only 2% above the original Beck Anxiety Inventory's threshold for SEVERE ANXIETY.)

I do also offer a Pre-Exposure Evaluation of Anxiety Levels (stress thermometer) on the day of testing, and if it is high I will reiterate that participation is not compulsory.

3. When devising the ***Pre-Exposure Intensity of Perceived Sensations,*** I added 7 questions which would establish baseline mood levels and the changes post-exposure. The nature of these questions meant that they needed to be set an appropriate Lickert Scale, which inevitably has a different weighting from the rest of the questionaire. The questions were "How much **pleasure**/ how **content**/ **relaxed**/ **in control**/ **relieved**/ **happy**/ **sad** did you feel?")

- Completely (0 points)
- very (1 point)
- neither content nor discontent (e.g) (2 points)
- quite (3 points)
- not at all (4 points) (the reverse for sad)

These obviously allocate much higher value scores to even positive symptoms: the participant merely saying they were "quite happy" would give them 3 points, which undoubtedly racks up their overall percentage and edges them closer to and even over the the exclusion threshold. Also, these questions do not directly relate to the original *Beck Anxiety Inventory*, so they should not be counted as markers of Anxiety, rather they are indications of the prevalence of positive or negative mood. So, I propose to allocate those 7 questions a separate score, which would not be used as exclusion criteria.

According to these changes, the first participant who I reported to Alison Hay that was only just over the original exclusion threshold would now actually be eligible, as their anxiety-symptom focused score would be 25 (39%) (11.5 below the new threshold). The second participant I mentioned would score 28.5 (45%) (8 below the new threshold) with these adaptations, so would also be eligible. This adapted exclusion threshold will now be much more appropriate, allowing room for those who have experienced everyday anxious situations, whilst still protecting highly anxious individuals from sound exposure.

(I also notice a participant's tendency to focus on one specific event, which can overshadow the average anxiety over a month. I will remind participants: “Please account the **overall** intensity of symptoms, the average over the past month, rather than focusing on rating one isolated event.”)

Ethics Form Revision 2: 22nd September 2015
Addition to Questionnaire: *Long-Term Catharsis Evaluation*

I have recently completed a pilot experiment, *Immersive Soundscapes to elicit Anxiety in Exposure Therapy: Physical Desensitization and Emotional Catharsis*, with five participants. Before proceeding to the larger-scale 30-participant experiment (starting on 3rd October 2015) I met with all three of my supervisors: Dr. Daniel Livingstone (DDS, GSA), Prof. Christoph Kayser (School of Psychology, GU) and Ronan Breslin (DDS, GSA). We are delighted with the pilot results, and mostly content with the established framework of the experiment. However, we agreed that it would actually be hugely beneficial to ask the participants to complete a brief follow-up questionnaire one-week after the experiment, to evaluate possible improvements on their physiological and psychological wellbeing (compared to the ***Pre-Exposure Participant Eligibility Screening***). This essentially reveals if the participant has experienced a psychological catharsis after addressing emotional issues triggered by the soundscapes.

The experiment is designed to elicit anxiety in a participant on a short-term time-frame, so they can re-visit and evaluate unpleasant memories and physical sensations, to encourage mental and bodily resilience to anxiety in real life. We can accurately gauge the particicpant’s physical and mental state in-situ, but understandably the participant will to need time to recover from the mental work and tiring conditions of being confined in the Soundlab for extended duration, to be at a more optimal state. Thus we deem it essential for detection of catharsis to question the participants about their wellbeing one week following the experiment.

The ***Long-Term Catharsis Evaluation*** questionnaire is not too demanding, and it will be optional for participants. It is sufficient for them to complete the questionnaire via email. It is a condensed version of the ***Pre-Exposure Participant Eligibility***

Screening, consisting of the same 3 essential components (based on the Beck Anxiety Inventory, Subjective Units of Distress Scale and Emotion-Time Distibrution) so I can accurately cross-reference the pre- to the long-term post-exposure scores. I will also ask straightforward questions, based on Saarikallio et al.'s *Music in Mood Regulation Scale* (2012) and Bylsma et. al's 2008 study, *When is crying Cathartic?*

For office use only:

Approved (Convenor of Research Ethics Committee) YES / NO	Declined (Convenor of Research Ethics Committee) YES / NO
Signature: [redacted]	
Comments?	

Approved (Member of Research Ethics Committee) YES / NO	Declined (Member of Research Ethics Committee) YES / NO
Signature: [redacted]	
Comments? As advised via email	

THE GLASGOW SCHOOL OF ART

25th May 2017

Dr Alison Hay,
Research Developer
a.hay@gsa.ac.uk, ext 1408

Immersive soundscapes to elicit anxiety in exposure therapy: physical desensitization and mental catharsis

To whom it may concern,

Jessica Argo, is a postgraduate student registered for a doctoral degree with The Glasgow School of Art. Her thesis title is given above and she is supervised by Dr Daniel Livingstone of the School of Visualisation and Simulation.

It is my pleasure to confirm that Jessica sought approval for her doctoral study, thesis title above, during the first year of her studies. Jessica complied fully with the policy as outlined at:

hhttp://www.gsa.ac.uk/media/861048/gsa-research-ke-ethics-policy-2016.pdf

She identified the relevant ethical issues, dealt with them accordingly within her doctoral research and the GSA Research Ethics Sub Committee approved her work.

Should you have any questions in concern of this, please do not hesitate to get in touch.

Yours sincerely,

[redacted]

Dr Alison Hay
Research Developer