Investigating the design of Smart Objects in the domain of forgetfulness

by
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Abstract

When we forget things, we feel anxious which can impact our day negatively. Some individuals believe they are forgetful, so emphatically, it disrupts their day. There has been little discussion about perceived forgetfulness in design and HCI, combined with few studied smart objects to aid with memory. However, embedded systems, radio frequency identification (RFID) and HCI research provides inspiration towards creating a solution. Challenges of creating a day-to-day smart object that can enhance a user's lifestyle are explored and recommended design guidelines for creating a smart object in a specific domain are the focus of this thesis.

Using an experience-centred approach, 'Message Bag' and 'Tag Along' are two purpose built object-based memory aids that have emerged as a result of investigating the design processes for smart objects. The work examines smart objects in the context of forgetting what items to pack in a bag. A solution presented is a device consisting of an RFID system involving (a) pre-tagging essential items; (b) scanning those tagged items and; (c) viewing a corresponding light illuminate, to communicate to the user. Although the conceptual model is simple, success depends on a combination of technical design, usability and aesthetics. These scanning interactions result in a person feeling more confident as suggested through autoethnography reporting, real-world, third person engagements - single user walkouts, conference demos, professional critiques, and residential weekends with potential users (focus group) studies conducted.

My work involved extensive autobiographical research and design-led enquiries. Testing was undertaken with investigative prototypes, followed by field testing high-fidelity prototypes. This involved an in-the-wild comparative study involving six users over several months. Results show that people feel more confident and respondents claim no longer needing to continually check items are packed, thus 'gaining time', and feeling less forgetful.

Although the application of RFID is not new to ubiquitous computing, this implementation, styling and system immediacy is novel. This thesis presents the development of ten prototypes as well as design guidelines. The research provides a solid base for further exploration, and includes discovery of the importance of a user's style universe and extreme ease-of-use. I conclude with the presentation of early positive results including; (i) the unique form factor becomes a reminder itself and; (ii) usability coupled with the intuitive nature of the system is shown to be essential. We found that when you are creating a smart object, usability and an intuitive nature is even more important than in a standard system. When dealing within the domain of forgetfulness, this is paramount.

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Definitions

The following short codes are used throughout the thesis to label the prototypes, studies and participants. In Chapter 3, Table 3.1 details all the prototypes and studies featured in the thesis.

PROTOTYPES		
POC	Proof of Concept	Chapter 4
MB1	Message Bag 1.0	Chapter 5
UNI	Unisex Messenger	Chapter 6
UPA	Upcycled A	Chapter 6
VARIATIONS:		
UPB	Upcycled B	Chapter 6
UPC	Upcycled C	Chapter 6
SA POC	Stand-alone Proof of Concept	Chapter 6
EM1	Embedded 1	Chapter 7
VARIATIONS:		
EM2	Embedded 2	Chapter 7
EM3	Embedded 3	Chapter 7
SA	Stand-alone	Chapter 7
LED	Led Only	Chapter 7

STUDIES & PARTICIPANT NUMBERS		**SECTION**
NEEDS1	Survey of Needs Online Questionnaire	4.1
RECRUITMENT1	Recruitment Online Questionnaire	7.4
EOFU	End of Use (device specific) Questionnaire, paper based	7.6.4
EV1	Events, Conferences, Professional Critique	4.4.5
EV2	Events, Conferences, Professional Critique	6.4 & 6.5
AU1	Autoethnography	4.4.4
AU2	Autoethnography	5.4
AU3	Autoethnography	6.3.5
AU4	Autoethnography	6.6.4
AU5	Autoethnography	7.1.8
RW1	Residential Weekend with potential users Participants: [RW P1 through to RW P11]	5.3
PS1	Pilot Study Participant: [PS1 R1]	5.5
SU1	Real World Single User Study Participants: [SU1 P1 through SU1 P3]	6.2, 6.3.6
SU2	Real World Single User Study Participants: [SU2 P1 through to SU2 P6]	7.5

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Wuthering Bytes, Hebden Bridge, UK, October 2015. Talk information available online https://oomlout.co.uk/blogs/news/45897089-anxiety-reducing-smart-objects-christine-farions-wuthering-bytes-talk and talk viewable online https://www.youtube.com/watch?v=Edq7FUSdjhE&t=120s

Creator Faire, National Space Centre, UK, September 2015. Prototypes presented at the two-day event.

The Wearable Technology Show at Excel in London, UK, March 2015. Presentation of prototypes over three-day event. Archived at the Daily Mail Online (2016), prototype photographed, and details. Getty Images. Retrieved July 2016 from http://www.dailymail.co.uk/sciencetech/article-2988482/Samsung-s-virtual-reality-headset-smart-handbag-health-tracking-earphones-gadgets-display-Wearable-Technology-Show.html

Farion C., and Purver M., *"Did you pack your keys?" Smart objects and forgetfulness.* Conference on Human Factors in Computing Systems - Proceedings 539-542 (CHI) 2014, Toronto, May 2014.

Interactivity track at CHI conference, May 2014
Presented interactive augmented bags for the duration of the conference alongside my prototype research, as part of the Interactivity track. Toronto, Canada. Proceedings 539-542 (CHI) 2014, Toronto, May 2014.

Presented "Message Bag", March 2013
At the 4th Annual Augmented Human Conference, Stuttgart, Germany. In Proceedings of the 4th Augmented Human International Conference, Stuttgart, March 2013. (Photograph on the thesis cover[1])

Christine Farion and Matthew Purver. *Message Bag: Can Assistive Technology Combat Forgetfulness?*. In Proceedings of the 4th Augmented Human International Conference, Stuttgart, March 2013.

[1] Photograph of Message Bag taken by Toby Harris, presentation at Queen Mary University of London.

Chapter 1 Introduction

"The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it." (Weiser, 1991)

As Weiser notes, technologies that disappear are profound. The subject of this thesis is to extend the function of an everyday item, using technology, to transform it into a smart object. My work looks to comprehend the design theories needed to create a smart object, the purpose of which is to help in the domain of forgetfulness.

One objective is to investigate the fundamentals of interaction between users and smart object systems in an every-day context. This will enable the design of improved devices in this 'wearable' context. Through an experience-centred design, ten iterations of prototypes were created and evaluated. The testing combined autoethnography and extensive research journal use as well as residential weekends with potential users, single user in-the-wild studies, professional critiques, questionnaires, and one-to-one interviews. The motivations of the work allow a humanistic approach to designing a smart object in order to enhance the lives of others.

A further objective is that the thesis will allow for research into previous devices and solutions, examining what configuration can be successful and to use that knowledge to support other researchers.

1.1 Background and Motivation

In this introductory chapter it is explained how my interest in physical computing, wearable technology, design, and my forgetfulness prompted me to study these fields in depth. The context of the work is described and a brief outline of the analytical and design frameworks which are drawn upon are given. My own perceived forgetfulness and how it negatively altered my day became a starting point for the research. It was through my own frustrations at forgetting items which were needed to succeed in my day-to-day life that prompted me to look for an object-based solution. When expressing my frustration to people who also experienced this irritation; they admitted to feeling negativity too. It prompted my desire to explore these irritations of forgetfulness further. Forgetfulness was a problem that needed to be explored; a focus on research concerning individuals who feel negative emotions when they forget, and can a device help them?

My autobiographical approach to design allowed for a keen insight into the issues that could affect a user. I was able to empathise and understand from an inside perspective due to my own fears. This aspect is detailed, through autoethnography, when I documented my experiences of extended use of prototypes in public. Can a device help relieve this frustration?

My background of creative computing, interactive artworks and exploring hardware components brings a varied skillset together to explore a potential solution to the problem. Initial input into the design-led research was the idea of a portable solution, in this instance a bag, that would be augmented and studied. This idea will be explored throughout the research looking at historical origins and concepts in wearables, smart objects, forgetfulness and memory aids. The research areas of cognition, computer science and technology that this thesis covers is presented graphically in Figure 1.1.

Forgetfulness is associated with both feelings of embarrassment and shame (Imhof et al., 2006). There is little attention given to forgetfulness in a healthy population. However, forgetfulness is a cause for concern when it begins to affect our daily lives. Over 75% of participants from a group of almost a thousand individuals (Ginó. S. et al., 2010) reported frequent subjective memory complaints (SMC). Ginó (2010) also records that younger people are more frequently told by others that they are forgetful. This may be due to a lower tolerance to 'subtle memory difficulties', and the possibility that they have more tasks and professional requirements than older individuals. This requires a higher level of memory performance.

Many people describe forgetting as having an "off" day and experience repeated negativity. At times, people alter their daily routines because of what they may or may not forget (Ponds et al., 1997). The focus of research is on individuals who have a strong belief that they are forgetful (subjective memory complaint) as it is those users who are affected the most.

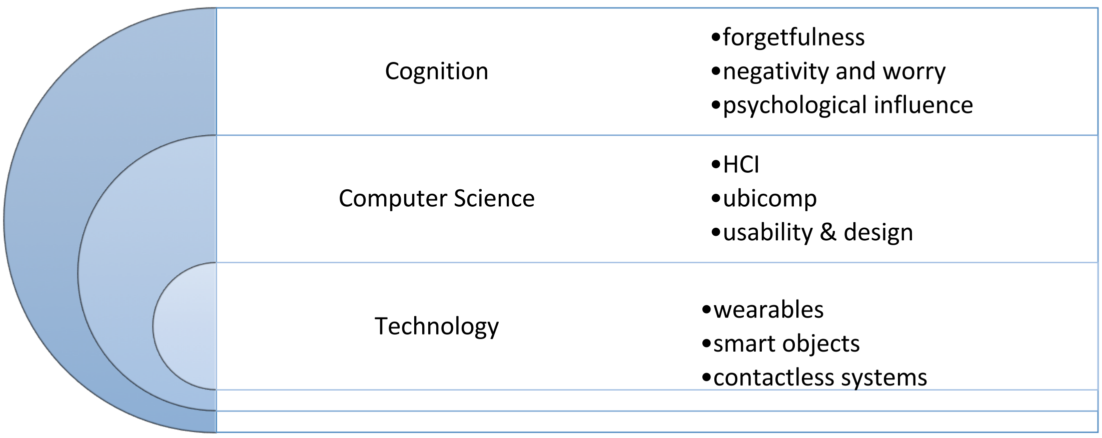

Figure 1.1 The main areas of research presented in this thesis, Cognition, Computer Science and Technology, which come together in this thesis.

The more someone believe forgetfulness to be a problem the more it affects them (Ponds et al., 1997). It is this perception of forgetfulness the research is concerned with; people who believe they are forgetful, which can have negative long term effects on an individual’s life. Chapter 2 provides further reading about forgetfulness and memory.

The specific research area I am interested in refers to everyday memory research which is; ‘remembering is a form of purposeful action’ (Neisser, 1996). Neisser discusses memory as purposeful, personal and influenced by situational demands and motivations. This topic of research deserves a significant amount of work into solving a problem many of us face every day, forgetfulness. That, coupled with finding an effective way to create a usable smart object everyday item, in this case a bag, that people will use and find effective for their journeys.

This thesis provides details of producing smart devices ultimately as high-fidelity prototypes. These prototypes are tested in-the-wild for usability and how they can address forgetfulness. The content of my thesis is a combination of work in human computer interaction (HCI), ubiquitous computing (UBICOMP) and wearable technology while referring to the context of forgetfulness.

1.2 The aims and scope of this thesis

If you have found yourself feeling negatively about your day due to forgetting something, then this research will be of interest. Also, if you are interested in finding ways to improve smart objects, my research aims to uncover what effective ways devices can be designed. This research challenges a memory-aid problem from an alternative perspective and looking at the effects of an ‘in-situ’, object-based memory aid.

The scope of research requires extended knowledge in certain fields, for example memory, and as part of my investigation I need to:

- Understand how individuals are affected by memory conditions, to discover ways forgetfulness could be addressed using technology. This will be achieved through surveying the state of technology. The literature review will also aid in understanding current systems in place, their limitations and where there are gaps in knowledge.
- Uncover how to create an effective smart object in this domain. What knowledge is needed to gain understanding about embedded systems? Are there unique properties a device would need to be successful?

- Design an exploratory study to gain comprehension about the user and how their needs will be addressed. Is a bag the most appropriate embedded object? Do people carry items and bags with them? I need to create a design concept plan to guide the process of development and research.
- Decide what testing methods I will need to engage with to successfully investigate the devices created – and what is essential to test? The device usability, function and form need different techniques to be tested effectively.
- Discover what special tools may be needed - understanding component configurations for a contactless system and how to build one.
- Develop advanced insight into the development of everyday items into effective smart objects.

This idea of augmenting a bag does have comparisons within the field of wearables, which is also looked to for inspiration. However, the way my proposed smart object operates is different from others. The smart 'bags' that are currently marketed only have a feature of charging a mobile phone. They do not provide explicit interaction or engagement with a user.

Many wearables researched and brought to commercial markets are labelled as fitness trackers, smart watches, GPS tracking or heart rate monitors. The devices have concentrated principally on activity trackers or for sports and some medical usage. Studies of forgetfulness for individuals without a medically diagnosed condition are hard to find. Surprisingly, the few devices that are integrated with bags allude to possibilities for potential in forgetfulness but further research is not available, or they remain as concept ideas.

1.2.1 Contactless System

In this research, described is a combined system of light-emitting diodes (LEDs) and a radio frequency identification (RFID) reader integrated with a regular bag (messenger or backpack) to create a smart object.

Although the idea of providing a memory-aid system with an RFID-tagged object has been explored in a few studies, most of those studies target demonstrating the functionality of a memory-aid system. Typically, this is also for several users at a time, and about misplaced items. This thesis differentiates its work from the others by focusing on the human factors such as 'how badly a person feels', and the negative emotions around a memory-aid system. Also, the RFID systems from previous work are not portable or on-body systems. This is in addition to targeting individuals without a medically diagnosed reason for their forgetfulness. For me, the challenges are to take an object that already exists, something used in an everyday context, that functions on its own; to take that object and through the addition of technology, give it an alternative specific purpose.

Additionally the purpose of contactless systems research is to;

1. Take forward current work in wearables and propose possibilities of a smart device in this domain to be built upon, through a range of studies.
2. Explore standard off-the-shelf components, configure components to be used in a daily item and learn how the associated challenges of combining those components are addressed. Many ‘bags’ termed ‘smart’ only have basic mobile phone charging capabilities and no user interaction.
3. Investigate: In addition to similar designed systems, current established design theories need to be explored in the context of tangible interfaces as we appreciate the creation of devices becomes a more common occurrence.

1.2.2 The domain of forgetfulness

Memory is vital in everyday life, and if we start to forget, it is only then we realize how much we rely on it and how essential it is to our daily functioning. When we think of our own memory it is likely it will be in the context of when it does not work, what we are forgetting, why we forget or what we can do to make it better. An example would be, ‘Why do we forget a birthday card for a friend?’.

Research concerning individuals who have perceived forgetfulness is lacking; predominantly, research focuses on memory conditions with a medical diagnosis such as Dementia, Alzheimer’s or brain injury. However, the research that is available regarding forgetfulness indicates a long term negative effect (Jelle, Jollies, et al., 2006) on individuals who believe themselves to be forgetful. Additionally, there are very few studies and longitudinal study data about smart objects, making it difficult to understand what benefits the objects may have. The combined areas of forgetfulness and smart objects have been given little attention; my study is designed to remedy that inadequacy by researching significances through the design of a smart object for forgetfulness.

Cooper et al. (2011), Mol, Van Boxtel (2006), and Montejo et al. (2012) detail in their studies that individuals are feeling anxiety when they forget, and that this in turn contributes to forgetfulness. Even so, there are no current solutions to this issue. Also, insufficient research has been undertaken concerning how or if the objects we currently carry with us every day could become more useful. For example, a bag offering a supplementary use - how can we develop additional capabilities for an object that already has a purpose? Can we merge these two unexplored areas to create a successful way to address that anxiety? Can we suggest how to develop and highlight the issue of anxiety about forgetfulness to raise more questions to be able to build solutions? Can we apply design models to a new generation of device proposals as the availability of components becomes easier for others to create devices? How does applying a case study (anxiety and forgetfulness) to a device alter the needs it can fulfil?

1.3 Research questions

This research body of qualitative, quantitative, and mixed methods studies examines the following research questions:

- RQ1 Could technology embedding into an everyday item be effective in the domain of forgetfulness?
- RQ2 What specific factors are critical to the design of a smart object?

I explore augmenting everyday objects to assist us in our daily routines, ultimately to answer the research questions posed. Alongside those, other questions that surface forming essential themes throughout the thesis, include; (a) how do we design and, (b) how do we build this object, (c) should a device be embedded or be a single item that stands alone and (d) which format would be most effective?

Through the work I aim to discover if technology embedding into an everyday item can be effective to reduce worries about forgetting. I look to provide recommendations that are appropriate for designing a smart object for the domain of forgetfulness. Alongside those questions, I inquire if a contactless system will meet the challenges of a smart system and, is an embedded design the most appropriate design?

Investigating the research question RQ2 will provide an overview of design factors that can facilitate the implementation of smart object technology within the context of forgetfulness, and to provide directions for further technology research within this specific group.

1.3.1 Design-led approach

The general approach to this research is an account of a specific reminder system. The foremost idea is to provide reminders 'in situ', reminding users of what they need to pack.

Communication is assisted via LED lights attached to a bag. The system will be prototyped and deployed with a small number of users. Firstly, by using a low-fidelity prototype as a proof of concept, which allows me to postpone consideration of low-level details to focus on the overall concept (Virzi, 1989; Norman, 1990). Secondly, the incorporated results of the low-fidelity studies enable me to construct higher-fidelity prototype systems. The research involved designing a series of prototypes that were initially tested by myself and then were tested by users. The data gathered from the usage enabled stronger and better designs to emerge and experience gained from design and use enabled higher fidelity prototypes to be created. The understanding of a smart object system will be revealed more concretely through qualitative investigation. The designed prototypes enabled more questions to be posed to directly inform iterations in the design.

Looking critically at the previous devices created is essential, the designs inform the progress routes of the work. Many iterations take place once feedback and data is received and analysed. Examining the needs of an individual with perceived forgetfulness, or negative feelings about their forgetfulness, is important to create a device that will enable them to complete their goals successfully. Is a device that is simple to use and encourages routine, able to aid people who are worried about their forgetfulness. In turn and over time, would the device reduce this negativity experienced? Would it provide beneficial gains to an individual's life?

Due to the exploratory nature of the work it was not clear at the start of the course of research how the final system would take shape in terms of appearance and feature set. This development and research process was dependant on the data obtained from the prototype that came before it.

With a design-led approach and ethnographic observations of everyday usage, attention was paid to the interaction of the system and user. Through autobiographical design, the process of design was a way of conducting the inquiry, through using my own perceived forgetfulness and the emotions I experienced as a starting point. My usage of the prototypes was documented and my thoughts, feelings, observations and context of use was collected. This included where my journeys were taken and the events that took place. There is a richer understanding of the needs of an individual who has perceived forgetfulness as I can empathise and understand first-hand what may or may not work. However, for the interest of balance and rigour to the work, additional studies with users in a variety of situations and environments is also done.

An additional purpose of the thesis is to demonstrate the effort into designing the right 'thing' based on the background research. A research through design approach, "…designers produce novel integrations of HCI research in an attempt to make the right thing: a product that transforms the world from its current state to a preferred state." (Zimmerman, Forlizzi, Evenson, 2007) is the most suitable. An objective of this research is to provide a systematic approach to the design of an everyday smart object, to be used by a group of individuals which will be presented as guidelines. The scope of this is limited to this domain and it is not the intention to develop an in-depth engineering process model for the design. Considerations for the object are for parties interested in creating wearables and smart objects, and how devices would need modifications and adaptations when designing for users with anxiety about forgetfulness.

The work presented in this thesis aspires to solve real world problems that affect individuals, while also contributing to further research. To be able to satisfy both these needs, I employed user focused methodologies and qualitative studies. The investigation was conducted with participants in real-world situations with prototypes created and adapted to reflect the needs expressed by individuals. To enable successful testing, it was essential to implement a high-fidelity Integration Prototype of the proposed smart object. The practical work conducted throughout the research through the iterative development of prototypes led to developing the build reference, presented in Chapter 4. This reference became a design guide in the creation of smart objects, particularly for my domain of research; forgetfulness.

Results from my early studies are primarily about usability issues to enable a more useful system to be created. The studies completed in the second stage of the research examine usability as well as how the prototype affects a user's life.

1.3.2 Data collection strategy

The data collection strategy is specific to this type of smart device system. Since the research pertains to everyday objects, people need to use the device in an everyday natural setting, and their opinions after use need to be collected. Having the device tested with real-use in everyday situations is essential, allowing qualities of an effective device to be observed; for example, public acceptance and the users' own style could alter a user's view of the prototype. Typically, in HCI research, interviews and focus groups are used and these are subjective, focusing on human thought, feeling, attitude, emotion, passion, sensation, reflection, sentiment, opinion, mood, style, approach, and so on. This type of user testing is the most appropriate for my research. The prototypes are also used for extended periods of time which is documented in research journals. These journals contain notes, comments, drawings, memos, images and are often rewritten several times for clarity and as reflections occurred.

The methods employed to collect the respondent's responses involved note-taking, audio recordings and questionnaires (both online and paper based). These were issued at several stages throughout the research. Observing also included – individuals using, touching, and trying the devices whilst at conferences, talks, events or (generally) in public. It is through observing how an individual interacted or used the device that often prompted changes to it. This is an imperative part of informal testing. Data in ethnography traditionally arise from interviews, participant observation field notes, document and artefact analysis, and research diaries (Mayan, 2001; Morse & Richards, 2002).

In addition, information was gained from semi-structured interviews; interviews defined by a pre-set question guide used as prompts. This resulted in successful data collection of an individuals' thoughts about the item they are testing. Primary data was collected from participants using online questionnaires, paper questionnaires posted to them, and semi-structured interviews via Skype. Data from the semi-structured interviews was collected through recording the Skype conversations with recording software on a Mac computer and the conversations then transcribed. Additional testing involved professional critiques at engagement events and conferences, autoethnography, and a residential weekend with potential users.

1.4 Contributions

This thesis presents the first attempts of extended autoethnography using prototypes designed for the domain of forgetfulness. The process detailed is an extended rigorous approach through multiple tests, studies and observations to inform further device developments. Overall, there were ten functioning prototypes created through a design-led approach that were iteratively designed. The first prototype was an initial low-fidelity proof of concept which helped to inform the higher fidelity prototypes. This collection of prototypes was an extensive amount of research that collected data from in-the-field studies. The experience-centred approach and the researchers own anxieties and negativity regarding forgetfulness allowed a rich collection of data in a variety of real world settings over an extended period of time.

These prototypes were tested with extended trials, in-the-wild testing, single user studies, interviews and questionnaires to discover what essential features contribute to a successful everyday smart object.

Encouraging findings

These observations and the data collected answer the research question, ‘Could technology embedding into an everyday item be effective in the domain of forgetfulness?’ During the testing there were positive aspects that surfaced indicating that embedded technology to an everyday item can be effective. The data collected through observations, questionnaires and interviews revealed that people were confident when using the device, they forgot less and came to rely on it.

Through the studies with users in real world environments we discovered: the form factor of an ‘in-situ everyday item device’ reduces feeling that they may forget through using a non-typical memory aid. Respondents noted that the form itself became a trigger to remembering, i.e. the object was ‘special’, so has a special purpose. Based on the feedback from the users, pausing to pack gave them a space to contemplate, therefore remember. The low learning curve of using the designed smart object enabled immediate use. Users were confident using the device, and they would use it again. This ease of use allowed continued use, if a prototype had not been used before or was left for some time, a user would still be able to use it effectively. Many of the participants wanted to continue using the device after the trails. Overall, the data revealed users found the devices helpful, they forgot less, and they would recommend the device.

Also, through feedback obtained, a new device, the Stand-alone, was created. This device does not use off the shelf components and was a purpose built device, created with an original circuit board, this was a radical design change. The research up to that point culminated in creating this purpose built smart object, as people had voiced interest in a device they could use on their own bags.

Undesirable issues discovered

During the testing there were some negative aspects that surfaced. The lack of knowledge about how other individuals may react to a smart object whilst travelling could pose an anxiety risk. Although comments and questions regarding anxieties for security when using the device were recorded by the researcher while out with the prototypes and at critique events, these worries were not echoed by the participants in the single user walk outs. The participants were confident using the device. The illuminated lights provide instant visual feedback from afar that allows a user to feel calmer knowing the item is packed, audio and haptic cues also signal confirmation. Additionally, prototypes were used extensively in order to discover if there were travel issues, and the use recorded in research journals. Journeys to airports for example, and hospitals, were documented. Throughout these trips no single negative issues presented itself at any of the locations. However, if there is a perception that there may be a security risk this would need to be studied. I ask, what about the device leads people to think there will be a risk?

Other negative issues raised was a concern for usage in bad weather, however the device was successfully used by participants and throughout the autoethnographic studies in rain and wind and harsh weather. Throughout this usage no unfavourable reactions were recorded, the users found the devices robust. Additional issues including the ability to ensure the device was working correctly, or that the battery was charging or needed charging were voiced. These concerns regarding the correct operation of the device had not been directly addressed as they mostly surfaced during the last study. This would be an area for further development. Nevertheless, even with those worries recorded, the final single user study reveals respondent's described being able to trust the device.

Design of an everyday smart object

The research question, 'What specific factors are critical to the design of a smart object?' is answered through the design observations regarding smart objects. This includes my design and build reference, and a mix of positive and negative feedback.

The Design and Build Reference as presented in Chapter 4, includes details of the interaction system, and is a useful guide and exploratory point for researchers in the memory and smart object fields. This also provides a springboard to create a proof of concept prototype and then further development - one of ten prototypes, designed iteratively based on feedback from a variety of users.

Through an in-depth and extended autoethnographic study of several prototypes at different developmental stages, a variety of detailed design information was collected. This included the discovery of desirable characteristics for a smart ubiquitous device in the domain of forgetfulness: to include; a discreet system (not bulky); an easy power solution; little to no learning curve; extreme ease of use; reliability and; appropriate styling as essential.

Overall users found the devices robust and attractive, some users commented that the appearance of the device was so attractive they would use it even if it had no function. However, early on in the research some users regarded the device as too 'girly' or not the right size, which would prevent them from using it. These issues were addressed and tested through later prototypes. These later devices confirmed styling issues and it is clear that without appropriate styling, for example perception that the bag is for women only, or it is not the right size, the item becomes useless, an individual will not use it.

Observations revealed the unique form factor became a reminder itself and usability coupled with the intuitive nature of the system is shown to be essential.

1.5 Thesis Overview

The structure for the remainder of this thesis is as follows:

In Chapter 2, the literature review contains background information including work in forgetfulness, smart objects and contactless systems. There is also information on memory, the types of memory, and memory aides used. Lastly, information regarding autobiographical, user-centred design work, experience-centred design, autoethnography approach, and research through design methods.

In Chapter 3 This chapter describes the methodology followed for the research undertaken, as well as the studies conducted. An experience-centred approach is described and how autobiographical design is used. These are alongside more traditional methods including, survey, real-world third person engagements, conference demonstrations, professional criticisms, and a residential weekend with potential users. The combinations of these methods allowed a rigorous process of iterative and experience-centred design. The information in this chapter is also a 'build reference' to be used alongside future developments of smart objects. This potentially is a guide to follow when specific design issues need to be considered. Lastly, the data collection and analysis methods used are described.

The focus of Chapter 4 is the large survey of needs and the first implemented prototype, Proof of Concept (PoC). This low-fidelity prototype was the first created and was presented for public critique. The data collected from my autoethnographic observations and experiences and a public event where the prototype was demonstrated is detailed. The prototype study data informed future prototypes.

Chapter 5 is an experiential prototyping chapter. This describes and discusses the Message Bag 1.0 (MB1) prototype which was created after the initial PoC feedback was analysed. The work is detailed through the iterations of designing, testing, and reworking the prototype. The autoethnographic process and use of research journals to document my extensive use with MB1 is described. This is the first time extensive in-the-wild testing was done on one of the prototypes.

Chapter 6 details new prototypes that were developed as a result from the feedback of the previous investigations. The focus for this chapter is on the higher fidelity devices that emerged. This is also the first time the prototypes are used by participants in a single user walk out study. The devices were also used for professional critiques at five events which are discussed. Lastly, this chapter also features a new radical design the Stand-alone (SA PoC) Proof of Concept, that was a result from the feedback from the previous testing.

In Chapter 7, the three final high-fidelity prototypes and the large single user walk out study is detailed and presented. This is an in-the-wild study where participants were testing three devices and documenting their experiences. It is also the first time the Stand-alone (SA) prototype is used for participant in-the-wild testing.

Lastly, in Chapter 8 the thesis concludes with a review of the findings and implications. The conclusion is presented in light of the initial aims of the thesis, the contributions to knowledge and practice that were made, and future directions in research.

Chapter 2 Literature Review

"Memory problems make us all less efficient in our work. If these can be alleviated, even in a small way, the gains would be enormous." (Brown & Bovey, 1995)

2.1 Introduction

Brown and Bovey (1995) highlighted that having issues with our memory makes us less efficient. This led to discussing wearable computers as an aid to memory. They note in their paper that most of us suffer memory lapses, therefore, if memory issues can be diminished there are direct benefits to be had. Ideas to improve memory such as building a 'memory repository' to capture information about our lives are studied. This is built on previous work at Rank Xerox Cambridge EuroPARC (Lamming et al., 1994) which describes guidelines for building a memory prosthesis as a smart computer system. This is becoming a reality with intelligent device functions such as Siri[2] and Alexa[3] providing current information on demand for the user. "The power of the unaided mind is highly overrated. Without external aids, memory, thought, and reasoning are all constrained." (Norman, 1993)

This chapter defines issues regarding forgetfulness and the devices that are being used to aid memory. The research presented relates to (a) memory, specifically forgetfulness; (b) smart objects and wearables; and (c) devices used to aid memory and their limitations. The technology systems used for forgetfulness are compared and the reasons these devices have a low uptake noted; such as being technically too difficult to learn to use; or the styling embarrasses the user. The subject matter researched overlaps in several areas including; reference to ubiquitous computing; everyday communication systems (as a solution to the problems around forgetfulness); and for research to create a solution that is both functional and aesthetic, it is essential to draw upon previous HCI research for reference to guidelines in design, ergonomics, engineering and interaction.

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2 Siri is an 'intelligent assistant' on Apple devices and computer systems, activated by using natural voice commands to operate information retrieval.
3 Alexa is an 'intelligent assistant' developed by Amazon and used on an Echo device using natural voice commands to enable information retrieval.

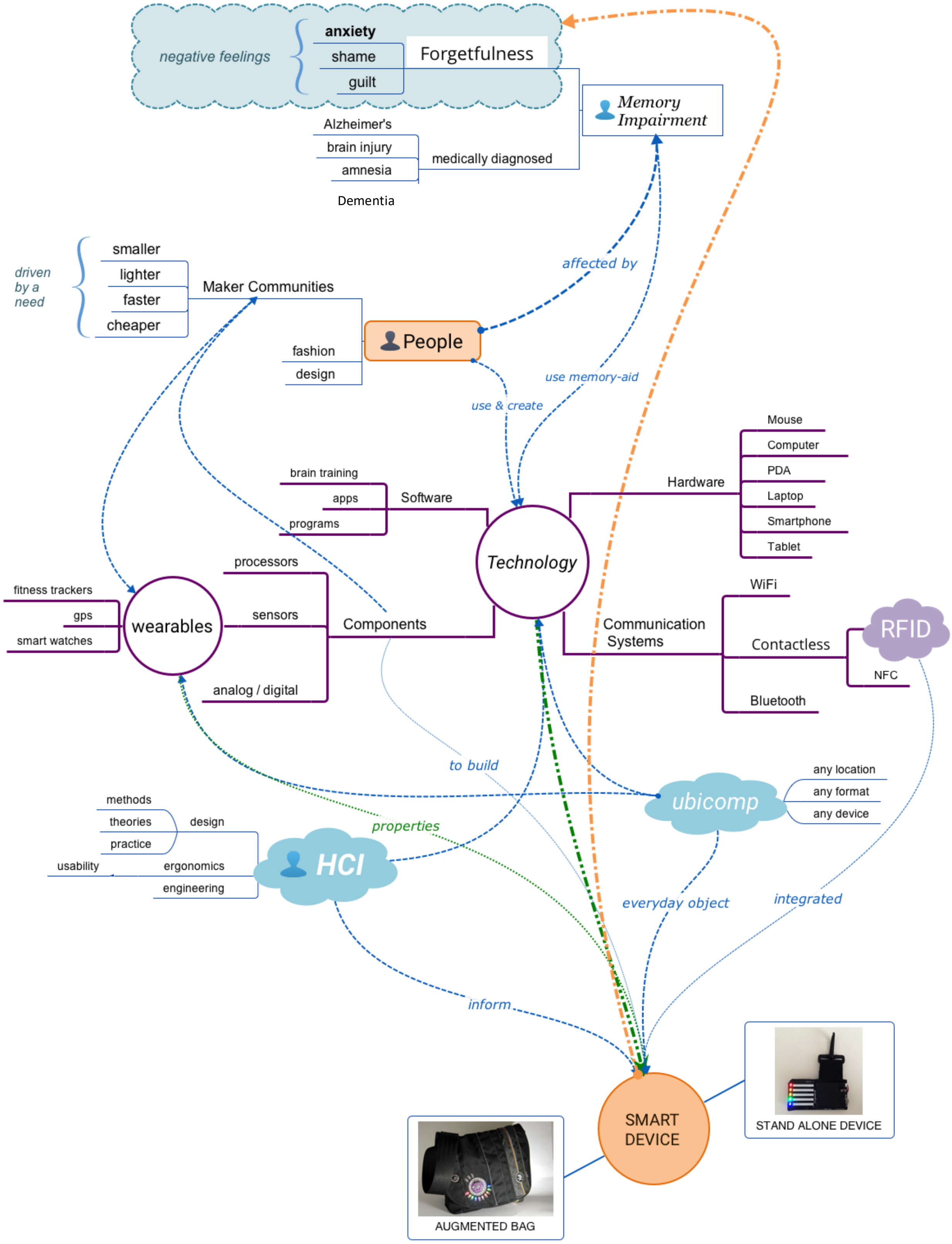

Figure 2.1 Main research areas that the work draws upon.

A visual representation of the fields of study my work draws upon is presented in Figure 2.1 as a mind map; showing the research areas studied and illustrating how they connect. The purpose of the chapter is to uncover key points about; (a) Memory: What research exists in the field of forgetfulness? What types of memory are affected and under researched?; (b) Smart Objects: Is there scope for a smart object in this field? What are the negative issues that affect wearables and smart objects that need to be overcome? What hurdles exist for designing a smart device for forgetfulness? What everyday objects are appropriate for augmenting? What theory of how an 'in-situ' task-based memory device might help an individual. (c) Contactless Systems: What are the systems in place, can these be miniaturised and what benefits can they have?

2.2 Memory and Forgetfulness

To understand the context of the work, a brief overview of memory is integral. Still, it is outside the scope to define all the intricacies of memory and cognition. There is no argument concerning memory and how greatly it affects our lives, only that a definition should be made concerning the type of memory affected, appropriate to my research. Throughout the research, the context of forgetfulness is referred to; and issues that affect a person with forgetfulness for the requirements of designing a smart device.

Forgetfulness is a lived experience for many healthy individuals and something that happens in our day to day lives. Because it affects many people this makes it a critical area to investigate. Although there is ongoing research in various areas (such as Alzheimer's, brain injury, Dementia and others) there is very little work on people without a medical diagnosis. There are however, studies on everyday human error that are relevant. We see stress and anxiety influencing human error and a person's ability to remember. This gap is central as forgetfulness impacts an individual's life in a negative way – leading them to change routines and feel ashamed (Collerton, Forster, & Packham, 2014; Lovelace & Twohig, 1990; Mol, Van Boxtel, 2006; Mol et al. 2009; Unsworth et al., 2013).

2.2.1 Types of Memory

Remembering to perform an action or an intention at a performed time means that prospective memory (to-be-performed) is used every day. Example tasks would be remembering to turn the oven off, take medication at a certain time of the day or reply to an email. Prospective memory tasks represent everyday memory functioning, the commitments to remember such things as meetings to attend, people to call, papers to read or other various tasks (Roediger et al., 1996). Memory for things to do in the future is different to that for things that happened in the past. It is this specific type of memory (future) with which the research is concerned. Retrospective memory (to-be-recalled) is defined by recording events, people and details of the past and recalling those memories. Sometimes prospective memory is termed memory of the future because it focuses on intended future events. Specifically, working memory keeps information accessible and active, in order so that we can use it for cognitive tasks (Cowan et al., 2005).

There are numerous reasons for forgetfulness and they are varied, Schacter describes them succinctly as 'seven sins of memory' (Schacter, 1999), as shown in Table 2-1. The taxonomies that Schacter defines helps us to understand how we can be forgetful and reasons why it may happen. Other factors that affect prospective memory are matters such as age, stress, genetics or drug use. The six involve forgetting and distortion, the seventh "persistence", is a pathological inability to forget. For the creation of a device, it is the six represented in Table 2-1 that are relevant.

Prospective memory is divided into three main capacities, namely event-, time-, or activity-based (McDaniel & Einstein, 2007). Event-based cues involve remembering a certain thing or action, when there are specific circumstances present; such as driving by the local shop which may trigger a reminder that all the milk has been used and more needs to be bought. Time-based cues are defined by remembering to do something at a specific time; for example, to remember a favourite TV show is on when it is a certain time.

Lastly, activity-based reminders focus on a specific thing you may be doing. It could be that driving the car reminds you to purchase fuel for it, or maybe talking with a family member triggers a reminder to send them a birthday card.

Table 2-1 Schacter's taxonomy (six of the seven, as these are central to designing memory aids)

Forgetting	Distortion
Transience; memory fading over time	Misattribution; right memory, wrong source
Absent-mindedness; shallow processing, forgetting to do things	Suggestibility; implanting memories, leading questions
Blocking; memories temporarily unavailable	Bias; distortions and unconscious influences

Kliegel and Martin (2010) reported 50-80% of all everyday memories are in part related to prospective memory. It is crucial for normal functioning. Factors affecting prospective memory include:

- Age
- Genetics
- Substance abuse: smoking, alcohol, cannabis, ecstasy and methamphetamine
- Disease and disorders
- Pregnancy

Imhof, Wallhagen, Mahrer-Imhof, & Monsch (2006) emphasize that people with memory issues make allowances to get through their day. Imhof explains, the well-being of individuals who experience forgetfulness depends on how successful they perform strategies of 'doing forgetfulness'. He details "daily life through three strategies, conceptualized as doing forgetfulness" this includes:

(1) reducing complexity
(2) creating and maintaining routines
(3) dealing with feelings of embarrassment and shame

These three points inform my research in crucial ways as any memory aid should aim to be in line with those strategies to ensure the individual's well-being. Typically, as explained in subsequent sections of this chapter, external memory aids act as compensation for memory function using a cue. This cue then initiates an action (Kapur, 1999) and does not focus on 'improving' the users' memory, but to assist it. Harris (1984) finds that, "An active reminder obviates the need for monitoring because it eliminates the prospective aspect of the memory task leaving just the retrospective one". His research on prospective memory included asking participants to call an experimenter on a specific day, or to return postcards.

The work presented in subsequent chapters revolves around the negativity of forgetfulness. However, research into this area is currently lacking. Due to this deficiency of research, the existing knowledge presented is for what is known about forgetfulness. Also, it is understood that the term "forgetfulness" applied throughout, is particularly perceived forgetfulness, sometimes called subjective memory impairment (SMI) and subjective memory complaints (SMC). Subjective memory complaints are typically attributed to fatigue, sleeplessness and trying to do too many things at once and self-perceptions can have an impact on memory performance (Cooper et al., 2011; Garrett, Grady & Hasher, 2010; Ginó et al., 2010; Montenegro et al., 2013). Research for memory issues that have no medical diagnosis are few and far between, making this an area that needs further work. It is acknowledged that most people who do not have neurological memory deficits do use memory aids, which typically consist of lists, notes and calendars (Harris, 1980; Lovelace & Twohig, 1990; Kapur, 1999).

> "Human memory is generally poor, prone to error and to manipulation."
> (Vemuri & Bender, 2004)

Is there potential controversy regarding prospective memory? Prospective memory typically has a social/moral aspect to it when it fails. If an individual forgets a person's phone number as they prepare to phone them, excuses of, "I can never remember phone numbers", allows them to distance themselves from the forgotten detail. This also applies to giving an excuse if we forget a person's name, but how many times are we permitted to forget before it is socially awkward or seen as rude? Can we ask more than three times? Does it become a barrier to further conversations with that individual?

These failures have the potential for others to view us differently, for example; 'if I forget where I put my keys too many times, friends may see me as disorganized'; or 'if I forget a name, people may label me as someone who doesn't care'. These incidences of forgetfulness may call an individual's reliability into question. Are they reliable if they seem forgetful? If you are depended upon to complete a task for someone else, there is social pressure to complete the task successfully (Einstein & McDaniel, 2005; Winograd, Gruneberg, Morris, & Sykes, 1988), but, there are many factors that can affect the successful completion. This can range from interruptions while doing the task, to a lack of good sleep - so the task is not recalled and it becomes a memory failure.

A prospective memory task encompasses several diverse processes; attention, awareness, planning, monitoring, behaviour; and there is controversy regarding if it is truly memory or just good planning. One case is Crowder (1996) who argues that the term prospective memory could be a distraction to researchers. A switch of terms could change the intention of the phrase, 'I must remember to do that task'. By removing the words 'remember to' the problem simplifies from a memory task to a task of planning and intention — 'I must do that task.' Crowder, questions the wording of 'forget to perform' when changed to 'fail to perform' to produce the same result. His views are detailed as, "the loss of the term prospective memory would leave us better off, not impoverished."

There is also the suspicion that, because prospective memory is explicitly defined as "successfully carrying out the intention," it is suggested that how people set intentions is a more essential area to study. Memory is about forgetting or remembering; successfully carrying out a remembered promise is about something other than memory, social rewards or self-image, for example (Crowder, 1996). ‘Intention’ as a concept could be subdivided into the memory for the intention, remembering the intention, and then executing the intention.

2.2.2 Strategies for improving memory

The term ‘memory aid’ in this context is a strategy or tool used to increase memory performance, to consciously decide to use something. Most people, regardless of whether they suffer from a memory impairment, employ some type of system to remember objects or activities. Typically, this is broken down into (a) external or (b) internal systems that they put into place (Intons-Peterson & Fournier, 1986; Intons-Peterson & Newsome III, 1992; Kristiansson, 2011). They also note that memory aids are important and have a role in the study of memory. Understanding memory aids can assist progress towards a more ‘comprehensive understanding of the totality of memory’. These external and internal systems will now be defined further.

2.2.3 External

External memory aids are defined as a modification to someone’s environment, to remember. Some examples are memo writing, calendars, appointment books, grocery lists, writing on your hand, putting objects in specific places, clocks, timers, photographs and similar (Bolla, Lindgren, Bonaccorsy, & Bleecker, 1991; Intons-Peterson & Fournier, 1986; Intons-Peterson & Newsome III, 1992). Generally, external memory aids are considered more accurate, easier to use and more dependable than internal strategies. Harris (1980) found that overall, people say they use external memory aids more than internal ones and this is echoed by Intons-Peterson & Fournier (1986). Charness, Best, & Souders (2012), point out that memory performance can be bolstered by self-managed external memory aids. However, external aids potentially rely on regular use or good habits. If you do not remember to check a calendar, for example, it will not be much use. If you do not open the app on a smartphone then there is no point in relying on it.

When there is interplay between both the internal and external then the external memory aid is typically of less use than when used alone. It is the distribution of information across both external and internal aids that looked to cause this limitation. This hindrance is complicated as it depends on many factors such as (a) the nature and level of causality, (b) the systems involved, and (c) the commitment of the user.

Technology based memory aids are considered external, and the prevalence of email use has meant it too has evolved into a memory aid (Jovicic, 2000). Users send emails to themselves to be used as reminders and leave them in their inbox until the task is completed

(Ducheneaut & Bellotti, 2001). This operates under the assumption that a user will generally be using and checking their email once or more a day. Is this a good system to use, are computers the way to solve our memory issues? It could be, however, that a user has an abundance of emails to attend to. If they do not act on the email they have written to themselves as a reminder, it may slip further down in their inbox resulting in the reminder no longer being visible or within easy access. The usefulness of email as a reminder becomes compromised. Peek, Wouters, et. al. (2014) also list concerns regarding technology including forgetting or losing technology, obtrusiveness, impracticality and low ease of use, to name a few.

Lamming and Flynn (1994) consider the following about our computer use – which has increased vastly since 1994 when they observed the following: "Considering how often computers are presented as devices capable of "memorising" vast quantities of information, and performing difficult-to-memorise sequences of operations on our behalf, we might be surprised at how often they appear to have increased the load on our own memory." Even so, work by Leong et al. (2006) found that sending a text message for an appointment reminder improves clinic attendance rates. Similar studies for outpatient and health care centre attendance is documented by Car et al. (2012), Koshy et al. (2008) and Chen et al. (2008). Koshy et al. (2008) reported that non-attendance rates were 38% lower in patients who received a message reminder. Other benefits noted by Peek, Wouters, et. al. (2014) regarding technology is perceived usefulness, increased independence and reduced burden on family caregivers.

Previous work in the field established the most commonly employed strategies that aid memory (used by people with a brain injury) as; wall calendars, notebooks, lists, appointment diaries and asking others to remind them (Evans, Wilson et al., 2003). Bolla et al. (1991) found that individuals use low-tech external memory techniques, such as writing reminders and grocery lists. These techniques fail, however, when they are in a static location or remain unchanged on a day-to-day basis (the item is in stasis). Additionally, seen as a drawback would be that the reminders might be lost, misplaced or difficult to display, or become a fixture (Caprani et al., 2006). Suggestions to address these issues include using bright colours, oddly shape reminders, or to display them in a prominent or unexpected location (Einstein & McDaniel, 1990; 2005).

2.2.4 Internal

Internal memory aids do not involve any changes to a user's environment; they purely rely on the brain. An example is mnemonics (Park, Smith, & Cavanaugh, 1990; Verhaeghen, Marcoen, & Goossens, 1992), which some research indicates gives better memory performance - in a lab setting. Adults have difficulty using it in real world situations and many memory researchers do not use, or recommend mnemonics. Mnemonics typically is described as a pattern of letters, thoughts or associations which support memorising something. Also used is repetition, rhymes, stories or other strategies of association. Typically, it is a technique that aims to assist more efficient integration of new information (Charness et al., 2012). Generally, the research indicates that these internal memory aids are less effective than an external strategy (Vortac et al., 1995) and research on non-memory impaired, young healthy individuals noted that some of these strategies are too difficult and cumbersome to be used efficiently. Research for effective aids points to writing down a list, which seems to be a more commonly used technique (Brooks, Friedman, & Yesavage, 1993; Brooks III, Friedman, Gibson, & Yesavage, 1993; McDaniel & Bugg, 2012; Park et al., 1990).

2.2.5 Off-Loading

Distributed cognition (Dcog) is an approach to cognitive science research (Hollan, Hutchins, & Kirsh, 2000; Hutchins, 2005; Hutchins & Klausen, 1996; Rogers & Ellis, 1994), it could be narrowly defined as involving external cues. This theoretical framework takes the view that tools amplify cognition. Who counts these external cues and their usage for memory purposes? One theory presented by Van Den Hoven & Eggen (2004) is that Dcog starts with external information, which triggers an internal cue. Dcog combines internal and external approaches as an alternative way to reduce cognitive load. It emphasizes off-loading cognition into the environment, which can be through social or technological means. A general definition of Dcog is that it ‘involves the coordination between individuals, artefacts and the environment’. External cognition has a main goal which includes externalizing to reduce memory load. This could include using calendars as a ‘cognitive artefact’ to help remember dates and appointments, as highlighted by Rogers et al (2001). This externalising could help to reduce some memory burden through reminding a person to do something; what, where and / or when to do it. Cognition is off-loaded and extended into the environment.

Salomon (1993) specified shared cognition and off-loading; Shared defined as being shared among a group of individuals, which could happen through conversation. This results in a change of cognition based on that group and another person’s response. Off-loading, is typically object based, where cognitive duties are off-loaded to a material object, for example using a shopping list to remember groceries needed. The extended theories of cognition (EXT) argues that the environmental resources when engaged through the body’s action, can constitute a cognitive process. The notion of off-loading is one that will be taken forward in the research presented. Likewise, we will focus on cognitive technology: a peripheral device on which data is stored. Something as simple as an external piece of paper with a phone number on it is a piece of cognitive technology (Dror & Harnad, 2008).

Section Summary

There are known strategies for coping with forgetfulness which include setting up time- or situation-specific triggers. Both external and internal memory aids are used and the research indicates that an external aid is more effective than an internal one. An external aid can be as simple as a Post-it note or a high-functioning technology system though it is worth noting that the high-functioning technology itself may become part of the burden if it is over complicated. The prevalence of email use has meant it too has evolved into a memory aid (Jovicic, 2000). The concept of distributed cognition, specifically off-loading, is touched on briefly with the comprehension that cognitive duties can be off-loaded to an external object, sharing burden.

2.2.6 Anxiety and Perceived Forgetfulness

To frame the work in this thesis it is important to define some terms, interpretations and the context in which those terms are used. A study by Cooper et al. (2011) hypothesized that subjective forgetfulness (in a non-dementia population) would be more prevalent as age increased. They found that reporting forgetfulness was not associated with age, however significant associates of reporting forgetfulness were anxiety, depressive and somatic symptoms (Cooper et al., 2011; Montenegro et al., 2013; Piauilino et al., 2010) also, that the complaints about memory differ with age (Ginó et al., 2010). It is noted that if there is a decrease in memory facility, it has a more pronounced effect on daily life. Sinoff & Werner (2003) describe that the elderly feel a great deal of anxiety because of memory loss and that anxiety is a good predictor for future cognitive decline.

Subjective memory complaints are common amongst older adults (Hurt et al., 2012) causing significant distress. Further studies also note that subjective memory complaints are associated with depression and anxiety (Derouesné et al., 1999; Montenegro et al., 2013; Bay et al., 2012; Balash et al., 2013; Carrasco et al., 2017). Although complaints of memory loss do not correlate with the actual memory performance in tests (Ponds et al., 1997; Imhof et al., 2006; Hänninen et al., 1994); individuals who most emphatically complained of memory disturbance had, (a) greater tendencies toward complaining, (b) higher feelings of anxiety about their physical health, and (c) more negative feelings of their own competence and capabilities, than those who did not complain of memory deterioration (Hänninen et al., 1994).

It was observed that people had begun to wake earlier to be sure they were prepared for their day, so they began to alter their regular routines. This was because the effects of forgetting led individuals to continually worry about forgetting something. Back et al. (2008) describe the opportunity to reflect as being essential for individuals. They give an example of anticipating being in a rush on a morning, so positioning your bag by the door becomes a strategy to be used, so you do not forget your bag. Mol, Van Boxtel, Willems, & Jolles (2006) demonstrate that relatively younger people tend to attribute their perceived forgetfulness to (a) tension and emotional problems, (b) lack of interest, and (c) poor concentration, as described in other research (Ponds et al., 1997; Imhof et al., 2006).

There are inherent issues with learning new routines or procedures; “Forgetting led to failures in social interactions and influenced their proper performance of everyday tasks. As such, they reported that forgetfulness changed their lives, producing worries and feelings of shame and embarrassment, and creating the need to establish new practices in everyday life. At the same time, forgetfulness decreased their ability to establish new practices.” (Imhof et al., 2006)

Additionally, the more someone believes their memory to be a problem, the more it affects them. Mol et al. (2006) noted that subjective forgetfulness was associated with a lower quality of life and for individuals who considered themselves forgetful, a significant increase was found in symptoms of anxiety, compared to those who had no perceived forgetfulness. Further to that, subjects tested at several year intervals, (3, 6 and 9 years apart) mentioned that reduced quality of life persists over time, indicating daily life functioning is affected. “Because complaints about forgetfulness do not correlate well with objective memory test scores, a patient’s self-reported memory complaints have been treated as unreliable information for diagnostic purposes.” (Mol et al., 2006) Memory dysfunction hampers the quality of life of those individuals affected, and can leave them feeling very dependent on others (Wilson, 2002). Additionally, older adults may hold negative expectations of their own abilities; decreasing motivation when remembering information and causing a lower likelihood of adopting memory strategies (Jennings & Darwin, 2003).

There is also a relationship between depression and working memory. Depression, is described by The American Psychiatric Association (2000) that as an individual feels sad, discouraged, and hopeless; they also typically report feeling fatigued. It is noted that, although it is not clear why, people with major depression have difficulty with some working memory tasks. People with depression often comment that they have trouble concentrating. It was concluded that, “these findings emphasize the profound impact that depression has on the day-to-day cognitive activity of people suffering from depression” (Christopher & MacDonald, 2005). Additionally, poor performance on these daily activities probably increases the level of depression further. Sternberg & Jarvik (1976), established that an individual suffering from depression may mistakenly misinterpret their diminished ability to think or concentrate as a memory failure. It is sometimes the treatment of depression that can alleviate memory complaints. Balota, Dolan, & Duchek (2000) observe,

> “While there may not be medicinal means to prevent the cognitive decline, having better memory aids may relieve some anxiety. In fact, the elderly, while showing decreased performance in laboratory memory tests compared to their younger counterparts, often perform adequately if not better on daily life tasks due to more efficient and diligent use of memory aids.”

Techniques are difficult to establish if an individual is feeling depressed. Even when the individual tries to put a trigger in place to help them remember, it is stressful. It is essential when designing a memory aid to take some of that worry away.

2.2.7 Everyday human error

Lapses in attention and everyday cognitive failures have an effect on our everyday lives. Cheyne, Carriere and Smilek (2006) present that, ‘A tendency to even extraordinarily brief attention lapses on the order of milliseconds may have far-reaching consequences not only for safe and efficient task performance but also for sustaining the motivation to persist in and enjoy these tasks.’ These are not detailed specifically as memory errors or forgetfulness, but attention and boredom having an effect on cognition. Lapses can be considered events such as missing a turn off a road, but it can also be from a lack of knowledge or misapplication of rules (Reason, 1984; Reason and Mycielska, 1982). Highly familiar or repetitive tasks reflect attentional lapses.

Other lapses documented that would affect a person’s life though not in a catastrophic way, included examples of, struggling to open a friend’s door with your own key, getting in a bath with an item of clothing still on, or switching on a light as you leave a room (Reason, 1984). These can be seen as ‘absent-minded’ errors. However, Reason (1990) also discusses human error on a large disaster scale such as the Challenger tragedy in 1986 and Chernobyl of the same year. Edmondson (1996) discusses the patient care in hospitals and implications for human error, some of which can be fatal. Errors are sometimes not picked up, even by those in charge of checking for errors. A well-documented phenomenon is that the human tendency is to perceive what you expect to see, and not necessarily what you do see (Norman, 1980, 1981; Reason, 1984).

Section Summary

Previous research that is focused on memory and forgetfulness is predominantly centred on medical reasons for the memory loss occurring. However, perceived forgetfulness is an area in the memory field that does not necessarily correlate with age. Even so, it can be associated with anxiety and depression in younger individuals. Individuals who perceive they are forgetful experience a lower quality of life over time. Everyday human error can have negative consequences for an individual. There are similarities between the causes of human error and forgetfulness including: anxiety, stress, substance abuse and lack of sleep.

There are known strategies for coping with forgetfulness that include setting up time-based or situation-specific triggers. Evidence of a need for reducing complexity and creating and maintaining routines are essential in systems for a user. Human memory is prone to errors and reducing the negative way that this affects an individual is beneficial. Research in the memory field demonstrates that the potential exists to improve an individual's quality of life through creating better memory aids that are unobtrusive and easy for an individual to use on a regular basis.

2.3 Memory Specific Systems

This section discusses hardware and software solutions in detail. Briefly mentioned are the personal strategies that people use, as these are numerous and outside the scope of this thesis but are important to note for context.

Some external solutions that people employ to help them remember include; Post-it notes (González & Mark, 2004); calendars; memos; asking a friend to remind them; and smartphones with lists on them that people potentially forget to check. Visual based items can be useful memory aids, if they are in the field of vision for the user. This includes, day and date clocks, white boards, labels on cupboards, notes on refrigerator doors, etc. Other examples include people leaving items by the door of the house or writing shopping lists on the bags themselves so they do not forget to bring the list with them. Additionally, people use mobile phones coupled with reminder, note, list and calendar apps.

The solutions presented in the next section will be categorized by their type and purpose of system. Some devices are better suited for retrospective and others for prospective memory. The systems described are task-based or object-based memory systems which may be used for different domains; such as medical, aviation, office or personal to name a few.

The devices described in this section are predominantly concerned with general reminders, or in some way affiliated with everyday life, as opposed to remembering events of the past that have been encoded and must be recalled. Some memory systems record the environment to help the user to remember.

2.3.1 Memory aids: hurdles and strategies

There are several hurdles which could impede successfully implementing a memory aid. Previous studies including Charness, Best, & Souders (2012), Gitlin & Burgh (1995), show factors that are significant for consideration of a memory aide include:

- to reduce multi-step procedures (reduce demands on memory and processing)
- that the device has easy usability / is reliable / and good portability
- to be an unobtrusive object
- potentially integrated into the user environment
- provide task information (audio / visual / haptic) / cues to assist memory
- low cost

Charness, Best, & Souders (2012), noted that participants concern about a device being ‘too expensive’ was a worry and potentially affects use rates or uptake of a device. Peek, Wouters, et al. (2014) collated the concerns that include the high cost, false alarms, obtrusiveness, no control over technology, and stigmatization. Parallels in literature for assistive technology devices highlight that there is stigma associated with using ‘a medical device’ as well as a general negative attitude of users and the public towards the device. Users of these devices note that using a cane or walker for example, point to a disability. This means that, even though using a cane or walker is beneficial, many people abandon them as they do not like the negative associations that they bring.

Memory aids need to be carefully designed to avoid a user feeling any stigma. Perceived usefulness and the ease of use, as well as reliability (Gitlin & Burgh, 1995; Lauer et al., 2006) are all factors that create barriers to using technology. In terms of reliability, technology memory aids typically need power, connection and user interaction to be reliable and effective. Some devices that will be discussed in this section also need to be within range of a network and carried with the user - which can be additional barriers to their use. However, is using some technology device a better option that using nothing?

2.3.2 Systems for Prospective Memory Tasks

The idea of using devices to record our environment, or everything in our daily lives is described as far back as Memex, 1945, "a device in which an individual stores all his books, records, and communications, and which is mechanized so that it may be consulted with exceeding speed and flexibility" (Bush, 1945; Gemmell et al., 2002). What is changing is the portability of these systems and computer memory available. Ubiquitous audio recording is no longer restricted to sitting at a desk. The progression of technology development ranges from; devices that record and transcribe later a desktop, to; devices that can do both on portable hardware. These systems record information about the user's environment. Typically, this system would use images, videos, audio, location and other data. This information is then used to prompt the user about events or notify family (or a caregiver, friends, etc.) about important information.

An example of a memory aid system, described as a distributed processing system is: The 'Remembrance Agent' from 1996, a computational memory aid, (Rhodes & Starner, 1996; Starner & Rhodes, 1999) it was presented as a wearable computer recording notes continuously for a user. It is an information retrieval system which is constantly running, allowing users to write notes on a full-time wearable computer. It triggers memories by retrieving the relevant notes from the past (Rhodes & Maes, 2000). "This is a program that continuously 'watches over the shoulder' of the wearer of a wearable computer and displays one-line summaries of notes, files, past email, papers, and other text information that might be relevant to the user's current context." (Rhodes, 1997). It mixes elements of remembering items and information from the user's past yet uses these items to help the user in the current timeframe or context.

NeuroPage (Hersh & Treadgold, 1994), is a computer-based reminding system with an aim to combine a computer with a paging device. NeuroPage is the first memory aid to capitalize on the possibility of mixing the two communication systems. Their system consists of three elements; a pager, a computer and a paging company. The wearer of the pager is alerted with an incoming message for a reminder of an event or routine, for example, that is previously set up on the computer through a caregiver or friend, family member, etc. following agreement by the wearer. The user is required to press a button on the device to read an incoming message (Wilson, Evans, Emslie, & Malinek, 1997).

Pager technologies have since been replaced by quicker and easier technologies, but the system basics of notifications is still an effective way to augment memory. This style of system has also been simplified because of the computing power being more powerful and smaller in 2016. The NeuroPage device is easy to use but it is also one-way communication. The information comes from a family member or caregiver and is sent to the user, who is unable to reply. Unfortunately, when this system would have been used (in 1994) using a pager company was expensive. Also, there is no way to check if the user had received or read the message sent. The system requires an external helper of some description, and due to this it could not be relied upon for medicine taking and similar essential functions. It also requires adequate reading and comprehension skills. Results from a study of NeuroPage of 15 participants (Wilson et al., 1997) aged 19-66 showed that the participants benefitted and found the device useful. NeuroPage was found to have the potential to support independent lifestyle in memory-impaired individuals.

Another example of a memory aid system described as a distributed processing system is the Mobile Extensible Memory Aid System, MEMOS (Voinikonis et al., 2005). It is described in terms of distributed processing as it is the ability of caregivers or family sending reminders to the user that allows its functioning. Schulze (2003) in a 6-person evaluation comparing MEMOS, palm pilot and mobile phones available at the time showed that all devices improved task performance and that performance was highest for MEMOS.

Audio Notebook, (Stifelman et al., 2001) records audio that is indexed along with a user’s handwritten notes. Memory prosthesis, iRemember, helps users access forgotten memories through recording contextual and audio information that can then be retrieved with a suite of software tools (Vemuri, Schmandt, Bender, Tellex, & Lassey, 2004). The Memojog system, (Morrison et al., 2004) is an interactive memory aid (PDA style) with remote connection, using text based memory prompts.

One artefact that strives to create technology that is both functional and aesthetically pleasing is the Reminder Bracelet (2000), in order to better integrate and be accepted by users (Hansson & Ljungstrand, 2000). It is a prototype that displays notification cues and using LEDs it can notify a user 15 minutes before an event in their PDA. Memory Glasses from 2007, but alluded to in DeVaul, Sung, Gips, & Pentland (2003), is described as a wearable, proactive, context-aware memory aid. The primary goal of this project is to produce an effective memory aid and reminder system that requires a minimum of the wearer's attention (Corey, 2003; DeVaul, 2004). The focus is on providing reminders in a timely, situation-appropriate way with the aim to have the system behave like a reliable human assistant. This system is interactive and is a step forward from a passive PDA which only uses a calendar and is unaware of the user’s context.

The Memory Glasses system could falter if a cue is delivered at an inappropriate time, for example crossing a road. It is essential that the context-awareness of when that cue gets delivered is accurate every time. The Google Glass project was an advanced on-body system (Glauser 2013; Lv et al., 2014) that had access online and to a user's personal details such as calendars and reminders. It had recording capabilities and the idea was that it could be seen as an 'extension of the self' (Starner, 2013).

TakeTwo (Greenwald et al., 2015) builds on the capabilities of the Google Glass device to provide a virtual extension of memory. Primarily this 'augmented memory' is to aid users in learning and recall. Events are captured with audio-visual content of ongoing events, and allow users to actively bookmark moments for later review. It also used the Apple virtual 'intelligent' assistant Siri, which can record reminders, through using commands in everyday language. The capabilities include the ability to set reminders, location reminders, alarms and calendar entries, to name a few services. This is also a service that Amazon has developed through their Echo products (Alexa assistant) as well as Google's own voice search capabilities (OK Google) to retrieve relevant information for the user. These personal assistants coupled with an online service, such as a calendar, can become a powerful reminder system.

Cook's Collage (2005), although it only assists within one task domain – cooking, it is a system worth mentioning for its unusual nature. This system uses images that document the user's actions as they perform them. The system displays their six previous actions undertaken; to serve as a reminder for what step they have already taken and what they should do next (Tran et al., 2005). This possibly borders on retrospective memory as it reminds the user about what they have just done, or what steps they have taken, in a recipe. However, it is so they can carry out a task.

Other devices include the MemoClip (2007), a memory aid in the form of a badge that is clipped to clothing that associates task information with time, location and context. AutoMinder (Pollack et al., 2003), is a wearable microcomputer using radio and ultrasound to communicate with the user's environment. It determines the user's location and provides task-related information.

Home Basic; a system created by Abilia (2010) uses a central memo planner on a tablet connected with wireless sensors around the house to detect motion. If a door is opened or left open, or if the stove or a cooker light is left on, then the system alerts patients and carers of danger. Home Basic also provides spoken reminders about daily tasks; such as when an individual should take medicine or remember events; as well as enabling carers and family members to check in remotely via Skype.

Non-specific software systems such as email, can create external reminders, for example scanning a document, and when a keyword such as 'attach' is found, the software is aware that there should be an extra document. This can pop up a reminder to attach the file. Many current email programs have the ability to create an email reminder, add emails to specific lists or calendar events, all becoming a useful external reminder system (Charness et al., 2012). Electronic calendars perform similar functions and systems will also (if allowed) notify a user of events or give location based reminders, for example if they are leaving work and need to pick up certain groceries on the way home.

Smartphone apps have become part of our everyday lives. Benefits of smartphone applications and other digital reminder systems (e.g., Google calendar) for facilitating prospective remembering in everyday settings has been observed (McDonald, Haslam, Yates, et al., 2011; Svoboda & Richards, 2009). With active reminders being the most successful. Smartphones need to be carried with the user, and accessed when reminders are triggered. This may fail if there is low or no battery, the device is switched off, the user forgets to bring their smartphone with them, the volume is too low to hear, or if they forget to add a reminder in the first place.

Research into the effectiveness of reminder apps by Stawarz, Cox, & Blandford (2014), Gal, Zite, & Wallace (2015), Santo, Richtering, Chalmers, et al. (2016), Dayer, Heldenbrand, Anderson, et al. (2013), and Jamieson, McGee-Lennon, Cullen, et al. (2015), focuses on individuals remembering to take medication. Dayer et al. (2013) report that ‘medication nonadherence remains a common health care problem’ and that poor adherence causes approximately 33% to 69% of medication-related hospitalizations.

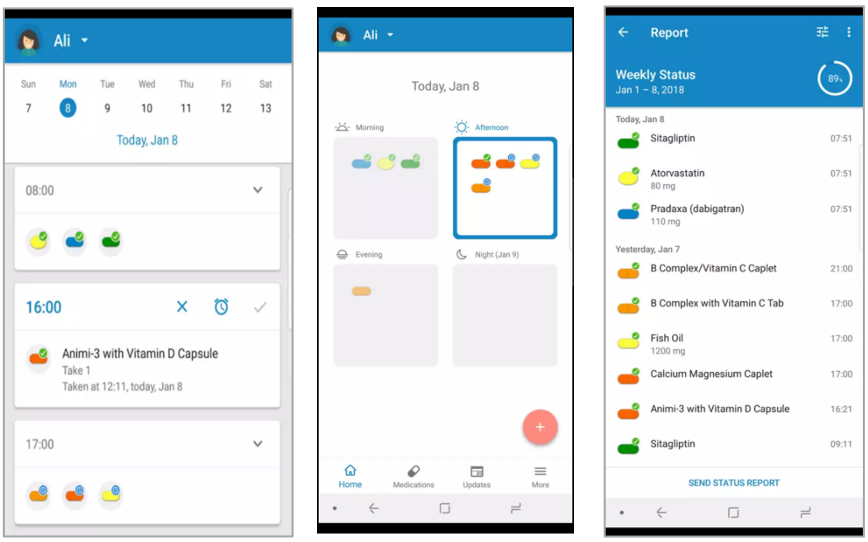

Figure 2.2 Pill Reminder and Medication tracker, Medisafe® app for Android.

However, Dayer et al. (2013) identified a shortlist of 160 smartphone apps that were then identified and ranked. These were reduced to a final three (on the Android system), MyMedSchedule, MyMeds, and Rxmindme, Figure 2.2 is the Medisafe ® Android app.

The 'app only' solution was far more useful when coupled with Short Message Service (SMS) text messaging which improved adherence and behaviour. Santo et al. (2016) examined 272 apps that could be used as medical reminders. After comparing features, ratings and cost, they concluded most them did not have many of the desirable features and were, therefore, considered low quality.

The work of Stawarz, Cox, & Blandford, (2014) estimated that in the USA there are over one million unwanted pregnancies due to forgetting to take oral contraceptive. They document that although daily routines do support memory, design requirements for building medication reminders need to support the routine aspect of medication-taking and its individual nature. They suggest this can be done through implementing a switch from passive alerts to a smarter memory and routine assistant. Another study for using apps as reminders for contraceptive discussed features that overcome common causes of missing an alarm, hypothetically, may minimize likelihood of an oral contraceptive user missing a daily pill (Gal, Zite & Wallace, 2015). However, the emphasis that, 'health care providers should inform users of potential pitfalls and advise them that a contraceptive reminder app should be not be used as a sole reminder method'.

The use of a smartphone device is equally less pertinent for device functionality as some individuals have little to no access to one. A smartphone is an item costing hundreds of pounds; it has a large learning curve, typically a small text interface, and a user would have to both open an app and remember which app they were using after first downloading it. Lastly, another limitation to note is that the technology needs to be appropriate to the form, i.e. a handbag, backpack etc. which may reduce certain technology component choices.

Section Summary

Generally, these prospective memory systems need additional research with results published concerning their effectiveness in assisting memory. There are, however, many studies on usability which leads to further development of alternatives or improvements to existing device design. Gaps in research on memory support and their benefits are also segmented into the importance of forgetfulness. For example, forgetting a shopping list will prove to be an inconvenience, however forgetting medication can result in pregnancy

(Stawarz, Cox, & Blandford, 2014) or can be fatal – hence more important. This could negate the greater cost if it proves to be a life saving device.

These devices typically require a caregiver or family input as well as training for the users and some are at a considerable expense due to connectivity to services online. At the time of many of these devices surfacing (2000 onwards) the Internet and connection may have needed dialling into and was expensive. As we progress, the Internet is easily accessible and relatively inexpensive and many devices are now connected or 'always-on' with no additional cost to factor in. This allows for quicker and easier 'on-device' access to information and tracking, as well as access to internet search engines. Even so, we see 'always-on' devices such as Google Glass, that are rejected in society for social, security and styling reasons.

Lastly, although many apps are now available on many different smartphone operating systems, there are no clear choices for the most effective ones. Many are low quality or lack the features that would make them more effective (Santo et al., 2016). Studies in this area are ongoing.

Table 2-2 An overview of the prospective memory systems presented in this section.

PROSPECTIVE MEMORY SYSTEMS

SYSTEM	Year	
NEUROPAGE	1994	Computer and pager memory aid. Alert user to perform tasks.
REMEMBERANCE AGENT	1996	Computational memory aid, information retrieval, wearable computer recording notes continuously.
COACH	2000	Speaker, camera sensors and PC to help a user carry out actions.
REMINDER BRACELET	2000	Wearable bracelet, with LEDs for notification cues, uses PDA connection.
AUDIO NOTEBOOK	2001	Audio recorded alongside of users notes.
MEMOJOG	2003	Interactive memory aid, text based memory prompts. PDA style device.
AUTOMINDER	2003	Wearable microcomputer using radio to communicate with the environment. PDA
MEMORY GLASSES	2003	(concept in 2003 and 2007) Wearable context-aware device.
IREMEMBER	2004	Memory prosthesis.

MEMOS	2005	Distributed processing, for caregivers or family to send reminders to alert the user about tasks.
COOK'S COLLAGE	2005	Images of the user's actions, used for cooking. Integrated flat screen and cameras.
MEMOCLIP	2007	Memory aid in the form of a badge, associates tasks with time, location and context.
HOMEBASIC	2012	A central memo planner, spoken reminders i.e. when to take medicine.
SIRI	2011	A personal assistant available on Apple devices, iPhone, iPad and computers.
ALEXA	2014	A personal assistant initially specifically for Amazon brand of products, The Dot and Echo.
TAKE TWO	2015	Building on Google Glass as a wearable device for augmented memory.

2.3.3 Systems for Retrospective Memory Tasks

Retrospective memory, concerns events of the past and recalling those memories. The devices presented here are predominantly concerned with the recall of long term events and memories though for some devices it uses these events to also trigger daily reminders.

SenseCam (2007, patent Williams, L.[4] 2009), (Hodges, Villar, Scott, & Schmidt, 2012b; Lumsden, 2011; Silva et al., 2013; Vemuri & Bender, 2004) from Microsoft Research, is termed a 'lifelogging' device. It is a device to help someone remember what they have done throughout the day. Although it is primarily concerned with the current daily event, its purpose is to help remind a user of events that occurred in their past. SenseCam (Figure 2.4) passively takes pictures that can be viewed later. Researchers realized that looking through the images after they were taken, enabled a higher instance of recalling the day / event. It was intended to be used as a 'black box recorder' to track things all day, but they realized that through looking at the images after they were taken there was a higher instance of recalling the day / event.

SenseCam has been a base for other systems such as, MemeXerciser (Lee, Davidoff, Zimmerman, & Dey, 2007) which additionally collects GPS location information, and the device has been further refined through testing and prototyping. WearCam (Starner et al., 1995) is used particularly for face recognition as is DejaView camwear model 100 (Reich et

4 SenseCam. Retrieved July 2016 from http://research.microsoft.com/ hwsystems/

al., 2004) and StartleCam (Healey & Picard, 1998) which also explores using video recordings for memory.

WWIT Recorder, is a wearable mobile device which creates a daily recording of audio and location (Vemuri & Bender, 2004). This uses miniaturization of computing devices as well as their capability, in terms of adding GPS data and recording abilities.

Through using audio, video and proximity biometrics, it means there is potential for new devices that can be a lot more capable in a much smaller form factor.

Hoisko (2003) observed an early wearable computing system for supporting memory. This visual memory prosthesis (Lamming et al., 1994) consists of a database, and data collection consists of several cameras and microphones mounted on spectacles, as well as an interface. Hoisko believed that memory prosthesis was becoming increasingly possible due to the technology strides being made i.e. processing power getting stronger and devices becoming smaller (Hoisko, 2003; Vemuri & Bender, 2004). At that time, PDAs and other wearables were underpowered to do all the processing necessary on the system itself so it relied more on saving the data, to be processed later on a desktop computer.

Portable memory aid, Forget-Me-Not (Figure 2.3), was operated by using technology available at the time (Lamming & Flynn, 1994). This is a prototype from Rank Xerox which focused on a simple conceptual model so any user could understand it (Brown & Bovey, 1995). It passively collected data and a user could review past events when forgetting occurred.

Another device is a wearable portable conversation library from Carnegie Mellon University, which records conversations and face recognition. The implementation consists of a laptop in a backpack along with a small camera and two microphones Lin & Hauptmann

Figure 2.3 still from forget-me-not video demonstration (1994).

Figure 2.4 SenseCam 'life logging' device, Microsoft Research.

(2002). These types of systems have been termed *Activity-based Information Retrieval* (AIR) systems, (Lamming & Flynn, 1994; Brown & Bovey, 1995).

Lastly, the OrCam[5], MyEye (2010) device is an intuitive wearable device with a small camera that hooks onto a user's spectacles. The purpose of the device is to recognize text which is then read to a visually impaired user. There is also the capability of face recognition for visually impaired users – which would provide the same features for an individual with trouble remembering faces. The implications of this device for memory are worth noting due to its unique form and could potentially be integrated with an online database for recall similar to Google Glass.

Table 2-2 Information for Retrospective Memory Devices

RETROSPECTIVE MEMORY DEVICES

DEVICE	Year	Features
VISUAL MEMORY PROSTHESIS	1994	Cameras, microphones (on spectacles), interface
FORGET-ME-NOT	1994	Prototype, forgetfulness with past events, but in the present data collection
WEARCAM	1995	Face Recognition, for recall
STARTLECAM	1998	Memory, video
DEJAVU	2004	Face recognition
WWIT RECORDER	2004	GPS, Audio recordings
SENSECAM	2007	Lifelogging, photos, memory assistance through looking at the photos
MEMEXERCISER	2008	Photos, GPS
ORCAM, MYEYE	2010	Face recognition, sight loss, camera mounted on spectacles

5 OrCam. Retrieved March 2016 from http://www.orcam.com/about/

2.3.4 Object-Based Memory Systems

Established research into contactless systems highlights work with Radio Frequency Identification (RFID) technology. An RFID system provides hardware that can be implemented for a low cost, that can be easily portable due to their small size, and is reliable and accurate (Min et al., 2007; Want, 2006, 2011). An RFID system consists of a reader and tags with unique IDs. The tags are passive making batteries unnecessary. The tags contain integrated circuits with a small antenna that is sealed. (Passive tags can be less accurate than active tags.) Their energy comes from the RFID reader when near – via electromagnetic induction.

RFID systems have a history of being used for tracking items and can create a more personal system. RFID technology used as a tagging identification framework is relatively new if compared with barcode technology. However, RFID systems have advantages which includes that tags can be scanned in any orientation and there are no lighting requirements. Examples of systems using RFID are numerous (Ni et al., 2003; Patil et al., 2008; Guerrieri et al., 2006; Reyes & Jaska, 2007; Ling et al., 2007). Compared with barcode technology, which is established, a barcode requires line-of-sight reading across a scanner as well as a reflective lighting condition. The barcode can be printed onto an item at low cost versus a tag being a physical object that needs attaching in some way.

RFID technology has many applications across several domains. These include: retail (both store operations and item level inventory), healthcare (asset management), heavy industrial (oil and gas equipment, container or vehicle) tracking, government (asset and inventory management) and large-scale or small-scale and personal asset management. RFID systems, which can be stationary or mobile, have a wide variety of applications, (Jeffrey Hightower, 2001; Römer et al., 2004; Becker et al., 2009; Vogt, 2002; Cormode & Muthukrishnan, 2005), so have been tested for usability in many environments such as: medicine, robotics, sensing, warning systems, locations such as points of interest - and automated inventory systems which is our focus.

Tags used in these systems do not degrade over the course of normal usage, nor are they affected by dust or dirt (Want et al., 1999). Tags can be added or incorporated in to a system later. Although multiple tags are easily used within a system, many systems are unable to read more than one tag at a time and some separation of tags may be needed as they typically have a close read range and tags in close proximity may be read in error. RFID is also used for 'personal' healthcare, (Amendola, S., Lodato, R., et. al., 2014) describes the evolution of traditional medical tracking, with the Internet of Things (IoT) model. They discuss personal healthcare in smart environments and using RFID for gathering information. He & Zeadally (2015) mention the convenience of RFID systems and IoT for healthcare professionals and patients.

Schmidt, Gellersen & Merz (2000) pioneered a wearable RFID system by integrating it with a glove. The embedded reader (in the glove) detected the tags on objects that the glove touched. The glove needed an additional unit worn on the hip to provide enough computing power to process the data. The prototype helped to establish miniature RFID systems with a power supply that could potentially be used for surgical gloves or in bracelets, to create object-touch detection (Gellersen et al., 2000; Fishkin et al., 2005). The iGlove presented by Fishkin et al. (2005) is a modified bike glove containing small inexpensive hardware. It was used as a prototype for testing daily household tasks. A further model was implemented for medical use and a bracelet built upon that work – specifically for a home environment for in-home care.

Currently RFID systems are used to help with memory tasks in other existing systems. For example, aviation safety systems can tag tools and equipment to ensure that items are checked in and out and other automated inventory management performed, requiring real-time object identification (Want et al., 1999; Want, 2011). Using RFID systems has advantages due to their fast response time, cost effectiveness, life time and low maintenance. Other applications are for document tracking, livestock tracking, library check outs, parcel tracking and keyless entry systems (Stanford, 2003).

2.3.5 Example RFID Systems

Systems using RFID technology to support memory include Tool Control, a Smart Toolbox (Römer et al., 2004; Sinha & Couderc, 2013) that has individually RFID / NFC tagged tools and a corresponding box that has a reader and antenna. It is primarily a safety system used in the Aviation industry. A worker can 'withdraw' a set of tools and they are alerted if a tool is missing or not returned. It is cost effective as it is very easy to build and is also effective for time management as the encoding for the toolbox happens quickly and easily based on the tools selected. The tags themselves are cheap and the system easily scales to add as many tools as necessary. There are similar ideas for a smart surgical kit, Caretag Surgical (Swedberg, 2013), to eliminate post-surgery x-rays to verify that no surgical equipment has been left inside a patient. There are also many examples of RFID used for ubiquitous computing (Lamming & Flynn, 1994; Lee et al., 2010; Römer et al., 2004; Want, 2006, 2011; Want et al., 1999) and behavioural change.

Some devices that try to help with memory issues include: Smart medicine cabinet, (Siegemund & Flörkemeier, 2003) enabled by an RFID system, which sends a text message to remind users when it is time to take medicine. It keeps track of the cabinet contents with an RFID reader that reads tags on medicine boxes. Many versions of pill dispenser boxes have LEDs and timers and are found to be useful, (Guynn, McDaniel, & Einstein, 1998; Park & Kidder, 1996). A 2014 version of a pill dispenser box with LEDs on it, LEDs glow so the person has a visual notification that they have forgotten to take their pills, was developed. This would mean the pillbox had to be somewhere in the open or where it was visible. Some of these types of electronic reminders are part of a wider strategy: a 'smart home' system becoming part of the building design.

Systems such as Apple Home, using Siri or Amazon Echo's Alexa can be used to remind the individual to take their medicine. Other pillboxes dispense pills several times a day. Taking daily medication is greatly affected by memory errors, which can be reduced when linking it to an event, for example, taking it with a regular meal (Pew Research Center, 2009).

Research for making RFID systems faster, light-weight and have easier to use interfaces is being undertaken which will make implementing an RFID system even easier (Oh et al., 2010). Sinha & Couderc (2013), propose a framework with a function comparable to the Internet of Smart Objects (Kortuem, 2002; Kortuem et al., 2010), whereby objects are physically tagged with RFID tags, turning these physical objects into smart objects. Examples are used for recycling purposes or do it yourself (DIY) furniture systems such as at IKEA. Throughout the literature of studies on RFID integrated systems, similar themes surface throughout their use. These are: (a) Scalable; (b) Low cost; (c) Reliable; (d) Flexible; and (e) Speed of use and implementation.

A Note on Tag Only Systems

Around 2013 onwards, a 'tag only' style of device has surfaced, typically for tracking. Small 'tag' style devices have become popular through 'crowdfunder' websites that do various tracking or tagging using Bluetooth. The devices can be attached to personal items which can be monitored and checked on a smartphone. As of 2016 these devices are on the market: Tile first appeared in 2013, as reviewed by Guy, N. (2016) is a small device that you can attach to your personal objects, Tile App (2016); as is Trackr. There is currently little research on these tracking devices, but it is important to mention them as it is a new take on tracking (single item) style devices that aim to help memory. There are issues with these 'tag only' systems such as battery life (some are quoted at 3 months' usage), reliability and durability – which are key components for memory devices that need to be addressed.

Section Summary

When examining the systems designed as retrospective memory aids, the majority rely on some way to record a user's environment. This is done through audio, video, still photography or a user's writing and notes. From these, the device then requires that a user process this data in some way on a computer. To have some success in recall it requires that the user revisits it at some point – perhaps on the computer or in another form. We also see that advances in miniaturization and processing power have enabled the creation of smaller, lighter and more convenient systems.

RFID systems have been in place and used with success in a variety of different domains. Many of these types of contactless systems have been tested and used over long periods of time with success. We also know these systems bring many advantages such as their relative low cost, easy implementation, ability to expand the system and durability. Using this type of system as a base for a memory aid has many advantages as discussed.

2.4 Smart Objects and Wearables

This overview provides a brief history of early visions that have led us to current developments in smart objects and wearables. The digital revolution has taken us from Licklider (1960) suggesting man-computer symbiosis and D. Engelbarts' vision for man-machine systems to improve the effectiveness of the individual human. Englebart (1962) and Weiser (1991) present a vision that introduces ubiquitous computing; a vision of people and their environments accessing information - when and where they choose. This is all in a desire to break away from interaction that was previously seen as desktop-bound only. Alan Kay proposed the Dynabook in 1968, "Imagine having your own self-contained knowledge manipulator in a portable package the size and shape of an ordinary notebook." (Kay & Goldberg, 1977), which is a design of an early laptop vision.

Other early examples of technology capable devices with a specific purpose such as carrying a music collection, essentially, wearing it, was made possible in 1978 when a Sony Walkman engineer wanted a way to listen to opera music on flights. Wearing headphones and a Walkman device on our belts makes a portable music collection possible (shown in Figure 2.5). The 1980s brought us calculator watches, which allows the calculator to be made wearable on our wrists (shown in Figure 2.5). Now, we use mobile smartphones - which are always on and always within reach - we essentially have computers in our pockets. Trackers that we wear on our wrists stream or store our data and demonstrate a growing consumer market for small, always-on technologies, and they are offering potential health benefits.

Figure 2.5 Sony Walkman being worn in this advertisement, and Casio Calculator watch.

These technologies meet with Weisers' ideas of physical space, breaking away from a desktop model; and time, making interaction available 24 hours a day, 7 days a week. Roy Want bridges the physical and virtual worlds with electronic tags (Want et al., 1999) using inexpensive technologies, off-the-shelf applications, everyday objects and computational devices. Those tags and technologies used, have changed relatively little today and continue to be relevant.

2.4.1 Smart Objects

The definition for smart objects used throughout the thesis is an everyday item that is augmented with technology to create an object with a particular function. O'Driscoll, MacCormac, Deegan, Mtenzi, & O'Shea (2008), provide a definition of a smart device being an "everyday physical object that is enhanced by the addition of technology" (to create a smart device). One of the defining features of smart technology is the capability of context awareness. By this understanding, smart wearables could be described as: being capable of exchanging data between the user and their environment due to the awareness of the locations and the possibly activities in which the user is participating.

Kimura & Nakajima (2009) describe smart objects as offering alternative interactions with users, a digital interaction with the world & context sensing. This is consistent with previous descriptions from Siegemund & Flörkemeier (2003) and echoed with Silva, Pinho, Macedo, & Moulin (2013). For example, Sinha & Couderc (2013), describe smart objects, smart environments and smart interactions as core concepts in pervasive computing; in their case through the use of RFID tagging. For context, one illustration of a smart object is MediaCups, a 'design and use of Computer-Augmented Everyday Artefact' (Beigl, Gellersen, & Schmidt, 1998). MediaCups, is a regular looking coffee cup, augmented with sensors and networking. This includes; an accelerometer for sensing movement; a thermometer for temperature of the liquid inside; and a sensor for location to track events through understanding how many cups are being used together with a hot drink. For instance, if there are several cups in close proximity, it is likely a meeting is occurring at that location (Beigl & Gellersen, 2003; Beigl, Gellersen, & Schmidt, 2001; Gellersen, Schmidt, & Beigl, 2000).

2.4.2 Wearables

When Starner et al. (1995) discussed wearable computing it was with the idea that it will, "change the current paradigms of human-computer interaction". They went on to explain that many aspects of everyday life could be electronically assisted and provided examples for specific situations. The context in which the term 'wearables' is used throughout the thesis is based on the work of Mann (1997) Starner (1996, 2015) and Starner & Rhodes (1999), who define an 'innovative form of personal computing brought about by continuously worn, intelligent assistants that augment memory, intellect, communication, and physical senses'.

Mann's (1997) definition, suggests that wearable computers should be situated in a way that makes it part of what the user considers to be himself or herself. Additionally, Plessl et al. (2003) highlight that wearable computers have to have adequate speed; and typically wearables have stricter power consumption constraints. Additionally, in the twenty or so years that have since passed, the hardware has become increasingly faster and smaller (Motti & Caine, 2016) enabling much more freedom for wearables to permeate our everyday life. These changes have fostered greater use and commercialization of wearables (Motti & Caine, 2016) particularly wrist watches. This is due to the easy access and fitness capabilities. Results from Kim & Shin (2015) indicate that the user's attitude and intention to use the wearable depended on subcultural appeal and cost.

The definition for what constitutes a wearable evolves as more devices saturate the market and the tag 'wearable' gets attached to increasingly styles of items. There are wearables to encourage good health, well-being or to be assistive in their nature which has been explored and developed for decades. Piwek et al. (2016) detail concerns when using wearables for health care.

Although they highlight benefits of personalized health data, they list security, safety and reliability as concerns. These wearable items go through a design process and research in

HCI and UBICOMP offers ways to investigate, design, build and test these devices. An early example of a wearable for the everyday and with a goal of being both functional and accepted, is a running shoe with a compression sensor in the heel Adidas_1[6] (2005). The sensors in the shoe senses the users running style using a solenoid; a memory metal that changes how stiff it is depending on the current running through it. Therefore, it changes its physical properties according to the user's steps.

2.4.3 Advantages of Smart Objects

For an everyday item to be augmented, it requires having an object with its specific purpose, and adding additional function to it. Some of the more impacting advantages of a smart object include:

- the ability to collect data and send it,
- the ability to provide feedback,
- the ability to give additional use to an existing object,
- the potential to recognize conditions such as blood pressure and diabetes,
- the ability to be context aware so that location changes its use.

For example, a cup has a purpose of drinking liquids from it. It may be that the additional capabilities such as tracking location are created and they are kept away from the user, as is seen with Mediacup shown in Figure 2.6. Then processing and information is done through servers, and an individual could use a cup as they normally would, without interference of that object's purpose.

Figure 2.6 Mediacup shown with technology components.

[6] Adidas_1. Retrieved July 2016 from http://newatlas.com/go/3810/

Any additional information obtained such as location, would be available to the user, without their explicit effort. It is this subtlety that can enhance a user's daily activities without being overbearing or requiring abnormal effort or attention.

Other advantages include that technology is becoming available to a broad range of individuals due to lowering costs and greater availability (Evald, 2017). Additionally, wearables that are on-body have an advantage of leaving a user's hands free. They can do other tasks while the device is still functioning (Rawassizadeh, Price, & Petre, 2015). A desktop computer or smart phone requires more attention from the user.

2.4.4 Limitations and Disadvantages

Some of the limitations associated with smart objects concern the form factor – can a user easily carry the smart object, and with confidence? Typically, cost is also a factor which can be a barrier to taking up the technology. If a user can purchase an object at a much-reduced price; and if unaware of the additional functions – would they pay a higher price for something that is not necessarily tangible? Additionally, if users are unsure or even unaware of the function of the device, then they may be unaware of advantages to be gained from using it. If someone is unaware of an object's potential, they may see little benefit to using that object. A lack of contextual sensitivity (Motti & Caine, 2016) is an important issue. There could be incorrect identification of a user's activity and poorly designed screens.

Also, many smart object devices remain in prototype phases, early stages of development or have only been used in small trials, and therefore may not be at the stage of becoming commercially available. There are also concerns about safety, reliability and security, particularly when wearables are used for health care (Piwek et al., 2016). Also, the small size of a wearable device means there is weaker processing and battery capabilities (Rawassizadeh, Price & Petre, 2015). A small screen size also restricts the input and output. There are also potential differences in data collection if a smartphone is being used to track activities. If the phone is on a bag, pockets or car this can all affect the data collected. However, a smartwatch has typically one location so the data would be consistent (Rawassizadeh, Price & Petre, 2015).

With regards to forgetfulness, there are few clinical trials for smart object memory aids. Typically, this means that there would have to be considerable research investment into smart devices to: understand their effectiveness, to continue their development and, to discover usefulness and benefits for a user. Additionally, despite the improvements in smart wearables, there is little consideration for emotional, social and fashion-related qualities (Lee et al., 2015).

Section Summary

Smart objects are defined as technology that augments an everyday object and offers it an alternative or additional purpose. Wearables are typically items that are; on-person, always on, and connecting and typically transmitting data about the user wearing it. Both should be non-obtrusive nor obstructive in a users' everyday life, so they can perform their typical activities. Both smart objects and wearables can be considered as man-machine or augmented systems. So far, however, there is little research into their effectiveness for forgetfulness. In some fields, such as for medical applications, the terms have been merged, the term 'smart wearables' is used when discussing remote health monitoring, for example (Lymberis & Ieee, 2003; Karahanoğlu & Erbuğ, 2011). Wearable technologies have changed the way we interact with technology, wanting lighter, more intimate pieces that are always available.

The advantages of smart objects are that they can provide additional functions to an object, can collect data and provide feedback for an individual. Some of the negativities that were highlighted included the cost being a barrier as well as the user potentially not understanding its functions. Additionally, due to limited research on smart objects, many products that do come to market can disappear just as quickly. This can be due to a host of copycat objects, or the object not doing what it promises or of being no benefit to the user.

2.5 Everyday Objects (augmenting a bag)

One of the components of the smart object definition specified earlier, is that it is an object used every day. A bag (handbag, backpack, briefcase etc.) is an example of an everyday object that would be a good candidate to add functionality to create a smart object. Some bag based systems and concept systems include; the Smart Schoolbag (Jing et al., 2006); LadyBag 2006[7], Smart Purse 2013, Chameleon Bag 2014[8], Ricky Bag 2014[9], and the iBag 2014, which is still in a concept phase at the time of writing iBag2, 2016[10]. These systems all use a bag as the base object of some description and then add other capabilities to it. Through adding

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[7] LadyBag. Retrieved July 2016 from https://www.nextnature.net/2006/05/rfid-ladybag/

[8] Chameleon bag and Image from Make Magazine in Figure 2-8. Available to view online as part of *Make Magazine*. Retrieved July 2016 from http://makezine.com/2013/06/20/core77-diy-design-award-winners-inspire/core-77-chameleon-bag/

[9] 'Ricky Bag' Image shown in Figure 2-7. Retrieved July 2016 from http://www.ecouterre.com/ralph-laurens-5000-ricky-bag-comes-with-built-in-phone-charger/

[10] iBag and iBag2 and videos available. Retrieved July 2016 from https://www.finder.com/ibag

additional features that are uncharacteristic its original purpose, which is to carry items, is enhanced.

The Smart Schoolbag that they describe as an educational system, reminds students of forgotten items. A teacher can make a list to remind the pupils of what they might need for the day. The bag also requires a tablet making it much more expensive than a traditional bag. Lau, Wong, Luk, & Kwok (2015) found that it was effective to help the pupils to remember what to bring and to reduce the weight of the bag they were carrying, but parents worried that their children would lose the ability to organize themselves if they relied on the system too much.

The LadyBag is a concept for a handbag that uses (light emitting diodes) LEDs. The LEDs are represented in various icon shapes to indicate to the user what is missing from the bag. There is also an ‘emotional’ light display based on how you are holding it.

A light is activated if you forget an item, or there are 3 specific icons for 3 objects - keys, phone and wallet. Mighty Purse is used for charging your phone on the go - though there are now several of these types of bags.

The Ricky Bag (shown in Figure 2.7) also contains a smartphone charger and light, adding basic functionality to a handbag, created by American fashion designer Ralph Lauren. This bag is one example of early smart styles of bags to be made commercially.

Currently, there is not any additional data on the sales or success of it but it is a designer handbag sold in the $5000 (£4100) price range. iBag aims to discourage spending using technology; to remind a user that they are over their overdraft or spending budget. The iBag uses radio frequency identification (RFID) technology to notify the user when they remove their wallet from the bag. It will send a text message to the user or a family member about their spending. This bag can also lock itself during peak spending times to help a user curb expenditure. The Chameleon Bag (shown in Figure 2.8) is a large cumbersome maker project that uses multiple LEDs mounted in plywood and an RFID system to track items. Due to its having a large piece of heavy plywood it does not make a suitable daily object.

Figure 2.7 ‘Ricky Bag', containing a smartphone charger and lights, by Ralph Lauren

Figure 2.8 Chameleon bag

A study by Park & Zimmerman (2010) was conducted concerning a smart bag proposal and a potential way to design a smart bag. The smart activity bag is described as 'a family system'. It enables kids to pack their bags more easily to help the parents. The paper focuses on breakdowns; when were items forgotten and what types of items – removable items or items left in the bag: a wet swimsuit or empty bottle of water, for example. This research was to enable the design of a solution that would be useful to the family. The paper proposed designed concepts for bags trying to reduce the number of breakdowns that occur, although no bag was built. They note that, "families would experience a breakdown triggered by forgetting a non-routine item.

A well-designed smart bag would need to have different rules for what is missing at different times and touch points. Additionally, the smart bag would need to know which items needed to be removed at any of the various touch-points." Many participants stressed their desire to interact directly with a bag. Lastly, they noted that it was not an effort to cure forgetfulness. Instead they saw it as a bag which could function like spell checkers in word processing software which reduce the risk of sharing a message or document with a spelling error. Additionally, they discovered that items that were atypical for their day were more likely to be forgotten.

Buse and Twigg (2014) published research highlighting that handbags are significant to making 'personal or private space within care settings'. Other observations included that the bags were an important part of the presentation of self, and they represented 'memory objects and stores of items of personal significance'.

2.5.1 A gap for electronic bags

When looking to other modified bags, there are others that refer to themselves as 'electronic'. As presented, the Smart Schoolbag, LadyBag, Ricky Bag and Chameleon bag all implement technology. However, the use of the Smart Schoolbag involves others having an additional devices (a tablet) as well as other users (parents and teachers). This adds to the cost of the system and we know the cost can affect a device's usage (Charness, Best, & Souder, 2012; Gitlin & Burgh, 1995). This also complicates the system. A person has to rely on other technology being available and working as well as the reliance on other people. A teacher or adult needs to program the classes and then it will check the items are packed. This system is not solely controlled by the user and the research suggests that maintaining independence can be a primary concern with forgetful individuals. Furthermore, the research presented in the memory section notes that keeping a memory device as simple as possible is a requirement

(Imhof, Wallhagen, Mahrer-Imhof, & Monsch, 2006). The system proposed will be self-reliant and not need the input to or from other devices or people.

The LadyBag adds other ‘features’ such as an emotional aspect but the documentation is not clear on the use or benefit of this. In addition, the actual use and concept of LadyBag is not clearly documented with testing or descriptions beyond a concept idea. It has not been tested with extended usage, nor with any real world evaluations. Prototypes created for this domain would require extended research and to undergo testing for extended periods of time as well as with users in-the-wild. Testing in a scientific or closed environment is not an effective way to obtain accurate data.

Also, electronic bags such as the Ricky Bag only serve to charge electronic devices for a user. This is likely to be a mobile phone or small tablet, for example. There is no interaction or secondary purpose with this bag. No testing or documentation is found to support what engagement there is with the bag. These fashion item styles of bags are given the label that they are electronic and perform extra features. However, they only perform what carrying a portable charger would already provide for a user. There is also the consideration of cost, as seen in the literature, cost is a potential prohibitive means to get people to use a device (Charness, Best, & Souders, 2012). A device would be more successful through using off the shelf or low cost parts. The Ricky Bag is a very expensive luxury bag. It is likely that it would not have mass appeal or uptake. The Devices for memory for real world usage need to be cost effective not prohibitive.

The electronic bags could all benefit from sustained user studies and real world testing to allow researchers to discover what are the main essential build features and how to implement those features in a smart object. There are currently no detailed autoethnographic findings or extended single user studies and so would benefit from real world research. A bag with embedded technology that would respond to a specific purpose, the domain of forgetfulness, has not been prototyped or extensively tested. Research is needed to discover what essential design implementation is necessary and how it will affect a user’s life.

Section Summary

There are some different bag systems that are suitably used as smart objects, though there is currently not enough research to demonstrate their effectiveness. However, as bags are objects many of us carry around with us daily, it would be an item categorized as ‘everyday’, and would make a suitable object for augmenting. Also, the work by Buse and Twigg (2014) demonstrates an important link with identity and self, and that handbags are important to support identities. An electronic bag, with a specific purpose in the domain of forgetfulness with extensive testing would enable further studies and research to take place. It would be a contribution towards HCI, Usability and Cognitive communities.

2.6 Experience-centred Design

Experience-centred design is described as, "a humanistic approach to designing digital technologies and media that enhance lived experience" (Wright & McCarthy, 2012) encapsulates the overarching goal of the research. "The experience of even simple artifacts does not exist in a vacuum but, rather, in dynamic relationship with other people, places and objects." (Buchenau & Suri, 2000). A lack of in-the-wild studies was highlighted by Mottie and Caine (2016) even though real world usage is important to consider in the context of designing for wearables (Lyons & Profita, 2014; Smailagic & Siewiorek, 2002). Current wearables work is done using "a small sample of participants in a laboratory setting" (Mottie & Caine, 2016). These tests can offer no insight into a real-world setting and the user's interaction in the wild. When doing pre-defined tasks in a controlled environment finding the variations, or the impact of the wearable on the user cannot happen accurately. Therefore, the experience-centred approach becomes necessary to obtain accurate real-world information on the interaction and use of a wearable device.

One understanding of "experience" (Buchenau & Suri, 2000) is close to what Houde and Hill call the "look and feel" of a product or system, that is "the concrete sensory experience of using an artifact — what the user looks at, feels and hears while using it." (Houde & Hill, 1997). In early development stages, and with successive iterations an experience prototype becomes a way to explore and evaluate design ideas. This coupled with autoethnography where research and design journals are kept for documenting all aspects of research, becomes a powerful way to create prototypes. Part of that experience is aesthetics and the importance of aesthetics with interaction. From Graves, Petersen et al. (2004) aesthetic interaction aims for creating involvement, experience, surprise and serendipity in interaction when using interactive systems. Additionally, aesthetic interaction promotes bodily experiences as well as complex symbolic representations when interacting with systems. This is seen in concepts such as playfulness, surprise and enchantment (McCarthy & Wright, 2003; McCarthy et al., 2006).

Experience Prototyping allows the designer to experience it themselves, rather than 'witnessing a demonstration or someone else's experience. (Bucheanu & Suri, 2000). Part of the concepts of experience prototyping is that experience is subjective, therefore, the best way to understand the experiential qualities of an interaction is to experience it subjectively. This coupled with the autobiographical design is used to directly inform certain design aspects that are important in forgetful individuals.

It is through experience-centered design that we can, “continue the humanist agenda by giving a voice to those who might otherwise be excluded from design and by creating opportunities for people to enrich their lived experience with and through technology.” (Wright & McCarthy, 2010).

2.6.1 Autobiographical Design

Autobiographical design can be described as, “design research drawn from extensive, genuine use by those creating or building the system” (Neustaedter & Sengers, 2008; 2012). Though there is value in more traditional methods of design, when evaluating systems which typically may last one to three weeks, the evaluation of autobiographical design is very long term. Autobiographical design cannot produce results known to be generalizable to a broader community of users.

“Some designers feel that autobiographical design allowed them to uncover detailed, subtle understandings that they likely would not have found with other user-centered design techniques because they might have seemed unremarkable. Autobiographical design seems best suited for exploratory systems that fill a new design niche, where there is no existing system or established culture of use.” (Neustaedter & Sengers, 2008) As the research involves creating several different stages of prototypes, which are new in their construction, the use of autobiographical design will initially generate essential feedback for improving upon the system.

Autoethnography is a genre of writing and research that connects the personal to the cultural placing the self within a social context (Reed-Danahay, 1997) those texts are usually written in the first person and feature dialogue, emotion, and self-consciousness as relational and institutional stories affected by history, social structure and culture (Ellis & Bother, 2000). When making observations and documenting use of prototypes there is a reflective process that informs the research. While using personal accounts, autoethnographers follow ethnographic research processes of data collection, analysis, interpretation, and the writing of reports in their goal of gaining a cultural understanding of self in interaction with others (Chang, 2008).

Other researchers (Greenberg and Buxton, 2008; Rogers, 2011) document that, it can be increasingly difficult to design technologies, understand how they are used in real settings and evaluate new systems to understand their true effects. Autoethnography is a research method that (Adams, Jones & Ellis, 2014):

- Uses a researcher's personal experience to describe and critique cultural beliefs, practices and experiences
- Acknowledges and values a researchers relationships with others
- Uses deep and careful self-reflection, typically referred to as reflexivity, to name and interrogate the intersections between self and society, the particular and the general, the personal and the political
- Shows people in the process of figuring out what to do, how to live, and the meaning of their struggles
- Balances intellectual and methodological rigour, emotion, and creativity
- Strives for social justice and to make life better.

There can be a number of pitfalls in doing critical ethnography that could potentially threaten the scientific merit of the study. This potentially includes: seeing only what serves the researcher's purposes, placing passion before science, making claims beyond the evidence, and replacing reason with stridency (Thomas, 1993). In the interest of balance of the work the autoethnography used here is supported by more traditional methods such as in-the-wild studies, a residential weekend with potential users, paper based questionnaires, one to one interviews and online surveys. There are also two single user walk outs where other users take the prototypes out for extended amounts of time and report their findings.

2.7 Limitations Affecting Systems

Intons-Peterson & Fournier (1986) questioned the use of electronic systems, and noted some techniques are less reliable and more difficult to use than non-electronic systems. This could be from the aid itself being difficult to understand or interpret but could also be according to how adept an individual is as compared with another.

> "Most current memory aids require active effort to engage the aid in order for the memory to be triggered." (Vemuri & Bender, 2004)

Most of these previous solutions require teaching someone how to use them, and require a user to have a new, foreign object in their house. Some objects were so bulky that it made the person who used them feel uncomfortable or socially awkward. Therefore, the social aspect needs to be considered when designing these aides. The following section highlights limitations of memory aid systems presented, and issues that need to be addressed for future research.

2.7.1 Easy set-up

Regardless of the type of memory these devices are trying to assist with, when developing an assistive tool, Galvin & Scherer (1996) notes that it must be kept simple to set-up, customize and use. Developers should design set-up to be intuitive and similar to tools with which caregivers may already be familiar (Kintsch & DePaula, 2002). It is desirable that devices require minimal user input and minimal maintenance.

2.7.2 Durability

Devices must also be durable. Systems should be lightweight yet able to sustain a fall to the ground without damage. There are also requirements that devices must be able to go with users outside and experience different sorts of weather and temperature; as well as be usable in different sorts of lighting conditions and where users may be eating. It is key to note that a durable device is not necessarily a chunkier, larger device. ‘Hardware solutions for memory devices can be clunky in nature’ (Vemuri & Bender, 2004), and require some degree of learning such as using a Personal Digital Assistants (PDAs), item locators or voice prompters also tend to be very large; for example large button phones or pill bottles with reminder alerts.

2.7.3 Testing of new devices

Like previous limitations mentioned, many of these memory aids are still emerging, and changing frequently. There are devices that are primarily non-intelligent and uni-functional and through advancements in technology, more devices are incorporating sensors and artificial intelligence. However, even with advancements we still see similar issues as previously noted; devices need to be (a) portable; (b) inexpensive; and (c) address the individuals’ end goals. The success of a device is a combination of the functional improvement of it, the technological improvements, and to be personally meaningful in its impact on a user’s quality of life.

2.7.4 Uptake of new technology

There is also still a reluctance to take up a new technology. Bharucha et al. (2009) commented that many older adults express their receptiveness towards technologies in a hypothetical scenario - but this attitude does not typically materialize when the devices are offered to them. The older adults tended to minimize their personal need for a device when they were offered it. Devices that are ubiquitous and monitoring the environment have ethical considerations as well. They are designed to promote independence for the individual but a varying amount of privacy is compromised due to the nature of tracking and data collection to ensure the systems are effective. There can be negative associations when using a device possibly seen as 'assistive' which can reduce its uptake, even if it is useful (Galvin & Scherer, 1996; Kintsch & DePaula, 2002).

2.7.5 Acceptance, Adoption and Comfort

Aside from being usable and useful, the technology must also be aesthetically pleasing, age appropriate, fashionable, and culturally and socially acceptable. Devices that look "handicapped" are not adopted (King, 2001). Starner (2001) states many challenges of wearable computing; noting that 'a user's taste is an important factor for acceptance. The perception of design also affects the acceptance of a wearable.

Ariyatum, Holland, Harrison, & Kazi (2005) echo Starner's views and state that the physical appearance of a wearable plays an significant role in its acceptance; that it should fit the users' lifestyle and personality. Comfort needs to be taken into account (Bodine & Gemperle, 2003; Knight et al., 2007; Knight & Baber, 2005) as part of the reasons for new technology uptake. When taking into account all the factors for a successful device, the essence of what McCarthy & Wright (2004) wrote to 'view technology as experience' captures the essence of the thinking behind the device design, "Perhaps the most important aspect of experience that it makes visible is the potential for surprise, imagination, and creativity, which is immanent in the openness of each moment of experience." Figure 2.9 illustrates the links between the different areas of acceptance of a smart object. These terms are based on researchers linking topics throughout various studies in the papers studied for the literature review.

Acceptance: For a smart object to become part of a person's every day routine it needs to fit in with social aspects – to identify social boundaries that could limit a smart bag's

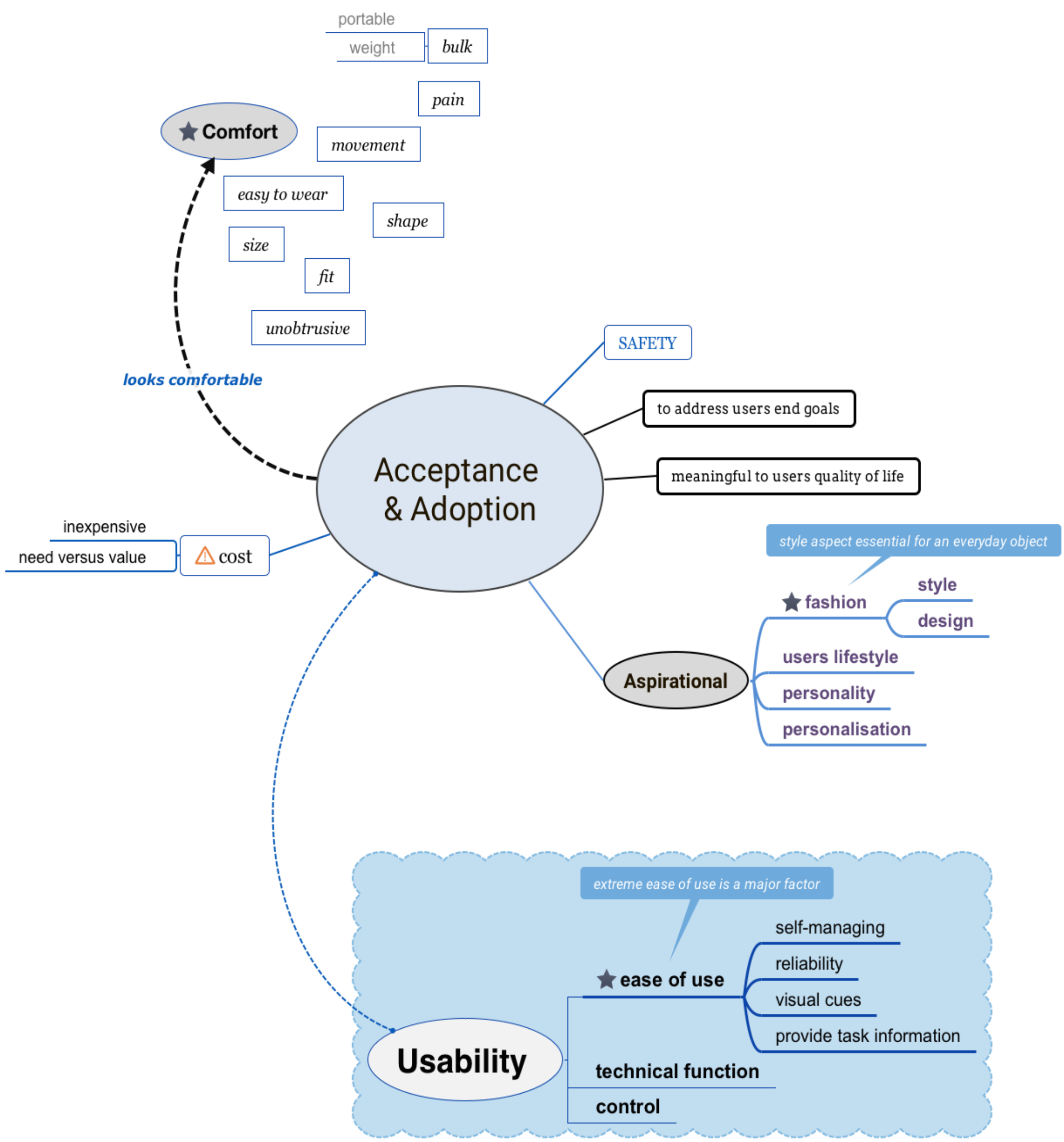

Figure 2.9 Factors to influence the adoption of a smart object.

acceptance. An interview with Kate Hartman by Nora Young on Spark[11] commented that things that look and feel more comfortable or more aspirational for us are adopted more quickly. This has an extreme influence on the rate of adoption. Also, they noted that a 'wearable' should become more of 'a part of us'. To increase adoption, factors such as cost and fashion as well as the design of these objects is a huge consideration. Therefore, we need

11 Nora Young (March, 2013) interviewing Kate Hartman for technology 'Spark' Podcast, Episode 212: 42min

to understand how it fits into a person's style universe. The level of acceptance mentioned for Weisers' concept, requires non-invasive technologies. These should be intuitive, self-organizing, self-managing and require minimal interaction by the user (O'Driscoll et al., 2008).

Adoption: Sonny Vu, CEO of Misfit Wearables, commented in an article (Buntz, 2012) that many of the wearable technology products are not wearable. "People 'don't 'wear' electronics, they wear jeans, tee shirts and belts", and following from work in UBICOMP it was found that products need to be invisible or unobtrusive[12].

Currently, the wrist is an area that people have accepted for wearable technology (Profita et al., 2013). Smart watches are socially acceptable, though the majority are using them as tracking and reporting devices and interaction with the device is minimal. Fashion is one way to drive acceptance; to enhance someone's everyday style and potentially allowing personalization. Duval & Hashizume (2005) did a study to understand how users adopt wearable technologies. They suggest requirements including, comfort, safety and control of the product. They also note cultural differences have implications for a product's properties and its acceptability.

Anderson & Lee (2008) also found that the primary concern for users is the style of the wearable. This was followed by price with technical function and widespread use also affecting its adoption. Comfort, bulk and the fit of a device are also highlighted by Bryson (2007) and Lin & Kreifeldt (2001).

Comfort: Comfort of a wearable can be affected by its physical properties. This includes the size and weight of the system and the effect the wearable has on movement and pain. It could be limited by psychological responses of the user; for example, the pride of the user when wearing it (Knight & Baber, 2005). To successfully 'mount a computer on a body', comfort issues need accounting for. The weight, size, shape, placement and method of attachment potentially alters the way a user can achieve their goals. Excess stresses could cause discomfort which could affect how a task is completed (Knight et al., 2007). A user expects both comfort and ease of use, and a product that is efficient (Bodine & Gemperle, 2003; Knight & Baber, 2005; Lin & Kreifeldt, 2001).

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12 Dufus Factor (2010) Retrieved July 2016 from http://www.qmed.com/mpmn/medtechpulse/overcoming-%25E2%2580%259Cdufus-factor%25E2%2580%259D-designing-wearable-devices-people-actually-want-wear#node-90791

2.8 Summary and directions for research

The design of a system to be used as a memory aid is a significant challenge, which demands an innovative approach, to assure that it is acceptable to and usable by individuals who think they are forgetful. Analysis of practices, both historical and current, into HCI, smart objects, and forgetfulness, advances us towards object-based solutions in creating a smart object to reduce negative feelings when we forgetful. If we can remember our essential items for the day, they there is a by-product of not feeling that negativity.

Research in the memory field demonstrates that the potential exists to improve an individual's quality of life. There is scope for further research to examine creating better memory aids that are unobtrusive and easy for an individual to use daily. Gaps in research on devices to support memory function and their benefits are also segmented and a technology device needs attention to be a success.

Previous research has revealed that there is scope for further research to bring together HCI, wearables, smart objects and the domain of forgetfulness. The following outlines the scope for a smart object in the domain of forgetfulness:

- Examining hurdles to designing a smart device for forgetfulness. Hurdles include issues such as; ease of use, reliability, unobtrusive, portability, provide task information, cues and costliness.
- Avoiding documented negative issues that affect wearables – addressing them with a new design. Typically, this includes: acceptance & adoption, primarily comfort.
- The usefulness of making an external memory aid; wide application across a variety of individuals of all ages.
- That an everyday object, a bag, is an ideal object to augment for a device dealing with forgetfulness as it is typically on-person daily, and few of these devices have been created and tested:
    - How an 'in-situ' memory device can help an individual.
    - The gap in creating an everyday object, augmenting a bag with technology.
    - That potentially, a contactless system can be easily understood by a user.
- The lack of extended user surveys or longitudinal autoethnographic research to document the use of smart objects.

Most of the devices discussed show evolutions through the designs, predominantly due to increased computer processing power and miniaturization of components. The devices also improve on functions or issues that needed addressing from earlier designs. Many of the designs use acoustic notifications, a visual interface, and some use vibration. In several of the designs the limitations are due to technological factors. Most the earlier technology systems relied on text based output and we see in the later devices that other various interfaces are being used, such as LEDs for notifications and reminders. There can be issues with a text-based output if a user does not remember to check them. We see this with apps and programs used as reminders. These types of reminders are often inappropriate to specifically target physical items. Additionally, the use of technology needs to be specific to the context. In this instance it is technology for a bag. Using an alternative approach for notifying a user may yield alternative results.

Also, many devices focus on retrospective memory rather than an object-based approach. We can understand from the systems presented within this chapter, that technology holds a lot of promise for supporting memory processes. However, there are many factors that need to be considered to ensure its success, as is seen by the many domains the literature spans.

Chapter 3 Design Methodology

"The faintest ink is better than the best memory" Chinese proverb.

Chapter Two surveyed previous work in the field on forgetfulness, smart objects, and wearables. Practices people use to aid with forgetfulness was studied to understand the need for a device. As Chapter Two highlighted, the design of a smart device to assist healthy individuals within the context of forgetfulness would benefit from further research. This requires addressing the current limitations of the lack of a 'task-based' memory aid and extensive in-the-wild and autoethnography testing with smart objects.

In this chapter my design-led approach of the research is described, the overall strategy adopted, and the reasons why. These are key questions for a qualitative methodology (Onwuegbuzie et al., 2009; Strauss & Corbin, 2008). My personal experience of forgetfulness coupled with the idea of a smart bag were joint starting points for the research. These prototypes are then tested through a variety of methods, from autoethnography with research journals, and single user studies.

The first section of this chapter details the questions asked and their context. The approach and study design follows. Next are the strategies for data collection and data analysis process. Table 3-1 lists all the prototypes built throughout the research. The Table contains the prototype name, the approach, how long the device was used for and what thesis section the full testing and documentation can be found.

Table 3-1 Guide to the object-based memory aid prototypes in the thesis.

Prototype Name	**Approach**	**Section**
Proof of concept (PoC) 	**Design** This prototype was used to establish the proof of concept. Based on feedback through an initial questionnaire, an autobiographical approach to design is used to create this first basic version.	4.4

This prototype is to first test the idea of an integrated bag with RFID ‘tagged items’. This is a Look and Feel prototype, as it will address the sensory experience of the product as well as an implementation prototype. This will address how the prototype will work. INTERFACE The interface consists of 5 flashing LEDs on the reverse of the bag. There are decorative LEDs on the front. There is also an LCD screen to be used for communicating information to the user. It has a large circuit board and 9V battery and case.	**Testing / Studies**	
	AU1 Autoethnography approach for the initial usability and operating of the prototype.	4.4.4
	EV1 professional critique. Participant observation.	4.4.5
Message Bag 1.0 (MB1)	**Design**	**Section**
 This is the first higher fidelity prototype that was created to be used over an extended period of time (18 months in total) by the author. INTERFACE The interface consists of ten LEDs around a front mounted circuit board. The five LEDs on the left of the board are for notes of items to remember, the five LEDs on the right are for objects. There are also three signalling LEDs at the top of the circuit board. These indicate an item being scanned as they flash. There is a rechargeable battery pack sewn inside the flap of the bag. In addition to the autoethnography study for this prototype, it was also used for a Pilot Study.	Integration prototype. Elements of the role, the aesthetics and implementation are all tested. Used to establish what changes in the life of the user, the sensory experience, and how the product will work. It was created after the feedback from the proof of concept prototype (PoC) was analysed.	5.1
	Testing / Studies	
	RW1 Residential weekend with potential users (Focus Group)	5.3
	AU2 Autoethnography approach will be used over 18 months. Over the course of time observations, notes, comments and drawings will be collected.	5.4
	EV2 professional critique: CHI Toronto, Canada CogSci London, UK	6.4
	PS1 Pilot including one to one interview	5.5

Unisex Messenger Bag (Uni)  This is one of three a prototypes that were used for the first time by participants in-the-wild (single user walk out SU1) away from the researcher. They are higher fidelity than previous prototypes. INTERFACE Through feedback from previous autoethnographic research, the form of this bag is different to the others. It is a larger unisex style. The interactive RFID system coupled with 5 LEDs is used. These 5 LEDs represent an object and is the corresponding light to a tagged item.	**Design** Experience-Centred design resulted in the Unisex Messenger iteration. Through using the previous prototype, feedback informed the changes that are reflected in this bag. This prototype is used for a single user walkout to establish what effects it has on a user's life. As it will be used in the wild, data regarding the aesthetics and implementation was collected. **Testing / Studies** **SU1** Third person engagement: single user walk out. One to one Interview. **EV2** presentation for professional critique: • Wearable technology show, Excel, London, UK • Creator Faire, National Space Centre, Leicester, UK • Wuthering Bytes, Hebden Bridge, UK • CHI: Toronto, Canada • CogSci Launch, London, UK	**Section** 6.1 6.2 6.4 & 6.5
Upcycled A (UpA)  From styling feedback received, a series of three handbags were created to be used as part of a single user walk out. This was to gain knowledge about the prototype with users in a real world environment.	**Design** The upcycled handbags (UpA, UpB, UpC) were all used for a single user walkout. This was to establish what effects it has on a user's life. Also, due to the styling data regarding the aesthetics will be collected. A research through Design approach is taken alongside autobiographical design to compliment the more traditional methods used.	**Section** 6.3

INTERFACE

This prototype has a form change that is using a classic 1950s handbag along with the modern technology components. The circuit board is visible in this version (and the UpB) rather than being hidden, as in the Uni prototype.

The form factor and quality of this handbag creates a high-fidelity prototype. It mimics how the item would be in real world usage using the actual materials for the actual device.

VARIANTS

Variations were made as there were two devices used at the same time for testing as part of the single user walk out.

Upcycled B (UpB)

Upcycled C (UpC)

Testing / Studies	
AU3 Autoethnography: Research Journals	6.3.5
EV2 Observation, Conference and Events: • Wearable technology show, Excel, London • Creator Faire, National Space Centre, Leicester • Wuthering Bytes, Hebden Bridge • CHI: Toronto, Canada • CogSci Launch, QMUL, London	6.4 & 6.5
SU1 Third person engagement: single user walk out. One to one interview.	6.3.6
EV2 Observation, Conference and Events: • Wearable technology show, Excel, London • Creator Faire, National Space Centre, Leicester • Wuthering Bytes, Hebden Bridge • CHI: Toronto, Canada • CogSci Launch, QMUL, London	6.4 & 6.5

Stand-alone Proof of Concept (SA PoC)

This is a proof of concept for a version of the device that a user can place on their own bag.

Design	**Section**
Experience-centered design. This prototype is a radical iteration from previous designs. Research through Design approach. This prototype was used by the author. The design was as a result of feedback obtained from the previous studies and comments at critique events.	6.6

INTERFACE This device has a small LCD screen that loops thorugh a pre-programmed list of items. This list matches a set of RFID tags given to a user. It has haptic capabilites to notify a user when an item has been scanned.	**Testing / Studies** **AU4** Autoethnography: Research Journal	 6.6.4
Stand-alone (SA)  This device is the same concept as the previous prototypes but in a different form factor. As seen through a proof of concept (SA PoC). A user will clip this to their bag and be able to use the system anywhere. This device is not off-the-shelf and the circuit board was created new and unique as the device did not exist.	**Design** This is a second iteration of an earlier portable proof of concept device (SA) that is presented in Chapter 6. The design was modified to be the same components and functions as the embedded (EM) prototype other than the form. When used for the field-testing with 6 users, role data will also be collected as we look to gain insight into changes in a user's life.	**Section** 7.1
INTERFACE There is a clip that is used to secure the device to any bag. There are five LEDs, each representing an object attached to an RFID tag. The device has an RFID reader on it that will read those tags. When read, the device will vibrate and a corresponding light will go on or off. There are also five white areas on this board so a user could write their items or reminders down.	**Testing / Studies** **AU5** Autoethnography documentation in journals and research diaries during a 3-week period of use.	 7.1.8
	EV2 Professional critique: three public engagement events.	6.4 & 6.5
	SU2 Field-testing: Comparative single user walk out with six participants. One to one interview. Paper questionnaire, online questionnaire.	7.5
Embeded (EM1, EM2, EM3) Message Bag 	**Design** The embedded prototype has evolved from the Unisex Messenger (Uni) that was described in Chapter 6. The EM bag is an integration prototype that will be used as a	**Section** 7.2

The original unisex messenger (Uni) prototype was badly damaged and this Em prototype has been built from that previous device. This is a masculine high-fidelityversion that was used for public engagement, and a comparitive single user walk out. INTERFACE Due to it being rebuilt for functioning purposes, the design was also modified from the feedback that was received from testers of that earlier prototype. Note there are three styling versions of the embedded style bag. These are documented in Chapter 7.	role prototype to learn about the effect it has on a user's life, as well as the look and feel and implementation.	
	Testing / Studies	
	EV2 Professional critique: three public engagement events.	6.4 & 6.5
	SU2 Field-testing: Comparative single user walk out with six participants. One to one interview. Paper questionnaire, online questionnaire	7.5
LED Only (LED)  A low technology solution with little interaction. The user clips this to their bag and the lights blink for fifteen minutes when the button is pressed.	**Design** This LED only design is used only in the comparitive single user walk out. It was offered as a low technology solution. This is in an effort to discover if 'any technology' at all is a good solution.	**Section** 7.3
INTERFACE This LED only prototype is made from a piece of felt that has the same clip as the SA prototype. It can be clipped to their bag or elsewhere if they prefer. There are two LEDs on the front of the device and two on the back. There is also a small replacable battery on the back and one miniture button. This button will turn the lights on. The device will turn itself off after a period of 15 minutes.	**Testing / Studies** **SU2** Field-testing: Comparative single user walk out with six participants. Used as an 'alternative' to the two similar prototype devices. One to one interview. Paper questionnaire, online questionnaire	7.5

3.1 Introduction

To initiate the research[13] the methodology followed was to outline the design stages: from establishing the system needs, the user profile, and creating working prototypes. The planning, my assumptions, the constraints and a generic system build for an RFID smart object are all described. That concept is then used as a design plan to guide the building of smart objects, which are described fully in Chapters 5, 6 and 7.

As per the design-led model of research, my own experience of forgetfulness was the epiphany that initiated change. Research was needed in to if others felt the same negative thoughts, and if it was also detrimental to them. That coupled with the use of an everyday item, which was a bag, and how technology could be integrated to create a smart object. These ideas formed the joint starting point for the research. MacKenzie (2012) describing human factors and creativity captures some of the initial motivations for this research.

> "Human factors is both a science and a field of engineering. It is concerned with human capabilities, limitations, and performance, and with the design of systems that are efficient, safe, comfortable, and even enjoyable for the humans who use them. It is also an art in the sense of respecting and promoting creative ways for practitioners to apply their skills in designing systems." (MacKenzie, 2012)

This chapter describes methods for designing the proposed smart bag concept. It builds upon the research presented in Chapter Two to address a gap in knowledge, bringing together:

- an augmented object,
- an established system in other domains (RFID),
- extended user studies, and
- users with perceived forgetfulness.

Questions discussed in this chapter which are particular to the domain of forgetful individuals include:

1. What system characteristics are important when designing a smart object for individuals with forgetfulness?
2. What is the 'use case' for designing this smart object?
3. What considerations are made for usability, according to the profile of forgetfulness?
4. What ways of working (planning, building…) should be considered?

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13 Work presented here appears in (Farion & Purver, 2013)

5. How to address hurdles for designing a smart device for forgetfulness - issues such as: *ease of use, reliability, unobtrusiveness, portability, the provision of task information, cues and costliness*
    - What design considerations are necessary for the device to integrate with someone's 'style universe [14]'?
6. Are contactless systems understood easily enough by a user, and what would the users mental model be?
    - How or what form could an 'in-situ' object-based memory device have?
    - Is there an everyday object that could be adapted through having technology embedded to augment its use? Embedding a contactless system?
7. What are the important hardware specifications for a proposed system with RFID Interaction?
    - What hardware components are to be considered?

It is anticipated that through answering the questions through the use of prototypes, and various testing methods, from single user studies to the autoethnographic approach, the research questions are addressed: Could technology embedding into an everyday item be effective in the domain of forgetfulness? and, What specific factors are critical to the design of a smart object?

3.2 RFID Interaction System

The central system across all ten prototypes consists of RFID interaction using lights for communication. This system does not need external support – meaning it is not connected to external information, databases, or rely on processing data elsewhere. Advantages for an RFID system includes: (i) the tags do not need a direct line of sight; (ii) low cost; (iii) scanning in any orientation and; (iv) no lighting requirements - the reading of the tags is not dependent on a specific light condition so it can be used at any time in any condition (O'Driscoll et al., 2008). The design methodology used relies on moving forward with higher-fidelity prototypes that become more robust and higher-fidelity as they progress. This is achieved through experience-centred and autobiographical design. The prototypes are all used in real-world settings to obtain information that can inform the next version of prototype. This iterative approach allows for errors to be flagged and fixed as they are discovered. A high-fidelity prototype is one which is as close to a real world version as possible (Norman, 1990; Rogers et

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14 Style Universe was a term used by Nora Young interviewing Kate Hartman for technology 'Spark' Podcast, Episode 212: 42min

al., 2011; Virzi, 1989). In the context of the prototypes designed for testing, the terms 'resolution' and 'fidelity' refer to the amount of detail and closeness to the eventual design. The prototypes presented in Chapters 6 and 7 will be close to how the eventual design is envisioned and with the detail of all the intended features to be implemented. These are Integration prototypes, "built to represent the complete user experience" (Houde & Hill, 1997). An incremental design process allowed small but necessary changes to be made when new information was discovered using the bags.

The first prototype (PoC) is an investigational design as a proof of concept. A proof of concept is a fundamental part of the design process, as at this stage the design can fall down before any investment is made, and a redesign can be done without much cost, of either time or financially (Rogers et al., 2011; Virzi, 1989). This is to help establish the concept of the device and is presented in Chapter 4.

3.3 Experience-centred and Autobiographical approach

The ten prototypes discussed in the research were initially used by myself before being tested by more traditional methods. These methods include survey and other real-world, third person engagements such as the single user walkouts (SU1 and SU2), the conference demo professional criticisms (EV1 and EV2), and residential weekends with potential users (RW1). My initial use of the prototypes was to establish: programming errors resulting in the device not functioning correctly, building errors such as zips not functioning which may create additional frustration for a user, or other factors that may inhibit as clear a user experience as possible, such as, the switch to turn on a device placed in an area that is or is not intuitive.

The context of autoethnography as a research method is that the prototypes were used on a daily basis, for real world observations. The smart objects were evaluated and observations were recorded uncovering detailed understandings through their regular use.

The design and experience-centred approach is used for all the final ten prototypes made. These devices were used separately in different environments, such as shops, cafes, work and travel. All testing is detailed in the Chapters that follow and there is an overview guide (Table 3-1) that contains the testing done on each prototype.

The design for the ten prototypes involved my sustained use of the devices in a variety of situations. One example, Message Bag 1.0 (MB1) was used over eighteen months which involved visits to supermarkets, airports, coffee shops, colleges, and work offices. The details of this can be found in Chapter 5, alongside testing from autoethnography research journals, a residential weekend with potential users, and three conference presentations, and a pilot study.

3.3.1 Autobiographical design

Autobiographical design was used extensively for the research. Through using my own perceived forgetfulness, I empathised with the potential users of the device. When documenting my experiences with a device in public, it mimicked the experience of others in my situation. Autoethnography allowed me to gather a variety of information including memos, notes, and photographs. Journals were updated daily to document the encounters had with people. Errors and glitches that were experienced were also documented on paper and sometimes with photos. These errors would be fixed as they happened, or shortly after. When it was not feasible to fix the errors for the version being using, the errors were documented in detail. These were then photographed so they could be fixed later or for the next version. Using the bags daily meant that details about the system usage and how it was received in public could be discovered. Alongside that, I was able to use prototypes unusual or irregular places and places that are not traditionally part of many people's regular experiences. People questioned if there were safety concerns when travelling with an 'electronic' bag, so it was used in those situations to respond to worries presented to me.

3.3.2 Qualitative research

Qualitative research suits the needs of my work. When information and feedback comes back from respondents, a fuller picture will emerge. Their feedback is used to make small but necessary changes to the device. Understanding is gained through sympathetic comprehension how an individual uses the prototype – in their own everyday setting.

> "Any object, product, system or service that will be used by humans has the potential for usability problems and should be subjected to some form of usability engineering" (Nielsen, 1994)

Qualitative research allows exploring everyday life; the understanding, experience, imagination and thoughts of a research participant. Qualitative research is interesting, important and exciting (Cox, Cairns, Thimbleby & Webb, 2010; Lazar, Feng & Hochheiser, 2010), it engages us with things that matter to us, in ways that are significant. The methodologies allow the capacity to build up compelling arguments with regards to how things are interpreted or perceived on a personal level and for contexts. It is qualitative research that will enable my understanding of (a) how using a device has affected or not affected a user, and (b) how they engaged with it. If they did not use the device daily, why not? Do they find it indispensable or do they leave it behind? Why? The nature of a qualitative study enables actual views about the device they are using to be gathered. It can then be interpreted and collated with others to make a device even more useful for more participants.

Where a quantitative approach would work for new software design for a memory deficient user, through counting clicks for example, that is not suitable for my area of study, as the device is very experimental at this stage. This is primarily because my work is trying to establish a new device, so there needs to be an awareness of that initial barrier – previous research highlights how personal decisions and thoughts can form a barrier to using a device. Do I get past this initial barrier with the device? This is essential for my research, "qualitative studies that focus on people's experiences with the technology could help researchers understand why and how their system is working—an outcome that we consider a central contribution of HCI work in this domain." (Klasnja et al., 2011).

Generally, qualitative methods aim to understand the attitudes and experiences; typically addressing, what, how or why; rather than, how many or how much. This is an appropriate approach for my work as understanding the perspectives of the participants and explore the meaning they give to the technology is paramount. This relates directly to looking for that 'quality of experience', defined by a range of items from 'how people use a product, the way it feels in their hands, how well they understand it works, how they feel about it when they use it, how well it serves their purpose, how well it fits into the entire context in which they are using it' (Alben, 1996). If the experiences are engaging, then users value them. However, a criticism of qualitative research (Rogers et al., 2011) may be that samples tend to be small, so they might not include an accurate spread of the population.

Many of the studies for wearables use qualitative research due to the subjective nature of the systems or artefacts. A central contribution of HCI work is through qualitative studies (Johnson et al., 2012; Cox et al., 2010; Sellberg & Susi, 2014; Strauss & Corbin, 2008) and as my focus is on a user's experiences with the technology - to gain an understanding of why and how the system is working and where it needs improving – qualitative research is the most appropriate. Guidelines for usability extended to five dimensions, as presented by Quesenbery (2003): Effective; Efficient; Engaging; Error tolerant; and Easy to learn. The idea is a question of balance, and all 5 domains are allocated a 20% portion. As you evaluate your designs, prioritise what is essential to your system; the balance for your design will become well-defined (Murchison, 2012).

3.3.3 Inductive and Deductive

My research adopts both an inductive and deductive approach, employed at different times throughout the study. The design of a smart object can be examined and tested with users to create a device that will be accepted and used by them. Data collected alongside their subjective views looks at the object itself and the way it is designed according to criteria. The criteria are formed from background research (as presented in Chapter 2). The nature of the research undertaken is exploratory. Researching to discover what responses are to a system that has not been built before, with an audience that is not typically tested. Due to the indiscriminate nature of many of the factors in my research, it makes sense to test things in a qualitative way. At this early stage, it is unclear if people will use a new device at all, if they will use it intuitively, regularly, or in a different way than hypothesized. It is unclear what effect using such a device will have with an unknown user group and although it is possible to anticipate certain outcomes.

The inductive approach (theory-generating) involved having a level of focus, to gather data and look through this information, see Figure 3.1. For my work, patterns were sought in the designs and devices: what was successful, what needed to be changed and from there what theory is developing? It is anticipated that a smart device could help in this field if it follows design criteria.

This work then becomes ‘reversed’, and so follows a deductive approach (theory-testing), Figure 3.2. This is used to examine the theory, create a device based on that hypothesis and test it. This approach is used in an initial phase, described in Chapter 5. After obtaining results from testing the prototypes described in each chapter, this deductive research approach is repeated to create a device that would meet more of the criteria, and ultimately be able to be tested in-the-wild .

Figure 3.1 Initial inductive approach taken.

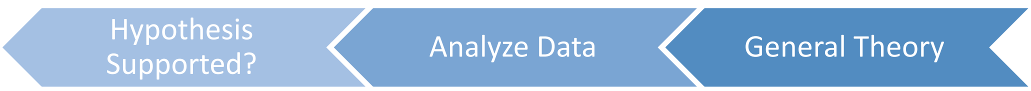

Figure 3.2 The deductive approach.

3.3.4 Iterative Design

Due to the research being highly exploratory in nature, the iterative design process is a suitable way to approach creating the prototypes. It will involve discovering what requirements are necessary in the device, and then modifying the design as research is conducted. This is a cyclic process to take the work from early stages of development to produce a high-fidelity prototype.

There are many strengths for my research to be using this type of system development methodology. Iterative design is useful for undertaking a system where there are potentially unclear objectives. At the early phase in the work, there are general ideas stemming from the research about what may or may not make a good smart object – as a prototype is developed the objectives will become clearer. It allows a space for experimenting with and comparing design solutions, experimenting with the HCI aspects of the designs, and it encourages innovation. Additionally, the prototype can be incomplete, and aspects of the design tested and modified. There is also the chance that unclear or missing functions will surface through testing the iterations.

Designing the perfect solution on a single attempt is not likely therefore HCI work needs to take into account the concept of iteration (Nielsen, 1993). There are benefits to working in this manner including that it encourages feedback so the device can be moulded into the best fit for requirements, any errors can be solved as they are discovered and lessons are learned as each iteration is made. Nielsen advises that redesigning user interfaces with iterations can substantially improve usability.

Additionally, as I too will be testing the devices as they are created for initial errors related to software or components it becomes necessary to fix errors as they surface so testing the device can continue.

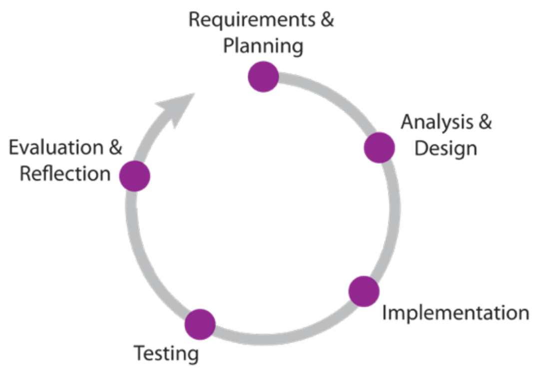

Figure 3.3 The design flow cycle for my system that is used, an interpretation of SDLC.

The mapping of the cycle of design to be followed is shown in Figure 3.3. The build of the system will follow a cycle of planning, designing, implementing those designs, then testing them and depending on the results, evaluating followed by planning modifications. It is necessary to have a phase of evaluation and reflection after different testing is taken. This is very much following the Systems Development Life Cycle (SDLC), which is along the spectrum of development methods such as Agile, Iterative, Rapid Prototyping and similar. Figure 3.3 is the version of design flow used. During the testing phase issues might surface that may need to be addressed to have a more efficient or easier to use system.

The Systems Development Lifecycle (SDLC) has development stages that ranges from definition to creation, implementation, and modification. The SDLC originated in the 1960s for developing large scale business systems – the usage has changed over time. Elliott (2004) describes, "the traditional life cycle approaches to systems development have been increasingly replaced with alternative approaches and frameworks, which attempted to overcome some of the inherent deficiencies of the traditional SDLC.

Part of this design phase looks towards the questions "Is my design a good design?", as asked by Dieter Rams (Cobarg & Rams, 1972; Rams, 1970b; Rams, 1970c; Rams, 1970a) alongside principles used for good design, the following six are predominantly relevant to smart object design (Rams et al., 2009):

Table 3-2 Principles of design, Dieter Rams (1970)

Dieter Rams Principles	
Innovative	Not an end to design – done to improve technology
Useful	A product needs to satisfy functional, psychological and aesthetic criteria. Good design is product usefulness.
Aesthetic	Integral to a product's use, especially when used every day.
Understandable	Aiming for self-explanatory object, user's intuition
Long-lasting	Able to last many years
As Little Design as possible	A focus on the essentials, simplicity

These Principles of Design as presented by Dieter Rams (1970) are a guide that will be considered as prototypes are mapped out, sketched, designed and considered. As the process of designing different prototypes to test different aspects of the system, for example, the use, look, or implementation, continues, there is an overall goal that the final versions of prototypes should encompass these principles to contribute to an overall successful design. This is revisited in Chapter 6 and 7 when the high-fidelity prototypes are presented and tested.

3.3.5 Mental Model

Work in HCI applies the idea of a mental model to improve usability. For example, we will see later in this chapter that some users preferred the lights to be always ON when the items were all packed, so that their bag would be a little unusual in public. The original designers model however, anticipated if the lights were on, it would signify that the item was missing. In turn, it was intended that they would scan the tagged object to turn the light off. This would also eliminate additional battery power required to keep a system lit during the day or evening. The users model may differ slightly to the designer's model leading to consequences.

It is essential to understand the user's mental model as the usability of the system will depend on it matching what the designer envisioned. Observing the user with the device will enable improvements to the usability of the system to make it more effective or easier for the user to understand (Aldrich, 1998; Johnson, Rogers, van der Linden, & Bianchi-Berthouze, 2012; Rogers, Sharp, & Preece, 2011; Satyanarayanan, 2001; Shneiderman & Plaisant, 2005), and through various visual cues the system can be designed so it is easier for someone to use (Nielsen, 1993).

There are three models of a system all defined slightly differently (Norman, 1983, 1988, 1986) using Norman's terminology (see Figure 3.4) :

1. **The Design Model** is the designer's conceptual model. The designer expects the user's model to be identical to the design model.
2. The **User's Model** is the mental model developed through interaction with the system.
3. The **System Image** results from the physical structure that has been built. All communication between designer and user takes place through the system image.

People form mental models through experience, training and instruction. Johnson & Henderson (2002) describe a conceptual model as, "a high-level description of how a system is organized and operates". The user's goal and their forgetfulness in mind suggests that a user would want to avoid reading a large detailed instruction book on how it operates (Gribbons, 1999; Norman, 1988). The best conceptual models are those that appear obvious.

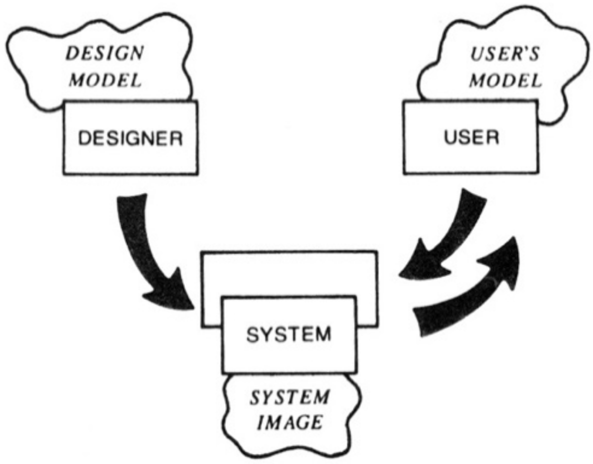

Figure 3.4 Three Aspects of Mental Models, (from Norman, 1986).

People form internal mental models of themselves and of the things with which they are interacting, using their mental model to reason about a system and how to interact with it. The more someone learns about a system the more the mental model develops – the internal constructs. The Design Model described as three phases:

According to the designer's conceptual model, there are 3 phases to using the device. These three phases or stages are needed for successful operation. The first and second phase are single 'set-up' occurrences, and then the third phase is repeated during use. This is illustrated and described in detail in Figures 3.5, 3.6, and 3.7. The goal is to have a system that is intuitive and predictable for the user. We will refer to our persona, Stephen as the representative.

PHASE ONE: Tagging

Stephen has an initial step to perform before he can use the system. This is the tagging phase (see Figure 3.5).

In this case, Stephen has a set of tags that are to be attached to the items of his choice. He may choose the items he most commonly forgets, such as keys and his wallet. Typically, this is a single use step but may be repeated later. The tags can be removed and applied to an alternative item should Stephen want to do so.

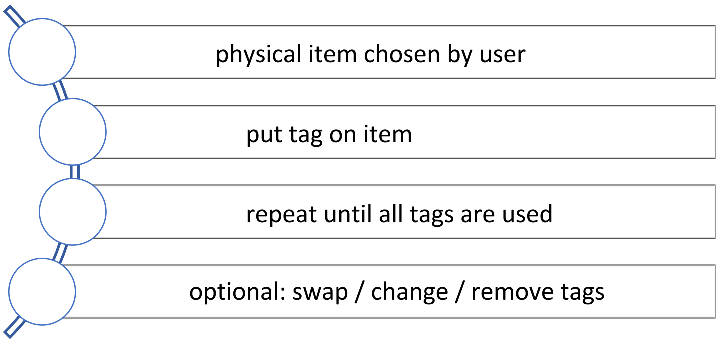

Figure 3.5 Phase one illustrates the first things the user would need to do to set the system up.

PHASE TWO: On & Pack

Once Stephen's items are tagged, he needs to turn the system ON. The lights / visual system will illuminate or not according to what has been scanned. The system is then ready for Stephen to scan an item that he has tagged, to pack for his day or a specific trip.

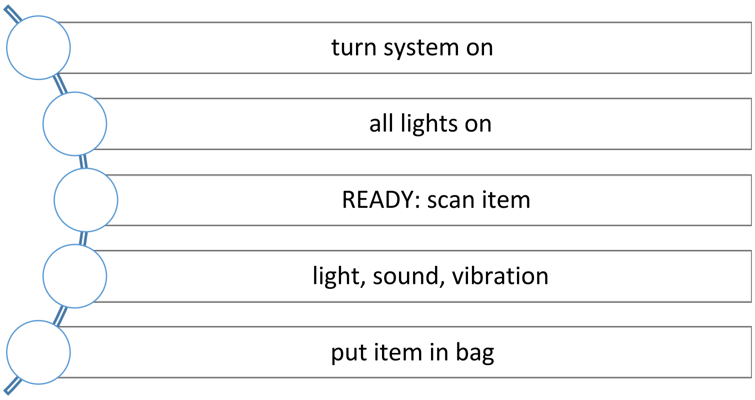

Figure 3.6 Second phase of using the system; on and pack.

Then Stephen notices the light turning off (or on, depending on their use), there may also be a sound or vibration to accompany this interaction. Stephen then goes about his journey and if he needs an item and removes it, he will rescan it 'out', and again the light will respond to that to turn on or off. This is shown in Figure 3.6.

PHASE THREE: Ready phase

Stephen may have placed the device on a surface, where he can glance across to it and see from the lights being lit or off which items he has packed, or is missing. It is this cycle that would repeat itself, shown in Figure 3.7.

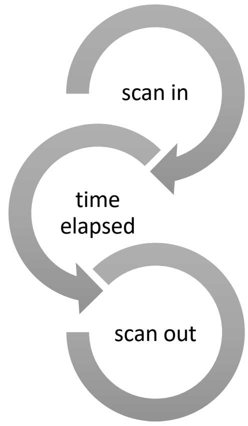

Figure 3.7 Phase three, perpetual use cycle.

Phase three has a common element of checking the lights; firstly, scan in or out, place the item in the bag then check the lights; secondly, take the item out, scan out the item (a loop interaction behaviour). This may occur after several hours have elapsed between each scan. The 'time elapsed' is the time until the user needs to remove the item from the bag.

Assumptions about the system and system use:

An assumption is made about Stephen predominantly packing his items indoors, largely based on the knowledge and experience that when individuals pack for their day ahead they are not outside.

Also, to note, systems with an RFID reader need to account for the tag reading range. The tag reading range is potentially limited, so objects with tags will need to be held close when packing. If the system is used outside, there is potentially bright sunshine that may drown out the lights. For this research, it is assumed the smart object is predominantly packed in an indoor environment and visibility and auditory signals would be perceived across a room.

3.3.6 Prototyping Models

Throughout the research a series of prototypes have been built and tested. The 'device' is the interactive system being built and the 'prototype' is the representation of the idea. The prototypes are used to evolve the design and explore options for the system. The prototypes look at, (a) what role the device will play in the user's life, (b) how it should look and feel, and (c) how it should be implemented. These are fundamental questions about an interactive system being designed (Houde & Hill, 1997). Throughout the research, different prototypes are developed and modified as testing reveals aspects to adapt. When looking at the model of what 'prototypes prototype' (Houde & Hill, 1997), there are three classes of questions – all requiring different approaches to prototyping, Figure 3.8 illustrates the model.

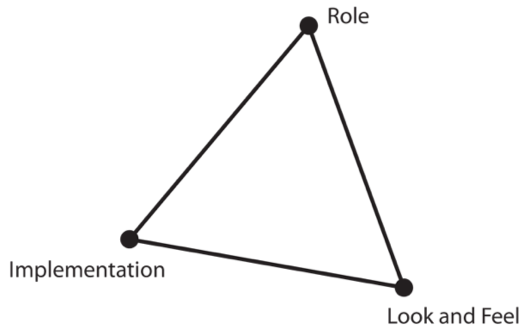

Figure 3.8 A model of what prototypes prototype (Houde & Hill 1997).

The prototypes developed filled several roles. Some were to establish initial 'design' aspects, such as modifying the appearance of the device. However, the role was tested after the initial proof of concept device, this device was not carried with a user nor used regularly. In the later prototypes, the role of the prototype was tested.

The main prototypes iteratively designed were the (1) Proof of Concept device (PoC), (2) Message Bag (MB1), (3) Upcycled (UpA, UpB, UpC) and, (4) Unisex Messenger (Uni). Later, (5) the 'Stand-alone' device concept (SA PoC) and (6) the Stand-alone, Tag Along (SA) were tested. For the prototypes developed, initially the Proof of Concept stemmed from needing to create a prototype to test the implementation, and to a degree the look and feel. It was too early at this stage to check for Role data as there were no users of the system. Once information was collected regarding the implementation and the look and feel, the second prototype was created.

It was clear from this stage when creating the prototype that it was Integration according to the Houde and Hill model. Therefore, the model became less useful by the second iteration of the prototype. This was because the prototyping phase needed to test all three elements. Single purpose prototypes were not being created to observe a single aspect. Had a prototype been created to just study the Role for example, data collected about the implementation would not have been possible, which is crucial for fixing errors. Additionally, when previous researched pointed that the appearance of an item for the domain of forgetfulness is important so there would need to be aspects of that studied.

It became apparent that this model would need to be adapted and that did not work for this type of prototype and testing – as higher fidelity prototypes were needed, that tested multiple areas. It was not suitable beyond the first two prototypes. Rapid iteration to fix errors and take the bag out for usage in-the-wild became the most important aspect.

3.3.7 Timeline of prototypes

The first prototype (PoC) was used to establish the look and feel of the device in its initial form factor of a handbag. It was not effective to study the role at this point as there was not a long user engagement phase. There was also a basic implementation of the working interaction. It also was only discussed and demonstrated in an artificial environment (critique engagement event) and not taken in-the-wild for usage. The first steps of the observations were to generate a conversation around the device and could users potentially see a use. The prototype has implementation, but only at a basic level to provide some interaction to the user and not necessarily how the system would operate in a final version. The workings of the system were not established in a final working way at this point.

The Message Bag (MB1) prototype aimed to discover the essential functions that the user may need. It was also to determine the look and feel, through implementation of functions. The MB1 prototype balances all aspects needed for initial user testing. This was the first prototype to be used extensively and so it was able to collect Role data as well. Through using an experience-centred approach, MB1 was carried for an extended and ongoing period of eighteen months. This was the officially recorded part of the research, with documentation in research journals. However, this prototype is still functioning and after some minor repairs, it is still used by the author. This prototype aimed to pull together information and feedback from all three prototype design areas. Early feedback and results were used to establish the next version of prototypes.

Prototypes (Uni, UpA, UpB, and UpC) focused on the aesthetics based on the feedback received, while the implementation was also modified based on participant's comments. The more masculine style of bag, Unisex Messenger was used for a third person single user walk out. The Upcycled prototypes were also each carried by a single user on a walk out. The design of these three are only different in aesthetics and they were created as additional bags were needed to run concurrent testing. These were the first prototypes to be used in-the-wild by users.

Lastly, the stand-alone device (SA PoC) was created as a proof of concept. This was primarily an implementation and look and feel prototype. This was because it was a radical departure from the previous prototypes as it was the first that was stand-alone – there was no embedded device with a bag. This design came about through the user testing where indications were that users wanted a device to be used with their own bags. I was the only user of this device as it was a proof of concept.

This was followed by the (SA) after usability, function and aesthetic information came back from using the proof of concept (SA PoC) device in the wild. This prototype was a higher fidelity. The prototypes (Em1, Em2, Em3) created and presented for final evaluations and studies in Chapter 7 were integration prototypes and high fidelity. All three prototype were used for a single user study that involved testing the EM prototype and the SA device.

3.4 Design Plan for Experiments

How will these devices be study and adapted to produce a prototype suitable for more robust concluding testing? As each prototype is created, the merits or flaws are not visible until it is studied. This section details a map of the studies undertaken to build up a range of prototypes. Table 3-3, is a guide to the studies that are employed and described in detail in Chapters 4, 5, 6 and 7.

Table 3-3 The guide for the studies as detailed in this section.

GUIDE TO STUDIES FOR TESTING DEVICES

	Study Method	**Details**
1	Questionnaires	Survey of Needs, Recruitment, End of Use Questionnaire The studies conducted were: Needs 1: Section 4.1 Recruitment 1: Section 7.4 EofU: Section 7.6.4
2	Conference, Events and Professional critiques	Prototype displayed in public for feedback. This may range from obtaining information concerning the overall look and feel of the device, to its use. Observations and conversations are noted after they happen and between encounters. These are noted in a research journal. The studies conducted were: • EV1: Section 4.4.5 • EV2: Section 6.4 & 6.5
3	Autoethnography: Research Journals Observations Recordings	Throughout the research the researcher will use the device, across different domains, (home, work etc.) and various situations. This will include general use of the device but will also include the prototype of the code to how the device operates. Errors in the code has the potential to alter the

		operating of the device and it will mostly be the researcher testing for the code errors that can modify the operation for future prototypes. The studies conducted were: • AU1: Section 4.4.4 • AU2: Section 5.4 • AU3: Section 6.3.5 • AU4: Section 6.6.4 • AU5: Section 7.1.8
4	Residential weekend with potential users: Focus Group	To collect data regarding the operation, as well as the look and feel, from several users at once. This took a discussion format. It involved many participants talking about similar views, opposing opinions and questions they had. Notes were taken at the time into a research notebook that was initially written down in short form and smaller chunks. This was expanded using recall after the discussions took place that same day. A focus group is qualitative research where a group of individuals are asked about their opinions on products, services, concepts etc. They offer their opinions, perceptions, beliefs and attitudes (Cox et al., 2010; Onwuegbuzie et al., 2009). This is done by asking them questions in a group setting and the participants are free to talk with others (Greenbaum, 1998; David, 1997). The study conducted was: • RW1: Section 5.3
5	Pilot Study	Primarily to check the overall study design and execution. This was in preparation of the single user walk out study that follows. The study conducted was: • PS1: Section 5.5
6	Third person engagement: Single user walk out in-the-wild study	Testing over several weeks, using a high-fidelity prototype. A comparative study where 6 users are using all three different devices. There are surveys, observations and notes as well as a short interview with users. The studies conducted were: • SU1: Section 6.2, 6.3.6 • SU2: Section 7.5

At each stage in the development and testing, prototypes are changed, and evaluated. One device leads to the next and so on. Due to the nature of the research being an iterative approach - with previous results shaping the next steps - the studies and testing is essential to the development of the work. Multiple design iterations forms a stronger and more successful device (Motti & Caine, 2014; Miner et al., 2001; Gellersen et al., 2000).

Additionally, as the prototypes are made, iterative methods are used to make changes as errors or inconsistencies are found. Additionally, relating to the earlier noted 5 Dimensions of Usability, each ‘dimension’ has its own testing technique (Quesenbery, 2003). With regards to particularly relevant areas of ‘Engaging’ and ‘Easy to use’, the following can be done: Engaging, user satisfaction surveys are conducted, or; Easy to learn, information given to the participants is controlled.

3.4.1 Professional Critiques and Events (EV1, EV2)

Throughout the research all the prototypes will be tested daily and at several events. Primarily this will be myself who will use the device created, and then take it into public and use it as intended. It was very important to fix problems as they appeared especially if it may prevent a prototype from working.

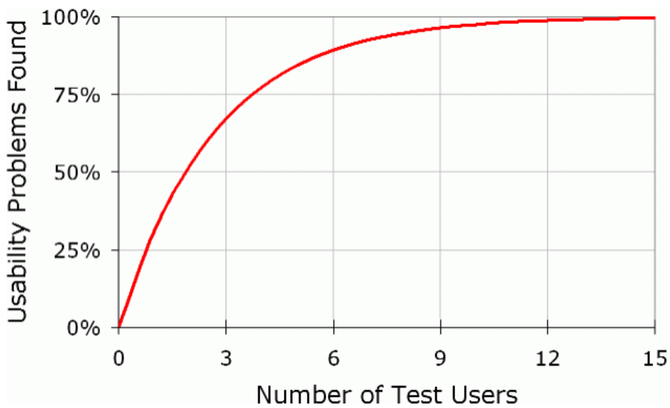

Figure 3.9 Graph showing number of test users and usability problems found, from Nielsen & Landauer (1993).

Professional critique events, enable a unique and very real perspective on a device as it elicited comments from the public in a variety of different situations. For the research, the understanding is of an iterative approach to prototype development and testing as proposed by Nielsen (1993), though there is a controversial aspect of his recommendation to use only three to six test participants.

The reasoning for this is that — as pointed out, most serious problems are found with a few participants, enabling prompt revision and repeated testing. This is a method to be used for the early prototyping phase. The idea proposed is to run as many small tests as you can, having no additional benefit from more than 5 users. The more users you add, the less you learn (Nielsen & Landauer, 1993, Lewis 1994, Turner, Lewis and Nielsen, 2006). It enables addressing issues that are pointed out, say, at a conference or other large event, so that the prototype will be refined. This method is used predominantly as a formative evaluation (while the designs and use of the item was changing) and then use alternative testing for a summative evaluation (nearing the end of the prototype design process). This is detailed in Chapters 6, where there are many iterations to the design, and Chapter 7 where the design is ready for its final testing and there are no more changes.

Additionally, my own extended use of the prototypes as they are developed will be of benefit to the discovery of fixes and improvements to the system. This is through my own 'need' for this system, I do not have a medically diagnosed memory condition, but feel strongly that I am forgetful and so can empathize with the users of this system.

3.4.2 Final Study Design rationale: Single User, in-the-wild

The study design described in this section refers to the main final in-the-wild comparative study (within subjects) that is undertaken and is profiled along with the devices used as described in Chapter 7. Having the device tested with real-use in real situations is essential so that many of the qualities of a successful device can be observed; for example, public acceptance and the users own style.

In-the-wild studies are increasing in prevalence as ways of understanding how new technologies may potentially disrupt, support or enhance our everyday activities. In this thesis the term in-the-wild is used as Rogers (Rogers, Sharp, & Preece, 2011; Johnson, Rogers, van der Linden, & Bianchi-Berthouze, 2012; Liu & Clemmensen, 2011) use it: to mean studies which involve deploying new technologies in real-use, real-world situations, then studying how they are used in this context, often with the intention of improving a design. Implicit within this type of methodology is the idea that physical and social context will have a critical effect on usage (Rogers, 2011).

These studies, which evaluate prototypes in ways that acknowledge the realities of their intended context of use, offer richer findings to those from a study conducted in a lab setting. The collection of thoughts from testers will be truthful to a real-world scenario if they take the device with them and use it as they normally would use that item. Using an item temporarily and in an unnatural way, as can occur with a lab setting, is of no benefit for my research goals.

3.5 Strategies for Data Capture

Common techniques used for HCI research are interviews, field investigations, field studies, contextual inquiries, case studies, focus groups, storytelling, walkthroughs, cultural probes etc. Because of the nature of subjectivity, it can be difficult to measure the effects or results, and tends to focus on human thought, feeling, attitude, emotion, passion, sensation, reflection, expression, sentiment, opinion, mood, outlook, manner, style, approach, strategy, and so on (Carroll, 1997; Carroll, 2003). These human qualities can be studied through observational methods, but are difficult to measure. Observations involved note-taking, photographs, videos, or audio recordings rather than measurement. Qualitative data, economical, fast, efficient method for obtaining data from multiple participants (Krueger & Casey, 2000) is appropriate for the study of these devices.

Research journals were used extensively throughout the research. This involved having notebooks that were carried with me while using a prototype. The prototypes became my main handbag and substituted my own bags. These memos, notes, observations were recorded as they happened where possible. On the occasions where this was not possible, note were taken as soon after as possible. Any notes that were done in haste were then re-read soon after, the same day if possible, and then transcribed into legible documentation.

Questionnaires

There are several questionnaires that are used for the testing in the final study:

- Initial recruitment questionnaire (online) Recruitment 1
- Pre-device questionnaire (online)
- Daily questionnaire (online)
- After device use questionnaire (paper) EofU Section 7.6.4
- Post-device questionnaire (online)

Each of these questionnaires served a different purpose. An initial recruitment questionnaire was used — to collect initial data and suitability. A pre-device questionnaire was used for participants that may have responded to a request for participants from a different method. It makes sure they completed an initial questionnaire and met with the requirements. The Daily questionnaire forms the bulk of the study. This should be completed every day whether they use a device or not. If no device was used, the questionnaire would finish and track that it was not used for their journey. The post-device questionnaire is used after a user has completed using the device. They should fill one in after using the device for the 5-10-day period.

The questions to assess how forgetful they think they are, are difficult to word, "Because complaints about forgetfulness do not correlate well with objective memory test scores, a patient's self-reported memory complaints have been treated as unreliable information for diagnostic purposes." (Mol et al., 2006). Questions that have been used for self-perception include; "Do you have problems with your memory?", "Do you find that you have trouble with your memory?" or "Do you have complaints about your memory?" (Geerlings et al., 1999).

The online questionnaire is to be used in the first instance for recruiting participants. Questions vary from rating scale questions, individuals are asked to state their opinion on an issue on a 1-10 scale, to tick box style questions. One open ended question offered the opportunity to the respondent to voice how they felt about certain issues. Additional data was included to establish certain status, preference and contact information.

An additional feature of online questionnaires is that questions can be created that are mandatory, to progress through. This should be used sparingly and for when a response is necessary, for example if someone is unsuitable for the survey or to eliminate further questions. The quantitative questionnaires were disseminated in two formats, online and paper-based. Quantitative questionnaires are useful as the results derived are measurable against other variables in an objective manner.

Observation & Notes, Informal feedback

Observations were done in an informal way – observing individuals using, touching, trying, the devices while at a conference, talk, event or generally in public. Many observations of how an individual interacts or uses a device should prompt changes to the device. If a user is finding the device difficult to use, or cannot figure out the communication of it then it may need changes, this is a paramount component of informal testing. As observations took place, entries were made into the research journal. This would often be accompanied by a drawing or a photograph if possible.

Qualitative semi-structured Interviews

This was an interview that was defined by a pre-set question guide which was used as a prompt. The aim was to gather in-depth findings through an informal discussion with a participant. This interview method was chosen over unstructured or structured interviews, for a few reasons. The main study intends to answer the research questions by asking some specific questions, but not so many (unstructured) that will generate useless data. Additionally, not too few or so precise and inflexible (structured) so unanticipated information is not missed. Semi-structured interviews afford the opportunity to go into some detail of the user's personal experiences. This is directly in line with gaining knowledge as to how useful the device is to the participant and if any changes to their daily routines occurred. The interviews were suggested to be a five minute duration, but some participants spent longer, up to 15 minutes. This was useful as it gave participants an opportunity that an online questionnaire could not. When an online questionnaire is used, it could be that individuals do not wish to type out long answers about their experiences, or that stories of their usage would not surface. The questions are structured around issues raised in the literature review about forgetfulness, which is crucial for the development of the smart object.

The semi-structured approach offers an opportunity to probe answers where needed to gain a better understanding or to fill in the gaps a partial answer may have left. These interviews, provide rich insight data illuminating an individual's experience and attitude to the device. Potential drawbacks of interviews are the time-consuming nature to organize, conduct, transcribe and analyse. Data collection and analysis for this study was guided by, but not strictly held to, a grounded theory methodology in terms of the interviews taking place at different times, so will be transcribed after they take place. In some instances, this leads to findings from an interview shaping questions for a subsequent interview. Each respondent will be asked for their consent to the interview, prior to any questions being asked.

Primary data is collected from participants using online questionnaires, paper questionnaires posted to them, and semi-structured interviews over Skype. Data from the semi-structured interviews was collected through recording Skype conversations with recording software on a Mac computer. The conversations are then transcribed.

Video Capture

Initial considerations were to use video interviews, observations and a lab setting as possible ways to get more detailed, measurable data. This would have enabled me to capture details such as how long it took a respondent to pack their items (in a timed amount for comparison) or to observe general demeanour and if the situation has certain levels of stress or similar. It was decided that the data obtained from these methods would not be as beneficial as a users' own observations when using the system. Also, a video in a person's home might not necessarily reflect the true nature of that activity. Typically, a user might pack one or two items at a certain time, and pack others as and when they need or remember them. It would not be practical to film over such long timeframes or different user locations.

3.6 Approaches to data analysis: Coding

For my work, data is continuously collected and analysed. This is in part because the iterations on early devices created rely on user feedback which is acted upon to create the next working prototype.

Coding is an analytical process in which data, in both quantitative (such as questionnaires results) and qualitative form (such as interview transcripts) is categorised to facilitate analysis. It is an interpretive act, and when initially reading my research journals, there are first impression phrases that are derived from initial coding. For the residential weekend focus groups, there were field-coded terms. Codes were assigned as data became available. There were participants commenting on similar functions of the device, so a code emerged that best described the groupings of their thoughts. This was important as it allowed (Marshall and Rossman, 1999):

- Focus on everyday life experiences
- Valuing participants' perspectives
- Enquiry as interactive process between researcher and respondents
- Primarily descriptive and relying on people's words

For comments from individuals during the events and conferences, a Descriptive Code was applied to capture the theme of what that individual is describing. Descriptive Code summarises the topic of the excerpt (Saldaña, 2015). For questionnaires and single user studies, pre-coded terms were anticipated. Information and results that were made will be a part of that classification. For example, 'types of faults' were used as a category for early testing, and this was divided into software, hardware and design or form errors. Based on the type of research conducted and the experimental nature of the device, it was not possible to pre-code all the terms to apply to the data for classification. There were also times when the data was highlighted as coding was undertaken and direct text codes were selected. These in-vivo codes became important as it highlighted the similarities of direct words between participants. Also, in vivo coding allows the data to stay rooted in the participant's own language.

During this process memos were extensively used alongside the research, "Memos can be used to map research activities, uncover meaning from data, maintaining research momentum and engagement and opening communication." (Birks et al., 2008). Memo writing is used in GTM to support coding and developing categories. It is stated that memos be kept continuously as this enables a researcher to reflect on the interviews and are thought to be of high relevance as they can spark ideas. Memos featured heavily throughout my research. These memos became invaluable to reflect on what had been done previously, what did not work, what others commented to me that could modify or improve my research and general designs and images to trigger ideas.

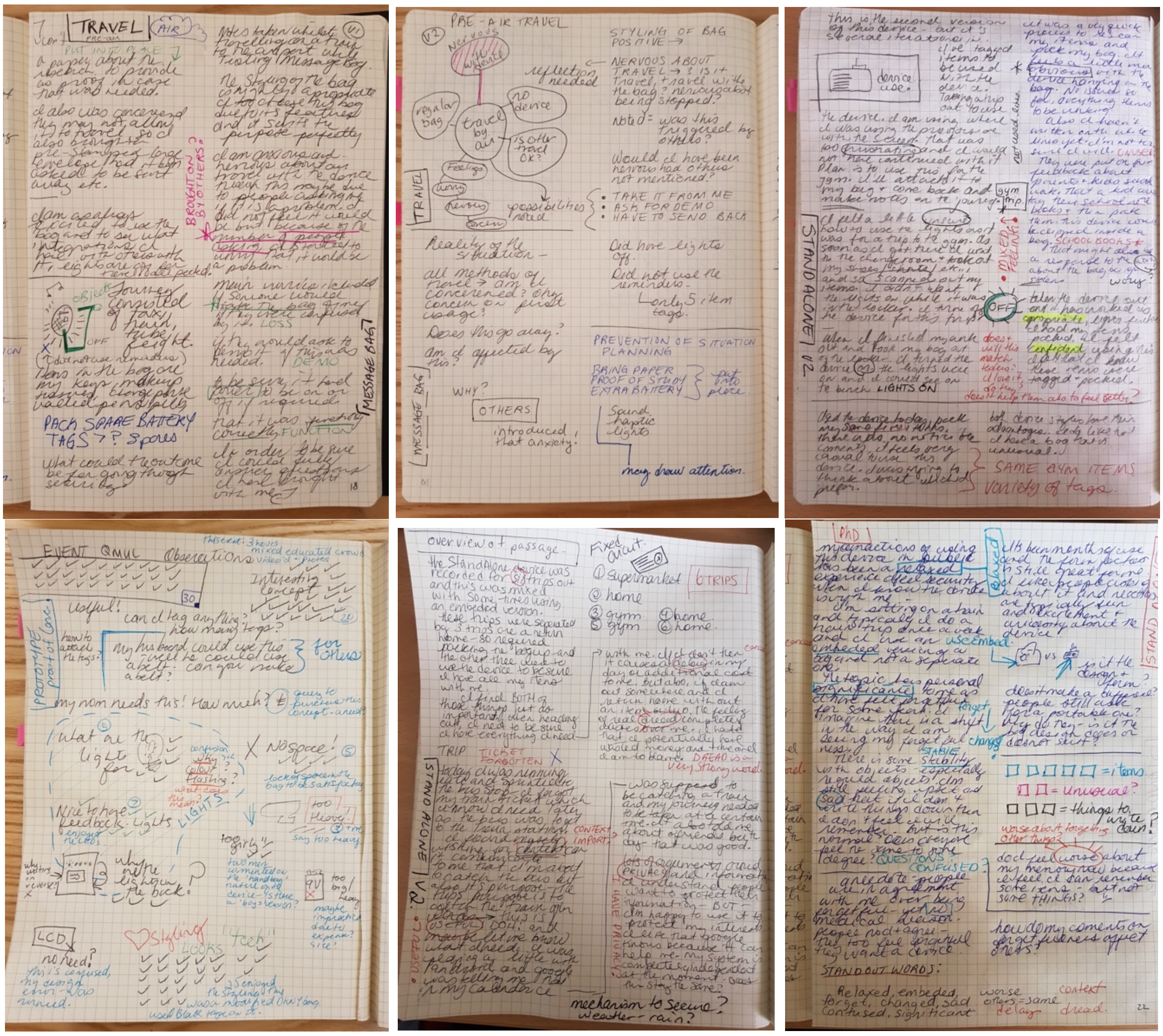

Figure 3.10 A selection of pages from my research journals.

The documentation in the research journals (shown in Figure 3.10) is primarily text, and occupy several notebooks and hundreds of pages. Being able to refer to work from the past made the work stronger and has an accountable history. Therefore, there was an account from where particular ideas, or themes originated and developed. The journals, as they became full were reread and using the margins, memos were written to group similar thoughts, ideas and observations. Essential ideas and planning were carried forward to a new journal. The remaining journal was then grouped and highlighted for recurring themes and thoughts. Memo writing is considered a priority by Glaser (1978) who describes it as a way to ensure retention of ideas that might be lost without committing it to memos. Many research journals were kept throughout the whole of the PhD research with me. When using the devices in-the-wild over a course of many months, notes were made, drawings and photos taken of interactions that took place with people and places. These notes were then often re-transcribed as they may have been written in haste, and to collect my thoughts in a more organized way. That transcription would take place at the end of the day so the event was still fresh in my mind. After a week or more, depending on the number of notes and entries collected, the margin areas were used to write headings, codes, content titles and similar (marginalia). This was a way to organise in a first instance what the general content was on that page. Notes and entries often also became part of a to-do list of errors to fix or improvements to make on future devices.

The data was organized by creating a thematic analysis that grouped data points. Where this is explicitly used in the thesis there is a table in the corresponding section, for example as shown in Tables 5-2, 5-6, and 6-4. These themes are characterized by the user and their relationship with the device. Themes such as critical issues, user variants and additional qualities were developed from one particular study. In subsequent analysis iteration, themes were revisited according to the data. Coding is the initial step, it is not just labeling, it is linking, "it leads you from the data to the idea, and from the idea to all the data pertaining to that idea" (Richards & Morse, 2007). The themes are the outcomes of coding, categorization and analytic reflection.

When a research journal became full, I went through the entire journal and copied essential notes forward, as a starting point for the new journal. In total there have been over twelve Moleskine Extra Large, 162 pages, both sides, squared notebooks used.

Grounded Theory Methodology (GTM) provides a researcher with the tools to learn about an individual's perceptions or feelings regarding a topic. Strauss and Corbin, (1994) describe for example using questions such as the difference of *wanting to know if one drug works better than another*, "[…], if someone wanted to know what it was like to be a participant in a drug study […], then he or she might sensibly engage in a grounded theory project…" (Strauss & Corbin, 1994). This is useful where there is a small sample number of participants. My largest study involved six participants. GTM has characteristics of qualitative methods that are used for my research, namely; valuing participants' experiences it is descriptive, it relies on individuals' words; and has a focus on everyday life experience (Marshall & Rossman, 1999).

Where semi-structured interviews were recorded, the recordings were transcribed afterwards on a computer so that any gap in knowledge became apparent. Predominantly, GTM utilizes in-depth interviews which are structured. As the respondents have spent a short amount of time with the devices, in-depth interviews were not appropriate as the user's contact time with a device is not a prolonged experience. Additionally, Glaser (1978) advises to make initial findings before conducting a literature review, so the researcher does not come to the study with preconceived ideas. However, studies were done with the guidance of Charmaz, (2006) for the study and literature reviews were carried out before collecting data. Without conducting an initial review, deciphering what had already been done in the field, where there was a gap and how a device potentially needs designing to meet with the needs of a forgetful individual would not have been possible to know.

Interview transcriptions had been initially put into MAXQDA software as had other data collected. When reading and rereading the transcriptions, it was more difficult to follow my own codes as they were highlighted them than when on paper. Paper allowed me more manual control of my codes and freedom to analyse according to the text itself and not the capabilities of the software. As my datasets were small, typically six was my maximum, bringing out the intricacies of their comments in a more informative way was done effectively on paper. Arrows added to reference other parts of their text and highlights or comments in an immediately visible way.

The software does have advantages in terms of being able to quickly search and tag codes, in-vivo codes and similar. One search for the code 'scan' was brought up across my data 102 times for example. Had my interviews been of a longer duration or if there were more participants then MAXQDA (shown in Figure 3.11) or similar software for those studies could be more effective. On reflection, for future studies importing all the data into an application such as MAXQDA and use a combination of both methods. It would be the type of data that determined the best method to follow.

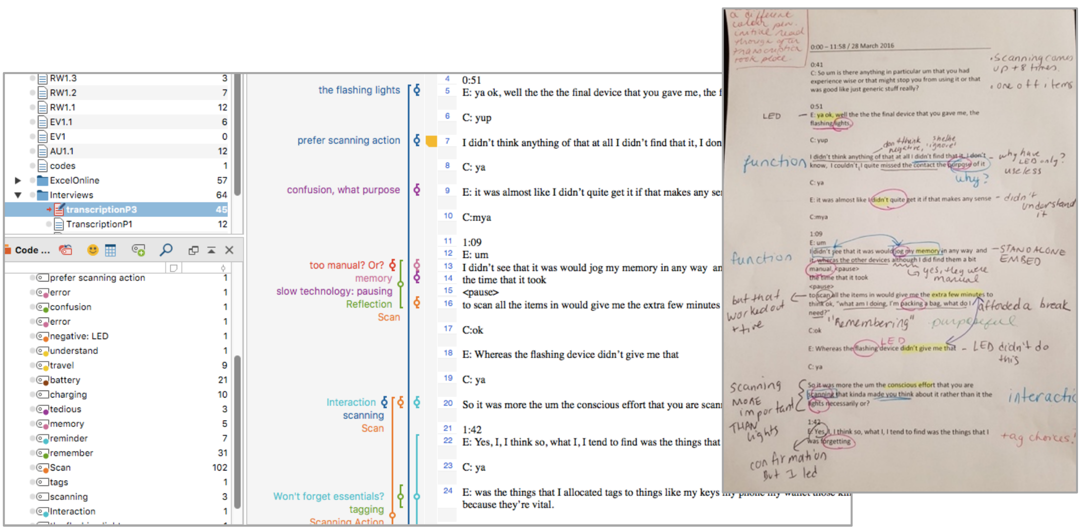

Figure 3.11 Initial coding with MAXQDA software and paper based coding.

3.6.1 Error recording and repairs

An additional integral part of the development of these prototypes to the work stems from note-taking and sketching. Sketching ideas happens throughout the design process. It is an effective visual communication tool. These drawings can be used for reference or built upon later. Throughout the development ideas were sketched, connections, comments, small areas of focus, entire systems and any thoughts that may later become central to the development of the device and research. Figure 3.12 shows a typical sketch in my notebook. The sketch is a result of previous sketches with corrections and annotations of individual components and their mappings. This was an integral part of my work as the sketches were referred to throughout the building phases. It also provided a way to establish where things may have gone wrong and equally, how to reproduce a system.

The Lean UX principle, ‘Permission to fail’, is applied to my way of working. One of the goals to creating a high-fidelity set of prototypes to be used to test a variety of factors applies the permission to fail principle, which leads to an increased mastery of skills (Gothelf & Seiden, 2013). This is through feeling safe to fail, to allow experimentation — which breeds creativity, and in turn yields creative solutions. Gaver, Bowers, Kerridge, Boucher, & Jarvis (2009) indicate in their paper, Anatomy of a failure…, “Although it is commonly argued that failure is instructive, reports of failing designs are rare in the literature.”

Instead of focusing all the energy and resources on one perfect ultimate device made once, many iterations happened. Sometimes they worked, other times they failed – or devices did not address or work in the way anticipated, and the process adapts to learn and adapt. Through this learning process an end goal was achieved of creating a set of prototypes that clearly address my research. Additionally, as research accompanies each development phase, as new ideas emerge and are tested, errors were responded to for improvements.

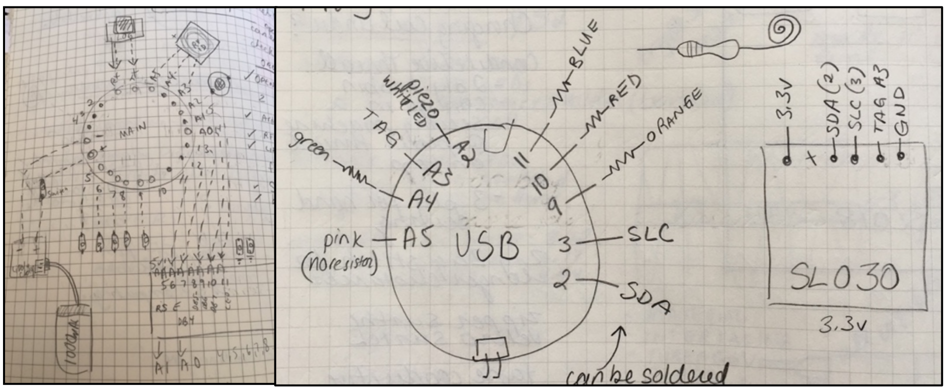

Figure 3.12 Pages from one of my notebooks with a sketch of a circuit.

This is very much a ‘test everything’ approach. Possible ways of addressing the issue, the solutions, how this affected the prototypes and these changes are noted at every stage of the work were researched. Once the general theory of the design was acquired, it was checked if it worked.

3.7 Potential Limitations of the Experiments

It is essential to anticipate limitations within the study. Broadly within my analysis, potential areas of limitations occur for: location; timescale; device return and age. These are discussed in abstract terms and questioned as possibilities. These issues are examined in detail and addressed once the prototype systems are created and problems are encountered.

Location: Participants will not all be physically located in the same region. Is it important to ensure the respondents are all situated in certain geographical locations – they would all experience the same weather conditions for example, or should this have no bearing on the study? It is decided that all participants are in the UK, for the conditions to be similar and ability to post items out for testing.

Timescale: Potential participants and recruitment could take longer than anticipated or planned for. Will individuals holiday plans need to be taken into consideration? Do the participants agree to use a device over a period of time? Do they ‘give up’ part way through? This is also related to the concern of a device being returned which is another potential issue.

Device Return: Other timescale issues could involve some participants having to wait for a device to be posted to them. What if a device is not returned at all? Will the device be returned in a working state, as it was handed to the participant? What will be my course of action if the device is returned broken or heavily damaged or in a state that the next participant will have altered views on it if it was used in the state it was returned in?

3.8 Access, ethics and informed consent

Informed consent was obtained from all participants in all varieties of testing that was undertaken. This was gathered at two intervals in the SU1 and SU2 study, firstly, when the initial recruitment questionnaire is provided via a consent form that is electronically signed to proceed. Secondly, participants who were selected to be a part of the in-the-wild comparative study were given explicit instructions as to what the study would involve. They also sign an electronic document in advance of participation if they agreed.

There were also semi-structured interviews conducted with many participants through Skype and this was recorded. Permission was asked for at the start of the recorded session and was given verbally. The verbal consent was also recorded at the start of the interviews though this was not transcribed. All respondents were given participant numbers to mask their identity, to use their number allocated to fill in the questionnaires. All other online questionnaires also had electronic consent and participants were not able to continue with a questionnaire unless they were able to agree to the terms and conditions given in the 'information for participants' section.

Ethics understood as the appropriateness of one's behaviour in relation to the rights of the participants about a study in which they participate. The study conducted concerned adults with no cognitive difficulties and all had signed a consent form. For my study, there were no ethical considerations or dilemmas found. However, as a precaution due to the nature of interviews, they were designed in a way that it did not offend, harm, provoke or stress any of the participants. It was also discussed prior to the interview that participation was optional. The study itself was presented to the ethics committee at Queen Mary University of London and received approval Queen Mary University of London, Research Ethics Application No. QMREC1159. This is in Appendix A as well as the form users complete for permission to proceed with the survey.

Lastly, evaluating one's actions (Duncan, 2004), or critiquing extant literature on a topic of personal significance (Muncey, 2005) can have personal consequences. Reporting for example, anxieties or forgetfulness episodes can bring upon embarrassment and shame in itself. The researcher has a responsibility to report honestly for the autoethnographic findings to ensure the fidelity of the research. Especially when reporting from their own point of view, a researcher also needs to be aware of mentioning others that they encounter and not revealing details that may identify someone. Ellis and Bochner (2003) question, "Is the work honest? Does the author critique and show herself? Does the writer [or reader] have an emotional epiphany? and, Does the story enable the reader to understand and feel the experience it seeks to convey?". These questions became important guides as experiences were recalled when using the prototypes. What is the authenticity that is need to transcribe and record that best reflects the accuracy of what happened?

3.9 Design Cycle

My methodology followed a framework which is mapped out as: **Everyday Items into Effective Smart Objects**. The goal of many technologists is to create effective smart objects. In my research specifically, the focused domain concerns forgetfulness. My work followed the design cycle outlined in the 'Everyday Items into Effective Smart Objects' model in three main areas. The following are the key concepts and the relationships between them. The first central element of the proposed approach is the creation process of generating a design. Figure 3.13 illustrates this process.

The Everyday Items into Effective Smart Objects Framework incorporates the following parts:

(1) Creation Process: Definitions

The creation phase included a (i) well-defined user goal as a reliable foundation, which explains the basic concepts of that user's needs, how they can achieve them and how a potential system can address this. This includes the use case scenario. Then (ii) apply the domain specific definitions.

For example, within my own research the user has an overall goal to pack their bag successfully. This is so they can go on with their day feeling less anxious. Therefore, the system design should address, forgetfulness and how focusing on this is described as 'doing forgetfulness' - conceptualized as, reducing complexity, creating and maintaining routines, dealing with feelings of embarrassment and shame.

This builds on previous work by Norman (1988) stating the importance of defining the user's goals. Additionally, the notions of designing 'for' users comes into play, as a first degree of involvement (Ståhlbröst et al., 2009). This creation process will also establish (iii) what features and functions specific to a 'smart object' the device will have. Does it need Wi-Fi, Global Positioning System (GPS), photographic ability, sound recording, lights or similar.

(2) Build Procedure: Variations for suitability

A build procedure followed that consisted of a period of research and testing to discern (I) the suitability of the system components for use. This build phase is referenced to the research carried out during the previous creation process, where the definitions of the use case scenarios will be defined. During this procedure, when prototypes are being constructed, notes concerning what the prototype establishes and to match Implementation, Role, Look and Feel, or Integration Prototype to suit the task. As with my own work, it is likely that there will be a combination of prototypes to be able to discover different aspects of the total system. It may also be appropriate to test these different prototypes using different methods that are suited, from expert, novice individual or focus groups for example.

There is a phase of (II) prototype building, testing and rebuilding. Once the prototype is created, it is tested in-situ for real world results. This phase highlighted component durability and usability issues (for example) such as; battery life, components not working correctly, coding free from errors, and similar useful information. After this phase is repeated as many times as is necessary, a (III) dominant high-fidelity prototype emerges. This cycle was a departure from the Rapid Iterative Testing and Evaluation (RITE) method (Medlock et al. 2002).

The proposed framework highlights the need to reference the previous phase (1 – Creation Process) to access the research that took place concerning the specific domain the smart device is addressing. It is this prototype that is then used for a final testing phase which is for performance activity, to check that this device performs according to the user's needs.

The cycle for this phase is defined as:

I. System Components Planning & Research for build
    a. reference the research from Phase 1
II. Low-Fidelity Prototype Building
    a. Testing in-situ
    b. Collect feedback
    c. Review feedback
    d. Plan changes
        i. check against user needs / variations for suitability
    e. Modify prototype
    f. Repeat
III. Dominant design emerges, high-fidelity Prototype

(3) Performance Activity: Macro Level

This phase consists of using the high-fidelity prototype to check for the 'usefulness' according to the user definition in the first phase. This stage is a detailed look at the user feedback and examining usability – to check if the user's needs are met and goals satisfied. This should be taken to a macro level. The specific goals cannot be achieved if the basics and lowest level of the device are not operational. Examining, for example, why the battery weight affects a user, how it impacts their day if the battery is too heavy, and how suitable and useful is this device according to that user. The information from this phase is more user focused in terms of performance and ease of use; is it working as intended and does the user successfully complete their task? Figure 3.13 is the process as documented in this section.

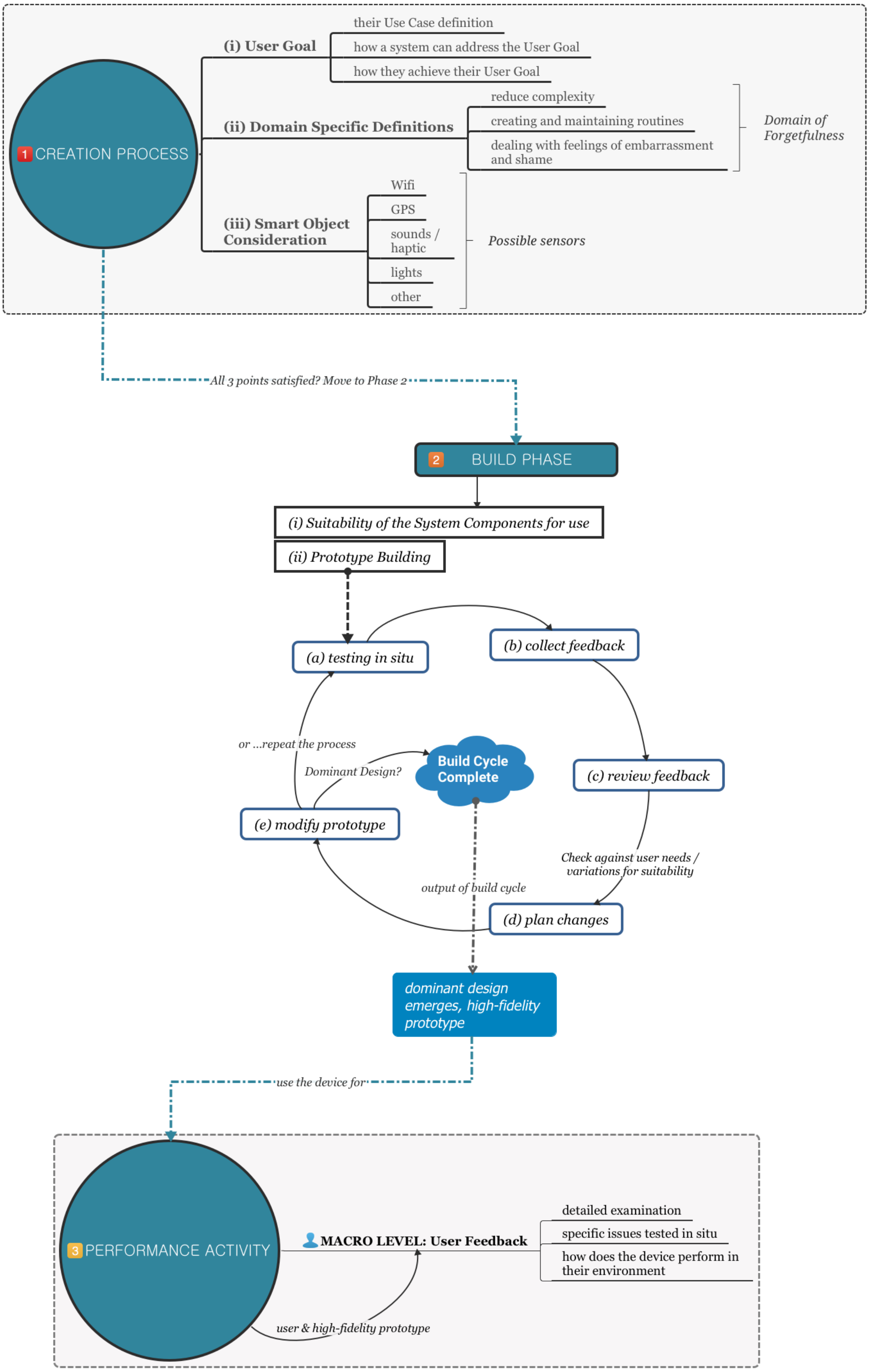

Figure 3.13 Everyday items into Effective Smart Objects framework mapped out.

3.10 Chapter Summary

This chapter begins with an overview of all the prototypes, their conceptual model and the studies that were conducted for each of them. Table 3-1 provides the details and the section where each of the prototypes can be found throughout the thesis.

In this chapter qualitative studies are described as an appropriate way to evaluate the prototypes created. The reasoning is that my work is explorative and as information and feedback is obtained from the users, a fuller picture of the device and its use will emerge. That feedback is then used to make changes to the device. The nature of qualitative study will enable me to discover exactly how an individual used the device – in their own everyday setting. Further into the chapter, the studies are defined that allowed me to collect data regarding (a) the design of smart objects, and (b) what impact this device could have on an individual's daily life.

Autobiographical design enabled me to reflect on my own needs and my empathy with the user's to create a prototype to be used and tested. This is supported with autoethnography documented through research journals. My experience-centred approach allows for many iterations of the smart bag device to be developed as and when errors surfaced.

The proposed system using RFID for contactless interaction was presented. As part of that discussion, the designer's mental model, which consisted of three phases was highlighted as: (a) an initial Tagging phase, followed by (b) an On & Pack phase, which then became (c) Repetition of Interaction phase of scanning and checking items.

This chapter closed with my ways of working and the methodology that were used to create devices according to the research domain of forgetfulness. First described was an inductive approach; to collect as much information as possible in my research domain of forgetfulness, followed by a deductive approach; to examine the theory collected to design an appropriate concept device. Illustrated during the deductive phase were many iterations of designs that will happen. A Design – User – Iterate – Present – Design – User – Iterate and so on… cycle emerges. The concept of iteration is important in HCI work (Nielsen, 1993) and it needs to be taken into account to ensure a successful design.

Chapter 4 Proof of Concept

Following from the methodology chapter, this chapter discusses the first design implementation, a proof of concept prototype. After a survey of needs was conducted, a user profile, the system requirements, and the initial design was developed. This was used to create the proof of concept (PoC) prototype. This Chapter details the results of my reflections when testing the device in the wild, and feedback obtained from one public engagement event. Primarily, the prototype was used to explore the experience of the device and its interaction. This was documented through detailed journal notes. This initial testing was also used to discover user errors and abnormal functioning of the device before testing in the public. Once this initial testing phase was complete, the device was demonstrated and discussed at a public event.

Table 4-1 Details of Proof of Concept Prototype (PoC)

Proof of concept (PoC)  This prototype is to first test the idea of an integrated bag with RFID ‘tagged items’. This is a Look and Feel prototype, as it will address the sensory experience of the product as well as an implementation prototype. This will address how the prototype will work. INTERFACE The interface consists of 5 flashing LEDs on the reverse of the bag. There are decorative LEDs on the front. There is also an LCD screen to be used for communicating information to the user. It has a large circuit board and 9V battery and case.	This prototype is used to establish the proof of concept. Based on feedback through the development of a tangible object is this an area to pursue. Autobiographical approach to design is used.	Section 4.4
	Testing	
	AU1 Autoethnography approach for the initial usability and operating of the prototype.	Section 4.4.4
	EV1 One public event, (professional critique) to collect comments and observations.	Section 4.4.5

It is anticipated that the work in this chapter will contribute to addressing, 'What specific factors are critical to the design of a smart object?', to create a higher fidelity prototype to test the designs and concepts further. The data will inform further development in my design-led approach.

Through my own forgetfulness and the stresses I believe it causes in my life, I wondered if an existing object that was carried with me daily, a handbag, could be used to create a smart object, to help me. After realising that I carry a bag regularly, it was decided that observing people in public was needed to see if there were other everyday items that could be appropriate. A casual observation phase was spent throughout three weeks at different times, noticing men and women and the bags they carry. From these initial observations it was apparent that most did carry a bag with them. This starting point prompted me to take a further step of investigating. It was necessary to discover what items people were forgetting and if they do use a bag. At that point it was decided to conduct a survey of needs for more direct answers.

The concept initially was to create a smart object from an everyday item – in this instance a bag. A bag would be altered with technology so that items that needed to be packed were tagged. A person could look at the bag across the room and see if items were missing through visual feedback. The feedback would be simple, in the form of lights. One light per item.

4.1 Survey of Needs (NEEDS1)

An online survey was conducted to establish the needs of a memory supporting device. There already was a pre-conceived idea that a bag might be a good object to augment. This was based on casual observations over several weeks of what items people used daily. To establish if this would be an appropriate item as well as how people feel about their forgetfulness experiences, an initial questionnaire was established.

4.1.1 Study Design

This questionnaire was used to examine data that would be current and establish if there was credence into people experiencing forgetfulness in their everyday lives. In this instance, an online survey was chosen over a paper based one: for economies of paper as it was a long questionnaire so it would have had many pages, cost effective reasons such as printing and postage, and a potential delay in getting responses. As the questionnaire was to establish if there was a need, results were needed in a timely fashion.

The questionnaire set out to establish how people felt when forgetfulness occurred in their lives and to see what types of emotions they experienced. It was also to collect information on the types of items they carry with them. This data gathering was important to collect sufficient and relevant information to help plan the initial course of research. The only prerequisite was to establish if the respondent had any medically diagnosed memory issue. If they did, the questionnaire would finish. They also had to agree that their information would be used for research purposes.

Details

This was a 20-question survey. There was initial general survey information at the start of the questionnaire, followed by 'Information for Participants' that explained privacy, data protection and how their responses will be used. They had to accept the information in order to progress with the questionnaire.

The survey was divided into four sections: Self-Perception and Memory; Specifics of Memory; Systems; and Demographics. (The full questionnaire can be found in Appendix B.)

Goals

1. Aim to learn the nature of forgetting: what, when, how often?
2. Aim to learn the impact of forgetting: feelings and thoughts.
3. What common items are forgotten?
4. What strategies are used?

Details

This questionnaire had 91 individuals respond and of those individuals, there were 59 males (67%) and 29 females (33%). Three people had no response to the gender question. The range of ages of participants was 18 – 60 (the average was 35 years old). All 91 (100%) of the respondents have no medically diagnosed memory condition as it was a requirement for this questionnaire. The questionnaire was posted online through Twitter, Facebook and Google +

It was essential to establish the perception of their own forgetfulness, and 57 (63.3%) respondents considered themselves forgetful.

1) Nature of forgetting: what, when, how often

Discovering *how often* an individual feels they forget things was the first goal. Respondents were asked, "Do you feel you are forgetful?" The wording of 'feeling forgetful', is based on work that established that it was not whether a person was actually forgetful, they just needed to think they were forgetful in order for these negative emotions to be apparent and affect their lives in some way.

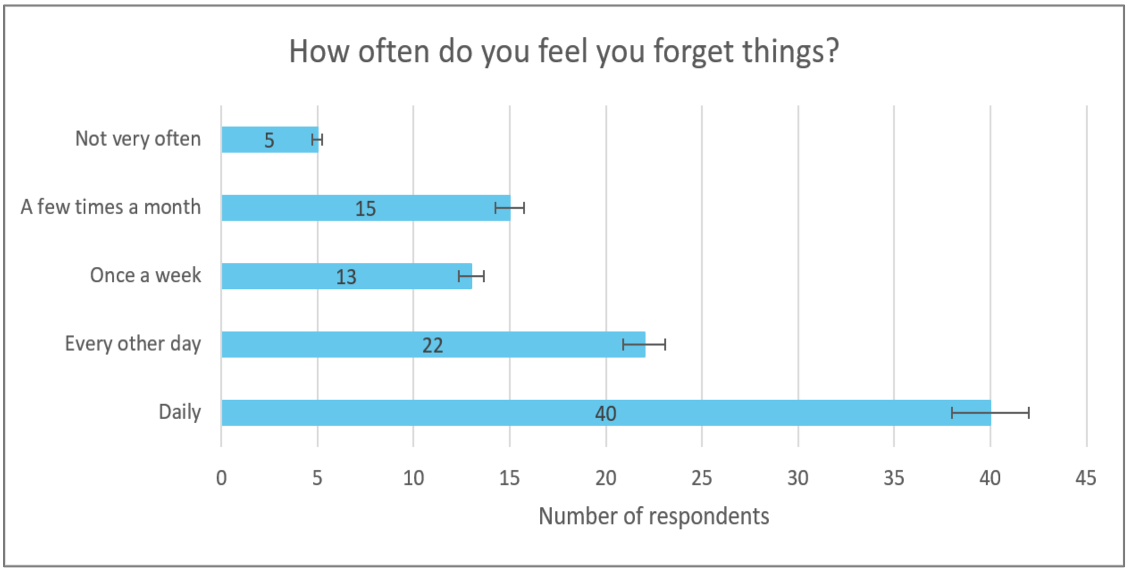

Figure 4.1 How often respondents say they forget things.

Although 63.3% Responded that they see themselves as forgetful, when asked how often they feel they forget things, many respondents, 75 (83.2%) said that they forget once a week or more often (shown in Figure 4.1). Note that 95 responses were collected from that question as some participants selected more than one answer.

When asked about the *types of things* an individual forgets, there were common items listed by respondents as seen in Table 4-2:

Table 4-2 Commonly forgotten items.

QUESTION: DO YOU TYPICALLY FORGET…
Items you need
56.7% (51 respondents)
Things you're supposed to do
66.7% (60 respondents)
Most commonly forgotten items
Keys 95.6%
Phone 95.6%
Wallet / Change purse 93.3%
Pens / Glasses both are 45.6%
Other **various items** that came up several times are Laptop (32 respondents mentioned), travel card 30, notepads mentioned by 29, business cards by 23 people.

The number of people who included ‘other things’ that they forgot was:

46 forgot their train of thought
24 forgot their appointments
9 forgot locations
30 individuals chose ‘other’

From the online survey, we see motivating evidence of people forgetting ‘objects’ that are typically smaller items. Also, 95.6% of the individuals listing keys & phones as their most commonly forgotten items. These become important to note as all the top items; wallet, change purse, pens, glasses, are all items an individual would be able to carry with them.

The largest item listed, by 32 respondents, was a laptop. If we look to a commonality – we know all these items can be carried in a bag – they are not forgetting very large items that they can not bring with them, for example a large work laptop. This point becomes very motivational for the design of a possible augmented or embedded smart object; we could create a bag in which to store all these commonly forgotten items.

It was important to establish what systems people use to help them remember, so open ended questions were asked such as, “Do you have any systems in place to help you remember? i.e. Post-it notes or things you do to help you remember?”

A representative sample of some of the responses as they were written included:

- *“Yes, I leave things in predictable places where I’ll see them or automatically have them” (in a bag for example)*
- *“Yes, I use a GTD*[15] *system on my phone”*
- *“Notes in iPhone Lists on scrap paper At work a post it to remind of anything in the fridge!”*
- *“Reminders on iPhone, also calendar reminders. Notepads at work”*
- *“I use google tasks a lot”*

Also, even with all these systems put into place, and apps and various other methods used, nearly 75%, 65 respondents, still forgot things when using their systems, see Figure 4.2.

The questionnaire followed this up by asking individuals: if they do use alternative systems, how effective do they think they are, on a scale of 1-9, (shown in Figure 4.3). Overall, people did feel confident in their systems, though their comments included things like – ‘*as long as I remembered to check my lists’*.

[15] Get Things Done (GTD)

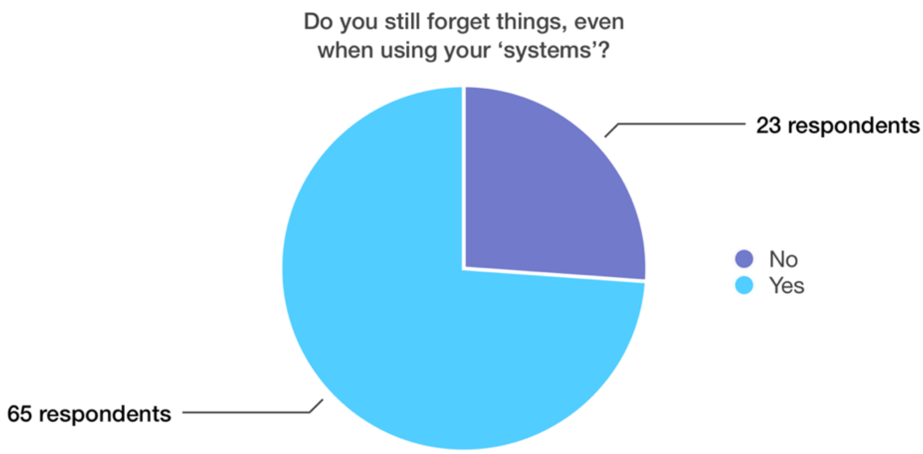

Figure 4.2 'Do you still forget things when using your systems?', 65 respondents (almost 75%) replied 'Yes', from 88 responses collected.

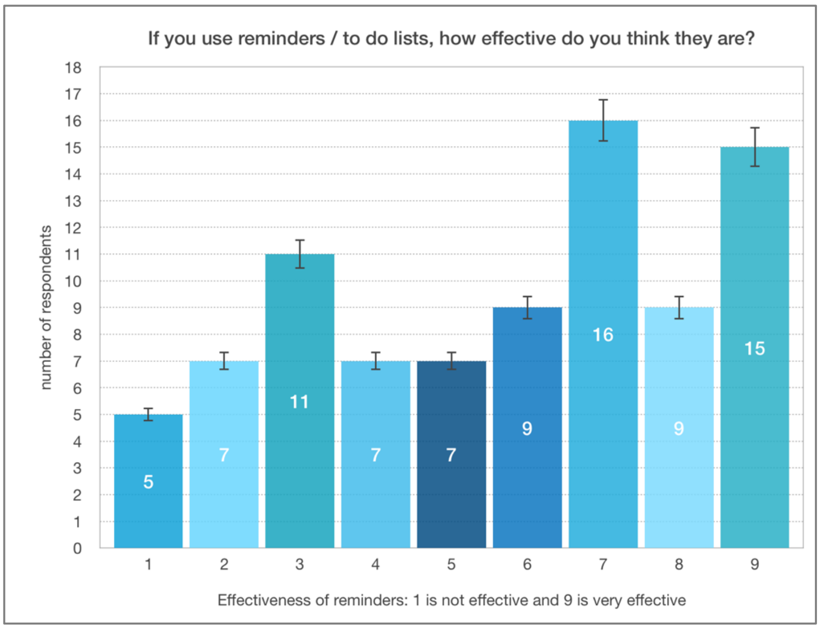

Figure 4.3 How effective do you think your reminders are? (1 is not effective 9 is very effective)

Comparing Figures 4.2 and 4.3 we understand that 49 respondents of the 86 that replied to this question (54%) feel strongly '6+' that their reminder systems are effective. However, when asked if they still forget things when using these systems almost 75% said that yes they do still forget. So, even though they still forget when using the systems, they felt they were effective.

2) Impact of forgetting: what, when, how often

Additional fundamental information to establish was; are there negative emotions associated when forgetfulness occurs? All respondents (100%), whether they felt they were forgetful or not, experienced very strong negative emotions. The following is a selection of the responses, transcribed exactly as written. Many words appeared over and over, such as stupid and angry (the full account can be read in Appendix C):

- *Foolish dumb, upset, Panicked, angry, stressed.*
- *Stupid, dumb, annoyed at myself. Even angry.*
- *Frustrated, sometimes embarrassed.*
- *In extreme cases, annoyed or worried that my forgetfulness will get worse.*
- *Anxious I feel that I forget something, but have no utter clue what*
- *Guilt, irritation, sadness, aggravation*
- *disappointed with myself, Confused mostly. Then annoyed. Then I try to concentrate on what I've forgotten. Annoyed/angry with myself, sometimes angry at the person who pointed out that I forgot something. Panicked! Throws me off my stride, makes me realise I'm stressed!*
- *anxious, a failure. stupid Annoyed.*
- *Depends on what it is I've forgotten. If it involves someone else (a meeting, a birthday or their belongings for instance) I feel guilty and irresponsible, like I've let them down. If it is my own stuff I feel resigned! If it is something unimportant that can be replaced or fetched later I don't worry anymore (aside from mild frustration).*
- *Bit pissed off with myself to be honest*

There is scope for further research about healthy individuals, as confirmed by the questionnaire, because of the negative reactions seen from all respondents. These negative reactions indicate there is a need for a solution, that could reflect positively on an individual's life. Lastly, an additional piece of information also gathered from the survey was how they felt forgetting impacted their lives. Most people described an "off" feeling for the day, being upset and / or agitated.

The full data set from: 'Does this impact the rest of your day when you forget something, how?' can be read in Appendix D. The full dataset from: 'Do you have any systems in place to help you remember? i.e Post-It Notes or things you do to help you remember?' can be read in Appendix E.

4.1.2 Questionnaire discussion

From an initial starting point of using a bag embedded with technology for the domain of forgetfulness, the survey was necessary to confirm several points and collect current data. These points are; what items do they forget, what strategies people use, and how people feel when they forget.

The survey revealed items that people forgot were: keys, phones and wallets, which are very commonly forgotten, over 93% each. We forget the items we need to successfully go about our day. These items can be placed in to a bag so it helps to confirm that a bag is an appropriate everyday item. These smaller items can all fit within it.

People surveyed said they used ‘get things done’ systems, notes on paper, post-it notes on walls and items, leaving things in predictable places and lists on fridges. Even when people are using systems they believe to be helpful – a ‘to do’ app for example, they still forget, almost 75%, or they do not remember to open the app. From the data obtained, current practices are not helpful.

Additionally, as 100% of the respondents felt negatively about their experiences when they forget, it is an area that would be able to improve people’s lives if addressed. There is a lot of negativity associated with forgetfulness and people felt badly about themselves and at times unable to go about their day. The sentiment of, disappointed with myself, was felt by participants. From the emotive language used in this survey it demonstrates the negativity that people are affected by when the forget. If the smart object can help in the domain of forgetfulness, then those negative emotions would be encountered less.

4.2 Design concept

As seen in Chapter 2, forgetfulness can impact an individual’s life negatively and has ongoing consequences that can include stress, anxiety, embarrassment, shame and feeling “off” or “unsettled” throughout their day (Ponds et al., 1997). Relatively younger people blame this forgetfulness on tension, emotional problems and poor concentration (Imhof et al., 2006). These daily feelings can lead to longer overall negative feelings and changes to a person’s lifestyle; they create coping mechanisms ranging from waking up earlier to ensure things are packed, to constantly checking their items. My research looks at ways a smart object (in this instance an augmented bag) can reduce their negativity therefore enhancing overall quality of life. Ubiquitous computing allows us to look at the traditional bag in a new way, by embedding technology to support the user through the ability to communicate with them, notifying them of the things that are in fact packed within. Although non-routine items are often forgotten, as the survey (Section 4.1) demonstrated that 93% of users still do forget keys, phones and wallets, the everyday items. It will be these everyday items, that the smart object will focus on.

It is also within this use case of forgetfulness that autobiographical design can play a part. Sengers (2006) argues that it could be appropriate to employ autobiographical design; to design with respect to details of the designer's personal experience. The circumstances to engage this would be in particular to the point of; when the designer has thought through carefully how his or her own experiences may be useful for or taken up by the target audience (Sengers, 2006). My own experiences of forgetfulness and the frustration that follows, provided me with a base to understand how others may also feel.

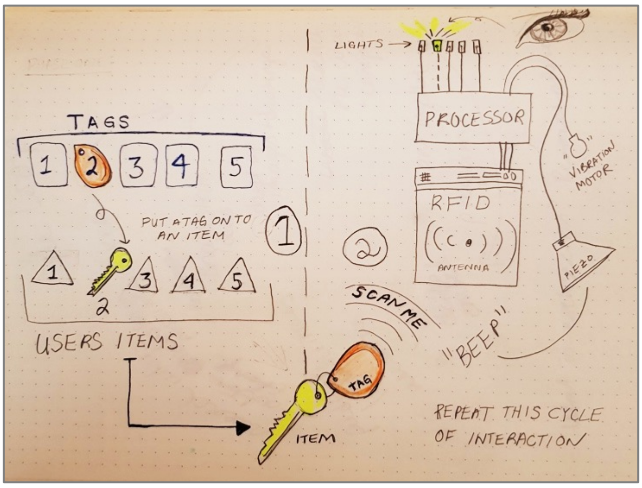

Figure 4.4 System sketch from one of my notebooks with 5 tags mapped to items

When the device is used in public it is with similar feelings and understanding as the individuals who will test it for me. Further examination into the design process is that the designer would need an empathetic understanding concerning which aspect of their experience is of interest to the intended audience (Neustaedter & Sengers, 2012). Self-usage is a means for better understanding the system design and that experience of my own usage with prototypes helped to evaluate and iterate the design.

The experience involved long-term, genuine use of the devices as they were created and in a variety of locations and situations during which knowledge was gained about the device. This is documented in Chapters 5, 6 and 7 as part of the experiential testing undertaken. Empathy is an important concept in HCI research. Concerned with the "influence technology has on how people think, value, feel and relate and using this understanding to inform technology design" (Wright & McCarthy, 2008).

For this research, adults with no medically diagnosed memory conditions are the target group of users. In our society, bags vary in nature from backpacks to wheeled luggage, sports bags, kids tote bags and designer purses; but none can communicate to us what is inside them, and through this lack of information, we frequently forget items we need or waste our time checking what we packed. This smart device concept, aims to improve the way we currently use bags, through recognition over recall to reduce the load on the user's memory.

Drawing on the research presented in the literature review, from the strengths and weaknesses of previous work as well as the needs of individuals with forgetfulness, the interest is in a system that:

- requires no additional cognitive load
- has a minimal learning curve
- provides information about what they have packed through visible feedback: what item is left to pack
- is a contactless system
- fits in with existing behaviour

4.2.1 The User

For a best use case scenario, it is important to design for a specific individual with a specific need. The idea of creating personas (Cooper, 1999) was introduced as a practical interaction design tool. User characteristics can capture the key attributes for the targeted user group of the device. This could be the user's abilities, skills, preferences, nationality, personal circumstances etc. These factors can affect the way we design the interactions. To bring users' profiles to life, they are often transformed into several personas (Cooper, 1999).

From the users' point of view, they may need or want to try a device that can help them to feel certain that they have packed an item they need for efficient functioning of their day. A description of the user includes that: the user does not have a medically diagnosed memory condition; will typically be an individual that may have at least one or more trips to do in a day; or they might be a professional or someone who is busy in terms of work load with appointments, etc. They might be a parent with responsibilities and many journeys that require different items packed for different trips, for example.

For my research, generally, it is assumed the user to be an adult, who has a busy lifestyle with goals of successfully packing their bag so they are prepared for the day ahead. They want to be able to work through their day with as few problems as possible. These assumptions are based on the initial questionnaire. This goal may allow them to function without any anxiety that may result from forgetting an item.

Persona

Based on real world observation, a collection of interviews, and data gathered for the literature review, a persona of Stephen emerged. The data collected for the Survey of Needs had 67% male response, and over 50% of those surveyed understood technologies. That information fed straight into the main aspect of the persona.

Stephen is representative of one of the users the system is designed for. It is important to understand what his concerns, issues and motivations are, how he lives his life, and what he needs. This persona was chosen as an amalgamation of some of the data collected through the initial questionnaire to establish needs. This persona will help to ensure that the design of the system is relevant and useful as he is a typical user who forgets objects, which in turn interferes with his daily activities. He is a busy individual, using a smartphone and very much an 'always on' type of feeling through email and messages being 24-hour access.

Name: Stephen
Age: 42-years old
Sex: Male
Occupation: Head of a Department (at a Sixth Form College)
Marital Status: Married, his wife works in another county as a college principal and commutes each morning.
Children: none
Wage: slightly above average & his wife brings in a higher wage due to her additional responsibilities and management positions. The figure is based on April 2014 ASHE report of median gross annual earnings of 27,195 for full-time employees.

Other: Ambitious, motivations to not forget essential items as it interrupts his day. Concerned about the view others may have of him is he forgets things. Dislikes what he sees as 'wasting his time' on paperwork that he may not strictly see as necessary as he feels there is 'always another form to fill in'.

Technology Use: Stephen has a smartphone and uses reminder apps, lists, email apps for work and for personal use as well as, other productivity and business apps. He uses basic technology when at work: this is mostly a 4-year old desktop computer with basic software installed. At times, he uses a laptop and projector for presentations. Programs are document editors, spreadsheets, databases and presentations. He usually has a break from technology at home. They do not have any computers or printers in their house but when needed they bring a work laptop home. They do not typically like to do this as they prefer to stay late if there is work to finish and to relax when home. However, sometimes there are many meetings to prepare for and presentations to finish and as they have a hectic lifestyle both he and his wife do on occasion must take work home in the evening. Technology in the home: They do not use Internet subscription services such as Netflix or Amazon Prime, preferring to watch TV or movies when they are 'live' through their television.

How he spends his time: Weekends are mostly spent remodelling their home together. This includes travel to other cities to search for vintage and classic furniture and ornaments. As their weekdays are very busy with early starts (his wife leaves very

> early in the morning due to her commute) and at times late nights they try to relax as much as possible on the weekend but can quickly become 'booked up' by seeing friends and family.
>
> *Memory:* He does on occasion forget essential things that he needs for his day, and he finds this frustrating and that it holds him back. At times, he feels because he forgets things that he is inept and at certain phases he can be very down about it. In his management position, he also feels embarrassed and would rather hide the fact he has forgotten something than to admit it to a colleague. Things he has forgotten office drawer keys, USB memory Sticks, and his paper-based diary, all have had a detrimental effect on his day.

A typical use-case scenario for Stephen described;

> Stephen is busy in the mornings, getting ready for work, and is uncertain where his keys for the office are. Stephen checks his work bag which takes a minute and then checks again, more thoroughly, removing items from the bag. He is still unable to locate the keys. Stephen then looks on the counter where he left the keys the night previously, and then checks his coat pockets' He eventually finds his keys. However, he is feeling stressed and anxious at having spent too much time searching, and will now have to rush to get other things done. He packs his keys by throwing them in the bag as he's in a rush, and continues to pack other items needed for the day. He returns to the bag after packing other items to check the keys are packed - because of the strains this morning he is left doubting himself, and hoping he's packed his keys.

Is there a more efficient way that Stephen can pack and check his items, especially on a busy morning? The use case scenario envisioned is one where a typical user, getting ready in the morning, only needs to look to their bag to see by the lights on it, that their item is packed or not.

4.2.2 Establishing the System

The object-based memory aid system to be designed has a specific function, and interaction occurs between 'person and system'. This object and user relationship has specific functions according to the user domain of forgetfulness. There will be communication between user and system to perform a task with an intention to meet the users goal. Looking to Norman's (1988) interaction model which focuses on the users thought processes, and their accompanying actions.

Norman proposes that actions are performed in a cycle of:

(a) Establishing a goal
(b) Executing the action
(c) Evaluating the results

Actions are performed until the expected result is obtained. Norman's Model of Interaction consists of Seven Stages of Action (Norman, 1988), "one for goals, three for execution, and three for evaluation" (shown in Figure 4.5).

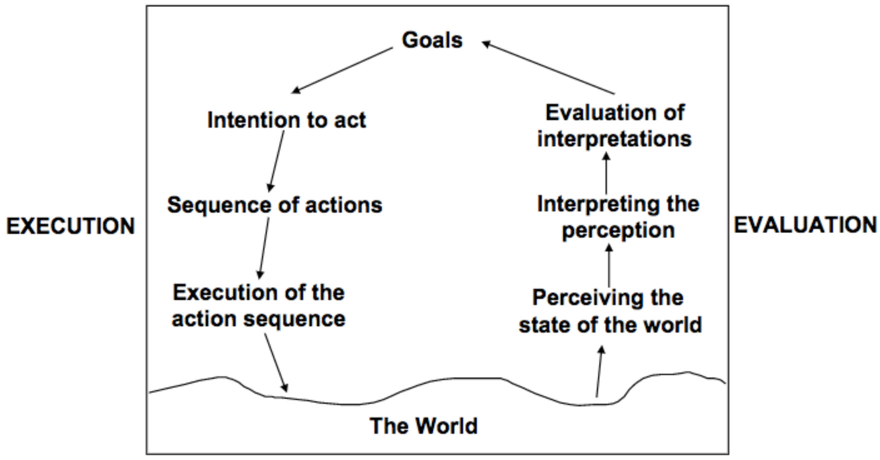

Figure 4.5 Seven Stages of Action, Norman (1988)

A goal is the 'object' to be achieved and the intentions are the specific actions that we take to get to the goal. The user will have a goal of not forgetting. This is to avoid feeling anxious – which happens when they forget. The system designed will need to match their goal and how to help them successfully achieve it.

The following system considerations will contribute to the system success, and make the system easier to use; the Usability and User Ability: a novice user and the usability considerations for this system; and Learnability. Other conditions are the Memorability and Environmental factors, which are noted in this section as they too play a part in the overall system design. Anticipating possible errors that the system may have and planning for contingencies should errors occur are generically covered here. Note that there is further information concerning errors and design choices in the sections that describe the development of the prototypes (Chapters 5, 6 and 7).

Usability: Usability is defined by, "The extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use." (ISO 9241, 2010). The goal for the system is to function with accuracy so that users can achieve their goals. It should also be efficient and the users need to find the system acceptable and comfortable for their lifestyle. In addition to the definition, usability can also be defined by learnability, efficiency of use, user satisfaction and retainability (Rodden et al., 1998; Dix, 2009; Bevan, 1995; Bevan & Macleod, 1994). This ability to learn and retain that knowledge concurs with the notion of the mental model, which can be learned and retained therefore making the system more usable. It makes the user more effective, efficient and satisfied (Constantine, 1995; Constantine & Lockwood, 1999).

A proposed device should let the user know when something is missing using easily understood cues. For example, the user could hear an audible signal, feel a vibration, or have something for vision, which will signal to them they were successful. In terms of 'user ability', if a user task is to pack items needed for their day and then understand with a glance what items are missing (or remain to be packed) - can this be done easily? If they are a new user, or someone who does not use technology, will they understand this system premise easily? Will they need training to use it? Or, are there simple instructions needed to be followed? When designing the smart object these questions need to be kept at the forefront. A user who is already anxious about forgetfulness prefers a minimal amount of strain when using a new device.

Learnability: How long does it take for a novice user to be able to do a series of tasks successfully? "Simpler aids were most successful" (Collerton et al., 2014). For the smart device (in the domain of forgetfulness) it requires as little effort as possible. We saw that individuals with forgetfulness find learning new routines difficult so a device needs to be as simple as possible (Imhof et al., 2006). Can the user successfully achieve their goals? Does a difficult to learn device prohibit this? The device should have *good mappings* (Norman, 1988), so that the user is able to determine what actions the controls have and their effects. Is it possible for the user to determine what the relationship is between the actions and results?

Memorability: If the device is not used for a week, or for a month, can a user remember how to use the system? How long does it take a user to remember how to do the tasks? The aim is to have the least cognitive load for a user because we do not want to add to their anxiety. This satisfies one of the four main principles of good design that answers questions resulting from the Seven Stages of Action: Visibility – can the user tell the state of the device by looking at it (Norman, 1988), or the alternatives for action? Even in the case whereby they believe they will have forgotten how to use the device, are they able to, just from looking at it, be aware of how it functions? Additionally, Collerton et al. (2014) noted that the participants for their study showed an interest in the electronic memory aids but "found them too complicated and not adapted enough to their needs". If the device is too complicated the user will not be able to recall how it works and this creates a barrier to its use.

Physical Environment: It is anticipated that a device will be used in a home environment initially. This is assumed as typically an individual may be at home on a morning and want to pack items for their day ahead. It may be noisy due to typical morning routines. This may be packing lunches, making coffee, and generally preparing for the day. This makes visual or haptic cues important to include alongside the sound.

The way a device is carried should be factored in if possible, as it may be shoved, squashed, or placed in small or squished places when travelling on public transport. Possible elements such as dust or rain are a potential issue so the technology should be water resistant with the technology safe if wet from rain. Any battery housing for a device should be located inside so it is protected.

Social Environment: The social environment of the device includes that it will need to be used at some point in work or similar settings so this will need to be considered. Will the device draw too much attention (negative or positive) to the user, will it have positive effects or is it an item that fits in well with their surroundings?

4.3 Initial Prototype: an implementation

The physical system proposed uses a combination of light-emitting diodes (LEDs), and a radio frequency identification (RFID) reader integrated with a regular bag (messenger, backpack, purse etc.). The interaction is built on the attachment of tags to physical objects which will have automatic identification when ‘scanning’.

Table 4-3 The main components to the system

PROPOSED SYSTEM OVERVIEW

RFID	LED	Piezo
Communication system	Visual cue for the user	Audible ‘beep’ for a successful scan
Tags & Reader	On the exterior of the bag	Integrated to the system

The system focuses on everyday users — individuals who believe themselves to be forgetful without a diagnosed medical condition for forgetfulness. The system will be explained along with its implementation to notify a user from a useful distance, typically across a room, and the benefits this has over using a typical non-augmented bag. The device can be used throughout regular daily activities, requiring no additional specialist knowledge to use it and with the aim of alleviating cognitive load. The proposed system overview is detailed in Table 4-3, with the purpose of the RFID, LED and Piezo functions.

4.3.1 Design and Build Reference

The design and build reference is a list of items that will be referred to throughout the design / redesign process, not only for the first prototype but for all prototypes. At every stage the items in the list need to be looked to as guidelines that form the basis for the structure.

Table 4-4 Stages of design and building: Build Reference.

User Goals

- a need to successfully pack their items
- reduced worry
- easy to understand their action or reaction
- easy to use
- to not check constantly or regularly their items
- no danger to the user or others when using

Ongoing Issues / Ideas

- what style or fashion
- communication method to the user
- screen or lights: system must provide feedback
- what interactions are there for the user
- system could be used for many users
- charging and power issues
- how often to replace or charge power

Statements / Constraints

- the user will be an adult
- the user will have no medically diagnosed memory condition
- the device to be appropriate for a novice user
- typically, the first packing will be in the morning
- financial considerations, using off-the-shelf items
- no wires from the device to the user, independent power source, must stand on it is own to be used i.e. no other device needed
- a set number of essential items

Additional Research: Questions

- Contactless system - is RFID a good way forward?
- Is a bag design feasible based on constraints?
- What hardware is available?
- What components work together?
- How to connect components?
- How to program different components?
- How to minimize the technology used in the system for cost and time: is it possible in a matter of weeks?

These will be addressed and researched to work towards the smart object system. These points are grouped based on previous research in the field – presented in the background chapter, Chapter 2, as well as my questionnaires and interviews suggesting that these points are the foundations of what would make this system successful in addressing the research questions.

There are many stages of design and building that will be undertaken and these areas are divided into User Goals, Ongoing Ideas, Statements, and Additional Research shown in Table 4-4. This helps to identify design elements that are essential, as part of the research question, 'What specific factors are critical to the design of a smart object?'.

4.3.2 RFID Interaction system design - A Smart Device

The RFID interaction system design (illustrated in Figure 4.6) used for devices operates the same across all prototypes. However, they are designed using different hardware due to different form factors, availability and cost.

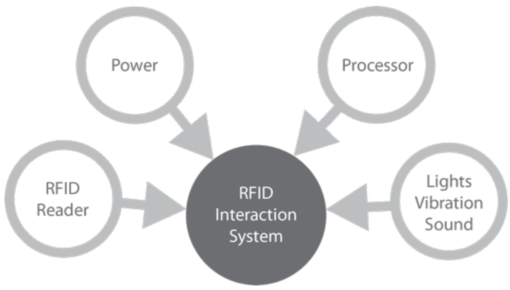

Figure 4.6 RFID communication, smart device system.

Why RFID Interaction? Using RFID tags is a suitable technology for this system, the tags create a smart object enabling the interaction. RFID is chosen to support this system primarily due to the implementation of previous RFID systems over many domains and backed by research in the field, as described in Chapter 2. Typically, users understand the basic premise intuitively of this system, it is inexpensive to implement, and additional tagged objects could be added or swapped. Also, as we will see in Chapter 5, 6 and 7, the RFID readers can be very portable and small enough to put into a bag. The design enables the system to blend seamlessly into day to day living, which is in alignment with the concept of ubiquitous computing.

There is also a 'fun' factor to using RFID. The interaction of scanning a tag and then packing a bag is novel compared to current systems available. The small systems enable the technology to disappear and weave itself into everyday life – which is essential — that disappearing technology gives the device user acceptance. Wanting the respondents to use the device everyday would require a non-invasive technology that is intuitive and minimal in its interaction.

With regards to how this is appropriate for a user with forgetfulness, according to one view, attention is a property of human behaviour that occurs when a person who is attending to one thing cannot attend to another (Keele, 1973). Coping mechanisms created by individuals range from waking up earlier to ensure things are packed, to constantly checking their items. From these points, we learn - to not overload users' memories with complicated procedures for tasks; and design to promote recognition over recall, with menus, icons and consistency. People find it very difficult to learn by following a set of instructions in a manual. Instead they prefer to learn through doing. Using RFID as a system to enable a quick recall should prove to be beneficial to the user. Additionally, scanning a tag is not a complicated procedure so it should not overload a user's memory.

The system consists of:

- an RFID reader
- tags (to be attached to objects) that can be read with a corresponding reader
- an Integrated Circuit for the processing power and program
- power
- a form of communication: lights / sound / vibration

Why this system? The purpose of the system is to track a person's items, an RFID reader and tags can be used as a 'scan in and scan out' system. In the smart device model, due to the external LEDs the user can 'see' which items are contained within the bag. Through that recognition, they do not need to take time to recall which items are present or that they have packed or go through the bag to hunt for a specific item to see if they have packed it or not. The LEDs should be bright and easily visible across a room so an individual can easily determine if all their items are packed without stopping any activities in which they were engaged. It is this communication of the bag which in normal circumstances never happens, which creates a unique device, telling us what is inside.

RFID Readers & tags: Some RFID readers operate on 3.3V and some on 5V which will influence the processing board that can be used. Due to compatibility with processing boards, availability and cost, different readers are used with different systems. The purpose of the reader is to transmit signals to receive replies from tags (passive) nearby. This is an Active Reader Passive Tag (ARPT) system. The tags have no energy source themselves however they do have non-volatile memory to store an id number and potentially other small amounts of data, so are cheaper and smaller than other types (active and battery-assistive). The passive tag uses the radio energy transmitted by the reader. If they are within the magnetic domain of the reader, then they will communicate. There are also several form factors for these readers and each one is described alongside the device that used it. These are wireless, non-contact systems. Example tags are shown in Figure 4.8. The frequency for the tags to be read also can differ, and systems using 125 kHz and 13.56 MHz have been used. The tags have a chip with memory and an antenna.

This is a short-range application and typically a few centimetres are the furthest it will operate. Tags have a factory assigned id number that is a 12-byte unique id, stored on a microchip, that will be scanned by the reader. This unique id is then used in the program to understand which item they have scanned in and to then perform the corresponding action as coded. The range of a 125-kHz tag is around 10cm and the 13.56 MHz tag has around 10cm – 1m as programmed by the reader. This is also determined by the size of the tags as the antenna has a limited size if the tags are smaller. The tag styles consist of three types; key ring, credit card size and shape, and small sticker 1” x 0.5”, however other styles are available. The tags are also washable, durable and small so they can be adaptable in their use.

Microprocessor Board: All systems need a main processing chip. This is where the code is stored and will read the scanned id tag into it for processing. All instances of prototypes will have a version of an ATMEL I/C in the form of an Arduino[16] or Arduino derivative board or the chip on its own. Each system may have slightly different power requirements.

Power: All the devices have power requirements to be able to use them. Because the devices are portable the power requirements needed are to have a battery, preferably one that is lightweight.

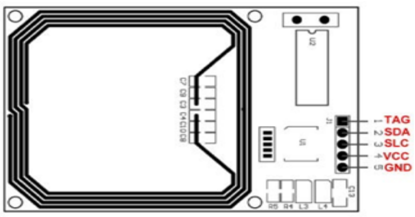

Figure 4.7 RFID reader and pin-out diagram from the datasheet.

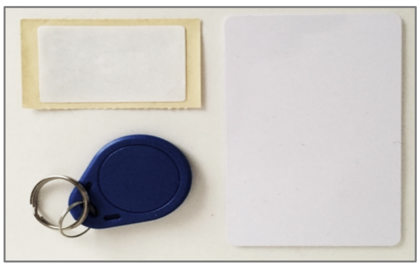

Figure 4.8 Tags; top left the sticker, on the right a card the size of a credit card, and a keyfob.

16 Arduino is an open-source electronics platform intended for interactive projects. Arduino Uno was a base module but it has now become Arduino in the USA and Genuino outside USA. Retrieved 7 May 2016 from https://www.arduino.cc/ Arduino is also the software used to program these boards.

LED Communication: The system has coloured lights for communication. It was decided to use LEDs for the system due to their high-brightness, long life expectancy, high tolerance to humidity in the case of a system being used in the rain, low power consumption and minimal heat generation. Equally essential was the aesthetic value it offered to the system. The small lights have a range of colours which is critical so the individual can identify to which item it corresponds. Each system may use a slightly different form factor of LED, e.g. sewable, through hole or surface mount. When a tag is recognized by the RFID reader, the processor will activate the corresponding light (on or off depending on the personal use case of that user). The lights are an essential part of the system as they convey to the user if their items are packed or not.

Hardware: Other additional hardware that features in this system includes a small speaker piezo component and a vibrating motor, as well as various methods for building the system such as wires, solder, glues, etc. A piezo element may or may not be used, depending on the device design, to provide audio feedback. When there is a successfully scanned item, there may be a 'beep' sound to accompany it. A vibration motor aims to provide haptic feedback when successfully scanning a tag. A brief software description and a flowchart are available in Appendix F.

4.3.3 Aims and Objectives for the evaluations

The qualitative feedback as well as the autoethnography data collected intended to discover (a) how the users felt using the device; (b) how often it was used, was it an everyday routine and; (c) what consequences were there in a user's life when using the device. The results from studies that were conducted were primarily based on subjective measures. For example, how a person reflects on the use of the object and how it affected their day is a matter of opinion. It is their perception of the device when they use it, and those comments and reflections that were collected. Therefore, the data was subjective, reflections and intuition. Each prototype, has a purpose for what information it is aiming to address. The earlier prototypes initially were created to address the function of the device, for example, does it work as expected, do users understand how to operate the system, and is it intuitive etc.

Potential issues that are looking to be addressed in the development of the smart object include:

- No satisfaction or poor aesthetics with the device, this would prevent regular usage.
- Packing outdoors or in a noisy environment would mean audible cues are not heard.
- Tag reading range insufficient, therefore tags would not register.

- Cues not perceived at room width distance.
- No informative feedback when using, the user would become confused and frustrated.
- Unclear control of device would prevent usage or regular usage.
- Lack of power or generic device errors would make the device unusable.

Also of significance was the need to measure satisfaction, fun, motivation, and aesthetics. However, these are all subjective so may be slightly different requirements for different users. Successful design is not only measured through how effective it is at a particular task, but concepts such as enjoyment, satisfaction and identity play a part (Wright et al., 2003).

4.3.4 Possible Errors

A potential issue concerns the quality of feedback to the user; Shneiderman & Plaisant (2005) advises that one should "offer informative feedback" and Norman (1988) argues to "make things visible". In the case of Norman's work, any switches or controls that are needed for the user will be explicit in their placement and control identification. Problems can arise when the user is uncertain what mode or state the system is in. How can this be incorporated into the design? Offering informative feedback is essential in order for the user to know where they are at and what is going on (Shneiderman et al., 2016; Shneiderman & Plaisant, 2005). Design-induced errors (Casey, 2006), occur "when designers of products, systems, or services fail to account for the characteristics and capabilities of people and the vagaries of human behaviour". This could apply to the placement of where the RFID scanner is placed for example, and how users map the scanning location.

Other possible issues may include if the device stops functioning for any reason – lack of power, for example. This could make a user nervous or anxious. It is imperative to be aware of the interactions between human and computer to anticipate and reduce misinterpretations. In this instance, the solution will be to look to implement a device that conforms with the idea of the 'invisible computer' (Norman, 1998), as we want it to be an item that requires no additional cognitive load, nor a need to learn any new skills. This is due to previous literature stating that users with forgetfulness often find it difficult to learn a new method to relieve the forgetfulness, even though they try to. An answer is to develop information appliances that fit people's needs and lives. Design considerations need to remain in focus as poorly designed systems can lead to errors, confusion, frustration and anxiety; all of which we are hoping to relieve with the device.

4.4 Proof of Concept Prototype (PoC)

An initial low-fidelity prototype was used to discover what features and functions would provide a solid basis for a smart device system. A low-fidelity prototype might not necessarily look like the final version, and will likely use different materials and on altered configuration (Rogers et al., 2011; Virzi, 1989) but it encourages reflection. This reflection is needed to resolve issues that building a prototype can address more easily, as opposed to sketching it.

Figure 4.9 Proof of Concept Device (POC)[17].

In the case of this first prototype it was used to establish initial feedback to decide on the following issues:

- What form should a smart device have; specifically, would a bag be appropriate?
- What interaction will be useful for a system to help a user track items?
- In what ways can we signal information or communicate to a user?
- What features would be necessary versus what is redundant or confusing?
- What is the power requirement and what is the best way to achieve this?
- What technology or components are available that can be implemented into a portable RFID system?

17 Photograph by Toby Harris.

The data collected from the initial public critique study (EV1) contributes towards the research question, 'What specific factors are critical to the design of a smart object?'.

4.4.1 Overview

The proof of concept device is an initial prototype establishing a potential system that would notify a user if they had packed designated items in their bag. It was decided an augmented bag (shown in Figure 4.9) would be the best fit for the function of 'an everyday object' based on initial survey information obtained (Section 4.1) and my own need. Note that the use of 'bag' is to encompass all types and styles of bags. This style could be a backpack, handbag, briefcase or other if it is suitable for the need. In this instance PoC uses a handbag that was purchased previously and was chosen due to having two separate sections to it. The smart object prototype was used by myself for a trip out as well as presented at a critique event (EV1) which is documented in this section. Time was spent observing and researching an item to be used daily with the following features,

- a potential common, everyday object
- an object that could have multiple purposes
- an object big enough to add components to it

Basic standards about the system are necessary for practical reasons such as time and budget constraints. Figure 4.10 lists some of these considerations that potentially limit the system. These conventions and constraints are necessary to be able to reproduce the system or to make several copies of it for further research. Additionally, as it is a proof-of-concept system, it needs to be created without a huge time or financial investment. At this stage, the needs are to establish the feasibility of further scope for development.

Hardware
- what sensors could be used
- relativly inexpensive system
- are sensors easy to build together
- are they readily available
- hardwearing

Software
- somewhat easily programmed
- could the program handle the interactions wanted
- scope to add to it at a later time

Usability
- easy to learn interaction
- aesthetic value, would a device make the bag too ugly / undesirable
- weight of device considerations
- easy to learn how to operate

Figure 4.10 Assumptions and constraints of the first prototype.

4.4.2 Materials and Build

The materials used and build followed is provided in Appendix G. The system conceptual model and use case is illustrated in Figure 4.11 showing the components of the system and how they interact together. The five tags are put onto items, and the tag will be scanned to register it as packed, or when removed from the bag to unpack it.

4.4.3 System Component Decisions

This first prototype was primarily concerned with getting a usable system made to facilitate examining the premise of using an RFID reader as an embedded smart object. Due to an overall need of a working system, many design decisions were based primarily on where things could be placed into the bag due to their size. For instance, the RFID reader was inserted onto a breadboard and this was left as an entire unit. This was bulky and restricted by wires and internal bag space.

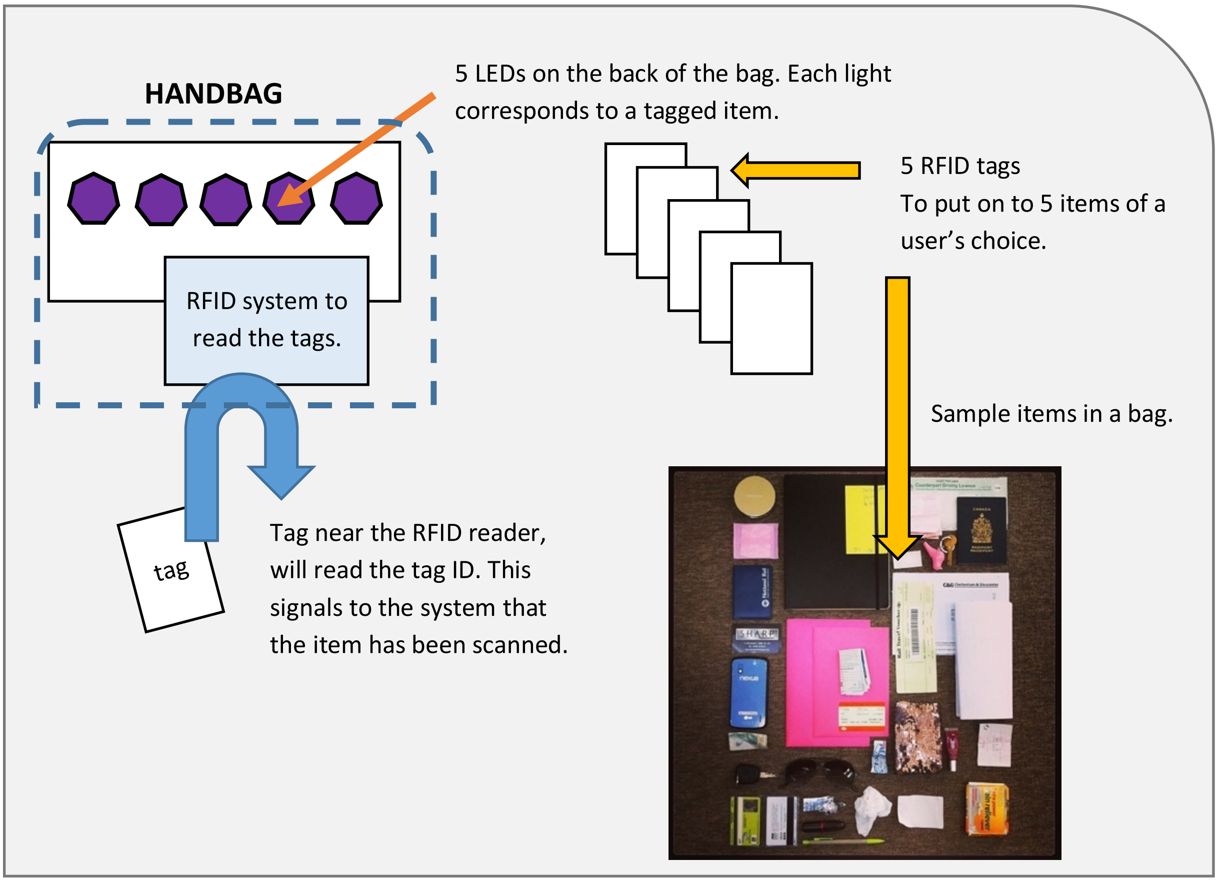

Figure 4.11 The proof of concept system.

It was decided to fit the entire unit into the front pocket of the bag, to enable the main interior bag space to be left free from technology so it remained usable for the individual. Even so, this meant that the entire front pocket was left unusable due to the size and fragility of this system's construction. It was not a permanent design and was left on a prototyping breadboard due to time constraints as well as understanding that it was created to check the proof of concept. A hard-wired option (soldered to more permanent boards) was not necessary at this point.

I wanted to test a per-item communication system as opposed to a singular traffic light' communication system: green light on all packed, red light off, item missing. This prototype use case would be, 'light 4 not flashing – keys are missing'. The battery run time was only tested on this occasion for the event at which it was showcased, an all-day event (10:00am - 16:30pm), and it lasted during that time. The prototype also had additional features which are not discussed here as they were superficial and not relevant to this design. (i.e. a motion and range sensor was implemented to activate the LCD screen to display a message when an individual was close enough to the bag.)

4.4.4 Autoethnography (AU1)

The nature of this proof of concept prototype is that it is lower fidelity and early feedback is used to help to develop the smart object concept. This device was used for a single trip on one day, it was not used regularly due to the aesthetics and build. The construction of the prototype was not robust and only served a generic purpose to gather information about a smart device.

Notes were recorded when out with the prototype which included writing field notes in a journal style as the device was used, to record my thoughts, experiences, feelings and observations while out with it. Later when I returned home, I read through the notes I took and highlighted some of the themes that became apparent.

I did not carry any other bag with me and used it as my sole bag. A selection of the field notes from that journey is shown in Figure 4.12 as well as a map section from the journey in Figure 4.13, as was in my research journal.

Field Notes for Proof of Concept: A first journey

[…excerpt] The proof of concept prototype was completed at my home in York. At the time of the construction being completed I felt excited to use it – this was a new device - but was apprehensive about the durability of the construction. I was concerned about how much of

my personal items I would be able to pack into the bag at the same time as the device. I did not want to over pack it and risk damaging it. Some of the components were help in with glue, tape, and plastic cable ties and wires to the device were put into breadboards which was not a sturdy construction. I packaged the bag up in tissue paper and padding to bring it to London where it would be on display for an event later in the week.

When I was in London for the week that the display would happen, I took the bag out for a single use trip. At this time I was early into my experience with testing prototypes in-the-wild and I initially felt nervous about carrying something around that was unusual. I decided to do a trip out of a few hours to use it and see how the construction help up. Before the trip I attached RFID tags to: the bottom of a lipstick, my travelcard wallet, my wallet for money, a small notebook, and my keys.

It was a cold windy day, with showers, I started my trip in the morning around 10am and walked 0.7 miles to the tube station.

I wanted to use the bag in a busy area so I planned to take the tube to Kings Cross Station where there would be more people. I found myself being very careful with the bag, when I went through the tube station I would move carefully so it would not get knocked by barriers for example. I had kept my travelcard in the main body of the bag. The travelcard was in a wallet that had an RFID tag on the other side of it.

The way the zipper was at the top of the bag and the small opening meant I had to stretch the bag somewhat to reach in and get my card. This movement did tug slightly at the main prototype area in the large outside pocket. Some slight loosening of the tape happened after repeating this movement throughout the journey.

I made a note to secure it with more tape and glue. I scanned out the travelcard along the front of the bag, the lights began to flash on the back of the bag. I scanned my travelcard out at the station and scanned it back into the bag.

When arriving at Kings Cross station, I sat outside of the station for around thirty minutes with a notebook. This was mainly to observe the area and to see if anyone seemed curious about the bag, or noticed it or asked questions. No one approached me and I felt disappointed that I had this technology bag with me yet people hadn't noticed. I walked around this area for a short amount of time, under twenty minutes and then went to a café. There I again accessed the use of the bag through getting out my wallet that was in the main compartment area. The wallet was tagged and so I scanned it out after I removed it, the light flashed signalling that an item was no longer packed. I paid for my item and then after finding a seat I replaced my wallet by scanning it in against the RFID reader and then placing it in the bag.

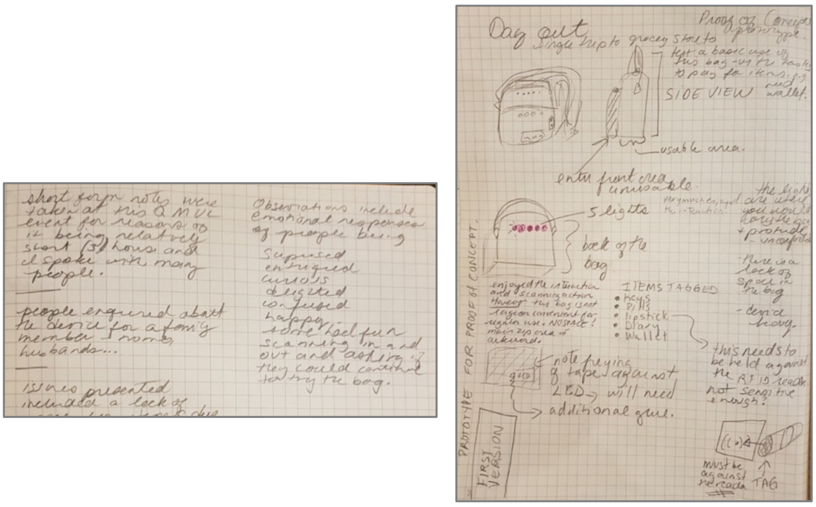

Figure 4.12 A selection of recordings when using the prototype.

As the day went on, my excitement for using it stayed with me. There was an exciting element to using a bag that I was hoping would help me remember to bring my important items. The bag worked as the initial intention was, that my personal items would be scanned in or out and a light would go on or off in response.

[… end of excerpt]

Summary

In that passage example, autoethnography was used as 'a means of explicitly linking concepts from the literature to the narrated personal experience' (Holt, 2001; Sparkes, 1996). During the day of using the bag, I noted issues in my journal that would need fixing. The main areas for concern were the front taped areas (AU1 issue 1) became stretched with movement

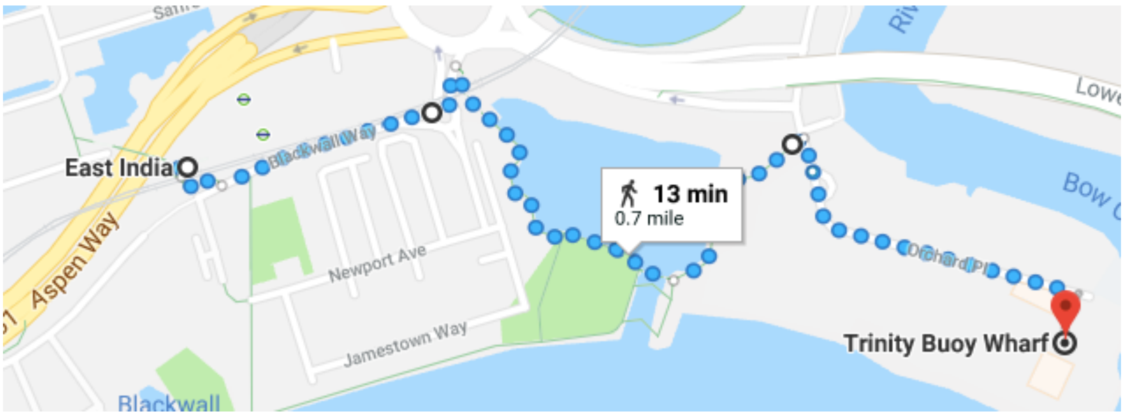

Figure 4.13 Part of my initial journey with the PoC prototype.

and so more robust tape was added. It did hold up well with the weather (AU1 Issue 2) and it did last the round trip. The scanning action worked well and it responded correctly as intended each time. In the case of items being used quickly and then returned there may be less of a case for scanning immediately. The LCD on the front would push back into the bag so it needed to be glued to the outer bag area. The front pocket of this bag became unusable due to the prototype hardware size (AU1 Issue 3). There is not much space inside the bag for a user's items so would be impractical if the smart object were to remain this size. I found the interaction of scanning fun to do. Initially when I went through my writing in the journal, at the first pass I did in-vivo coding, highlighting some of the concerning words that appeared. Those are highlighted '____' in the text.

Excited / apprehensive about the durability / was concerned
risk damaging / felt nervous / very careful / move carefully
stretch the bag / loosening of the tape

The bag lasted the entire journey and it was repaired when I returned home. The prototype served its initial purpose of allowing me to obtain feedback, it was then used for the public engagement event, study EV1.

4.4.5 Public Engagement Event (EV1)

The Proof of Concept device was demonstrated at Queen Mary University of London in a group exhibition. Conversations and demos with people in attendance provided a first look at the device viability. Between speaking to people, notes were made in my research journal of conversations, comments, questions and my observations. Participant observations included emotional responses such as excitement and happiness. The video still in Figure 4.14 shows one of the active demonstrations of the system.

Event Profile: This was an all adult mixed group with approximately one hundred people in attendance. I was only able to speak with around 30 individuals due to the time constraints. The duration of the event was three hours on a morning. Many people had a university or further education background, with a mix of staff and students at varying stages in their education. Some individuals had a technology industry background. There were a few people with curiosity about technology with no background knowledge in the subject. There were no specific prompts for information or questions asked to individuals who approached the device, but they were engaged in conversation on a casual level if they did approach.

The main purpose of the event was:

- to find system errors, inconveniences, inconsistencies
- discover hardware and software issues that can be fixed or eliminated to make improvements
- explore the general usability of this system
- discover any learning curve for an individual when first accessing the device
- do people understand what it is for and how to use it

Recording methods:

At the start of the event the journal was with me, Figure 4.15 is one of the pages from the event. As people talked and discussed their observations or concerns, notes were taken between conversations. As many comments were repeated, numerical notes became more appropriate as people shared similar thoughts. These main areas were grouped into codes such as, styling, interesting and no space. These notes were taken when there were gaps of time during the event as well as afterwards I spent time reflecting on what had happened. Then an overview was written about the event and made memos regarding the changes to implement for the next iteration. These observations included the emotional responses and what was observed through intonations and similar. There was a grouping of LEDs for example as there was overlap of a few issues: 'What were they for?', 'Why flashing?', 'Good to have lights for objects.'

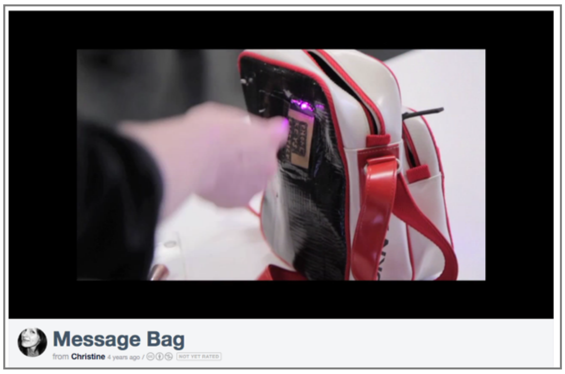

Figure 4.14 Video still: demonstration of the system at the Queen Mary University of London event.

Summary of field notes for EV1

The event took place in a large room and there were tables around the room for many displays. It was a slow starting event. The prototype was set up on a table with the 5 tagged items and I was stood with them. In this instance I kept the tagged items the same as when I used the bag in the wild. The way the event was structured welcomed interaction from people attending. They were able to touch the prototype, scan the tags and engage in conversations.

People arrived in a steady stream and became at maximum capacity about thirty minutes in to the three hour event. There were also photographic and video opportunities. Over the three hours I had around thirty people talk with me. I recorded in my journal thirty people talking with me but at times, the event became very busy and it was possible that some encounters got missed in these notes. There was excitement and enthusiasm for the device, people wanted to try things more than once and there were questions about the system hardware and workings of it, as well as the concept. People were smiling and enjoying the interaction and comments indicated that they saw potential in using it themselves or for a friend. There were clear observations of positivity from people interacting with the device and at times when more than one person was using it, I observed the person waiting being keen to give it a try themselves. This was interesting to observe because when I was using the bag myself I also felt excitement and 'fun factor' in the scanning interactions. Some people made jokes about safe travels with it, and would people think you 'had a bomb' with you. These comments were said in a way I interpreted as jokes, however it gave me an issue to consider, and wonder would others think the same?

Upon leaving the event and returning home, I sorted the field notes and reflected on the questions and concerns voiced at the event. It became apparent after reviewing the number of positive comments that there was potential to take this system forward. Additionally, the device would need to be improved to avoid the confusion that occurred over the LEDs, the large size of the device and potentially the styling.

To allow for the quick turnover of conversations, tick marks are placed next to similar comments.

These emerged as the event progressed and formed the codes concept, lights, and styling, among others.

Figure 4.15 Notes taken during EV1.

Table 4-5 A synopsis of code classification with comments made on the day.

Positives	Potential Issues
CONCEPT 4-5.1a The comments with the sentiment of “interesting concept’, and 'I need this'”, was made by over 20 people.	
CONCEPT 4-5.1b People mentioned that they knew of someone who could use the device.	**LIGHTS 4-5.2a** Due to the lights being on the reverse or back of the bag, 3 people questioned the location of them. They believed the location of lights would prevent clear reading of them.
LIGHTS 4-5.2c Around 7 people commented that it was ‘nice to have feedback on the outside’ of the bag.	**LIGHTS 4-5.2b** Some people (around five) expressed that they were unsure what lights signify.
STYLING 4-5.3 Many people at the event, over 25, commented on the styling of the bag and that they like how the bag looks 'tech'. So, it no longer has a regular appearance but now looks like a technology object.	**SIZE: DEVICE TOO LARGE 4-5.4** People enquired (5) about a potential lack of space in the bag as the device is big. It currently filled the whole front pocket. People questioned if the device would be too big if it occupied that much space in future versions.
	WHY SCREEN? 4-5.5 The current use of the screen is confusing. It offers no additional information benefit.
FUN 4-5.6 My observations of people using the bag was that they found it easy and fun to use. This was due to the smiles, emotional responses and excited nature of people who tried it.	**HEAVY 4-5.7** From a user’s perspective, due to the large device it is currently too heavy to be practical in the small sized handbag.
	HANDBAG 4-5.8 Two people said it was a ‘girls’ bag ‘unfortunately’. One liked it but commented, ‘it’s not for boys’.
	TRAVEL RISKS 4-5.9 What are the implications for travel, is the bag a security risk?

Overview: Comments surfaced about the system being useful, and informal observations indicated that people would have a use for this device, providing it included the ability to scan their items so they knew what was packed or missing. Also, comments were made from individuals who did not think they had forgetfulness issues but indicated that someone in their life, (husband, mother, partner, etc.) would have a use for it. Table 4-5 is a collation of comments from my journal. These are an 'in vivo' classification, staying close to the subject's words. These are the echoed ideas behind the sentiments as people at the event talked with me.

At this point in the prototype testing the concept is new as are the functions of it, and the prototype primarily is one of Look and Feel and Implementation. Role data was not determined as users did not have a chance to use the device for extended periods of time. As I spoke with people it became clear that initial codes surfaced. These were grouped into main categories of 'Positives' and 'Issues' due to there being a very random and large range of opinions at this point. During the event, I focused on making notes in the journal for comments, questions and observations. Overall, themes of Form and Function surfaced when I went over my notes at the end of the day, after the event happened and I had completed taking notes. The comments in Table 4-5 is an organisation of the themes of what I recorded in my journal at the time of the event and collated afterwards.

My observations (AU1) when I used the bag in the wild, and some of the comments from the event (EV1) echo each other. After using the device in public, it became apparent that the device hardware is too large to work successfully in that configuration. This was an overall observation that people at EV1 mentioned as well and those findings are reported.

4.4.6 Key findings and how it will inform further iterations

Table 4-6, is an itemisation of issues that people at the event discussed with me; what caused the issue, any immediate solutions that may be possible to address them, and if there are any long-term solutions to address. At this point in the first testing with the prototype, all comments were noted in my journal and then used as raw data. This has been categorized where possible into issues and solutions to be used as a guide for the next iteration. Similar comments were grouped. For example, the lights attracted many comments as did the bulky device. The positivity felt with the device interaction was stronger than the bulk of the device being an issue. This is likely because the participants involved in this event understood that it was a prototype.

For this event, it was essential to focus on what could be amended with the bag to progress with a second version. The comments and observations as noted in Table 4-6 became the starting point for a redesign of the prototype.

Table 4-6 EV1 Issues and Solutions Overview, Queen Mary University of London event.

Issue	Cause	Immediate solution	Long term solution
4-6.1 Lights flashing, unsure what that signifies	LEDs used are flashing LEDs	Change these for non-flashing LEDs	Examine which would work better: flashing or solid
4-6.2 Lights on the back of the bag?	Design issue	Test if the lights would be more efficient on the front	Placement of lights altered
4-6.3 Not enough space in the bag for user's items	Components are too large	none	Use smaller components for larger bag
4-6.4 A woman's bag so limits use.	Styling is for woman through the bag chosen.	none	Create a unisex or men's version with appropriate styling.
4-6.5 Too much weight for the bag?	Battery is very heavy	No immediate solution	Use a smaller battery for future bags
4-6.6 Screen purpose	Design - you need to be close to the bag to read	none	Try a prototype with screen removed
4-6.7 Battery being bulky and needing replacement.	Power needs were large and large battery case used.	Swap battery type / or casing Highlighted the cost and effort to replace.	Change for a permanent rechargeable battery
4-6.8 Object recognition through text.	Objects written are visible to all	Do not use this feature	Remove from bag

4.4.7 Discussion

Through my observations and conversations that were recorded in my research journal, the Proof of Concept was one method to establish the general usability and conceptual model and its accuracy. It was essential at this phase to take the bag out for a brief in-the-wild study (AU1) as well as the (EV1) event study. Both of these studies revealed different information. While the observations from (AU1) discovered issues that could potentially break the bag and prevent usage of it, at the Event (EV1) data was collected regarding issues which caused confusion.

Overview of the feedback obtained is that the device seems useful for a range of people, (Table items 4-5.1a, 4-5.1b, 4-5.3, 4-5.6). People at the event could correctly use the system without any help, although I did describe the general system of the scanning interaction. Twenty of the 30 individuals I spoke with could envision a use and application for it for either themselves or someone in their lives. While twenty-five people loved the styling of it. Others, three men, could not see past the 'girl' object as it was an adapted handbag, (Table item 4-5.8), so did not want to try it. Observed was a general positivity and excitement as well as people smiling when they used it as they appeared to also find the device fun to use. However, there are changes that would need to be addressed in this system if it was to be used as a part of a daily routine, notably: the size – if a bag was too small that could be an issue, also, if the device was too big then it would not be acceptable to have on a bag; weight – the device and battery are too heavy; shape of the technology – too bulky to be used daily; aesthetics – to suit men; screen definition made clearer – what is its function – in this prototype there was no useful application.

There was also some confusion about what need the screen would fulfil if there is already visual feedback through the lights. This initial prototype iteration established a basic working system created with 'off-the-shelf' components and offered a starting point for alternative components that could be used to address size issues. Also, the placement of those lights on the back of the bag meant there was a potential issue with visibility. Some people commented that the weight and size of the device inside the bag potentially meant that the bag would have to be a lot larger to accommodate their items.

As presented in Chapter 2, previous research in the field and gaps for developing a smart device for forgetfulness provided the basis for the exploratory work presented here. An initial prototype was created to examine feasibility of such an artefact and an iterative design process was begun.

Through this first study, my research of components, and trial and error, a suitable first attempt of a proof of concept prototype was created and tested. This testing in a public setting along with information gathered is taken forward for improvements to be made. In response to questions asked at the start of this section, the following was discovered after observations and conversations documented:

- The device format would suit an augmented bag as an appropriate everyday object.
- The interaction of scanning a tag to an RFID reader is a useful and fun base system for usability.
- There is an ease of recognizing that an object is scanned and packed due to immediate system feedback in the form of lights. Having the lights signals to the user what is packed in their bag.
- Necessary features are the RFID component, lights and power.
- The placement and operation of the lights is significant.

At this point other components seem unjustified and are not serving a specifically required purpose. The portable power constraint needs addressing and investigating further. Individuals suggested the ability to recharge would be highly desirable. Additionally, the weight of the battery should be considered. If we look to earlier statements regarding offering 'informative feedback' (Shneiderman & Plaisant, 2005), feedback and controls need to be explicit in their placement. In summary, this first iteration provided a way to establish general usability and a potential need for this device.

Table 4-7 Overview of PoC results.

OVERVIEW OF RESULTS	
4-7.1	Understanding the lights, what do they communicate, how are they read?
4-7.2	The use of space in the bag, the extra weight the device adds as well as the overall size of it are currently negative aspects. These issues would prevent usage of the bag.
4-7.3	Screen was not implemented to be useful and feedback indicates that it is unnecessary as LEDs are providing object information.
4-7.4	Battery too bulky and heavy. Look to alternatives and more acceptable power usage.
4-7.5	Styling – too women centric.
4-7.6	Potential travel risks? Unknown.

4.5 Chapter Summary

This chapter presented a survey of needs (Section 4.1) that highlighted the impact forgetting can have on a person. From the survey, keys, phones and wallets are very commonly forgotten, over 93% each. Additionally, as 100% of the respondents felt negatively about their experiences when they forget. The survey also showed that even when people are using systems they believe to be helpful – a ‘to do’ app for example, they still forget (75%), or do not even remember to open the app. The sentiment of, disappointed with myself, was felt by participants. From the emotive language used in this survey it demonstrates the negativity that people are affected by when the forget. The chapter then discussed the use case of forgetfulness as well as the User. This was done through a persona, Stephen, where his life and daily routine was described.

Following on from the user, establishing the system involved looking at design issues. This included, looking to Norman’s (1988) interaction model which focuses on the users thought processes, and their accompanying actions. Usability, “the effectiveness, efficiency and satisfaction with which specified users achieve goals in a particular environment.”, learnability and memorability were all profiled to create a design build reference to be used as a guide for a smart object. The proposed system was defined and included build references, hardware and software decisions and the aims and objectives for the testing.

Lastly, the chapter finished with a look at the first implementation prototype, Proof of Concept. The overview of the prototype was described along with the build and use. This bag was then used for autoethnographic observations on a single journey where issues that affected the proper operation of the device were observed.

The PoC was then tested at a public critique event (EV1) to collect data on the concept. This was done through observations, conversations and questions from a three-hour event with 100 people. The event was documented with photographs, video, and a research journal was used to document conversations between participants.

Overall, the PoC device was looked upon positively from a styling and use point of view, with twenty-five people of the thirty spoken with saying positive comments. These comments were grouped to understand that the main issues were confusion: over the lights, what did they mean, why were they that colour, did the flashing mean anything (Table items 4-52a, 4-5.2b, 4-6.1, 4-6.2, 4-7.1); also that it was nice to have feedback on the outside of the bag (4-52c); a styling that was to heavily slanted towards a woman (Table items 4-6.4, 4-7.5); and the hardware unit itself was just too large for this bag (Table items 4-6.3, 4-6.5, 4-6.7, 4-7.2, 4-7.4).

Chapter 5 Experiential Prototyping

Chapter Four identified the implementation for creating a smart object. An initial Proof of Concept prototype (PoC) was made and tested with members of the public (EV1) as well as autoethnographic documentation (AU1). Chapter four showed that the concept was possible and excitement was generated by the idea of it. Excitement was for using it and for sharing it with others. Now, in Chapter Five, we investigate what it feels like to use this device in real life. In this chapter, we present a slightly higher fidelity prototype that was carried over many months. This new prototype Message Bag 1.0 (MB1) emerged from the research through design process. The prototype is an integration prototype as the device will be used in-the-wild over 18 months enabling role data to be collected. Additionally, through autoethnography, information about the sensory experience as well as how it worked in a real-world situation was documented in research journals.

The research conducted was a two-part study: firstly, from the perspective of myself as the researcher (autoethnography AU2) and secondly, from the perspective of the participants (residential weekend with potential users RW1). At its core, my research is supported by an interest in understanding how my own forgetfulness can be impacted by such a device as well as discovering any cultural challenges of carrying around a 'technology' bag. Table 5-1 is an overview of the MB1 prototype and testing undertaken which is presented in this chapter.

Table 5-1 Message Bag 1.0 (MB1) overview.

Message Bag 1.0 (MB1)	**Design**	**Section**
 This is the first higher fidelity prototype that was created to be used over an extended time (18 months in total) by the author.	Integration prototype. Elements of the role, the aesthetics, and implementation are all tested. Used to establish what changes in the life of the user, the sensory experience, and how the product will work. After the proof of concept prototype (PoC) it is essential to test a device in-the-wild to obtain real-world results that can be built upon.	5.1

INTERFACE	**Testing**	
The interface consists of ten LEDs around a front mounted circuit board. The five LEDs on the left of the board are for notes of items to remember, the five LEDs on the right are for objects. There are also three signalling LEDs at the top of the circuit board. These indicate an item being scanned as they flash. There is a rechargeable battery pack sewn inside the flap of the bag. This prototype went through modifications as parts broke over time but the prototype is still functional to the date of writing and is still used.	RW1 Residential weekend with potential users (Focus Group)	5.3
	AU2 Autoethnography approach to design was used and research journals document the testing. The prototype bag was used over 18 months. Over that timeframe observations, notes, comments and drawings were collected.	5.4
	PS1 Pilot Study with single user.	5.5

5.1 Introduction

Chapter 5[18] is devoted to the emergent prototype Message Bag 1.0. In the chapter the design implications for building an RFID smart object system to be used daily for forgetfulness is described. There are many effective design processes and the processes used change with the results and findings.

Briefly, my system is in the form of an augmented bag that can be used in place of a users' own bag; it will track their items with a corresponding RFID readable tag placed on their item beforehand. This tagged item then interacts with an RFID reader integrated into the bag and will turn a light on or off depending on whether the item is packed or not. This chapter describes the usability, design implications and decisions, method of construction and the nature of how these devices work in an everyday setting. Additionally, the chapter explains initial findings as each prototype is developed and how these findings inform the next iteration.

In this chapter the investigative prototype is introduced, as well as the initial testing for design and usability. This helps gather information needed to construct a higher fidelity prototype. As seen previously, high-fidelity in this context meaning resolution and fidelity – the amount of detail and closeness to the eventual design. Those prototypes are presented in

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18 Some of the work presented here appears in (Farion & Purver, 2013).

Chapters 6 and 7. The prototype system (MB1) presented in this chapter is shown in Figure 5.1. The iterative approach used creates a cycle of design, test and measure and redesign, which is repeated as needed (Gould & Lewis, 1985). Following this process enables the creation of an evolved RFID smart tagging device that is used for several studies as it is developed. Questions to be addressed:

- What are the design considerations for the smart devices use? What usability issues are considered?
- How does a user interact with the smart device?
- What changes are necessary to the design or function? This forms part of the implementation, “questions about techniques and components through which the artefact performs its functions.” (Houde & Hill, 1997)
- What are the main, or repeated observations of the devices and how do they affect the design?
- Can a version be designed and developed to be used for a further comparative study? This should encompass all three aspects of a prototype (Houde & Hill, 1997) including the role, look and feel, and implementation.

5.2 Message Bag 1.0 (MB1) Configuration

The prototype version described here (shown in Figure 5.1) is a direct result of both the evaluation of the PoC prototype in Chapter 4, and my participation at the Augmented Human conference 2013, Stuttgart, Germany. After presenting a paper about the concept, plans and initial PoC device, feedback followed which resulted in honing the design to create a working prototype.

This section explains the changes made due to previous findings with the PoC prototype. My focus was continued work on the design of the system to fulfil the needs of an individual with perceived forgetfulness. Regarding the background described in Chapter 2, issues a user may have if they believe they are forgetful, the device needs general requirements of: ease of use; to be a part of a regular routine; not adding to worries or anxiety; being carried with them daily and suitable in all weather; provide a visual reminder; a low learning curve: learn a new system easily. The previous chapter highlighted that there was a need for the device but also that improvements were needed to improve the device’s usability and function.

Figure 5.1 First Integrated device, with a 10-light system to establish usability.

The early feedback regarding the confusion of the lights, the styling, the weight and size of the device and the number of tags helped establish the changes presented in this section. The clarity of the purpose and function of the lights was addressed, through making them each a unique colour. They were also made more visible by putting them on the front of the bag. Also, there is now more space in this bag for items as the device is almost flush with the bag so does not take up inside space. The combination of the feedback and changes resulted in the emergence of a new prototype MB1.

Other changes to this system, from data obtained from an online questionnaire conducted, resulted from the discovery that some people forget items, while others forget things they needed to do. Based on the findings, it was decided to augment the functionality of the device through additional lights; the idea being that the bag would therefore be able to hold more reminders for a user. These lights could be used for items or memos as a user would adapt for their own purpose and preference.

5.2.1 Interaction: Use case scenario

The anticipated use case scenario for this Message Bag is that a user will pre-tag five of their items, and there are five tags for reminders. These are each represented by a corresponding light. A user would be able to look across the room and see which lights are lit – indicating which items are packed or are missing. In Figure 5.2 the system concept is mapped out, illustrating the 10 ‘tags’ (shown previously in Figure 4.8) and the 10 matching lights. These paper-based reminders will be written down on a small card and kept with the bag. There is a secured small pocket on the rear of the bag for these card notes. Those cards will have sticker tags on them so that they too will be scanned into the system.

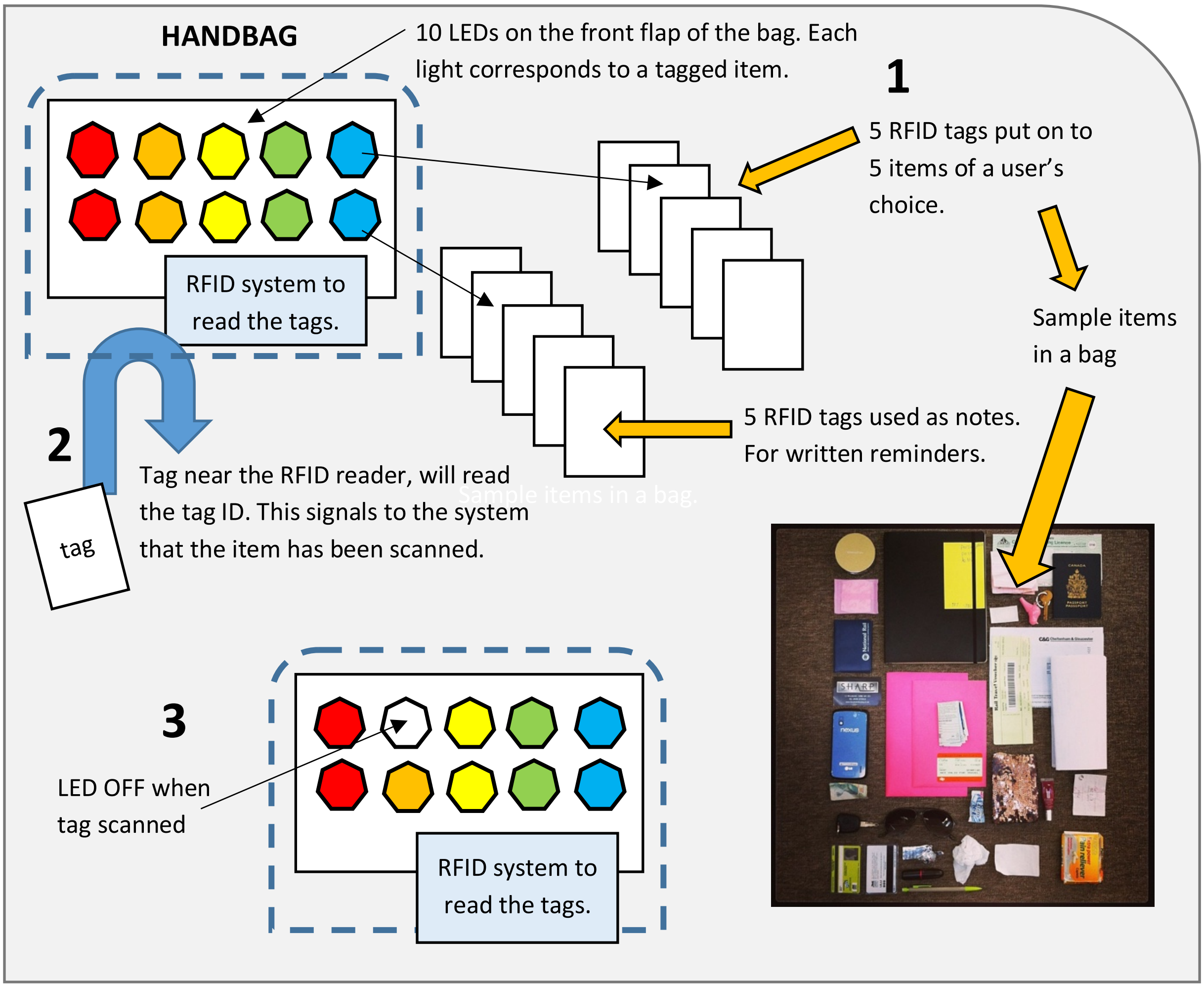


Figure 5.2 The 10 LEDs and corresponding tags in prototype MB1 system.

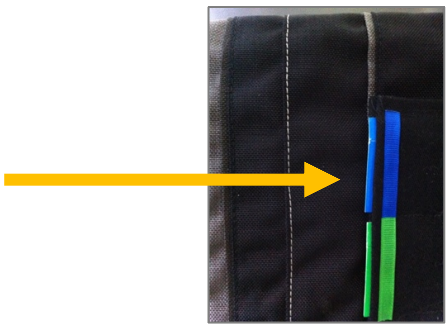


Figure 5.3 The back of the bag, showing a green and blue card in purpose made pockets.

5.2.2 Materials and Build

The materials used and build followed is provided in Appendix H.

5.2.3 System Design Decisions

The placement of the RFID reader into the top main flap of the bag was chosen so it could easily be hidden. Therefore, wires had to also be routed through the lining of the bag to reach the processor board but the wires are very pliable so it was not an issue. This board was also a much better design for this purpose because it was only 1 cm in thickness so it did not add any obvious bulk to the bag. The Lilypad Main board was chosen for the comparable number of ports to an Arduino Uno. There are other types of Lilypad boards but they operate at lower voltages and have less I/O ports for connecting components.

This board does require an additional driver to be put on to the programming computer as well as a cable for programming. It eliminates the issue with the previous RFID and Arduino board combination of having to remove the RFID board before programming as it occupied the same data transfer line. This combination of components meant they could all be attached and programmed without removal. The main Lilypad board was placed on the front of the bag very prominently and the lights were placed around it in circular fashion. This was designed for aesthetic reasons; it looks a suitable arrangement as it follows the curve of the board. Additionally, it requires shorter connections to the corresponding pad to sew.

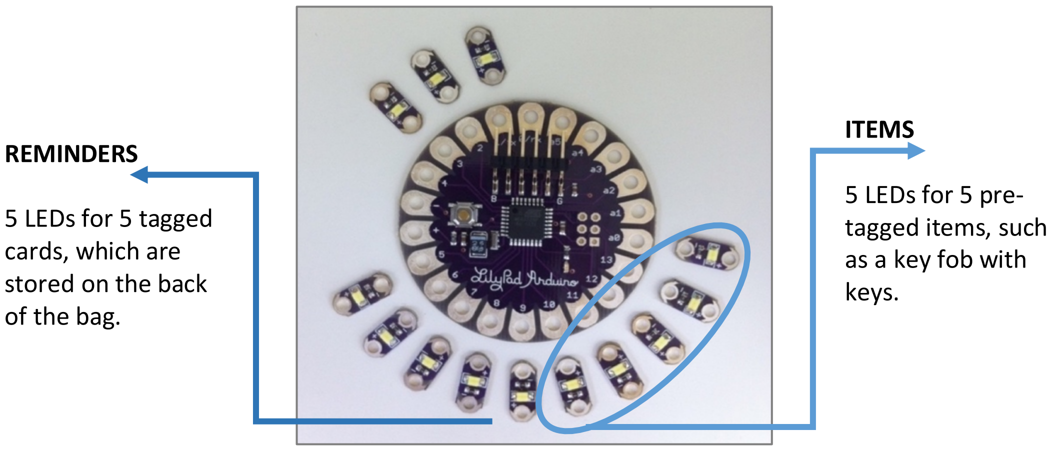


Figure 5.4 All 13 LEDs for Message Bag 1.0 (before being sewn into the bag).

For this prototype, 5 tagged note cards were added for written reminders (corresponding lights shown in Figure 5.4). This is to discover if this would satisfy the different types of things a person could forget. If they needed to remember events or shopping lists they could write it on one of these notes and then scan the note in when they have completed it. This addition meant that small pockets were sewn on to the bag. These pockets were black canvas material so the user would have to pull out the note to read it. These pockets for reminders were implemented due to a portion of people being concerned about others being able to read what they had written.

5.3 Residential Weekend with potential users (RW1)

A residential weekend with potential users was completed to find system software and hardware issues alongside usability and user experience with the prototype. The residential weekend was used to enable a rapid collection of immediate feedback to make iterations necessary to the Message Bag 1.0 (MB1) device. This feedback is then used to allow an iterative approach to design as a new set of prototypes are created and tested with users.

5.3.1 Study Design

A residential weekend with potential users is part of the development for a device that will be used daily, to be able to obtain feedback. Personal use information is fundamental, “qualitative studies that focus on people’s experiences with the technology could help researchers understand why and how their system is working—an outcome that we consider a central contribution of HCI work in this domain.” (Klasnja et al., 2011) This residential weekend is a form of focus group as it is qualitative research where a group of individuals are asked about their opinions on products, services, concepts etc. They offer their opinions, perceptions, beliefs and attitudes (Strauss & Corbin, 1994). This is done by asking them questions in a group setting and the participants are free to talk with others (Greenbaum, 1998; David, 1997). This study is relevant to the types of information needed to be collected.

Participants: There were 11 participants. The group comprised of females aged 30 - 68. None had any medically diagnosed memory conditions. Users had a varying amount of technology knowledge but were predominantly novice users.

Tasks: To use the bag for a journey or two.

The items were given a generic tag as the items would change per respondent, in the situation where they owned the bag they would have their personal items tagged in a more permanent way. Each respondent would use the device for a limited amount of time, for roughly half a day. Two focus groups were then held.

All users and myself would then regroup after a 2-day period and discuss for 30 minutes in a relaxed atmosphere where they could talk freely, joining conversation, with questions introduced by me.

The group sessions were conducted over 2 x 30 minute sessions with one group of 5 and another of 6; there was no formal selection for who would be in which group. I was not known to the group and had only met one of the women in attendance previously. The group did not know my background and I did not know theirs. The group was friendly and we did quickly establish a rapport between each other which allowed them to speak confidently and freely when discussing the device after usage.

Questions were written down in my journal to be used as prompts and included:

Do you feel you are forgetful? (assess the individual)
What was useful about the bag?
Were you able to use it straight away? (learning curve)
Where would you use it? (aesthetically, socially)
Did anything not work as expected, or did anything break?

Briefing / Preparing Participants: The participants were prepared only by being told that this was a bag with technology embedded. I described that the bag had lights, to show if an item has or has not been packed. Very little information was given at this stage because observing the participants own way of using the bag was essential to highlight areas that were not yet addressed, or that may arise in a real-world situation.

Open designs were used as a resource for design, to encourage users to appropriate the technology in the ways that it would suit them. The lack of direct guidance or formal briefing leaves the user to map their own conceptual model of how the system works. They use it in the way they imagine it to function.

For example, the lights will go on or off according to what they do e.g. did they scan an item in, or scan one out, there is also an audible beep. The lights and 'beep' will happen regardless of a user understanding why. I wanted to observe if a user has recognition and understanding of the system when this communication from bag to user took place.

Tags: There were 5 item tags with this system. These were: 2 cards, 1 sticker, and 2 key fobs. The bag could be taken to whatever location they wanted (homes, art galleries, shops). The other 5 reminder tags were not in use for this study.

Weather: The weather conditions over the weekend was heavy rain, cold temperatures and wind.

5.3.2 Data recording

The conversations were documented through notes written in my research journal both at the time of the session and immediately after the session. The initial notes were messy as they were written quickly and required transcribing immediately after the session to preserve the data captured. When it was possible I recorded direct words spoken from some of the participants and these became some of the direct quotes used to report the data captured. Later in the day my entries were read again and I elaborated with memory of the experience. This included documenting comments on how many people spoke over each other as well as their reactions and emotions expressed and observed at the time.

5.3.3 Data analysis

The journal entries were read over several times and a new page was started to initially clarify the notes taken. The second pass was then used to highlight similar themes emerging. Thoughts were grouped together, similar comments aggregated.

Table 5-2 Theme, codes, and descriptors for the residential weekend.

Theme	**Codes**	**Descriptors**
Suitability	User	Information about the user and their perceptions. What were their feelings or experiences when using the device.
	Device (Physical)	Features, Scanning Action; quality of the device, information related to the technology.
	Device (Interaction)	Communication: Audio & Visual; information about the system in use. Is the communication clear for the user? Do they understand the device? How is this of benefit? Does it work as intended, is it fit for purpose?
	Device (Aesthetics)	Information on the overall visible suitability for users. Is it an item they would take out with them? What indications would demonstrate the smart bag was suitable.

The documentation revealed the theme, codes and descriptors that emerged as shown in Table 5-2. Some of the directly commented or observed interactions were highlighted within the text as they were noted. These were in-vivo codes, for example, tag, sound…, and could be used for troubleshooting or implementing changes to the device where appropriate. These key findings are discussed in Section 5.3.4.

5.3.4 Key Findings from the Residential Weekend

The data collected from these discussions are useful to help guide the smart object development with regards to the research questions, ‘Could technology embedding into an everyday item be effective in the domain of forgetfulness?’ and ‘What specific factors are critical to the design of a smart object?’ The discussions in the sessions expanded and became a very open flowing conversation with general comments and talking about the bag and technology. After data collection, each of the 12 pages of memos, notes and comments were analysed, assigned a code and aggregated if they were similar. This focused on:

1) how usable the device was, easy to learn…, and
2) what potential they felt there was to use the device.

The focus was on the data for design and interaction problems to improve the users experience, and to create the next iteration of the smart bag. The data also included my observations of when they were using the bag, passing it between themselves and asking each other questions.

I observed during use: that when a respondent was unsure where to scan, their natural mapping was to scan over the processing board area.

In this instance, codes were elaborated upon to include specifics where several individuals commented on similar things and made observations that were agreed with by the others in the group. Suitability was used for the overarching theme, and within that area the codes were broken into four areas: User, Device - Physical, - Interaction, and - Aesthetics. With the help of prewritten descriptors of each of those codes, I went through the pages of documentation that were created during and post-focus group to annotate where occurrences were within the notes.

The findings from the residential weekend was then separated into four main themes: Features, Scanning Action, Communication (Audio and Visual), and Aesthetics. These groupings were determined by the comments of the participants and their discussion. There were overlapping comments that held the same sentiments. After going through my documentation in the research journal, several similar comments surfaced.

The discussion started with questions about forgetfulness prompted by me. All users felt they were forgetful in some way, 3 commented that they thought it was because they were getting older, 4 blamed having kids, and others voiced that they ‘had always just been forgetful’.

The following quotes are a selection of direct comments. They were selected as it was felt they best represented the feeling of the group on the issues about the tags and the system usability. In this case the quotes are not attributed to the participant as they are a selection with the purpose of representing the collective group voice and not the individual.

About having a ten tag system:

> *"I'm not too sure I would use the reminders; it seems too much effort"* [-RW1 P3]

> *"ya, the tags on keys I get – it would have to be something so important, but then I'd have to remember to look at my own reminder too." (laughs) "that just won't happen".* [-RW1 P9]

> *"I don't think I could remember what the 10 items (tags) were for"* [-RW1 P1]

About the usability of the device:

> *"...I thought, 'oops I'm a bit of a dummy' and 'didn't scan it correctly', then I got frustrated, and nervous, about why I did it wrong, ...and if I broke it."* [-RW1 P7]

> *"Oh, I was ready for something really complex …complicated, I was ready to ask questions to explain it more - but it's relatively straightforward is not it."* [-RW1 P4]

> *"I know a lot of people who could use this."* [-RW1 P3]

> *"My husband forgets everything, but he wouldn't use a bag, can you make him a belt or something that connects to his wallet and keys?* [-RW1 P2]

Table 5-3 lists the findings from the residential weekend with potential users. The findings are separated out into the main themes of: features, scanning action, communication: audio, communication: visual, and aesthetics.

Table 5-3 Findings from the residential weekend study (RW1).

FEATURES

5-3.1a Respondents wanted (one started this line of conversation and more than 4 nodded in agreement, as a cumulative effect) additional 'features', to actually help with forgetfulness in "all sorts of ways" and so wanted a device to be 'even more useful'.

5-3.1b No one elaborated in terms of suggestions to make it "more useful" but it was a comment on how they wanted it to be a bigger part of their morning or journey routines.

5-3.1c There were comments on getting the bag to tell them items were missing - and tell them where the items were.

SCANNING ACTION

5-3.2a Initially (without guidance or a 'guide') it was unclear where to scan their tags. Through observation of their body language, I noticed they became embarrassed about not knowing where to scan.

Also, two different observations were made regarding the actual *scanning action;*

5-3.2b Firstly, intuitively when I observed a single respondent, she scanned the tag over the circuit board in the belief that this is where it was activated. This was an action or connection I had not made before and was a pivotal point of design implementation for future systems.

5-3.2c Secondly, one participant commented, "oops I'm a bit of a dummy and didn't scan it correctly then I got frustrated and nervous about why I did it wrong and if I broke it." So a clearly marked area may be an improvement, or a larger active area is needed.

5-3.2d One issue with an active area is that it means there are scannable areas where an item may be accidentally scanned. However, even though the error that happened was minor, it made some feel uncomfortable as they were being observed or showing others. They knew to scan the tag but there was some confusion as to where exactly to do it (right intention, wrong action; see Norman, 1988, Ch. 5).

Communication: AUDIO

5-3.3a The respondents were mixed on whether sound was needed. Four of the women commented and agreed with each other that they just did not want sound at all, especially if they were in a public place. [I want] "…the ability to turn off the sound when I'm out?" [- RW1 P5] However, three did want the sound so they knew the tagged item was scanned positively and felt the sound was too low. So, this point had mixed reaction.

Communication: VISUAL

5-3.4a There was some confusion over remembering that the light being on means that the item is not there. Some respondents mapped the light being 'on' with items are packed.

5-3.4b The notes part of the bag (there were 5 LEDs for notes that we were not actively using in these focus groups) meant that those lights were on throughout the usage period and that was something they weren't sure about.

5-3.4c Carrying a bag with bright LEDs was an issue, although there was some confusion here because some wanted everything tagged to have even more items. However, then would it need an alternative way to communicate this information to them because it would take time to then remember what items were which colour?

AESTHETICS

5-3.5a Aesthetically, they liked the uniqueness. They liked the bag from a fashion perspective, with several nodding in agreement.

5-3.5b Some questioned having, "to open the bag" to pack it so the lights were not directly facing them as they pack.

Other selected comments, as an overview of collated remarks from the respondents, aggregated based on similarity, during the discussions included:

- Participants commented that the bag was helpful.
- One participant was curious if the tags needed charging, and agreement that it is good that the tags did not need charging.
- They (2) questioned how can a user know when to charge or change the batteries?
- Some participants wondered (3), would this cause a delay in the morning when they are in a rush (i.e. does it respond fast enough when they scan?).
- They enjoyed packing the bag, several respondents spoke at once and over top of each other at this point in an excited way, with raised voices, talking quicker and smiling at being able to "play" with it. This was a very enthusiastic time of the group when discussing that there was technology within their bags. This took place for over 3 minutes.
- A question of, 'could have more tags', came up as a comment from five users. However, 7 of the users mentioned they were confused by having ten tags, as opposed to five, so this is inconclusive.

- There were general questions about security at airports; would they be stopped?
- The weather conditions - they (one made the comment and many nodded in agreement) were worried about taking the bag out in the rain and harsh wind.

Table 5-4 Tags, Information, Battery and LEDs

5-4.1 Comments on tags
5 users would like more tags. (But, seven users wondered how to remember that many and the colours for each item.) Coding systems were suggested where the items tags would be the corresponding colours. (There is also a finite number of colour LEDs at this point, however there is a tri colour LED which you program to illuminate to any hue, though reviews of this LED are mixed as to if the colours are different enough to be distinguishable. Also, these LEDs take up 3 ports each).
5-4.2 Information Leaflet with System
Users would like a small insert or hand out about the system. This could include information about what the LED means, and where an item needed to be held to scan successfully as it sometimes was not sensitive enough to register the tags.
5-4.3 Battery
Issues regarding unsure how long the battery would last - so became anxious that it would wear out or not work.
5-4.4 LEDs
a - Display, aesthetics only: When the bag isn't 'in use' for tracking items, it would be pleasing to have a display with the LEDs just as it is a unique feature to the bag as a designed item itself. b- Some awkward or confusing usage: If they switched the system on, the reader may have registered a tag from an item already inside the bag. Then the device would beep and an LED would illuminate, even if it was not a purposeful scan. c - When the system is turned on, items needed to be removed and then scanned to 'put them in the bag' – can there be some memory if an item is already in the bag?

Summary

The varied reactions indicate a need for this technology but with an altered configuration. There could be a clearer placement of the scanning mechanism and the number of tags needs to be decided. This combined system of LEDs and RFID reader and tags has a visual way to alert the user to items they have not yet packed, potentially reducing stresses and worries that they may forget an item that they need to function successfully throughout their day. However, there are modifications that may enhance this system further.

The bags offered a positive experience in terms of a smart object that the participants enjoyed using and would like to continue to use. They wanted more functionality in terms of remembering objects or perhaps having more objects, but did say they were not sure that they would be able to use it the same way i.e. remember the correlation of colour to item.

One final essential comment to note, was that the issue involving confusions about the light system and registering tags (Table item 5-4.4 b) was an essential item to be fixed, or the prototype will not work with real world users.

5.4 Autoethnography, Research journal (AU2)

Autoethnography allowed me to gather information while using the MB1 prototype. Using Message Bag 1.0 daily meant that more about the system could be discovered and how it was received in public, as well as whilst using it in potentially unusual places or places that are not traditionally part of many people's normal experiences. There were some issues raised by the participants of the RW1 study, such as any security or travel issues, so these were priorities and particular goals of AU2 for me to test. However, before the bag would be able to be taken out for regular use, some repairs were needed.

5.4.1 Repairs informed from Residential Weekend

Before the use of the prototype on a daily basis happened, the Table item 5-4.4b was addressed, that issue was highlighted from the residential weekend with the potential users. The issue highlighted would actually prevent this prototype from being used effectively in-the-wild as part of an extended field study. From points 2 and 3 of Table item 5-4.4b:

> If they switched the system on, the reader may have registered a tag from an item already inside the bag. Then the device would beep and an LED would illuminate, even if it was not a purposeful scan.
>
> When the system is turned on, items needed to be removed and then scanned to 'put them in the bag' – can there be some memory if an item is already in the bag?

I had to implement less sensitivity in the RFID scanner and add memory of the items scanned. When the bag would be switched off, the device would remember which lights were on or off and so the user would still be able to correctly track their items. Figure 5.5 is a sketch of some of the design and planning work that was undertaken to implement changes from the RW1 study.

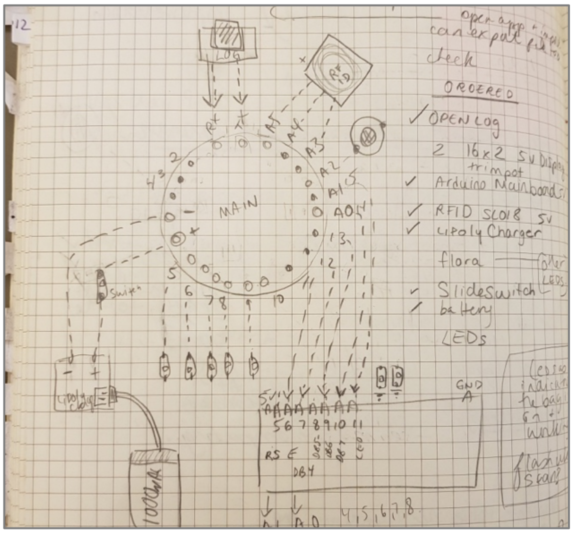


Figure 5.5 The hardware configuration of the device had to change after the residential weekend.

5.4.2 Study Design

Details: this prototype was used over an 18-month period. A research journal was carried in the bag (an extra large Moleskine, squared notebook) where details of the days were recorded. Recordings included observations to the device, questions people asked and comments that were made. Where appropriate the emotion was documented as observed such as excitement or confusion.

The device was used in place of what was my regular bag. The MB1 device was used for my essential items: wallet, phone, keys, notebook, pills, gum, makeup and similar items. From these initial items it was decided that a selection of keyfob, credit card, sticker and button tags would be used. The items tagged were my keys (keyfob), notebook(sticker), pills (credit card), lipstick (button) and gum (sticker).

The aim with the autoethnographic approach was to capture as much data in a variety of situations, to have as much real-world data as possible. The task is representative of actual usage in order to improve external validity (Johnson et al., 2012). After each research journal was full, it was looked over and marginalia notes added on the periphery of the pages. Often this was to form groupings of information. Initially this was to separate out what is direct comments and observations about the prototype versus what were design changes being worked through.

The quality and nature of comments received varied greatly for individuals making remarks. Some people provided in-depth conversations and questions through curiosity about the device, while others were in a hurry but they had a question or two about the device. Most of the people spoken with were not tech savvy and were members of the general public with a variety of ages, all adults.

When reading through the observations, comments, and memos if a theme surfaced more than three times an annotation was made that it is an item to note. Equally, if something only surfaced once throughout the research journal and a judgement call would be made if it was worth highlighting. This was based on looking to my research questions, and could the data help me answer: 'Could technology embedding into an everyday item be effective in the domain of forgetfulness?' and, 'What specific factors are critical to the design of a smart object?'

Issues such as the power supply not functioning, for example, a note was made but it was also fixed. It was not likely to happen again as it was a wiring error. There were many small memos in the journal that were addressed and not taken further. A final example of this is that sometimes thread would fray, and over time this could become an issue. The ends of threads were then glued down with a PVA to seal them and protect from weather and use.

I used the bag on an almost daily basis depending on my schedule. Through this observations were made of situations which would be problematic for other testers to experience through a lack of extended time with the device. By using it myself, this system is used on an almost continual basis through expert user testing. In this context, I am describing myself as an expert user in the sense of I know the system, and have used the previous systems.

This use of autobiographical design is an asset to the discovery of fixes and improvements to the system. My own 'need' for this system leads to real engagement with the system (Sengers, 2006; Neustaedter & Sengers, 2012) as I have a similar goal to the users profiled yet I will produce different results to those users. This type of testing is a valuable way to obtain unique information about the system. Nielsen (1993) explains that expert users are individuals with rich interaction knowledge, task knowledge, and domain knowledge of a specific type of system, and who are skilful in obtaining and using such knowledge to achieve goals or tasks in an interaction.

Through that regular use there is continual feedback from the general population; people who see the bag and may ask questions or make a comment. This highlights areas for improvements and general usability issues. The device can then be amended before handing it out to participants. It also makes it possible to test things that may be too difficult or uncertain for a tester to test - such as are there consequences when travelling? Being an expert user tester enables me to use it in a variety of manners that may be too awkward or difficult to ask testers, such as the travel issues.

This style of testing through ongoing use, is highlighted by Thad Starner who is an advocate of continuous-access. Since 1993, he has worn his customized wearable every-day use systems. Starner said at his keynote talk at Augmented Human 2013 conference, “use them or do something else” which also brought into focus the need for this continual testing approach (Starner, 1996, 2015; Starner & Rhodes, 1999).

5.4.3 Documentation, Data Recording & Analysis

The documentation was in several forms. For quick encounters, I would make a flurry of notes describing what I could in the time available. This style of annotation was then reread sometime after the event, typically at the end of the day, and the entry transcribed in a legible format. For a more formal situation information about the location or timings as well as drawn accompanying images were recorded. My research journals also had additional notes between observations regarding fixes, modifications or future design changes to the prototype. If someone approached me to speak about the bag, notes would be made immediately after the encounter. Sometimes these would be quick short entries to capture as much as possible at the time.

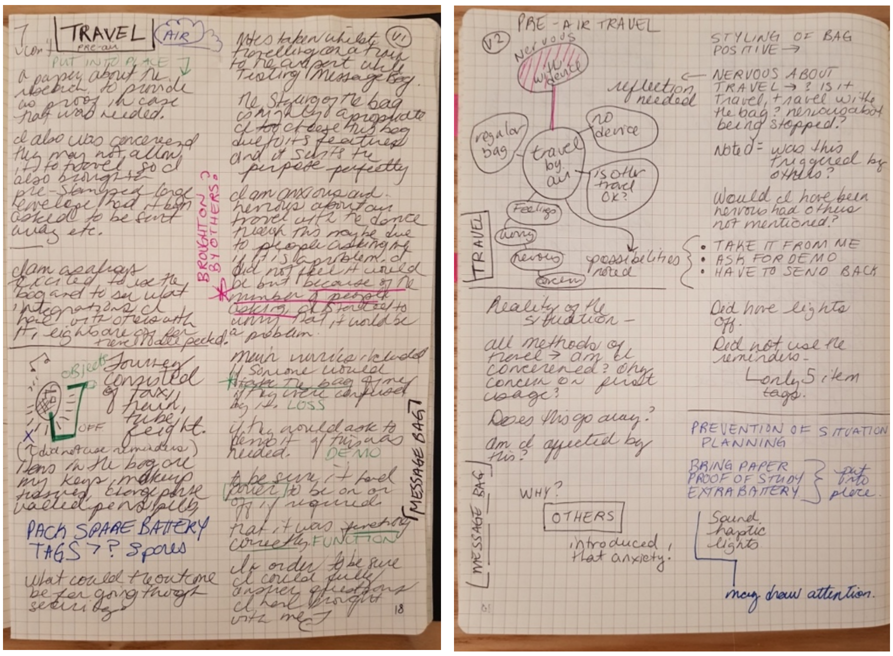


Figure 5.6 Initial recordings for air travel.

Journal notes were read and condensed several times as part of the analytical procedure. Key narratives were extracted and ideals that surfaced based on those ideas appearing several times, or on it being a one-off and having significance for that reason. These key issues were selected as the most accurate representation of using the bag in public. This data is presented as an ethnographic description. It was my key role to uncover these narratives that unfolded within the fieldwork process to most accurately represent a user similar to myself – someone who feels they are forgetful.

The two pages shown in Figure 5.6 are from documentation about impending air travel and the apprehension. The page on the left was initial thoughts and the page on the right summarizes the main thoughts from that first pass. After reflection and rereading the initial notes made, the realisation is that there is anxiety about travel by air, but that it stemmed from others asking questions about it rather than my own apprehension.

The raw data are transcripts of my recorded notes which at times became illegible due to writing them while travelling on trains or busses. When that occurred, there would be a reflection by the end of the day so data would not be lost.

Table 5-5 Theme, codes and descriptors.

Theme	Codes	Descriptors
Device Use Location	Travel	Information related to: Air Travel, Rail / Bus / Underground
	Regular Activities	Supermarkets, Coffee Shops, Daily Errands
	Out of the ordinary places	Theme parks, Hospitals
Device Assumptions	Communication	Information relating to how the device is perceived, how people assume it would work, or the types of questions and concerns an observer would have.
Functionality	Hardware / Cosmetic	Information in relation to the device functioning or not functioning, or why it would not function correctly.
	Use Case	Information regarding if the device performs as expected.

The process would be to start a new page and typically I would try to print things clearly. There is a complete read through of the data and concepts began to form that were closely related to the form of words in the text fragments. These fragments are taken and a wider general concept was created. From the data collected and reflections done, the following themes emerged: device use location; device assumptions, and functionality. These specific areas came up many times while using the prototype and as groupings of comments and observations were formed, these themes became apparent as the main groupings.

Codes then became the main categories for the information such as travel, regular activities and out of the ordinary places. The data captured for these main activities satisfied concerns voiced to me when reading through previous study data (EV1, SU1 and RW1). Concerns were raised about travel so I tested if the perceived concerns about travel were justified or just worries that don't surface in reality.

5.4.4 Findings

For this smart device system MB1, notable journeys recorded included; (a) travel at airports for trips to various destinations, or trains and busses, (b) regular activities including supermarket trips for example, and (c) out of the ordinary places or unusual locations, such as a visit to a theme park where the bag needed to be checked in on a per ride basis, covering all day lessons at a college for teenage pupils, and a trip to a hospital. The areas I explored are shown in Figure 5.7

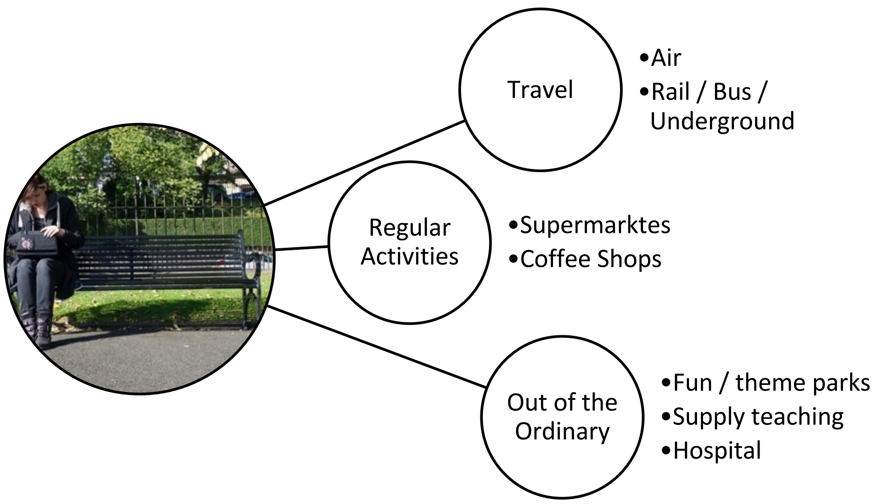


Figure 5.7 Areas of discovery when using Message Bag MB1.

(a) TRAVEL

Travel was explored, both air and surface, to ascertain what reactions and implications this might have. It was preferential that I used the device rather than a tester so that I would be able to answer any questions or concerns that potentially could arise. I prepared in the case that the bag may be taken from me. I imagined that I would be asked to pack it in alternative luggage or that it might be destroyed. These thoughts made me feel nervous when embarking on the journey. Previous to travelling, these thoughts had not occurred to me, but as I had been carrying the bag with me daily, some people began asking me if travel was a problem. It was only through their concerns that I became concerned.

To reduce the stress of the travel I prepared in a few ways. I carried information about being a research student with me, in case I was asked questions or needed to prove why I had such a device with me. I also printed out a paper that was published relating to the smart device prototype. Lastly, I had packaging with me in case I would have to destroy the item, this way I would be able to post it back to myself. In my journal, I recorded these worries (some can be seen in Figure 5.6) and in my mind they became the only possibilities for the situation.

Air Travel

Due to the security level when travelling by air, I had anticipated that I may need to explain the device. I prepared for travel which included having documentation with me to support and describe the device. This included proof of my research student status, as well as a paper the device concept had been published in. There were several trips at airports including trips to Europe / International, Long Haul International and Domestic flights. For these flights, there were various stages of security, from checking in, to scanning bags before going into the secure areas.

Domestic

Trip requiring security of Domestic air travel. One of the journeys required travel from Manchester International Airport through to Heathrow. The security at Manchester is very high as it is the third busiest airport in the UK. For this airport there are protocols of removing items prior to walking through a metal detector. After waiting in long lines, you approach the security area where items such as jackets, shoes, belts and any loose clothing are placed into low lipped plastic bins. Any other items such as bags, backpacks, luggage or *electronics are placed in these bins as well. These are then placed on a conveyer area and they go through to be scanned and x-rayed by security.*

As I was placing my bag into a bin, I was very nervous and equally excited to demo and discuss the bag. I had the paper with information regarding the bag just underneath it in the same bin. I watched as security held onto the corner of the plastic bin, and pulled it closer to the x-ray system. They then just pushed it with the other trays and it went through. There were no comments, no questions, no second glances even towards the device. The first experience of travel through an airport with the electronic device was uneventful. Air travel made no distinction between my electronic bag nor a bag with none. I was relieved it was so simple, but also wondered if this was because it was a domestic flight. Perhaps there were stricter security checks when travelling internationally.

There were no security issues or even questions at any point from any of the security areas. This was interesting because often when I used the bag people were curious and asked about security issues. Most who enter into a conversation with me, eventually asked about travel and what security issues, often joking that it could be seen as a security risk due to it being unusual and containing wiring and electronics. This was why I had not explicitly asked testers to use it for travel, yet from my own use with it, for many types of alternative journeys, no security felt it posed a threat nor asked anything about the device. The return domestic flight was the same. No concern for the device.

Trips taken: 2

Issues or concerns: 0

International Travel: Long Haul

Once my flight had arrived for the domestic flight, I was now making my way for an international flight. I would leave ample time to get through security in the event that there were additional checks or questions this time. The prep was the same as the previous journey. The experience was echoed with the security experience being the same. There were no questions or any comments in regards to the device at all.

Trips taken: 2

Issues or Concerns: 0

International Travel: Overseas

On an alternative occasion I also took an additional International flight, overseas. I prepared the device in a similar way as previously done for air travel. I had no concerns however when travelling with the device due to my previous experiences of no one having any issues with the *device. For the fifth time in this experience of air travel with the device, there were no comments or questions regarding the smart device.*

Trips taken: 2
Issues or Concerns: 0

Total Air travel trips taken: 6
Issues, Concerns, Comments: 0

Considering the observations made and the experiences I had while taking air travel, there were no issues raised for all six trips. This involved slightly different types of air travel and to different destinations and all experiences were the same.

Rail / Bus / Underground

Using the device for rail travel was a common occurrence for me and there was never any security or concerns for other travellers or train guards. Train travel is a little more intimate in terms of typically my journeys were two hours or longer. Conversations from travellers sitting next to me did happen occasionally, especially if the bag had some of the lights operational, and there was a general curiosity as to why there were lights on my bag. Questions and comments are almost always, '*how does it work', 'can you take it through airport security'*. That is a representative sample of the types of questions that noted in my journals over the course of time. Throughout the research those questions were asked many times in similar ways.

Additionally, once a conversation started, the majority of people spoken with asked if they could get one for themselves to help them remember their keys and wallet, or for a friend or relative / spouse that they felt were forgetful. Many people over time give me their business cards and contact details to provide them with more information. Throughout these journeys, no one at any point had cause for concern, the smart object bag seems to be accepted into the travel setting without any issues.

(b) REGULAR ACTIVITIES

The regular activities that are included in this section are for supermarkets, coffee shops, restaurants or a venue where it is placed stationary for long periods of time. These are places that may be typical in someone's everyday activities and so this was an imperative area to be explored.

For my experience of usage in a supermarket, typically a shop would mean a large shopping cart with many items going into it. The smart bag was placed in a diagonal way so that it was secured to me and it gave me the freedom to use both my hands. This meant the bulk of the components were under where my left hand would be moving. Because of this and the nature of the type of shop, with constantly placing items into a cart, the device would sometimes 'catch' or get hooked onto my sleeve and it would pull the bag or my sleeve. This was annoying and an undesired effect. It highlighted that the placement and styling of the device would need careful consideration because if anyone experiences snagging or damage to their jumper or the device, it would not be used regularly or potentially at all.

Table 5-6 Damage & Noise Issues

5-6.1 Damage
The processor kept snagging on jumpers and clothes, scarves etc. There were 5 recorded entries of my scarf and other clothing snagging. These were enough to result in having to choose certain items of clothing that would not snag. This issue warrants a redesign.
5-6.2 Noise
If it was used in a quiet coffee shop some people would look when there was a beep. This can be uncomfortable in some situations. I recorded a specific entry when the bag was used in Leon's on a quiet night where others were working on laptops. When I returned my wallet to the bag the beep drew attention to myself. This felt awkward at the time though equally I noted feeling disappointment that no one asked about the bag.

Usage of the bag in coffee shops and restaurants presented few problems. However, depending on the type of coffee shop it was, in terms of noise levels and brightness, this would make a difference to people noticing the use of the bag. When in a bright café with a lot of people there was no real attention from anyone looking at the device. However, reactions were mixed at quiet, smaller and more intimate cafes.

If the bag showed illuminated lights or an audible beep sound for a successful scan, at times people (one or two individuals nearby) would turn around to see what the cause of the light or the noise was. This highlighted that there would potentially need to be amendments to the brightness for the device in some situations. If the lights were very bright, this could potentially have an undesirable effect for someone who was experiencing anxiety from memory issues. Therefore, a system where lights and sound could be altered, or a smarter device where the ambiance and light levels are considered to reduce brightness levels accordingly, could be desirable.

(c) OUT OF THE ORDINARY PLACES

The device was used for an extended period of time which also resulted in it being taken on non-typical journeys. These included: Fun Parks, Supply Teaching in a Sixth Form College and a Hospital. I always hold the bag in an obvious way so that the technology can easily be observed. The lights are often off when carrying the bag around.

Fun Park

The nature of fun and theme parks and their high regard for safety means that when someone goes to queue up for a ride, as they approach the ride, the bags or any loose items are checked into secure boxes or given to staff to check on a per ride basis. This meant that there were a lot of times throughout the day that many different staff would see the device, be holding it and putting it into a safe storage area. Most of the staff I came across for this were young individuals, roughly in the age brackets of 16-22 (from observation) and most of them were very curious. It transpired that on most rides where the bag was checked, the individuals paused and looked at the device on the bag and were curious as to why it was on there and what functions it performed. Many asked for demonstrations and this was a very positive experience. The staff checking in the bags were enthusiastic and curious and wanted to have one themselves too.

The staff offered comments that I noted in my research journal – the following is a sample of some of the comments written down as spoken:

'Does it charge with USB?',
'Can you keep adding items to it?',
'Can you put it on any bag?',
'Can it make any noise or is it always just the same beep?'
'How much would it cost to make one?'

In general, they also seemed to be a group of individuals who were excited by the innovation, and potentially had basic experience with technology and general comments emerged:

'no way it does that, you're lying'
'Whoa - it can remember my keys'
'how is that possible'
'I didn't know things could do that'
'it seems so simple yet so cool'

These remarks confirmed comments from a previous group of individuals who were in different user groups and had given their feedback in earlier testing. This included feedback obtained through university events for example or from my peers. Their excitement for the technology and the interaction confirmed to me that there is potential for use. There is slight misinterpretation with the functioning and capabilities of the smart device. The excitement of the technology potentially had lead a person to believe that 'whoa – it can remember my keys', when it actually does not remember a person's keys. It will light a light if a person has remembered to pack their own keys, but this leap of understanding has maybe originated from their enthusiasm.

College

Another atypical day was doing supply teaching at a College for IT and Computing students who are aged 16-17 years. The group consisted largely of males and a few females (18 males to 2 females), the group had no prior knowledge of me, it was my first time meeting this group. As computing students, they seemed to be naturally attracted to technology. Once the lesson was underway and as the break approached, three students came up to me. One asked me what the system was on my bag, and did it do anything.

When the student group approached and I began to answer their questions, the rest of the group then became interested and most of the entire class (15 students) joined in the discussion. A general comment from some of them was that, *"it looks like a prototype"* so they would not want to have it on their bag in the current form, but they would want one if it could fit in with their style. The term prototype by them indicated it was unfinished or not quite ready to be used.

They all had items that they commented that they forgot – on a regular basis – which caused difficulties during their day; such as their student card, which they needed for printing and other facilities to their bus passes or wallets. Their questions revolved around how many tags would be possible, can they have more than one tag for different items and similar questions. Also, because of their interest in computing, they had technical questions regarding how to make a device that can do that. They were curious about how it worked, how it was powered and if they could build one similar too. This was one of the few interactions with direct questions and comments on the build of it, actual component requests and precise hardware information.

Hospital

Lastly the bag was used for a hospital visit, and there too I wondered about any potential security issues. The hospital is large with a main welcome area, there is a side entrance for emergency cases but on this occasion the main entrance was used. No one stopped to ask about the technology on the bag, or noticed it particularly. Observations of this nature leaves me wondering why I somehow think there would be questions or concerns. What about my own use or knowledge about the device leads me to believe there could be issues. I wondered if there was other technology I use that I feel would attract the same security scares. Again, this security would potentially need to be checked in different wards or areas. There were three trips to the emergency room, where the staff are busy and people occupied with their own issues. This is a separate entrance area and is typically full with patients, nurses, reception staff and doctors. There were no comments or questions or concerns from this department regarding the technology.

There was also one trip to a ward to visit a friend. Again, only a few staff were observed in the area at the time and they were very busy. The room on the ward had other patients and friends and family in it as well as staff. There was no comment or questions or any observations towards the technology. These alternative settings provided some unique perspectives and also an ability to see where potential issues may make the device less accessible or usable in public but that has not been the case at all.

When collecting data for an extended period of time, and repeated use, there were many days that passed that there was nothing remarkable to report. There were no questions about the device, there were no comments to me about what was I using. But I came to realise that this too is important. When undertaking initial research into the design of devices for memory and forgetfulness it was important that a device did not stand out or draw attention to a user. These things would prevent its usage. It was observed that although I was using the device daily, I would be out with the device and no one would comment.

Some of the overview of comments and questions asked while I was out using Message Bag 1.0 are in the following table (Table 5-6) along with the cause and a possible solution. These were selected as they all presented 3 or more times over in the journals during the initial testing phase.

Table 5-7 A selection of comments and questions recorded while using Message Bag 1.0.

Issue	Cause	Possible Solution
5-7.1 Confusion over what is scanned – item or something to remember written down	Possibly too many LEDs?	Reduce number of Lights or organize them differently
5-7.2 Number of items	What would an optimal number of items be for a smart device?	Through use and observation note what the number of items are for optimal use
5-7.3 Charging is not functioning correctly	Wiring issue	Address wiring and stability
5-7.4 Error when all items are scanned, system stalls	Faulty code	Edit code and retest
5-7.5 Battery life	Study more about battery life and power requirements for portability	Research into charging battery in an easy way / eliminate the need to change batteries
5-7.6 Replace battery	Does it run out of power quickly?	Offer charging solutions
5-7.7 There is currently bulk in this system (battery pack)	can it be reduced	Reduce weight by changing components – altering battery which accounts for a huge weight amount.
5-7.8 Snagging on certain clothing items	Different board without programming ports exposed?	Source a different board or cover it or remove after programming
5-7.9 Tag frequency was 13.56mhz, the 125mhz tags are less expensive, easily replaced?	research more into the types of tags that could work with this type of system, alternative uses	Keep the tags generic so they can be replaced easily
5-7.10 Can people use the system intuitively	Is it simple to pick up and use?	Make the gesture natural, observe people using it to see where and how they scan
5-7.11 Responsiveness	is it responsive enough, are there delays, does the user know	Communication to the user when an item is scanned so there is feedback.
5-7.12 LEDs	do the LEDs communicate effectively if the items are in or out of the bag	Plan testing for the uses of the LEDs and what the interpretation is
5-7.13 Women only?	Styling issue	Versions
5-7.14 Paper Recording was abandoned	tedious	abandon

Additionally, after extended use I had quickly mapped my item colours to match the LED colours. My association for 'blue' rapidly became the same as 'keys' as the keyring was blue and that activated the blue colour. This mapping seemed strong for the items that I needed daily and was so much so that if I was not using the message bag for some reason, I still associated my keys with 'blue' even when not using that bag. When I had set up the bag initially, I wanted to form a link through colour and I matched items that were similar. For example, my antihistamine tablets came in a yellow package and so this became the yellow card that activated the yellow light.

5.4.5 Summary of Autoethnography (AU2)

Overall the testing highlighted aspects of the device that likely would not have been exposed without continual use in all daily situations. Being able to use the device in situations where a novice user may not have felt comfortable, (for example air travel), meant that expert testing was beneficial to obtain unique information which would ultimately aid in the further development of the device. Also, by using the bag in public meant we gained access to all ages and lifestyles to experience a good cross section of the public.

Table 5-8 Summary from research journals.

OVERVIEW OF RESULTS AU2	
5-8.1	Number of objects to be limited, reduce to 5 items, not 10. See Table 5-6.14.
5-8.2	Battery Issues: Bulky battery, Battery life, Charging would all need to be sorted
5-8.3	Responsiveness – delays, feedback / scanning
5-8.4	Component placement, where to scan RFID
5-8.5	Tags Usability, is it one per item, can they be moved
5-8.6	Non obtrusive to a user's lifestyle, 'special device' can go unnoticed
5-8.7	Travel poses no issues, what about the device prompts people to believe it will, this is documented in Section 5.4.4
5-8.8	Damage to users clothing, due to snagging from the circuit board

5.5 Pilot Study (PS1)

Testing for Message Bag 1.0 (MB1) continues with the pilot study. This was created as a test run of the in-the-wild comparative study (SU1), where a single user has one of the smart objects for approximately a month. It was anticipated that there would be more accurate qualitative information about the device and the study design as participants would have used it for an extended period. It was felt that this should offer an insight to an accurate real world scenario of what using the bag over a period of a few weeks would be like. The pilot study was going to run for a month as it was used to establish and discover any errors in the testing methods.

Unfortunately for various reasons, the participant only was able to do 5 days with his bag and 5 days with MB1.

5.5.1 Study Design

Participant: One participant [PS1 R1] male, late 30s, no medically diagnosed memory conditions, technical knowledge is higher than novice but using technology is for work purposes and not a pastime or hobby. He was a volunteer that responded to a call for participants through Twitter.

Tasks: Goal-oriented task to pack daily items as normal, however the container (or bag) that is used will be different. For one week, they were to use their bag, and the other week or two would be with the augmented bag. The participant would then report their experiences using the bag, in both situations.

Briefing / Preparing Participants: The participant will be given information that he is participating in a pilot study and that all feedback is essential, regardless if it seems ‘substantial’ or not, and to discuss observations. There were no explicit instructions about using the device because it is essential to learn about the intuitive nature of the device and how much information or learning curve would need to be addressed for the study / future users.

Instructions given: The participant was asked to reply to a questionnaire when taking a journey and using a bag. A variety of passive RFID tags for physical items were provided: Credit Card shape, Key Chain form, rectangle Stickers and a Button style tag. A brief information sheet was given to the participant which detailed where to fill in an online questionnaire and what the general function of the bag was. The purpose of including so little information at this stage was to establish what information would be needed when giving a bag to participants. The respondent was self-reporting with an online questionnaire daily.

A Consent Information Sheet was given to the participant which was signed electronically. This informed the participant of the right to withdraw at any point, how and where the data was being held and confidentiality of the responses.

5.5.2 Key Findings

There were a few unforeseen events with this pilot study which made it difficult to get accurate information for finding out areas to improve or where things could possibly be misinterpreted. The respondent took longer than expected to collect the bag from delivery. The almost two-week delay resulted in confusion as to where the bag was and if he was using it at that point or not. This pushed back the study. Unfortunately, the respondent then fell ill, and then they also mentioned a family member had illness. They said they were now unable to devote as much time as anticipated to the pilot study. However, due to my own time constraints to run the study that would follow for a month plus a one-week period with their own bag, there was no time to run an additional pilot study.

The tester was briefly interviewed, approximately a five-minute conversation, one to one over Skype and his responses recorded were in the themes of; function, form and clarity.

Table 5-9 Themes and codes for PS1.

Theme	Codes	Descriptors
Suitability	Function	Information about the device and how it is used.
	Form	Information about the device and the suitability for their lifestyle.
	Clarity	Information about any confusion to the user in any aspects of using the device.

Function

The participant had comments on the bag itself and how it would be used. In particular, he discussed the number of lights on the bag and one comment to surface was;

> [PS1 R1]*: I'm wondering whether ten is too many things, and whether something with fewer lights/swipes[...] If there were four things I had [emphasis] to remember every day, then would this technology be of more use.*

Form

The bag did not suit their lifestyle aesthetics in terms of the bag size because it was too small. They were not able to use the prototype for all journeys as they would have had to bring an additional bag to be able to carry everything they needed. This highlighted the fact that respondents would need to be matched to the appropriate bags in terms of size to make maximum use of them. Users of this technology are potentially from all backgrounds so work requirements will vary and the size of the bag must be adjusted accordingly.

Clarity

The feedback, confirmed that there would need to be additional information given to the participants at the start. This is in terms of the printed information offered to the participant as well as any other (e.g. email) communications. The tester mentioned when interviewed, [PS1 R1]*: "I can't tell what I'm supposed to be scanning over what"*. Indicating that it was not clear where the reader was placed. Also, he felt a need for more initial information. There were no issues with the ability to access the questionnaires or comprehend the questions.

Ultimately this pilot study was serving the goal to work through any issues with running the future Single User (SU1) studies for the next prototypes. The main benefit from this pilot was that I would now be more prepared for users where the device is not returned or not picked up for use. We described an initial pilot study that was conducted to gain knowledge about what flaws would be highlighted before the major study would run. Although there was some initial information provided by the respondent, due to the nature of circumstances it was difficult to gauge additional changes or improvements. Unfortunately, this was less useful than anticipated and resulted in only brief notes and email correspondence. However, it provided enough information to amend the study that follows; for a more detailed information sheet needed to be given initially. Also, to make amendments needed to be made to the systems for future testers.

5.6 Chapter Summary

After using Message Bag 1.0 for various studies (AU2, RW1 and PS1) some similarities and differences across the studies emerged.

The main similarities to come from observations and through the research journals include:

1. People wanted a larger bag.
2. If people use more than one bag – they would want multiple devices.
3. There are issues with power: battery issues, charging and weight.

4. Some awkward / confusing usage:
    a. If they switched the system on, the reader may have registered a tag from an item already inside the bag. The device would beep and an LED would illuminate, even if it was not a purposeful scan.
    b. When the system is turned on, items needed to be removed and then scanned to 'put them in the bag' – can there be some memory if an item is already in the bag?
5. Descriptions about fun, interesting, 'wanting a device', were mentioned many times
6. Airport security was raised by almost all user groups, and when this was tested there were no issues to report.
7. Weather considerations could have been a concern but the device functioned well in harsh conditions.
8. The ease of use was a positive about the device.

The less frequent comments and points where participants were not in agreement on the devices. Although some users liked the scanning interaction a lot, a few found the scanning action tedious after long use with the device. Many users loved the styling, but a few did not feel it suited them, so potentially several styles may be important. The way the prototype was used did change with the users own conceptual model of the system. Some users left the lights on, rather than off when packed – this was not anticipated. There were requests for a separate device to be used with any bag. This would be a system that was not already part of or embedded in a bag. Lastly, some participants questioned if they could have volume control, some users did like it having a beep but others did not.

The feedback received informed the next level of higher fidelity prototypes. This chapter presented the MB1 prototype that was used for an autoethnography study (AU2), a residential weekend with potential users study (RW1) and a final brief pilot study (PS1). Findings included information about features, scanning action, communication: visual and audio, and aesthetics. This prototype still had battery issues that will need to be addressed in a future version. The issue of the prototype having some memory to record the items scanned even after shut off was implemented before the bag was used in-the-wild (5-4.4). There was also some confusion concerning where to scan the tags. The device is found to be non-obtrusive into a user's lifestyle and travelling with the device on a variety of different modes posed no issues.

Chapter 6 Variations through discovery

This chapter describes and discusses three main prototypes, with two variations, that have been designed directly because of the previous feedback received. Chapter 5 focused on an in-depth autoethnographic study to establish the role the prototype can play in a user's life, as well as the look and feel, the sensory experiences, and the functioning of it. These prototypes are slightly higher fidelity, and are the first time the devices are given to participants for a single user walk out (SU1). Additionally, due to feedback from the previous studies and SU1, a brand new radical concept was introduced - the stand-alone (SA PoC) – that was tested and documented in my research journal.

The chapter will describe the design and implementation of five prototypes. There is a detailed explanation of the studies done, and what the key findings were. These key findings are used to inform further iterations and prototypes that will then be used for a final in-the-wild study (SU2) presented in Chapter 7. The work follows an experience-centred approach and autobiographical design is used alongside more traditional methods. This includes five professional critique events (EV2) and a single user walk out. Table 6-1 lists all the prototypes presented in this chapter along with an overview on the design and testing.

Table 6-1 The prototypes examined in this chapter.

Unisex Messenger Bag (Uni)	**Design**	**Section**
	Experience-Centred design resulted in the Unisex Messenger iteration. Through using the previous prototype, feedback informed the changes that are reflected in this bag.	6.1
This is a group of prototypes that was used for the first time by participants in-the-wild (single user walk out) away from the researcher. They are higher fidelity then previous prototypes.	**Testing**	
	SU1 Third person engagement: single user walk out. One to one interview.	6.2
INTERFACE Through feedback from previous autoethnographic research, the form of this bag	EV2 Observation, Conference and Events: • Wearable technology show, Excel, London, UK	6.5

is different to the others. It is a larger unisex style. The interactive RFID system coupled with 5 LEDs is used. (reduced from 10) These 5 LEDs represent an object and is the corresponding light to a tagged item.	• Creator Faire, National Space Centre, Leicester, UK • Wuthering Bytes, Hebden Bridge, UK • CHI: Toronto, Canada • CogSci Launch, London, UK	
Upcycled A (UpA)  A series of three handbags were created after receiving styling feedback. INTERFACE This prototype has a form change that is using a classic 1950s handbag along with the modern technology components. The circuit board is on show in this version (and the UpB) rather than being hidden as in the Uni prototype. **VARIANTS** Variations were made as there were two devices used at the same time for testing as part of the single user walk out. **Upcycled B** (UpB)  **Upcycled C** (UpC) 	**Design** The upcycled handbags (UpA, UpB, UpC) were all used for a single user walkout. This was to establish what effects it has on a user's life. Also, due to the styling data regarding the aesthetics will be collected. A Research through Design approach is taken alongside autobiographical design to compliment the more traditional methods used.	**Section** 6.3
	Testing	
	AU3 Autoethnography	6.3.5
	EV2 Observation, Conference and Events: • Wearable technology show, Excel, London • Creator Faire, National Space Centre, Leicester • Wuthering Bytes, Hebden Bridge • CHI: Toronto, Canada • CogSci Launch, QMUL, London	6.5
	SU1 Third person engagement: single user walk out.	6.2
	EV2 Observation, Conference and Events: • Wearable technology show, Excel, London • Creator Faire, National Space Centre, Leicester • Wuthering Bytes, Hebden Bridge • CHI: Toronto, Canada • CogSci Launch, QMUL, London	6.5

Stand-alone Proof of Concept (SA PoC)	**Design**	**Section**
 This is a proof of concept for a version of the device that a user can place on their own bag. INTERFACE This device has a small LCD screen that loops thorugh a pre-programmed list of items. This list matches a set of RFID tags given to a user. It has haptic capabilites to notify a user when an item has been scanned.	Research through Design approach. This prototype is a radical iteration from previous designs. It was used by the author and was the result of the feedbcak from the previous studies.	6.6
	Testing	
	AU4 Autoethnography: Research Journals	6.6.4

6.1 Unisex Messenger Bag (Uni) Implementation and Evaluation

The unisex messenger has styling changes resulting from feedback in Chapter 4 (Table items 4-6.4; 4-7.5) about men using the same system integrated with a bag. In addition to that feedback, there were several questions and comments asking if the bags were for women only noted in Chapter 5 (Table item 5-7.13). This prompted a design change to ensure the bag would be appropriate for both male and female users. Experience-Centred design resulted in creating this Unisex Messenger iteration. Through using the previous prototype, feedback informed the changes that are reflected in this bag.

The unisex messenger also has an on/off switch on the front of the bag and a light indicator when the system has power. The conceptual model is the same as the previous systems. Users will tag their items that they have pre-selected with the tags provided. Basic operation is the same as the other iterations; scanning items that are pre-tagged, in and out. A user can then look across a room and see through the lights being on or off if an item is packed or not.

This version has 5 LEDs and not the 10 LED system as with MB1 previously tested. Feedback obtained indicated that users found this 10 light system confusing and also that the reminders part of the system wasn't used over time (Table items 5-3.4b; 5-7.2; 5-7.14; 5-8.1). This prototype was tested on a system level, to establish if there was any programming or operational errors. It was then used for a third person engagement in a single user walk out. Lastly, this prototype was then demonstrated at five events (study EV2).

Figure 6.1 Messenger Bag, unisex styling.

6.1.1 Interface Details

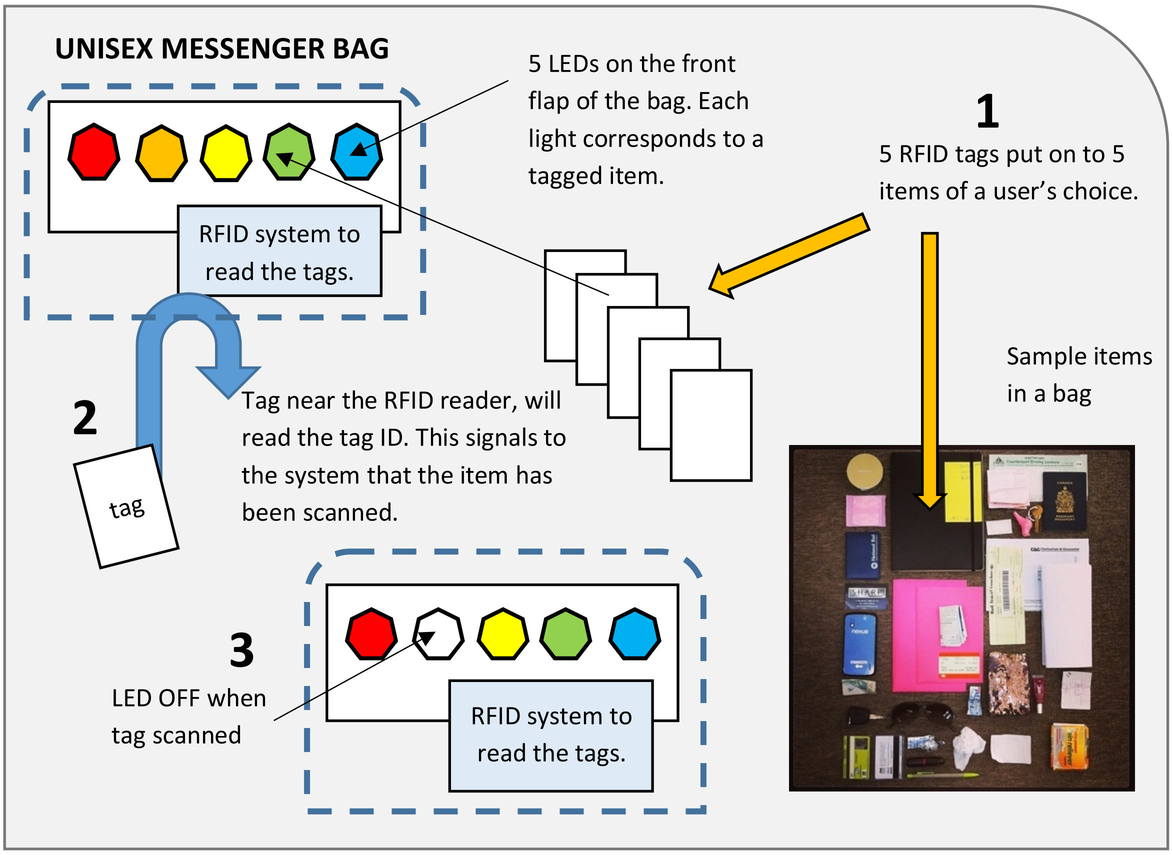


Figure 6.2 Interface for Unisex Messenger.

Figure 6.2 illustrates the conceptual model and interaction that a user will have with the prototype. It is similar in the actions that a user will do with the previous bag but there are a reduced number of tags and corresponding lights. A user will follow the same system described in Section 3.3.5 of tagging their five personal items with a selection of tags (shown previously in Figure 4.8).

6.1.2 Materials & Modifications

The working components of the system were completely embedded into the bag so an initial planning phase was needed to arrange the components before putting them inside. The first phase involved mapping out onto felt the possible circuitry routing, to establish where the components would have good connection, this can be seen in Figure 6.3. Once the initial route is mapped out and some of the early connections established, further annotating on the felt was made to show where the connections would need to be sewn to avoid overlapping circuitry.

This mapping out of the circuit is an essential part of the process as circuitry would potentially be the first area for errors introduced into the system. Once the routes were sewn in to their respective components and the connections made, the felt is placed for styling and location to be integrated into the bag (Figure 6.4).

Components used for the unisex messenger smart object are:

- OLED
- On/Off Switch (sewable)
- USB charging module
- Common components: Lilypad (ATMega328) Main Board, ID-12LA & breakout board, Vibration Motor, Piezo, Sewable LEDs, Breadboard, Wiring

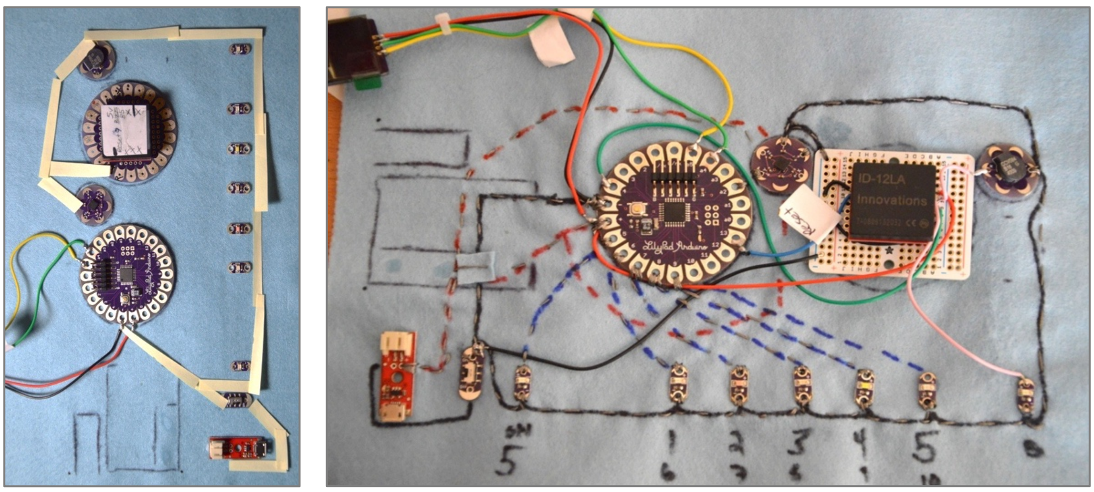


Figure 6.3 Initial routing with electrical tape and circuitry mapped out.

Figure 6.4 Placement planning of the device, thickness of the RFID reader, side on, 5-7cm.

This prototype used the larger Lilypad circuit board as there was a need for more I/O ports due to the small display and additional power LED. Although that board was prone to snagging clothes on a previous system (see Table items 5-5.1; 5-6.8), in the unisex messenger it is embedded so snagging is not an issue. The OLED is included for initial messages that the system works and is on. It will not be implemented in detail in this version and is there for future modifications to the system.

Issues with the hardware

The RFID reader SLO18 that was used in the other smart devices is slimmer and would be more appropriate to use. Unfortunately, the SLO18 was unavailable at the time of this device being constructed. There were deadlines that needed to be followed to allow the device to be ready in time for the testing phase. This meant unfortunately that the unisex messenger uses the previous RFID reader the ID-12LA (a variant on the ID-20 used in the first proof-of-concept prototype PoC).

Due to the unavailability of the RFID component, the bag has a slightly thicker area where the reader is placed and uses the 125-kHz tag frequency. The thickness of this board can be seen in Figure 6.4 (around ~5-7cm height). This reader also needs a breakout board due to its unusual pin spacing that does not map directly to the Arduino system.

Unfortunately, when I was trialling this bag before sending it to a tester to be sure the components all worked as expected, the USB charging connection snapped off the charger board. It was necessairy to modify the rechargeable battery pack and change the battery resulting in a larger 4AA pack being placed inside the front pocket. This added bulk and weight to the system that would not have otherwise have been there.

6.2 Single user walk out (SU1)

This study is the first time the devices will be used by other users exclusively, on their terms and with their interpretations. There are several objectives for gathering information about the device;

- to find system errors, inconveniences, inconsistencies or similar hardware
- software issues that can be fixed or eliminated to improve the smart device
- aesthetic and lifestyle suitability when using the devices
- early explorations concerning emotions associated with forgetfulness
- any impact of forgetfulness over the course of the day, or week, or month

The study will look at a participant using their own bag for a week and then to use the augmented bag for a month.

6.2.1 Study Design

There are three purpose built devices that will be provided (one for each tester), and they will spend one month with the prototype. Each participant was interviewed one to one in person for ten minutes before the study began. We followed up with a closing interview in person again at the end of the study.

Three people who had completed an initial online questionnaire with criteria of no medically diagnosed memory condition were randomly selected. Recruitment was through various social media sites, Twitter, Facebook, Google + as well as GumTree and posting ads in various places around York, UK. Although there was a slant towards social media, the links were often passed on to family or friends who people thought may be interested. They usually were not on social media and were reached through word of mouth.

After collecting 10 responses to a recruitment survey, people were selected based on who would be able to have the bag for a month and that they did not have a diagnosed medical memory issue.

Table 6-2 Participants for the prototypes in study SU1.

Prototype	Participant Name Codes
Participant 1 : Unisex bag	SU1 P1
Participant 2 : Upcycled B	SU1 P2
Participant 3 : Upcycled C	SU1 P3

One male was given the Unisex Messenger described in this section, and two females were chosen and given two similar devices (UpB, and UpC). This section describes the Unisex Messenger, Section 6.3 describes the other three participants testing the other bags. The tasks and briefing is the same for all participants in the SU1 study.

Tasks:

Goal-oriented task to pack their daily items, as chosen by that user. Tasks alternate between using their own bag without technology smart object, and the embedded smart bag. Afterwards, they report on their experiences using the bag, in both situations. The task is representative of actual usage to improve external validity. However, the more representative the task, the more the task is likely to include behaviours not directly related to the interface or interaction method under test (Johnson et al., 2012).

Briefing / Preparing Participants:

These participants had an initial conversation about their current practices and how forgetful they think they are. The bags were then demonstrated as well as providing video clips of how to use the bags / tags if they had forgotten or wanted additional guidance through a purpose website[19]. There is then an exit interview with the participant. These designs are used as a resource for design, 'ambiguity as a resource for design', (Gaver, Bever & Benford, 2003) to encourage the user to appropriate the technology in ways that were meaningful to them. There are no expectations on how they use the bags or what items they tag.

Participants were asked to use their own bag for a period of one week and to make notes or reply to the questionnaire online for the journeys that they took. They were asked to note if they had forgotten things or were worried if they forgot items. This was repeated for the augmented bag - but for a period of a month.

Ethics:

All participants were given a link to an online consent form, 'Consent Information', for proceeding with the survey. This was signed digitally and informed the participant of their right to withdraw, how their data was protected, and confidentiality.

19 Located initially http://mymessagebag.com permanently moved to the site subdomain of http://messagebag.christinefarion.com (available July 2016)

6.2.2 Data recording

The data collected was through email correspondence, online questionnaires and conversations with the participant, through skype or in person where suitable. These notes were written down at the time of collection or shortly thereafter. The recording procedures for my journals is as previously described in Section 5.4.3. Participant numbers were used where data was recorded.

6.2.3 Data analysis

The data analysis is as previously described in Section 5.4.3. Detailed note taking and thematic coding as described.

6.2.4 Findings for Participant P1 (prototype Uni)

The five chosen items for P1 were: wallet, keys, journal, laptop charger, glasses case.

When this respondent was initially interviewed one on one, he described that he felt very forgetful. He commented that when he forgets, it is a negative experience and there are *"practical problems and stress because it revolves around stuff I need to do and work around it".* He elaborated added that he forgets items and events. He commented that he tried to put practices into place to help with forgetting things. He has tried using to do lists, Evernote (software), and has created a to-do board at home where he can also attach physical objects. In his words he wrote,

> *"lists in all sorts of formats, post it notes to some extent. Intentive design of my living space, but still lots of clutter and piles here and there. Also custom application to tag priorities, and wearable technology, Google Glass…"* [- SU1 P1 and the methods they use to try to remember.]

This participant uses more than one bag regularly. They have a specific bag for when they go out with their child, and a bag for work which is large as it has to hold a laptop and books usually. It was predominantly these work trips for which the bag was needed. After using the Uni prototype, the respondent indicated that they wanted to use the bag more, however, it was a tight fit for the laptop and the other things (books etc.) that they needed to carry for work. Because of the size compromise, he did not feel able to use it as often as he would have wanted. He also felt that the lights might be too “girly” and wondered if there could be numbers or other symbols for the lights?

Also due to the respondent having more than one essential bag for the things they need to do, they asked if they could “*just have something to clip on to their bag*”. He remarked that this would allow him to use the device for more than one bag. He believed that he takes the same items with him - the same essential items; keys, phone, wallet… on most trips, regardless of the bag they are using.

This participant wrote in response to, ‘please describe how you feel when you forget things’:

> “*Frustration, the fact that a little piece of information is inaccessible in my mind makes me upset at the limits of our biology, and therefore excited about potential ways technology can help augment memory. Running around the house trying to remember where x item is such wasted time.*” [- SU1 P1]

Additionally, the user felt he was so forgetful he worried if the bag would stop working or not be accurate, and then would have more to be anxious about. Therefore, would need to be a way to confirm the correct functioning of the bag.

Table 6-3 Results for Participant 1 using Unisex Messenger.

OVERVIEW OF RESULTS

6-3.1	Wanted to swap the technology on more than one bag. This respondent used several bags, one for the gym and one for his kids, and wondered how the technology could be moved from each bag.
6-3.2	The overall comments he made were focused that he would like to use his own bag.
6-3.3	The respondent felt the lights might be too ‘girly’, he suggested to use numbers or symbols as an alternative.
6-3.4	Wondered if the lights might be obscured when in transit. He did not like having the lights on when using the bag out of the home.
6-3.5	Unsure about putting his “trust” in the bag. This would result in creating additional anxiety for the user.

NOTE: Issue that affects testing: This bag was returned non-functioning. Because no mention was made of this, it is unclear when it stopped working. The bag needed to be completely taken apart and remade. This lead to uncertainties as to whether there is an issue about the robust nature of the bag or if it was somehow damaged during use. Many components were no longer attached so, that it had to be completely remade. This prototype became Embedded bag prototype (EM1) as presented in Chapter 7.

6.3 Upcycled handbag (UpA) Implementation and Evaluation

Changes for this prototype are primarily focused on styling which highlights the need and desire for an item to fit in with our style universe. Issues surfaced in the pilot study (PS1) and the autoethnography studies (AU1, AU2), to indicate that this aspect is a critical factor to get right. Individuals are likely to not use a device, however beneficial, if it is not something they can match to their styling. We also know about the importance of styling from observations and previous work (Starner, 1996; Starner & Rhodes, 1999). This section describes the overall styling, a vintage handbag with technology, two versions were used for the single user (SU1) walk out.

6.3.1 Overview

The design of this bag is primarily aesthetic but changing the appearance of the bag, resulted in addressing component changes. This design increment is an upcycled handbag using a 1950's vintage handbag as a base.

Figure 6.5 Upcycled Handbags UpA as photographed by Getty Images for an article in the Daily Mail online[20] and UpB, UpC.

20 Daily Mail Online (2016), Getty Images. Retrieved July 2016 from http://www.dailymail.co.uk/sciencetech/article-2988482/Samsung-s-virtual-reality-headset-smart-handbag-health-tracking-earphones-gadgets-display-Wearable-Technology-Show.html

I choose this styling because after researching styles, it was observed that there are many vintage shops, vintage fairs, vintage themed events and a climate of recycling, reusing and upcycling exists. It was determined that taking an existing stylish item and adding technology to it would be a way to augment it and create an upcycling opportunity.

The design takes into consideration feedback received about reducing the number of LEDs to lessen the cognitive load (Table items 5-7.1; 5-7.2; 5-7.14; 5-8.1). Will reducing the number of lights make the system easier to use by designing fewer items as essential? All aspects of the handbags' configurations are the same. However, the 'base' handbag used for each differs slightly as each was a 1950s vintage used item.

6.3.2 Materials and Build

The hardware materials used and the build followed is provided in Appendix I.

6.3.3 Interface Details

The interface and interaction system is the same as presented in Figure 6.2.

6.3.4 System Design Decisions

After obtaining feedback from testing the previous bag (Message Bag 1.0 with 10 LEDs), it was apparent that managing ten items of mixed type – task-based and object-based was excessive, so there needed to be a reduction of the number of lights (Table items 5-7.1; 5-7.2; 5-7.14; 5-8.1). Keeping to one type of reminder, and as object-based reminders are the focus of the study, due to the lack of availability of this type of reminder system, object-based reminders became the focus for the upcycled prototype.

Additionally, styling for an object that is to be used daily meant that research was conducted into trends and fashion and a classic style handbag was the choice to satisfy fashion considerations. The timeless styling of the handbag meant consideration of placement of the device was needed and many of the components were hidden from view in a discreet way. Also, I observed during the residential weekend (study RW1) with potential users (Section 5.3) the interaction that when a respondent was unsure where to scan, their natural mapping was to scan over the processing board area (Table items 5-3.2a-d). This observation prompted me to move the RFID board to behind the circuit area as it appeared to be a natural assumption for users.

6.3.5 Autoethnography (AU3): Research Journal (prototype UpA)

This handbag configuration was used for the typical journeys I would have over the course of a week. My tagged items were my keys, lipstick, journal, change purse, and medicine. The purpose of using the bag was to establish that it was operating correctly and there were no programming or operational errors at this stage.

The scanning area had been moved to just behind where the circuit board was placed. This was due to my observations of the RW1 study (Table item 5-3.2a-d). The natural mapping for people when they use the bag was to scan over that area. A selection of field notes that were written in my journal at the time of taking the bag out is reproduced as they were written.

Field Notes from Journey 1

[…] *I've been so excited to use this bag. Once it was completed with the changes needed I wanted to pack it and just take it everywhere with me. It isn't as large an inside space as previous bags I've used, and I can't see anything replacing the Message Bag as it suits all my needs. This bag though is so stylish, it may be that when I use it it is more for going somewhere 'special'. The items I need with me are tagged and the journey will just be one into town to get a coffee. This way I can use the handbag to walk down the street, and to place it on a table while I have a drink.* [...] *I'm writing these notes at the table as the bag is placed on it. Everything worked as expected, I scanned my change purse out to pay and then scanned it back in again. I feel that because I know the system so well these actions almost happen seamlessly. They become part of the natural movement that I make when I remove things from my bag. I would be curious now to discover if I still do those movements if the bag didn't have any technology. Sometimes I do have to place things back into the bag in a certain position especially if the tag is large. There are still some issues where the tag does register if it is in the bag. It isn't often but any errors aren't good. My mind wonders if there is a solution about using some shield inside the bag to protect from that happening. I remember a conference I went to where a lady spoke at length with me about people in north America having anti RFID wallets, and they are mini shields against rfid. Is this something that I should be looking into for further iterations? How often does this double scan happen and even if it happens is it enough of an issue to prevent correct working of the bag?* […] *I feel confident and proud when using this bag, I don't worry about forgetting my essential items but I still do have to check for those unusual or extra items. My general feel is that I have a lot less worry about money and keys which for me already does make a big difference to my life.*[…]

Field Notes from Journey 2

[…] *everything was already packed and I'm not going to check my bag. I'm going to trust it and be ok about that.* […]

Field Notes from Journey 3

[…] *Today I am heading out to grab a few essential items at the shop. The weather is nice and the items I have with me are all I need. This entry is being written up after my journey as there was one unusual thing that happened that I couldn't have planned for. When out using the bag, it was packed pretty full today. This included packing a thick plastic bag for my shopping later. I'm not too sure how but my keys were a little tangled in with the plastic bag. When I pulled out the bag to pack some shopping items my keys actually fell out of the handbag. I hadn't had any items fall from the bag before. But what was odd about it was that the keys actually scanned as it went next to the sensor before falling (they just fell on to the counter and not the floor). The system beeped and the light went on. I was with my son at the time and he turned and asked me, 'Was the bag supposed to do that?,' I was a little confused myself at the time and stammered a little that sure sure that's the system, it scans in and out. But at the time, this was an accident but it just also happened to have scanned the keys. Was this due to the new placement position of the scanned area? Was it just a fluke? It did alert me to the keys coming out of my bag so it worked unbelievably well. I'm not sure I would trust it to do this again though. It was a very interesting experience. My son was so excited by how it was working and I wondered if the bag should in some way be able to scan in and out without that explicit scanning action a user had to do.* […]

Field Notes from Journey 4

[…] *Over time I had begun to realise that I always had the same types of items with me. If these items weren't a part of my journey, then there was a chance that I would be a part of a negative or uncomfortable situation. My medicine became part of my essential tagged items but then I also found myself making sure that all these items were in every bag I used. Also depending on how precious the item was would make a difference if I could tag it with a sticker. I had a beautiful compact from an expensive brand, that I did want on all journeys with me but I didn't want to put a sticker on it. On this particular journey, I was heading out to meet a friend for some breakfast. It was a Sunday, the weather was very nice and I was feeling confident because I loved the handbag so much. It was only my fourth time taking it out and although it wasn't a large bag which I felt might be a problem, it still fit everything I needed with me. As I approached the breakfast place down my street, I saw two friends who were* *headed towards me. A couple, who were also going for breakfast. It just happened that we all were stood outside the same place at the same time, so we decided to all eat together.*

Once inside I placed my handbag on the table, which the friend had then picked up and touched, and asked, "what are all the lights for?"[…]

Key words (in-vivo coding) and phrases from the excerpts are:

excited, size small, style, special purpose, all working, seamless system, natural, issues with double scan, shield, confident, unusual items, scanned, sensor, RFID shield, tag on expensive items

Those words are associated with my usage of the device over the week. Would my findings and use of the bag, along with the terms pulled out from my usage match the findings of the single user participants. The codes highlighted from the passages documented were categorised as similar themes surfaced through many similar ideas. They were then allocated to Form, Function and Feeling as previous themes.

Table 6-4 Modification from similar themes in Section 5.3.3

Theme	**Codes**	**Descriptors**
Suitability	User	Information about the user and their perceptions. What were their feelings or experiences when using the device.
	Device (Physical)	Features, Scanning Action; quality of the device, information related to the technology.
	Device (Interaction)	Communication: Audio & Visual; information about the system in use. Is the communication clear for the user? Do they understand the device? How is this of benefit? Does it work as intended, is it fit for purpose?
	Device (Aesthetics or Feeling)	Information on the overall visible suitability for users. Is it an item they would take out with them? What indications would demonstrate the smart bag was suitable.

Device: Physical

The styling and adapted nature of the device itself lead to compliments on the appearance and individuals wanting one they could use. This device attracted comments of a positive nature, individuals wanting the bag, and curious as to the nature of the lights and what

the purpose was. Some individuals commented that they would be happy to just have the lights as the bag stands out from a typical bag and they found this attractive.
In-vivo: size small, special purpose, all working, seamless system, natural, shield, sensor

Device: Interaction

There were no errors in functionality to report. Initial software issues were sorted before placement of the system onto the bag itself, and this bag was found to be suitable for full user testing.

The unusual 'self-scan' of the keys that had fallen from my bag was noted as a one-off occurrence and was something that happened that prompted an unusual observation. The interaction occurred without active engagement from the user.
In-vivo: excited, special purpose, all working, seamless system, natural, issues with double scan, shield, unusual items, scanned, sensor, RFID shield, tag on expensive items

Device: Aesthetics

The device had a positive effect, many positive in-vivo codes were noted and the styling helped contribute to those positive feelings. The pleasure in use from this bag, the enjoyment from the scanning motion and the added positive feelings believing that you would not forget items all led to a positive experience.
In-vivo: excited, size small, style, special purpose, all working, seamless system, natural, confident

6.3.6 Study SU1, Single user walk out (prototypes UpB and UpC)

This study is a continuation of the single user walk out (SU1) as previously described in section 6.2, please refer there for the details of: objectives, participants, tasks, and briefing.

6.3.7 Findings for Participant 2 (P2, prototype UpB)

The five chosen items for P2 were: notebook, phone, keys, wallet, makeup bag

When this respondent was initially interviewed one on one, they felt they forgot things they were supposed to do more than they thought they forgot actual items. However, they felt that when they did forget an important item, it made more of an impact to their day in a negative way.

Reminder systems they used were notebooks, calendars, and, "*Ridiculous amounts of lists!*". They also felt that they left things in unusual places and that is why they forgot them.

They asked if a device to track where the items were, not just in the bag was possible for them? Forgetting made them feel hassled, annoyed and would the cost involved if they needed to buy things such as a new water bottle or similar because they forgot it. When asked to ‘describe how you feel when you forget things’, they wrote, “*Irritated and frustrated but I've worked to get rid of this - mostly it's to do with guilt and feeling stupid, which I don't like and don't need to feel!*” [- SU1 P2]

This individual had priorities to have a stylish bag, and they commented that they loved the interaction of scanning an item in and out. Table 6-4 highlights the main issues for this user. They wanted the lights on all the time and would like a device that located their lost items. This respondent liked the styling of the bag a lot and would have liked additional colours / sizes to go with more things they were wearing.

“I am getting back more than 10 minutes a day from not checking my bag all the time!” [- SU1 P2 in conversation about using Upcycled B prototype]

That quote was selected as it captured the excitement and joy the user expressed when using the prototype. They were very positive about their experience with the device and they expressed that having that extra ten minutes in their day was important to them.

Table 6-5 Results for Participant 2, Upcycled B.

OVERVIEW OF RESULTS	
6-5.1	Liked the device for the styling (function or no function), which encouraged her to use it daily.
6-5.2	Would want to integrate their mobile phone in some way.
6-5.3	Would want something for when they go on holiday and have a lot of items to track.
6-5.4	Preference was the LEDs to be lit all the time when out.
6-5.5	More interaction, they liked scanning items in and out, and wanted the bag to do more – they could not suggest what, but they wanted ‘more interaction’.

For this user, the styling was a very high priority as to whether they would take it out or not. The respondent enjoyed the interaction with the bag, finding this fun, and wondered if there could be more interaction. No alternatives or ideas were offered for what this would potentially involve or how additional usage could be incorporated. The user liked the scanning action and wanted ‘more and more’ tags. Another point mentioned was to have the LEDs lit all the time when out – having a bag that was ‘unusual’ compared with a typical bag was desirable. For this user, the fashion aspect was a higher priority than other issues.

Additionally, because this tester loved the lights to be on, and found that a real perk of the bag, they used it in the opposite way as what the intentions were. Instead of the LEDs going off when items were packed, they had them go on, thus the bag would have all lights lit when packed. This meant, however, that there was a slightly larger energy need on the bag than anticipated, so this would need to be taken into future consideration.

6.3.8 Findings for Participant 3 (P3, prototype UpC)

The five chosen items for P3 were: phone, charger, wallet, notepad, keys.

They did add that they find additional items essential including; oyster card, headphones, laptop, kindle, books. They wanted to swap the tags to different items or have more tags to tag all the items.

When this respondent was initially interviewed one on one they said they were very forgetful, and checked things many times throughout the day. They were constantly worried about what was missing or what they would not have with them that they needed. They recounted a story about when they were using their camera,

> *"…even forgetting an important camera lens on the beach once"*
> [- SU1 P3 in conversation about feeling forgetful]

They loved the styling of the bag and felt that it fit in well into certain lifestyle choices. However, they felt augmenting a bag may also prove limiting, meaning that you would need to put smart devices into bags as they are made. This would have to extend to *all* styles of bags; so that there was choice – they felt it is so subjective the bags we choose. Again, the ideas of the external device surfaced and this may be an alternative way to have functionality for this type of device. They would like multiple styles of the technology on many 'modes' of bags, such as sports bags.

> *"Yes! I'm not spending an extra 10 minutes a day looking if I've packed something or not!"*
>
> and,
> *"if I could tag everything I would"* [- SU1 P3 in conversation about using Upcycled C prototype]

ISSUES:

One of the tags broke when P3 tried to curve it around an object they were trying to tag. They were not sure if they had broken it or if it just did not scan or what to do about / with it. They voiced concern to me in an interview over Skype: '*Are the tags replaceable?*', '*How am I to know that the tags couldn't be used that way?*', and '*Was it broken?*'

SU1 P3 additionally mentioned:

- The motion of scanning in and out became tedious over the course of a month, and after 3 weeks it *"felt laborious"* and they wanted the bag to just scan it for them.
- They believed the bag saved them around 10 minutes a day from not constantly checking and they had a more relaxed "weight lifted" feeling once they had packed a bag.
- Wants to keep and continue using the bag, wants the device on other bags.
- They would like to know that the bags will not stop working and that they can "trust" it.

Table 6-6 Results from Participant 3, Upcycled C

OVERVIEW OF RESULTS

6-6.1	Use one type of tag to eliminate confusion?
6-6.2	Battery / charging issues to make it easier for the user
6-6.3	Some comments of, "scanning is irritating", can we find a way to avoid an active scan motion
6-6.4	One tag broke because it was bent, and felt the documentation needed to be more explicit
6-6.5	Have an external device as an option?
6-6.6	Weight lifted feeing [SU1 P3]

This participant kept the device as they commented that it was a bag that they did want to use all the time and they had grown used to it and wanted it with them still. They felt it helped them to be sure their things were packed and they wanted the device on other bags that they own.

6.3.9 Summary of the single user study (SU1)

Several common themes arose around: styling and lifestyle, functions and inconsistency, common issues, software, and hardware. We see that the styling is subjective, with some respondents enjoying the visibility of the technology and others wanting it hidden. This is the same for having the lights illuminated – to keep them on or off when the item is packed.

There were also some issues with remembering to rescan an item on removal from the bag. This is needed due to the placement of the scanner. If it is placed any closer to the bottom of the bag it continually scans the items packed so becomes unreliable. A summary of results is listed in Table 6-6.

Table 6-7 Results from participants in the single user study SU1 P1, SU1 P2 and SU1 P3.

OVERALL ISSUE		DETAILS
STYLING AND LIFESTYLE	6-7.1a	Overall, users felt the styling reflected them.
	6-7.1b	Styling encouraged use because of the look of the bag, they wanted to use it.
	6-7.1c	Users want more styles of smart object bags, more choice.
	6-7.1d	They questioned, could they obscure the device when out with it? (this is a mixed issue, two participants loved it being visible, and one did not).
FUNCTIONS, INCONSISTENCY	6-7.2a	Were the lights to be on or off to indicate an item packed or missing?
	6-7.2b	Participants enjoyed the interaction / but one found it tiresome after a month.
	6-7.2c	Were there more tags? Some users were not sure what items could be tagged.
	6-7.2d	It is a problem if they forget to scan an item on removing it.
	6-7.2e	They need to trust the device.
	6-7.2f	Are there specific bags for activities? Can the device be used across multiple bags? (mentioned by all users)
SOFTWARE	6-7.3a	The software appeared to be functioning as proposed.
	6-7.3b	Was it possible that there was a delay when scanning, is this an issue?
HARDWARE	6-7.4a	Should they use only one type of tag?
	6-7.4b	A user was uncertain if a tag was broken by them.
	6-7.4c	A user questioned if the tags are replaceable.
	6-7.4d	Is the battery able to be charged, does charging work? Was the bag robust enough for use?
IMPACT ON LIFE	6-7.5a	Can the smart bag track where the items are located if not with the bag? A user forgets where they leave things, what help can a device be for that issue?
FURTHER FUNCTIONALITY	6-7.6a	Add mobile phone connection?
	6-7.6b	Saved time, though not checking bag all the time.

The single user study revealed new information (tag usage and breaking) as well as confirming issues that were surfacing, and it provides a good base for further improvement. Many of the discoveries echoed my own experiences while using the bag. I too felt the styling reflected myself, and would also want more styles. I also really enjoy the scanning action, however some people did find it becoming tedious. When I noted in my research journals that having the items scan in or out as the items are used, this is the similar feeling to SU1 P3. They would prefer scanning was an automated process. The broken tag was the first time this was observed, and potentially an informative guide would need to be issued to describe how the tags work, what they can be placed on and similar.

6.4 Observation: Events (EV2)

The prototypes presented in this chapter were created as robust high-fidelity systems that I can study what effects they will have on a user. The anticipation is that it will be a device that helps them remember what to pack for their day ahead and aim to reduce any anxiety that may normally be associated with forgetting items, or worrying about forgetting items. Part of my testing involved showcasing the devices at three public events;

- Wearable technology show, Excel, London
- Creator Faire, National Space Centre, Leicester
- Wuthering Bytes, Hebden Bridge

6.4.1 Study Details

These events enabled me to collect some initial feedback for minor changes and thoughts concerning the different devices. The general findings of which are contained in the following section. Primarily though it was to confirm that the devices were ready and to the standard necessary for the final single user study (SU2) that is presented in Chapter 7.

The three interactive devices underwent three initial public testing platforms. First, The Wearable Technology Show at Excel in London, UK, March 2015. This was also the first appearance of the Stand-alone device (presented in Chapter 7). Another was the Creator Faire, National Space Centre, UK, September 2015. Finally, a technology event called Wuthering Bytes in Hebden Bridge, UK, September 2015. These events attracted many people of distinct audiences. At this stage, the prototypes were in their final phases and these public displays served to confirm the styling, robustness, functionality, interaction and usability.

The events served as a final check that the prototypes were of the standard needed to start the final testing.

Wearable Technology Show

The Wearable Technology Show (shown in Figure 6.7) attracts many tech savvy and business oriented patrons. People were attending for demonstrations, talks and learning sessions all in the wearable field, and they came with expectations of quality and innovation. It was a 2-day event which involved standing at a display where the smart bags and other wearable items were on display. The majority of wearable devices were watches or other things you would wear on a wrist.

The handbags were unique at this event. When walking around to look through the other stalls and there were no other handbags on display. There were also no devices for memory that were purpose built and on demonstration. This event provided a forum for short conversations with many people about the devices.

Key words collated from the show: innovative, most interesting, useful, pretty, good idea, can I buy this, what other ways can this be used, who else is doing this, fun, attractive, clever

The Creator Faire

This event (shown in Figure 6.6) predominantly involved families with young children. Many conversations took place and one individual highlighted potential uses. A medical doctor was interested in using the device for his practice; to be sure the essential items the medical practice needs, which he pointed out are expensive, are packed in the doctor's bag when on call. He was very enthusiastic in the way he spoke about how this could fill a need in the medical community based on his experience.

Key words collated from the show: interesting, I like this, I can use this, can I make one, fun, useful, how else can I use it, doctors, sports, kids

Wuthering Bytes

I attended this conference for three of the days and delivered a talk (shown in Figure 6.8). The talk had questions afterwards, and then there was also a social aspect to the event where I was speaking to individuals afterwards. It was attended by a technical crowd of adults of varying ages. Most had some expert technical knowledge in a variety of computing fields. The conference is billed as an event for geeks and computer enthusiastic people.

Various interesting conversations stemmed from these events. Some topics concerned the power requirements i.e. what charging would be needed and would people remember to charge it. There were also questions such as, 'does it draw attention to having "stuff" on your person' i.e. 'I'm carrying valuables'. Could this be an additional source of anxiety if they believed this to be the case? Issues around weather conditions were queried: would the devices fare well in extreme cold or heat or rain for example, and would this alter battery life?

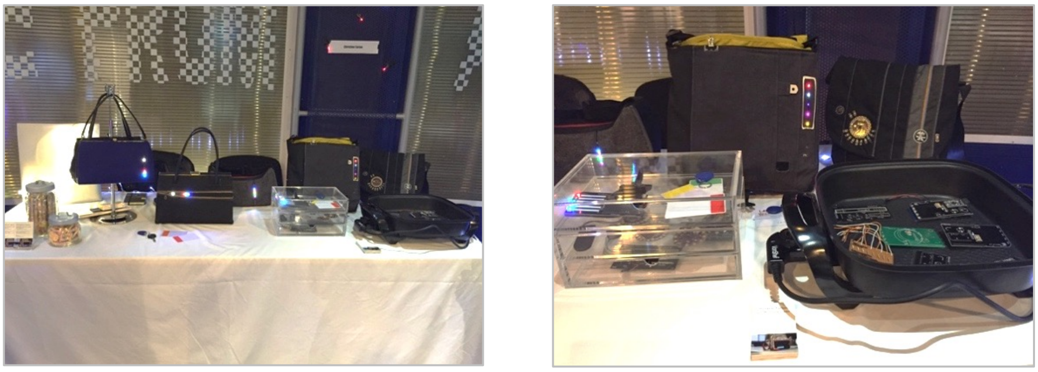


Figure 6.6 Images from The Creator Faire, National Space Centre.

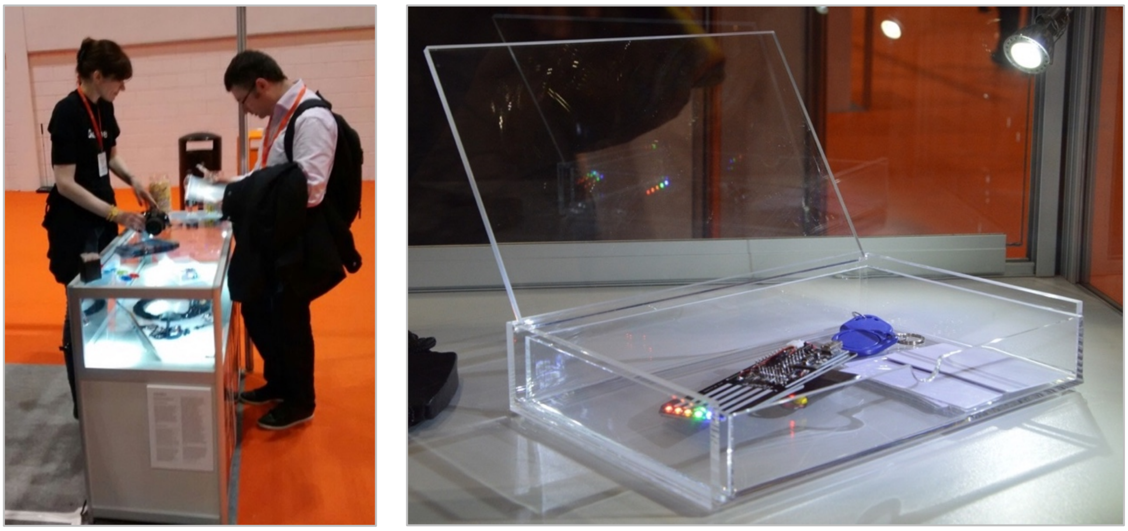


Figure 6.7 Speaking with one of the hundreds of people who visited the stand at the Wearable Technology Show. On the right, a prototype version of Stand-alone (Chapter 7).

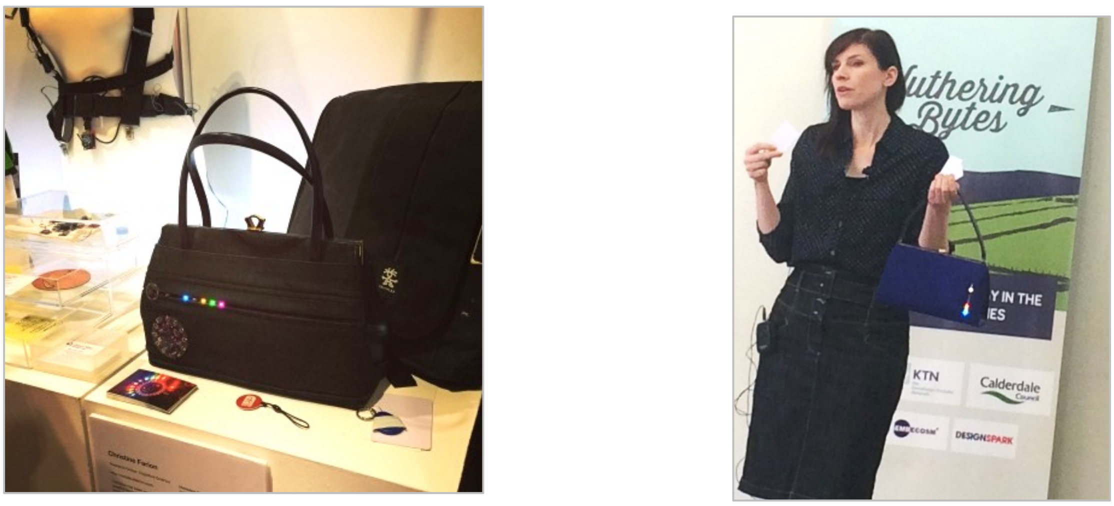


Figure 6.8 Devices on display at the Wearable Technology Show, Excel London 2015, and Presentation at Wuthering Bytes, September 2015.

After attending these events, it allowed me to see the usefulness of these devices according to people's perceptions and imaginations. When I observe people talking and engaging with them there is always an excitement, wonder and curiosity. The Wearable Technology Show was a two day show that was from 9am until 5pm and I did not stop for any breaks or lunch because there was a constant stream of people who were curious. I spoke with hundreds of people over the two days and had some people coming back on the second day that had already spoken with me. People were returning from other departments in their company who wanted to talk with me about the device after their colleague had heard about it.

The energy and excitement for these devices was confirmation of my own studies, AU1, AU2, AU3, and usage of the device, that they were fun to use and that having them on my bag with me daily was better than not having them. The next step of having the higher fidelity prototypes for single user studies to help with triangulation of the data.

The autoethnography, does not consist solely of the researcher's opinions but are also supported by other data that can confirm or triangulate those opinions. Methods of collecting data include participant observation, reflective writing, interviewing, and gathering documents and artefacts (Polkinghorn, 2005; Bogdan & Biklin, 1992).

6.5 Observations: Conferences (Study EV2)

The event evaluation in this section is taken from two conferences. Firstly, the devices profiled in this chapter were initially demonstrated as part of a conference that took place in Toronto, Canada in May 2014 (The ACM CHI Conference on Human Factors in Computing Systems) as part of the Interactivity Track. This served as an evaluation and a way to prepare the system for more rigorous user testing that would follow. Secondly, additional feedback was obtained at the Cognitive Science Research Group Launch at Queen Mary University of London (QMUL).

Audience 1: The CHI event (shown in Figure 6.9) had many thousands of visitors over the course of a few days. This was an international event taking place in Canada, and there is a high entrance fee. The people who attended these events were adults from high educational and social backgrounds, both males and females, and from a variety of countries. They were top professionals in their area, many were historically members of societies and research groups that are making ground breaking theories and pushing the boundaries of education and research. There are also many people from industry who are furthering their careers and developments in technologies.

Figure 6.9 Display of the devices, Cognitive Science Research Group launch, QMUL and demonstrating the bags at CHI Interactivity Track for three days, May 2014.

Audience 2: The Cognitive Science Research Group Launch at Queen Mary University of London (Shown in Figure 6.9), was a smaller event with a local attendance, some further afield in the UK. Individuals of a university and educational background. There were also people from local London Industry in attendance.

Overview:

Both events enabled a casual conversational approach, with individuals offering advice, suggestions, comments and opinions. Positive questions and comments were received from most people. They were interested to see how a device could be developed and used.

Comments were recorded on paper in a note book after the event, or after each day / break in the case of CHI. This evaluation was over a period of several days and with a large mix of people, most of whom had specialist technical knowledge which led to some very technical and precise ideas that could be potentially explored. All of these were noted down at the time of the discussions. As individuals were themselves in education, industry or research, they would contribute and give me their contact details if I wanted further information or opinions. It was a very intense event and the three days resulted in many conversations.

The Message Bag 1.0 (MB1), Upcycled Handbag (UpA) and Unisex Messenger Bag (Uni) were on display at these events. All devices were placed on a table near each other with tags in front. There was no order to their placement. People attending the events were invited to touch, pick up, and try the devices as they liked. Explanations were not always offered and sometimes waited to be asked, and other times people had many questions.

6.5.1 Findings

Observations and conversations were recorded at the events and Table 6-8 is the result of collating the similar themes and comments together. When reading over the many notes from several days of events, the following codes emerged: Power, Security, Environment, and Alternative Usage. The table has been split into the issue that was raised by people and details explaining or expanding the thoughts.

This section covered a professional critique that took place in two separate locations, in two different countries. The evaluation was an effective way to gain many varied opinions in a short period of time. There were a variety of different areas that were mentioned, from alternative applications (obsessive compulsive disorder in 6-8.4a) to making an alternative device for people who do not carry bags, such as a belt (6-8.4d).

Potential security issues were raised by some, wondering about if people 'know they had things in their bag', but this was not an issue when I had the conversation with individuals pointing out that by the very nature of carrying a bag it is assumed that there are valuables in it, so it is likely any thief would base this judgment on having lights on a bag, and may even act as a deterrent (6-8.2b; 6-8.2c) if they were uncertain why someone had a light on their bag – is it a security device?

Summary

These events (EV2) allowed a large range of people the opportunity to question and comment on several of the devices at one time. The comments were categorised into, (1) power: what are the alternatives, are there solar power alternatives and what are the new power devices on the market that could enhance these devices?; (2) security: do the lights make me more likely to steal the device, or is it a deterrent?; (3) environment: how well would the device function in extreme heat or cold, also noisy areas, will the beep be heard?; and, (4) alternative usage: Could the device be altered to alleviate OCD symptoms?, can the device locate items that are not packed but are missing?, could it register the proximity of the items, so if someone was stealing an item the device could alert them?, is there an alternative device that is not a bag, for people who do not carry bags?, and, could the device account for unusual items, such as a passport? People were accounting concern that their passport was an essential item but not necessarily a daily one. Would there be a way to have a smart device account for that scenario?

Many of the comments have echoed my own observations when using a prototype. These perspectives help to confirm the functioning and concept of the bag but still the role of the devices other than through my usage, need a more in-depth look. This will be the focus of the Single User study (SU2) presented in Chapter 7.

Table 6-8 Observations as noted in my research journal over the course of both events.

Issue	Details
POWER	
6-8.1a power requirements; what charging would be needed, would people remember to charge it	Issue for all our devices though so not exclusively just this device
6-8.1b Solar charging capabilities were mentioned by a few people, regarding different weather for different countries and how the device would account for that. Would it need a different battery type? Would it be able to use solar power efficiently? Would it function in extreme rain or heat?	Battery / power issues People expressed about what current battery technologies could be implemented? Smaller, flexible, lighter, solar? Weather affecting things – lack of sun, extreme cold?
SECURITY	
6-8.2a One issue brought up by a woman I talked with, (based in North America so mentioned NSA / security issues at the forefront of their minds), commented that as well as the RFID capabilities to these bags, to integrate RFID blocking for data protection.	She remarked that she does (and knows others who) buy several 'cases' or wallets with protection. Having RFID blocking in their bag would potentially save cost for people to purchase the items separately. This material could be used to line the bag but I'm unsure of any direct impact at this stage.
6-8.2b Question: does it draw attention to having "stuff" on your person i.e. "I'm carrying valuables" Comment: not sure I want people to know I have stuff on me? Will people know what I have in my bag?	Several people voiced that they wondered if lights drew attention to the bag being special in some way, that it may make it more desirable – would people want to steal this bag? What could be done to prevent this?
6-8.2c The device could be seen as an alarm system, deter theft?	A point raised in conversation and may be a side effect of lights on a bag, is this positive or negative?
ENVIRONMENT	
6-8.3a Alternative weather conditions; would the devices fare well in extreme cold / heat / rain, would this alter battery life	Mentioned in context of harsh winters in Canada

6-8.3b Can I turn off the beep? I don't want people to hear that or can the sound volume be adjusted depending on location?	Currently there are no other operating switches besides the power switch.
ALTERNATIVE USAGE	
6-8.4a a suggestion that this may have an effect (of some sort) for people with OCD or a form of OCD and this may be an additional / alternative user group / additional / future study; To paraphrase one woman who talked with me and who studies OCD and organizing behaviours mentioned, "many people in the technology field, as well as other fields show signs of OCD behaviours and this would be an interesting branch for research, or adapting current research."	This is outside my area of research so I am not currently sure how this could be taken further. A few people wondered if it may be a way to stop the confirmation checking of items if the system confirmed an item was packed.
6-8.4b Can it locate keys (or items) if they were not packed? This is mentioned by many people.	Addressing a new issue or enhancing abilities of the bag. Some devices exist for just this purpose.
6-8.4c Proximity comments were also mentioned by a few people, wondering if perhaps they would have an audible beep or something when the item, say keys, were no longer in a certain range, so that you would be aware that the keys needed returning. A photographer said that a lens cover had been lost when out on a job because it had been left outside. If the tagging ability and a purpose bag for photography equipment had been available, then they could have noticed the lens was not packed.	Proximity was not a consideration and is a new / feature that could be implemented if shown it would enhance capabilities Parents mentioned leaving behind their children's things like sports equipment, bottles etc.
6-8.4d A husband and wife approached me wondering if I could make the husband a device "for his pocket or belt" because he doesn't carry a bag but does forget essential things.	For someone not carrying a bag – is there a device that could be used? They wanted other devices explored.
6-8.4e people mentioned that when they need to carry an 'unusual' item, (any item that is not in the ordinary to their daily lives, such as a passport), that they were likely to be very worried and constantly checking for it. This brought up the issue how the device would be able to account for those anomalies.	Items that are not listed as 'regular' essentials.

6.6 Standalone proof-of-concept (prototype SA PoC)

The initial standalone proof-of-concept device was a result of the evaluation that had been carried out on the earlier bags. A recurring comment that surfaced from people who came across the Messenger Bag devices, was that they wondered about a portable version that could be attached to any current bag that they used, and not integrated into an entirely new bag. (Table items 6-3.1; 6-3.2) This prototype was directly motivated from the comments of the previous users.

Figure 6.10 Initial prototype with a radical change of form, a result of feedback.

6.6.1 Overview

The stand-alone proof-of-concept is an initial system to work through potential issues to establish if having a device that users can place on their own bags would work as intended. Figure 6.10 shows the finished prototype, and Figure 6.11 illustrates the conceptual system and how it would work. Having a bag as a ‘standard’ that suits all, may be one issue that will not be resolved as it is because apparent that people use different bags for different purposes. As it is an item they carry with them often, the style does have an impact for them. This stand-alone device could overcome that particular issue, as it would be able to be placed on any bag of their choice.

This preliminary mock-up uses items from the initial proof of concept bag, the LCD screen and the smaller but thicker ID-20 RFID reader. In this instance, it was designed for initial testing for function and use.

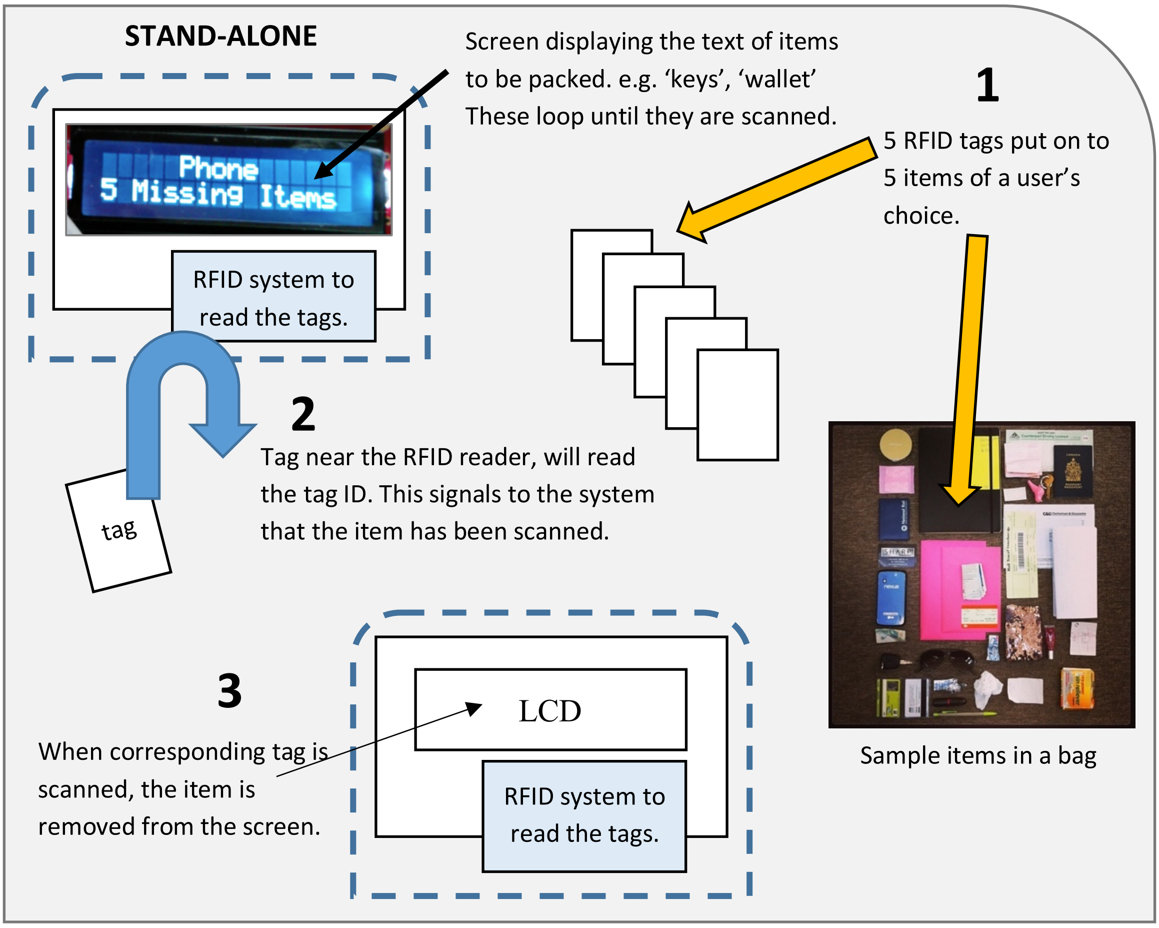


Figure 6.11 The concept of the system and how it would work.

6.6.2 Interface Details

This device communicates to the user, via the screen, which items are missing. This requires pre-programming of the user's selected items. The items are listed and this list scrolls continuously at a slow pace. As the items are scanned, they are removed from the list and the list continues rotating, showing the remaining items missing.

6.6.3 Use Case

This presents a different use case scenario than with the previous system. Due to the form of this device being a radical change, the way it would be used is also altered. The initial phase of tagging items remains the same. A user would have a set of 5 or more tags (tags shown previously in figure 4.6), however there is no colour associated with them. The lack of LEDs in this instance means the user would need to rely on the screen for feedback. Once items are tagged, they are also programmed into the device – for example, reading the id once a tag is scanned is then associated with that item number. For example, item number 4353254313 = house keys.

These item tags and associations are then programmed into the system and uploaded to the circuit board processor for use. The user then turns on the device, and scrolls in the items for packing (shown as a still in Figure 6.12). This requires a user to engage with the prototype up close. There was also the possibility however, of placing the items in a bag and then using the device more as a scanner system. For example, a gym bag containing towel, shoes, shampoo, deodorant, and so on, with tags already on them, would be scanned by placing the device in the bag itself, to see if any items were missing.

Figure 6.12 'All Scanned' message when successfully scanned all items.

The user has a choice of how they decide to use it. It is envisioned that after all tags are attached, they:

- secure the device to a bag
- look to the screen to see the items needed to pack
- make a note of the number of items remaining
- scan a missing item
- look to the screen to check the item is now removed and the numbers have decremented
- scan the next item
- repeat
- finish scanning all items

6.6.4 Autoethnography: Research Journals (Study AU4)

The system was used over the course of six trips over 2 weeks to establish if the device needed to be modified to work in an effective way. However, after several journeys with different ways of using the system, some major issues were discovered prompting a re-design, which is presented in Chapter 7. These issues and observations are also grouped in the previous themes of Form and Function as well as Feeling.

The items I tagged were slightly different to the items I had previously tagged. As the system did not have corresponding lights I was able to use as many tags as I wanted. This would require programming the device so that the screen reflected the correct items. If I wanted to change the items it would require reprogramming the device. I used it for trips to the gym so tags were sewn in to sweat pants, placed on a key fob on a makeup bag, a keyfob on a pair of shoes, keys and gym card, sewed a tag on a towel, and a sticker tag placed on a water bottle. From my journal, themes of form, function and feelings emerged about the usage with the device.

Form

- The form is not robust enough, parts of the device (screen) would shift. This needed fixing after 4 journeys were taken.
- There were some programming issues resulting in a delay to reload the loop of items when an item was scanned, adding to delay factor. The delay was frustrating.
- The screen is too different from the previous system mapped out to form any accurate comparisons. The device would have to be a direct comparison with the one currently on the bags.
- Being able to use it in an alternative mode – scanning items that are in the bag, as though it was a ‘scanner’ is potentially interesting, a positive point.
- Having a smaller device and being able to use it with any bag was an advantage as I have many bags for different journeys. Shopping requires a small handbag, work needs a larger backpack, travelling on the train I pack more and a larger bag…etc.
- It was difficult to make the device this size and to fit everything in with the components I had (components too large?); very time consuming to make a device which ultimately was too large.
- The ability to attach it to whichever bag you are using was positive, I could use any bag.

Function

- Having to pre-program items in would not be at all practical in a system that I would anticipate having many users with individual needs (such as personal items)
- After a journey to somewhere like a gym for example, the desire to throw stuff in the bag quickly and not wait around for the device resulted in not using it to rescan and just hoping I had my stuff with me.
- Became tedious to read the screen and wait for it to circulate. I knew the items that were pre-tagged, it was set to scroll at a rapid rate but even so it was slow to wait for an item.

- The screen uses more battery power than the LED system.
- Positive feedback, confirms that all is packed and is reassuring.

Feeling

- I had feelings of impatience waiting for the list to scroll. This did become tedious.
- I felt confident that I would not forget an item – provided I programmed it beforehand.
- I felt positive about the novelty of the device.
- I enjoyed the scanning action, it was different to the other system. I could move the device into the bag and scan the items if they were already packed.

Summary

This section established the ideas for a prototype of a stand-alone version that follows on from the initial concepts, to satisfy alternative potential needs of users. Early initial results of experiential observation indicate that although there is potential in this system – there are many errors, functionality hurdles and issues that need to be resolved. This device was modified to address initial findings and downfalls of the device, and create a final version that was tested.

6.7 Chapter Summary

In summary, prototypes were built and evaluated, which included a unisex messenger (prototype Uni), three Upcycled versions, (prototypes UpA, UpB, UpC) and a final proof of concept prototype. The Unisex Messenger and Upcycled prototypes were used for the first in the wild, single user study. The study confirmed that the devices are appropriate for use in-the-wild but that there are issues that should be addressed. I also conducted autoethnography with one of the Upcycled (UpA) prototypes and there were events (EV2) that the prototypes were displayed at. This chapter concluded with the design of a Standalone proof-of-concept device, which was developed based on feedback from people who wondered if they could have an external device to attach to their own bags. This low-fidelity prototype was presented and experiential notes regarding the use of the device were documented.

An overview of the findings from all the studies conducted throughout this chapter were; that the styling of the device did encourage its use, one respondent wanted the device to be put onto their own bag as they swapped different bags according to their tasks; another respondent was confused on the application of the tag and believed they broke it when using it; and the styling and adapted nature of the device itself lead to compliments on the appearance and individuals wanting one they could use.

Respondents believed the bag saved them around ten minutes a day from not constantly checking and they had a more relaxed “weight lifted” feeling once they had packed a bag. The participants, after their month of use wanted to continue using the device. Many of the discoveries echoed my own experiences while using the bag. I have become used to the system being with me, and the scanning action has become second nature. I do not worry about if my keys are in my bag, because I can look at the bag and see the blue light is not on. However, I recorded on one occasion an unusual ‘self-scan’ of the keys that had fallen from my bag. This was a positive action that happened and was not anticipated. One participant felt strongly that it helped them and they have kept the prototype, they wanted the device on their other bags as well.

The events (EV2) allowed a large range of people the opportunity to question and comment on several of the devices. An overview of the comments were categorised into, power, security, environment and alternative usage. Users questioned power alternatives and what power solutions could improve the device. There were potential security issues concerning; do the lights make someone more likely to steal the device, or is it a deterrent? Other people questioned the environment and how well would the device function in extreme heat or cold, also noisy areas, will the beep be heard?

Alternative usages for the device were brought up, could the device be altered to alleviate OCD symptoms; can the device locate items that are not packed but are missing?; and, could it be modified for a doctors medical kit bag? Also, as previous studies revealed, questions regarding an alternative device that is not a bag, for people who do not carry bags.

Chapter Seven now describes the final high-fidelity prototypes. These prototypes are used for a comparative field testing study with six users, which is described in the chapter along with the findings.

Chapter 7 In-the-wild Studies

This chapter[21] is focused on three prototypes which are the field testing devices. This is the first time the Stand-alone (SA) version prototype will be used in the wild, and it is the first time these devices will be used over a longer period of time by users, in the wild. The build configuration and design justifications of these three prototypes are described. Each of the prototypes are used by six testers. These real-world third person engagements, a comparative single user walk out, took place over several weeks. The participants used the devices in place of their own 'everyday' bags. The purpose of the research presented in this chapter is to establish and document:

- how the prototypes are used in real life;
- the effect the device has on a user's life; and,
- to discover if users have a preference for an overall design: the embedded, or a stand-alone design

Table 7-1 provides an overview of the prototypes, the design and the testing done and documented in this chapter.

Table 7-1 Overview of the three prototypes described in this chapter.

Stand-alone (SA)	Design	Section
 This device is the same concept as the previous prototypes but in a different form factor. As seen through a proof of concept (SA PoC).	This is a second iteration of an earlier portable proof of concept device (SA) that was presented in Chapter 6. The design was modified to be the same components and functions as the embedded (EM) prototype other than the form. This prototype is initially for testing the implementation as well as the look and feel. This will be documented through the autoethnography journals.	7.1

21 Work presented here appears in (Farion & Purver, 2014)

A user will clip this to their bag and be able to use the system anywhere. This device is not off-the-shelf and the circuit board was created as the device did not exist. INTERFACE There is a clip that is used to secure the device to any bag. There are five LEDs, each representing an object attached to an RFID tag. The device has an RFID reader on it that will read those tags. When read, the device will vibrate and a corresponding light will go on or off. There are also five white areas on this board so a user could write their items or reminders down.	When used for the field-testing with 6 users, role data will also be collected as we look to gain insight into changes in a user's life.	
	Testing	
	AU5 Autoethnography documentation in journals and research diaries during a 3-week period of use.	7.1.8
	EV2 Three events for public engagement with the device.	6.5
	SU2 Single user, Field-testing: Comparative single user walk out with six participants.	7.5
Embeded (EM1, EM2, EM3) Message Bag  The unisex messenger prototype was badly damaged and this Em prototype has been built from that previous device. This is a masculine high-fidelityversion that was used for public engagement, and a comparitive single user walk out. INTERFACE Due to it being rebuilt for functioning purposes, the design was also modified from the feedback that was received from testers of that earlier prototype. Note there are three styling versions of the embedded style bag., documented in this chapter.	**Design** The embedded prototype has evolved from the Unisex Messenger (Uni) that was described in Chapter 6. The Em bag is an integration prototype that will be used as a role prototype to learn about the effect it has on a user's life, as well as the look and feel and implementation.	**Section** 7.2
	Testing	
	SU2 Field-testing: Comparative single user walk out with six participants.	7.5

LED Only (LED)	Design	Section
 A low technology solution with little interaction. The user clips this to their bag and the lights blink for fifteen minutes when the button is pressed. INTERFACE This LED only prototype is made from a piece of felt that has the same clip as the SA prototype. It can be clipped to their bag or elsewhere if they prefer. There are two LEDs on the front of the device and two on the back. There is also a small replacable battery on the back and one miniture button. This button will turn the lights on. The device will turn itself off after a period of 15 minutes.	This LED only design is used only in the comparitive single user walk out. It was offered as a low technology solution. This is in an effort to discover if 'any technology' at all is a good solution.	7.3
	Testing	
	SU2 Field-testing: Comparative single user walk out with six participants. Used as an 'alternative' to the two similar prototype devices.	7.5

Through the prototypes being used by six people, there may be alternative uses or features for the devices that have not yet appeared. Six users have been chosen as this should highlight issues with the devices to draw initial conclusions. If there are additional users, there is a likelihood that information may be repeated and that no new information is offered.

As documented in my autoethnography research journals, observations, and third person engagements and in the field (documented in Chapters 5 & 6), the styling makes a huge difference to uptake or rejection. The two smart devices presented in this chapter are created because of the studies undertaken and are built to be used in the final testing phase. In this chapter a new device (LED only) is introduced that was created solely for checking if a low-technology device, (one with no interaction) would have the same effects we are looking to achieve from our smart device.

It is the work in this chapter that addresses the creation of a high-fidelity prototype – based on earlier work – to answer this problem statement of quality. My definition for high-fidelity concerns the amount of detail and the closeness to the final design, these were the considerations that were addressed in Chapter 6, to be able to create these prototypes that will address the role of the device, the look and feel, and the implementation of it.

The chapter has three main sections that describe each of the prototypes to be used for the comparitive single user walk out study. Each prototype is defined and detailed, including the build reference and initial autoethnography observations of the system after two to three weeeks of use. The last part of this chapter will be the field testing, which starts with an initial recruitment questionnaire (Section 7.5). This online questionnaire was used to find participants for the study. The study design followed by the results captured through online surveys and interviews are then presented. All aspects are noted from the participants from observations through to their written word. When building a system for people to use every day, the understanding of what went wrong is essential to these types of systems (Gaver et al., 2009).

7.1 Stand-alone (prototype SA): Build information

From the testing that took place with the previous devices, (which is described in Chapters 5 and 6), a common question surfaced – 'was there a device they could use on any bag of their choice?'. Individuals who attended the conferences or events that the devices were showcased at, often enquired about a stand-alone device. Participants and other people who spoke to me wondered if a 'clip-on' style of integration could be a preferable solution. This would enable users to keep using their existing bag. It was the result of this discovery that led to the design and development of a new version of field testing device; the Stand-alone version. This device is used as part of the comparison study and is described here.

7.1.1 Overview

The Stand-alone version is a device that an individual can put on a bag of their choice. The Stand-alone adds the ability to swap the device to different bags. While an embedded version may be appropriate for one activity it may not be suitable for another. The Stand-alone solves this issue. This device is still interactive, and uses the same system as developed previously. It has 5 RFID tags for placing on the items deemed essential by the user. The individual can remove the device from one bag (say a work bag) and attach it with the clip at the top of the device, to a different bag. This is described and shown in Figure 7.3 the information sheets.

An example journey would be to go to the gym and pack different items than may be used for work – items suitable for that trip. Additionally, a user could have a separate set of tags for each activity that they will be performing. The Stand-alone device also uses the same five light notification system as the embedded version presented in terms of operation and functionality.

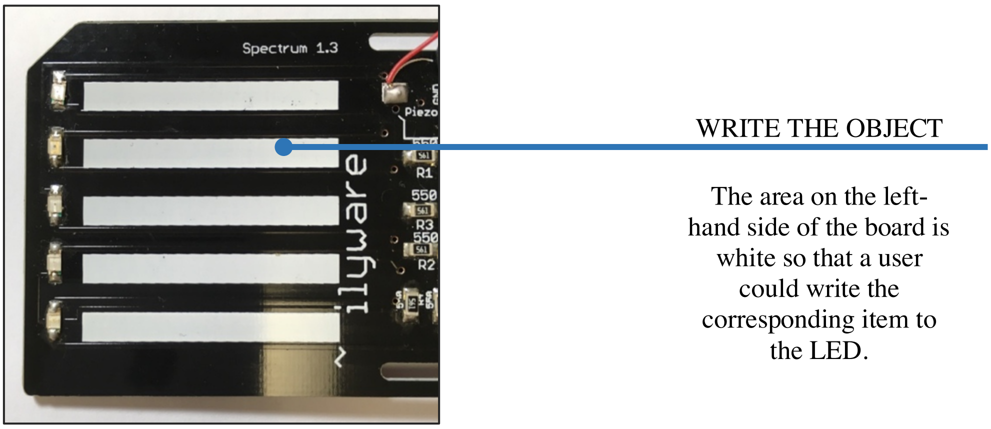


Figure 7.1 A close-up of the area (on the left of the device) where a user could write a list of objects.

The device housing in this instance was made from leather and was chosen for its durability and aesthetics. It was decided that it would be easiest to match individuals bags with something that would be black leather as a proportion of bags would already be made of this material.

The study for the devices is a comparative evaluation, so the devices needed to be as alike as possible. Both the Stand-alone version created and shown in this chapter and the Embedded Messenger bags EM1, EM2 and EM3 versions use the same RFID system: reader, tags for items, LEDs, and communications system with a piezo and vibration motor.

7.1.2 Interaction

The first phase of using this device is the same as previous devices. A user is given a set of tags that they place on their personal objects. The tags are in the form of a key fob, a card (credit card size) and rectangle stickers. Users can remove tags and tag different items if they wish. Once the items have been tagged the device should be turned on, then it is ready for the user to scan their tagged items.

The user then has a cycle of use, Figure 7.2, which is the typical use case scenario. The user has an item they want to pack (a) they take the tag portion of a pre-tagged item and (b) scan it over the device. Some users may also want to write on to the device in the white lined section, the article signified by that light. This is a user choice, not a necessity. Once they scan and the light goes on or off (depending on their personal use scenario) they pack the item. This cycle repeats for typical use.

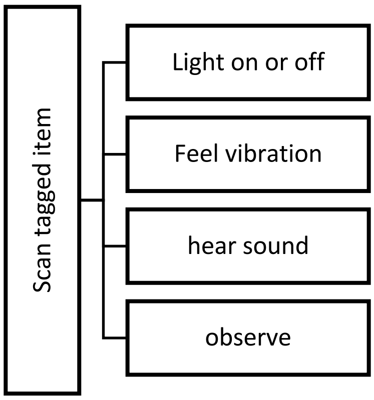


Figure 7.2 Cycle of use for the user.

The lights, vibration and sound all form part of the observation and all happen relatively at the same time.

The user cycle described:

1. Tag personal items
2. Place the Stand-alone device on a bag
3. Turn on the device
    a. Observe lights illuminated or off
    b. Scan an item that has a tag
        i. Observations of sound, vibration, and visual
    c. Pack item
4. Repeat item a, b, c
5. As appropriate - charge the device

There are contexts where a user may or may not hear the sound, for example. Periodically the device will need to be charged, running time varies on the usage. This is done with the USB mini cable. Typically, it takes 1.5 hours.

7.1.3 How to use the device

Information sheets were given to the testers regarding how to use the device. These are shown in Figures 7-3, 7-4, and 7-5.

Information sheet: Message Bag study

The bag you will be using has lights visible on the outside. These are for *reminders of 5 items* you want to be sure are packed with you on every journey.

The way to turn the lights on and off is by 'scanning' your item.

'Tag' 5 of your items

Use the 5 provided tags to log your items.

---

1 Add tags to your items

Tags to add to your essential items.
Card x 3, Key Fob and Sticker.

There are 5 'tags' included – use these tags by placing them on / with your objects (card in a wallet for example, sticker on a notebook, Key fob on your keys… place them on your essential items)

[to see some examples of how these tags might be used you can play a short video that will explain them in more detail http://messagebag.christinefarion.com/taggingmyitems/]

Using the Stand Alone Device

Using the device has a few simple steps.

---

1 Attach

The small device has a clip at the side, use this to attach it to a bag you are currently using. You may have previously tagged items and if so, you can continue to use those tags. They will respond to the same lights as previously.

For general information about the bag and study visit messagebag.christinefarion.com *or email me* *christine.farion@qmul.ac.uk* .

Figure 7.3 Information sheet (SA), page 1

2 Turn on the Device

The small on off switch is located on the right hand side of the board. One way is for charging and the other to turn on.

When you slide the switch to the on position, the lights should all be on. With this prototype, the idea is that the system can be left on, however, we recommend you switch it off overnight as it will save you from having to charge it often.

Attach the device somewhere to your existing bag with the use of the clip.

The components are very low power, additionally they are all waterproof and the system can work fine and is safe in bad weather. We would not recommend submerging the device in water while the battery is still attached.

3 Scan the items as you place them in your bag

Once your items are 'tagged', you can then scan them to the bag.

On / Charge switch

4 Charging the device

It may be that the battery gets low after several days of use. There is a USB cable provided with the device to charge the battery.

Depending on the power that was left in the battery, charging can take two to four hours.

Note: Even when the device is switched off it will remember the items you have scanned in.

For general information about the bag and study visit messagebag.christinefarion.com *or email me* *christine.farion@qmul.ac.uk* .

Figure 7.4 Information sheet (SA), page 2

5 Goal of the prototype

The goal of the device is to let you know if you have not packed an item. The lights are on to show that something is missing. When you 'scan' an item, the light goes off.

If you remove your item for long periods of time, you could re-scan it and that will turn the light back on, alternatively you can turn the bag off and then when you need to repack just turn it on again and do the process again.

Area where to 'scan' the tags.
Hold a tag up to this area.

A successful scan will turn the corresponding light on or off.

- Slide the switch to the CHG position (charging position)
- plug the cable into the charging area
- plug the USB cable into a power source

6 Log your usage

Please go to the questionnaire online http://bit.ly/1GtBg5p if you have a journey, **even if you do not use the prototype**. Note: the questionnaire is also accessible through the site: http://messagebag.christinefarion.com/current-testers/ where this information sheet can also be found.

For general information about the bag and study visit messagebag.christinefarion.com or email me christine.farion@qmul.ac.uk .

Figure 7.5 Information sheet (SA), page 3

7.1.4 System Structure

This is the first prototype that was created that did not use off the shelf components. Because this portable stand-alone RFID reader is a device that does not exist, I decided to build my own. Some of that process is documented here. A circuit board had to be created to have a device that would be small enough to attach to a user's bag.

The architecture is implemented on a 2-Layer printed circuit board (PCB) which is powered with a rechargeable polymer lithium 3.7V 1000mAh battery. The communication with the system is the same as the embedded versions, which has a visual display (LEDs), haptic feedback through the vibration motor, and audible cues with the buzzer. This ability makes it possible to create professional looking devices for a reasonable cost and acceptable time frame. In turn, the testers will be able to use a device that they feel confident in carrying. This quality consideration can make a difference when testing a device. A user may be less inclined to use it, even if they know it's a prototype, if they do not want to be seen using the device.

The circuit boards were designed using Eagle software – this allows the designer to design the schematic of the connections for the circuit, and then create the board design to be sent to a circuit printer after building the board with the electronic components, it was observed that it was too bulky. I decided to research using surface mounted components to reduce the overall thickness. The slots visible in the top and bottom of the right-hand side of the circuit board are for mounting the clip to make it portable. The clip is attached with mesh banding and a plastic loop that can fit on to a bag.

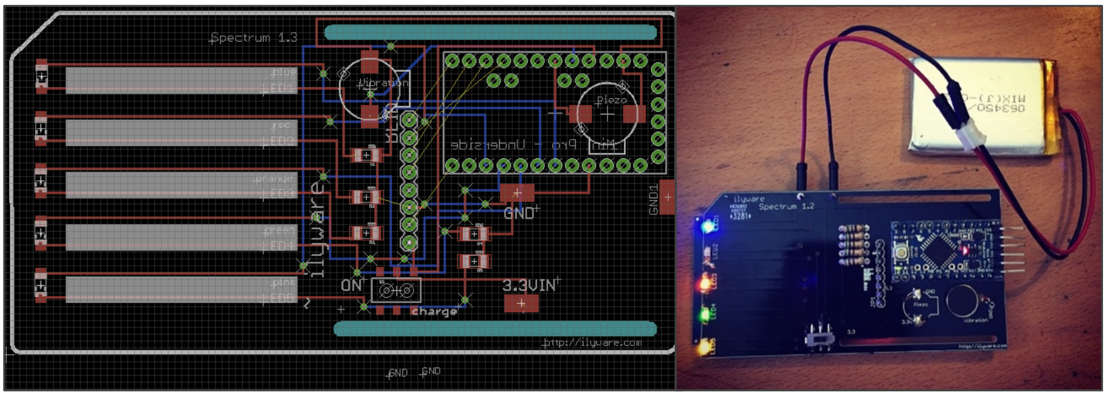


Figure 7.6 The circuit designed in Eagle, components are fitted and soldered.

7.1.5 Materials & Technology

The main processing component was an Arduino Mini board which was mounted and soldered on a purpose designed circuit board to accurately and quickly create the device. An 'off the shelf' version, using parts that can be bought from an electronics supplier consists of:

Table 7-2 Components for first version circuit board

COMPONENTS FOR THE CIRCUIT BOARD VERSION	
MAIN RFID SYSTEM	Arduino Mini Pro
	RC522 RFID board
	RFID Tags
FEEDBACK SYSTEM	5 LEDs
	Piezo
	Vibration motor
POWER REQUIREMENTS	Charging component
	Lithium Polymer battery
	USB cable needed for charging

Due to the requirement of a small / portable sized device, surface mount LEDs were used to keep the device compact. There is also an RFID reader board that is soldered to this circuit. Housing an Arduino Mini Pro board on a created circuit, the board needs space considerations and connections.

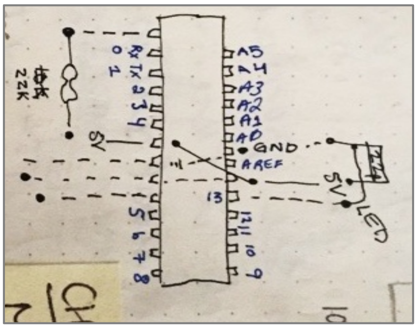


Figure 7.7 Design sketch of the circuit connections, mapping the ATMEL processor chip

The final circuit used for testing was version 4, which is the completed circuit board. This board enables the circuitry to be inserted into a single board for the assembly to become simpler. There only needs to be a housing constructed to cover the external parts.

Additionally, in the second version of the board, the Arduino Mini Pro board was substituted - primarily due to larger size – for an ATMEL processor chip. Figure 7.7 shows initial sketches of mapping the processor chip.

7.1.6 System Design Decisions

Due to the nature of this device being swapped to different bags and being portable, deciding what components and what size and weight would be appropriate was necessary. In this case, the RFID reader is placed directly behind the white lines of the front (the left-hand side of the device). The user will hold their tags up to this area, (near where the lights are), and the RFID will respond when the tag is scanned.

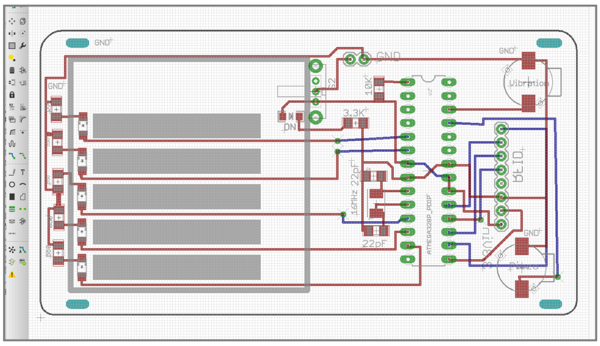


Figure 7.8 Screen grab from Eagle used to design the circuit board with spacing for the Atmel chip.

The range of a tag that can be scanned to the reader is limited to a few centimetres, taking under a second to be successfully scanned when it is in range. The components were all placed to the right of the device so that they can all be obscured with the single leather covering. The clip is placed in this area so when detaching and re-attaching the device you do not have to touch the lights or handwritten areas. The battery is secured to the back of the device and covered up by the leather.

7.1.7 Research journal for build errors

The device was first used by the author. Primarily hardware errors and configurations were tested and then the board slimmed down. The board with the integrated Arduino board was too bulky and it became difficult to plan how to cover all the components. This resulted in researching into creating a similar design but with the Atmel chip on the circuit board for Version 2. That board worked as intended with the features required however, the placement of the LEDs made it very difficult to mount in a portable way as there was very little area for the board to grip.

Table 7-3 Build Errors for SA device.

	INFORMATION	ERRORS	RESOLUTION
1	Version 1 circuit board used to hold the components together easily.	Circuit is too bulky for the system and programming is difficult when mounted.	Early prototype phase, redevelop with a chip not a board.
2	Version 2 Atmel	Placement of LEDs makes encasing it for a stand-alone device difficult.	Used an Atmel chip to reduce the size.
3	Version 3 Atmel & writing area	Board size too large and awkward to arrange with RFID so it's small enough to be portable	Make the board smaller, minimize the white writing area, add appropriate mounting cuts to make it portable.
4	Version 4 Atmel & writing area with mounting cuts.	The on/off switch unfortunately is not sturdy enough resulting in frequent breakage.	This board is the one now used in the prototype. The switch would need addressing in a future version.

7.1.8 Autoethnography (AU5)

The device has been used officially for 6 trips out. This was over a period of three weeks and it was used between using an embedded bag version as a main bag. The trips were one trip to a shop but after a train journey, two to the gym and three were a return home trip.

These were short trips and there was no remarkable information obtained from these trips other than my personal notes regarding the devices and how I am beginning to feel over time. Some of the key thoughts to emerge is that I am preferring the embedded version. I like the form of it and that people tend to have very positive reactions to it. They have positive reactions to the stand-alone version but it looks more 'tech' so they expect it to do 'something'. Because the other device is essentially 'a purse' there is usually a little more surprise or playful aspect to it. Some of the main themes to emerge was; feeling relaxed, preferred embedded, still forgot, changed what I forget, do I feel worse by still forgetting information, can reminders have context, delay in my day if I forget, cost of forgetting, feel dread if I forget at the start, and the end, and significant change to remember items.

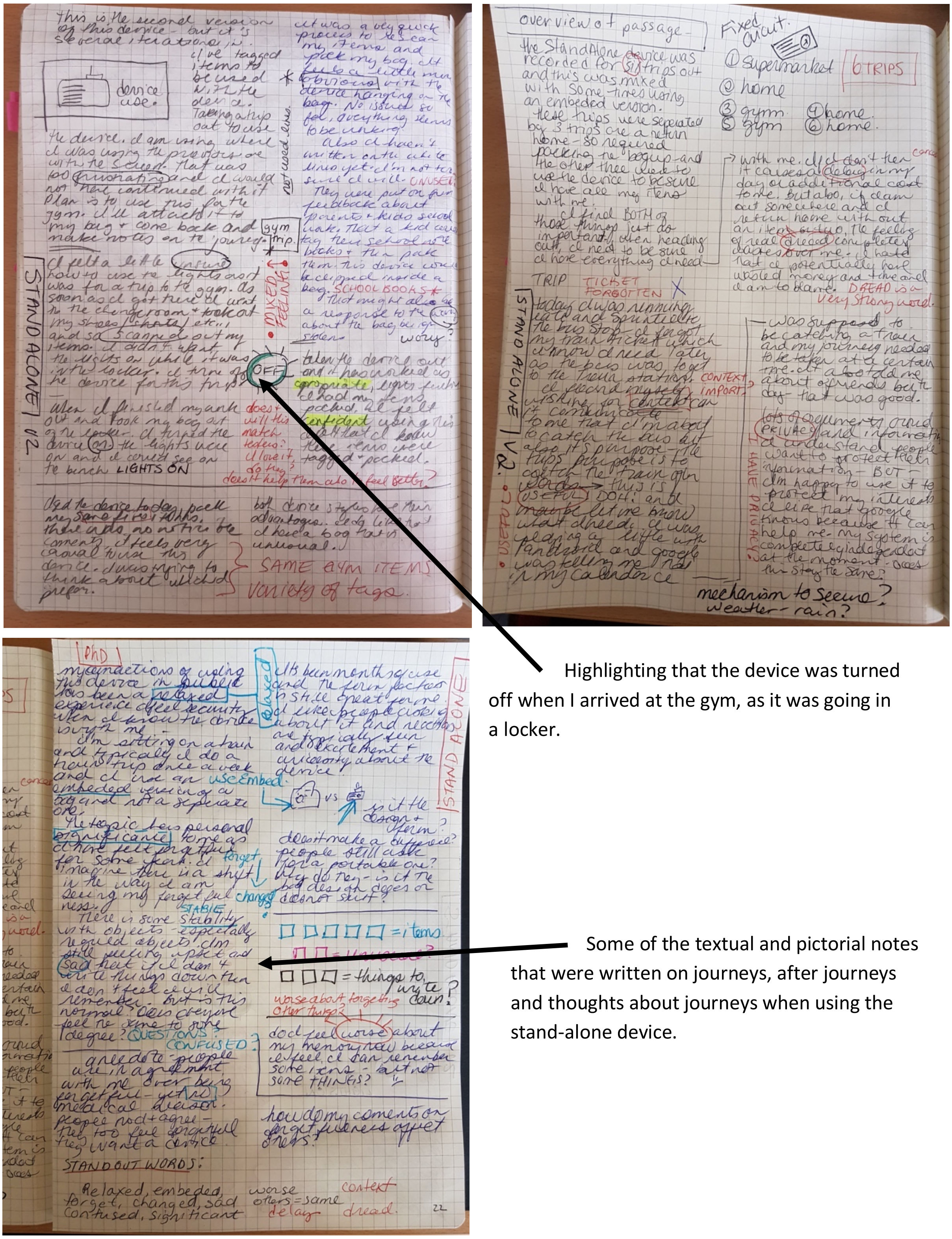


Figure 7.9 Some of the journal pages of using the stand-alone device.

7.2 Embedded Design (EM): Build information

The Embedded (EM1) Message Bag version is based on previous prototypes that were tested in studies described in Chapter 6. It is a version that the participant use ‘as is’ with the same concept as previous prototypes in that there are five lights that correspond to the items that are deemed essential by the participant. It is an augmented device with an in-situ RFID system.

Figure 7.10 Embedded Message Bag, unisex messenger styling.

7.2.1 Overview

A main function of the Embedded system would be that the user has a seamless experience in terms of not having to pack an extra item or use a separate device. These seamless systems should be part of their regular bag packing routines, and should cause no additional stresses or cognitive load. The intention is that they would simply be packing their bag for the day.

Two versions of the same system were developed, for styling reasons. One is a unisex larger messenger bag (in Figure 7.10) that both male and females can easily use. The second is an upcycled handbag version that is more exclusive to females for to styling reasons.

7.2.2 How to use the device

Information given to the participants on using the device, Figures 7.11, 7.12, and 7.13.

Information sheet for participants of Message Bag study

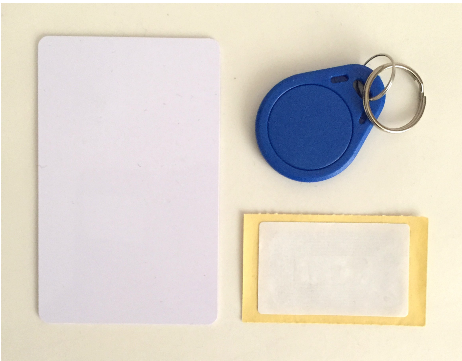
The bag you will be using has lights visible on the outside. These are for *reminders of 5 items* you want to be sure are packed with you on every journey.

The way to turn the lights on and off is by 'scanning' your item.

'Tag' 5 of your items

Use the 5 provided tags to log your items.

1 Add tags to your items



Tags to add to your essential items. Card x 3, Key Fob and Sticker.

There are 5 'tags' included – use these tags by placing them on / with your objects (card in a wallet for example, sticker on a notebook, Key fob on your keys… place them on your essential items)

For general information about the bag and study visit http://mymessagebag.com or email me christine.farion@qmul.ac.uk .

Figure 7.11 Embedded Bag Information sheet page 1.

Using Message Bag

Using Message Bag has a few simple steps.

1 Turn on the Bag

The small on off switch is located on the **front lower right hand side** of your bag.

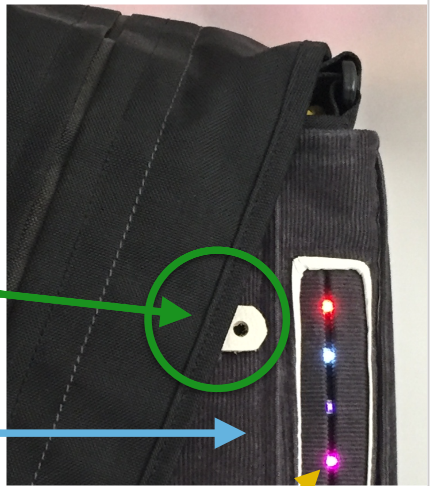
When you slide the switch to the on position, the lights should all be on and the screen will display a welcome message.

With this prototype, the idea is that the system can be left on, however, we recommend you switch it off overnight as it will save you from having to charge it often. The components are very low power, additionally they are all waterproof and the system can work fine and is safe in bad weather.

Area where to 'scan' the tags.
Above the lights is a square with a small cream colour leather flap.

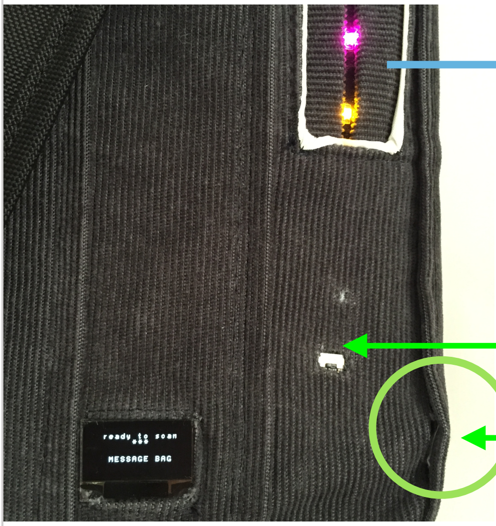
This is the active area.

hold a tag up to this area, you should hear a "beep" and feel a small vibration.



(showing the area)

A successful scan will turn the corresponding light on or off.



ON / Charge Switch

and USB Charge connection

For general information about the bag and study visit http://mymessagebag.com or email me christine.farion@qmul.ac.uk .

Figure 7.12 Embedded Bag Information sheet page 2.

2 Scan the items as you place them in the bag

Once your items are 'tagged', you can then scan them to the bag.

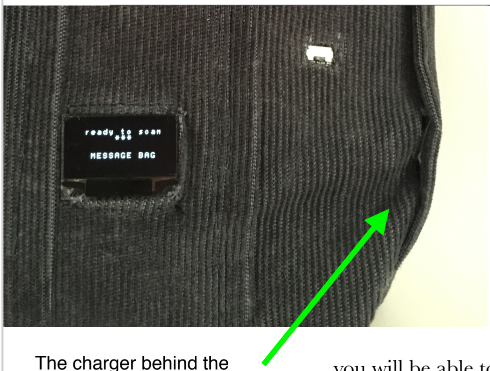
[to see some examples of how these tags might be used you can play a short video that will explain them in more detail http://www.mymessagebag.com/taggingmyitems/]

3 Goal of the prototype

The goal of the bag is to let you know if you have not packed an item. The lights are on to show that something is missing. When you 'scan' an item, the light goes off.

It is this system we are trying to test, to see if it is a helpful way to track important items.

If you remove your item for long periods of time, you could re-scan it and that will turn the light back on, alternatively you can turn the bag off and then when you need to repack just turn it on again and do the process again.



The charger behind the material on the right side of the bag.

4 Charging your bag

It may be that the battery gets low after several days of use. There is a USB cable provided with your bag to charge the battery. To charge the bag:

- behind the material on the right side of the bag is a small charging port

- plug the cable into the charging area

- plug the USB cable into a power source

This bag has a 3 power cell battery and we anticipate you will be able to possibly use it for the 2x5 day duration without needing to charge it. Depending on the power that was left in the battery, charging can take two to four hours.

When you turn the bag off it will remember the items you have scanned in.

4 Log your usage

Please go to the questionnaire online http://bit.ly/1GtBg5p if you have a journey, **even if you do not use the prototype**.

(Note: this is a prototype and so *all* information and comments / thoughts are needed, what was confusing, difficult to use, good / bad, opinions.)

For general information about the bag and study visit http://mymessagebag.com or email me christine.farion@qmul.ac.uk .

Figure 7.13 Embedded Bag Information sheet page 3.

7.2.3 Styling Variation EM2

The bag shown in Figure 7.14 is the unisex messenger bag style of embedded device. The device shown is the mini-messenger style that was used for some female participants who used it more as a handbag than for an everyday bag. The lights are discreet on the outside lower right side of the bag, and the circuit board is accessible with the zipper directly above it, which conceals the remainder of the circuit board, allowing only the lights to be exposed.

Figure 7.14 First attempt at this styling, the Lilypad scratched against clothing.

The styling for these evolved from the feedback of previous testers who were wanted a larger, more work appropriate bag, or a larger daily bag to carry around essentials easily.

The Embedded system allows the user a seamless experience as they do not have to pack an extra "memory aid" item or use a separate device. These seamless systems, which we know are critical for user adoption (Ishii & Ullmer, 1997; Starner, 2001) should be part of their regular bag packing routines and should cause no additional stresses or cognitive load. The intention is that they would simply be packing their bag for the day. The form factor and user interface will affect how the user interacts with it and their perception with how easily they can operate it (quality in use) (Petrie & Bevan, 2009; Bevan, 1995).

This prototype was then used for three journey's to check there were no errors with programming or design and it was observed that: the bag is a short shoulder style, meaning, the bag is placed over the shoulder, this resulted in the circuit area being just under the arm. When placed under the arm, it is uncomfortable through rubbing against the arm / chest, additionally, when jumpers or any knitted items or scarves were worn, they catch on the circuit.

7.2.4 Styling Variation (prototype EM3)

Figure 7.15 Styling of EM3.

7.2.5 Materials & Technology

The components used are from the Arduino System, specifically the wearable range known as Lilypad. These components are well suited to wearable tasks as they are created for designers who will be able to sew them on to or inside of clothing. This means they are discreet, usually slim, lightweight and have special mounting areas where they can easily be sewn to the connectors. They are also described as washable so would be durable in various weather conditions.

The materials used in the design and development are the same as described in Appendix H and I, so the details will not be repeated here, but this version uses:

Lilypad USB, SLO18 RFID Reader,
13.56 MHz tags, Sewable Piezo / Sewable LEDs,
Charging unit, low power 3.7V,
Wires / Conductive Thread / Resistors / breadboard
power source

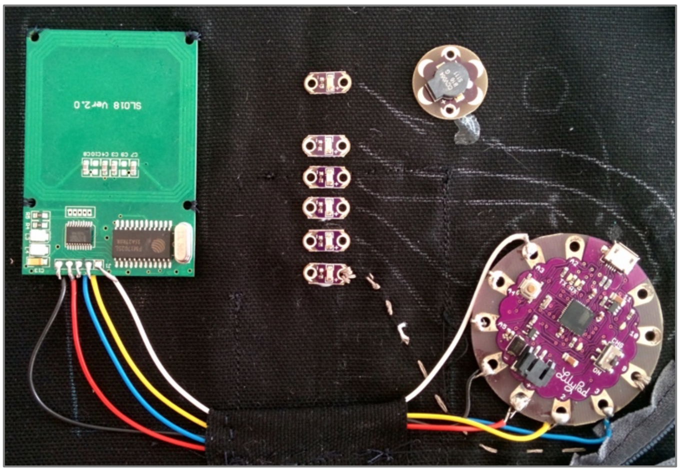


Figure 7.16 Shown is the layout and initial stitching of component connections on a black jean material before integration with the bag.

7.2.6 Other Design Decisions

In this design, the RFID reader was placed close to the top lip of the bag where the zipper is. It was anticipated that it would be a good location when actively packing the bag and not necessarily 'obviously' scanning their items. However, from my own experience due to the second or two delay, it causes a user to pause when packing. When items were removed from the bag, they would scan quickly and the light would go off; so it seems the placement of the RFID reader at that location was good for removing items. Larger range for the RFID reader is not appropriate in its current stage due to the items being re-scanned when they are packed if it is close range. This could potentially be eliminated by adding an RFID shield layer to the material inside. I did not however experiment with this myself at this stage in the design.

The lights in that location appear to be well placed due to feedback when out using the bag. Many people commented about the styling and how they liked it when I was out in public with it. The lights are placed behind a zipper that can be closed, which acts as a slight dimmer in brightness when in a darker space. The battery life on standby lasts over a month, and it needs around an hour to charge when there is no power left. It works for several days' usage depending on how many times an individual scans items or leave, the lights on. This varies between users.

7.2.7 How to use the device

Information sheets were given to the participants for when they will do the Single User study, SU2 shown in Figures, 7.17, 7.18, 7.19, and 7.20.

Information sheet for participants of Message Bag study

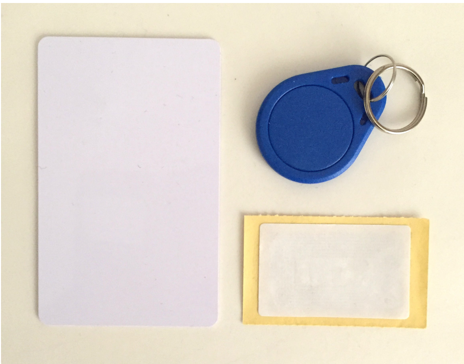
The bag you will be using has lights visible on the outside. These are for *reminders of 5 items* you want to be sure are packed with you on every journey.

The way to turn the lights on and off is by 'scanning' your item.

'Tag' 5 of your items

Use the 5 provided tags to log your items.

1 Add tags to your items



Tags to add to your essential items. Card x 3, Key Fob and Sticker.

There are 5 'tags' included – use these tags by placing them on / with your objects (card in a wallet for example, sticker on a notebook, Key fob on your keys… place them on your essential items)

For general information about the bag and study visit http://mymessagebag.com or email me christine.farion@qmul.ac.uk .

Figure 7.17 Information sheet for Upcycled prototype, page1.

Using Message Bag

Using Message Bag has a few simple steps.

The board with the switch and charging area is located behind the zipper on the right side of the bag.

1 Turn on the Bag

The small on off switch is located on the purple processor board. One way is for charging and the other to turn on.

This is located behind the zipper on the right side of the bag.

When you slide the switch to the on position, the lights should all be on.

With this prototype, the idea is that the system can be left on, however, we recommend you switch it off overnight as it will save you from having to charge it often. The components are very low power, additionally they are all waterproof and the system can work fine and is safe in bad weather.

For general information about the bag and study visit http://mymessagebag.com or email me christine.farion@qmul.ac.uk .

Figure 7.18 Information sheet for Upcycled prototype, page 2.

2 Scan the items as you place them in the bag

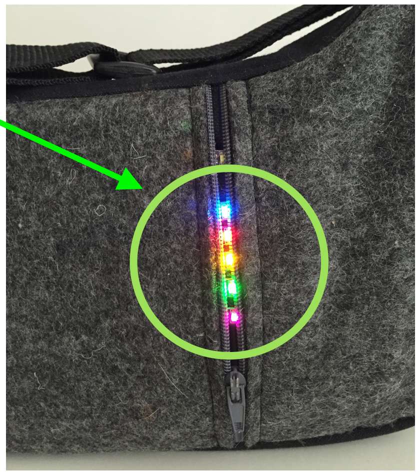
Once your items are 'tagged', you can then scan them to the bag.

[to see some examples of how these tags might be used you can play a short video that will explain them in more detail http://www.mymessagebag.com/taggingmyitems/]

Area where to 'scan' the tags.

Just hold a tag up to this area.

A successful scan will turn the corresponding light on or off.



3 Goal of the prototype

The goal of the bag is to let you know if you have not packed an item. The lights are on to show that something is missing. When you 'scan' an item, the light goes off.

It is this system we are trying to test, to see if it is a helpful way to track important items.

If you remove your item for long periods of time, you could re-scan it and that will turn the light back on, alternatively you can turn the bag off and then when you need to repack just turn it on again and do the process again.

For general information about the bag and study visit http://mymessagebag.com or email me christine.farion@qmul.ac.uk .

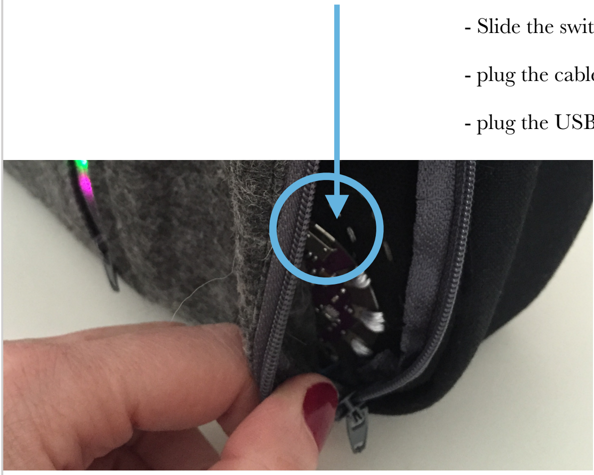
Figure 7.19 Information sheet for Upcycled prototype, page 3.

4 Charging your bag

It may be that the battery gets low after several days of use. There is a USB cable provided with your bag to charge the battery. To charge the bag:

Unzip the right side of the handbag, and there is the circuit board. At the top there is a small USB port.

- Slide the switch to the CHG position (charging position)
- plug the cable into the charging area
- plug the USB cable into a power source



Depending on the power that was left in the battery, charging can take two to four hours.

Note: Even when the bag is switched off it will remember the items you have scanned in.

4 Log your usage

Please go to the questionnaire online http://bit.ly/1GtBg5p if you have a journey, **even if you do not use the prototype**.

(Note: this is a prototype and so *all* information and comments / thoughts are needed, what was confusing, difficult to use, good / bad, opinions.)

For general information about the bag and study visit http://mymessagebag.com or email me christine.farion@qmul.ac.uk .

Figure 7.20 Information sheet for Upcycled prototype, page 4.

7.3 Low-Technology (LED): Build information

A low-tech device was also created. To establish if there was an effect of having *any* device placed on a bag that would trigger a likelihood to remember the items. The low-tech device was constructed from a small circuit that has an on button that when pressed, will flash the LEDs sewn to felt material. These will flash for a predefined amount of time (around 15 minutes) then turn off automatically. 2 LEDs were sewn to one side and one LED was on the control section. A single cell battery which was used lasts the duration of the study and so did not need replacing.

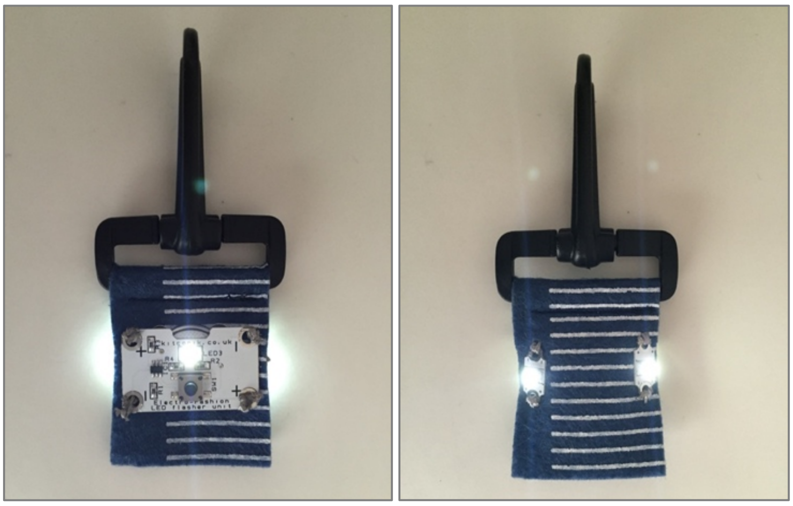


Figure 7.21 The LED only version, with clasp to attach to a bag.

The user had to attach it to a bag they were taking for their journey, and then press the button on the front to activate the lights to flash. It is intended to be used as a reminder that they are packing their bag and to be sure to pack the items. The device will switch itself off.

For this device, the main objective was to have something that can be strapped in some way to a user's bag. A plastic toggle was used as the means to do this and then just built on to it in the simplest way. A small piece of felt is folded it in half to cover the plastic toggle bar and then the LEDs were sewn to it. The implementation was done with this method as it was a relatively quick and inexpensive way to get the LED only device to be able to attach to a bag.

7.3.1 Materials

- Coin cell battery CR 2032
- 2 Sewable LEDs and 1 LED on the controller board
- Sewable controller board (from Kitronik)
- Material, Clip to attach it to a bag, Conductive thread

The sewable controller board is small (3.5cm), and has an area for the battery and a button to turn it on. The button can also change the speed of the flashing LED, but for the purposes of this study that was not a necessary function; it was chosen due to it being 'all-in-one' so quick to attach and cheaper than buying separate parts. The board automatically powers off to preserve battery life.

7.3.2 How to use the device

Information sheet for participants of Message Bag study

The device bag you will be using has 3 lights visible on the outside.

Using the LED device

This lights based device has a few options

1 Turn on the Device

This device only has 3 options. There is a small push button on the front, and when you press it once, the lights are lit.

- Press the button again and the lights will pulse
- A third press the lights flash fast
- Fourth press of the button will turn it off

Note: it also will turn off after 30 minutes.

2 Attach it to your bag

This device should be attached to your usual bag and when you are packing items or need reminding please turn it on.

4 Log your usage

Please go to the questionnaire online http://bit.ly/1GtBg5p if you have a journey, **even if you do not use the prototype**. Note: the questionnaire is also accessible through the site: http://messagebag.christinefarion.com/current-testers/ where this information sheet can also be found.

For general information about the bag and study visit messagebag.christinefarion.com *or email me* *christine.farion@qmul.ac.uk* .

Figure 7.22 Instructions for he LED only version.

7.3.3 System Design Decisions

Lights were placed on both sides of the device so that regardless of which side the device was facing, there would always be a light visible. Off-the-shelf hardware was used to make the devices quick and easy to build. The idea was to make the device in a minimal amount of time and with as little technology as possible.

7.3.4 Summary for LED-Only

In summary, this section describes the device that was created to provide a comparison. The goal would be to discover if having *any* technology is better than no technology, or if it really is too 'dumb' a device to have any effect. It is used to determine if the Stand-alone or Embedded versions of device are preferred to a device that does very little – prompting questions about the interactivity being a significant aspect to the device. The next section discusses early evaluations of these systems.

The participants use the devices in no assigned order and report back as to their experiences with it and whether if using the LED only device had the same effect of helping them to remember, and make them less anxious when using a device – any device at all, even a low technology one.

7.4 Recruitment Questionnaire (Recruitment 1)

When looking at the 34 respondents, understanding that 91.2% do use a bag as a minimum once a day. It appears the choice to use a bag as an object to augment was appropriate. These echoed early observations I did to establish what items people had on them, what might be a good 'everyday' object to use for augmenting in my research. Observations typically would be to sit at a bus stop for a short period of time (10 minutes) and note people walking past in either direction. I was looking for a common accessory that a person may have on them, and that had potential for adding technology to for the purposes of the research. It was through the early observations that I wanted to understand more about how often individuals do carry a bag with them. The online questionnaire satisfied the general observation of a bag as an appropriate item. The entire questionnaire is in Appendix L.

7.4.1 Findings from initial questionnaire: Recruitment

From the initial questionnaires that were online as part of recruiting participants, questions were asked relating to forgetfulness, technology, anxiety and habits.

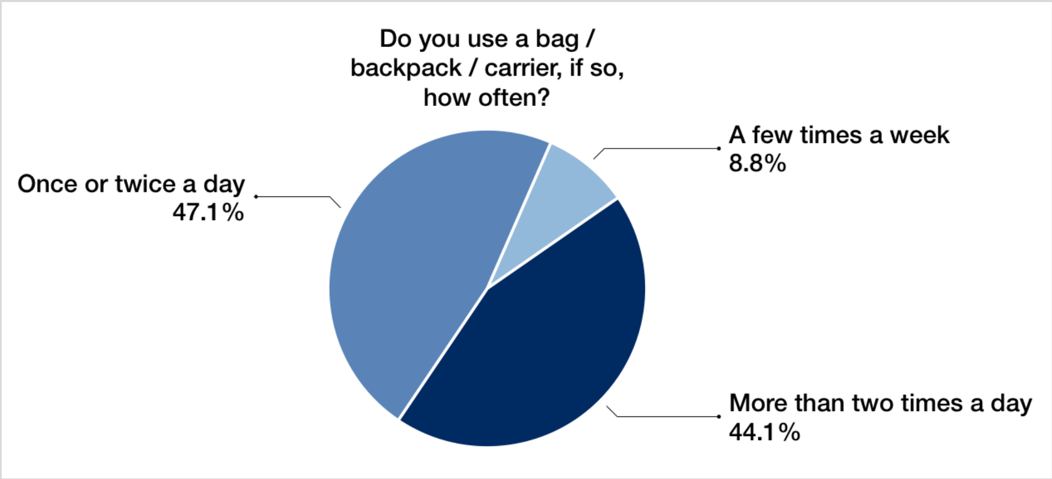


Figure 7.23 From 34 respondents the majority of them do use a bag at least once a day.

These individuals had no known medical memory conditions and it was important to understand their view of how often they believed they forgot. 27 individuals (81.8%) believed they forgot things about once a week or more frequently. There was no response to this question from one individual.

> *"I hate forgetting things, so have developed a lot of systems so my awful memory doesn't impact my life. However, it still happens and I feel like an incompetent. Utterly embarrassing."* [- respondent from questionnaire]

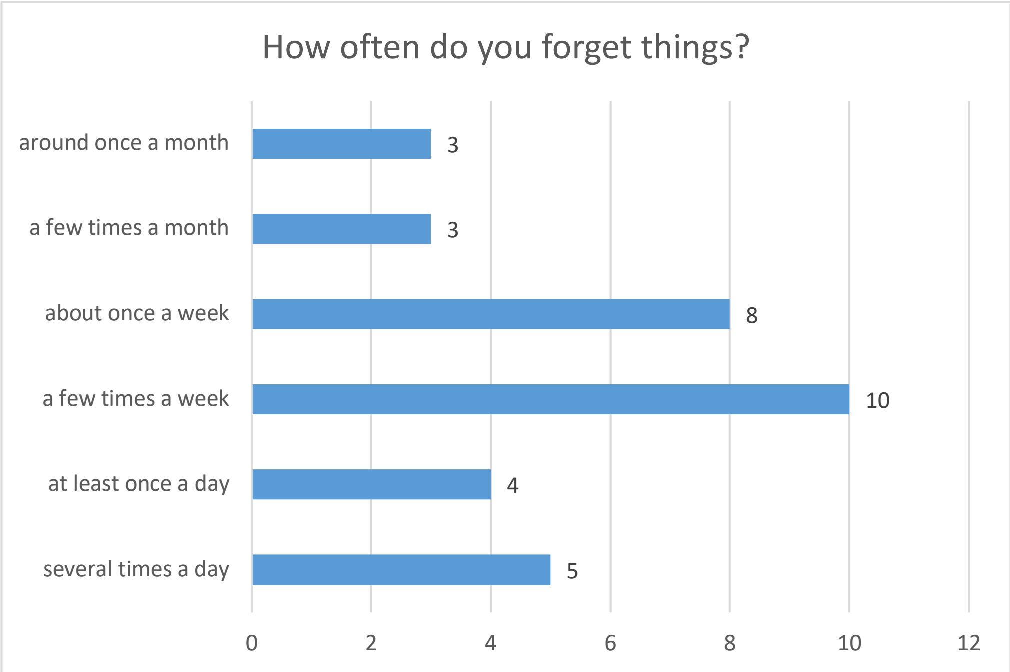


Figure 7.24 Participants (81.8%) believe they forget things once or more a week.

Feelings of negativity

All respondents said they had negative feelings when they forget. A variety of negative words submitted with regard to how they felt when they forgot such as "stupid", "cross" and "frustrated" as well as "disappointed" and "losing my marbles". Some also noted that they are "wasting their time looking for something" when trying to remember things. All responses are in Appendix M, a selection of some of the responses, chosen randomly to illustrate the overall negativity are:

One respondent wrote,

> *"Depending on what it is, it can make me feel stressed or unhappy. The act of wondering whether I've forgotten or lost the item can also be an issue."*

and another,

> *"I feel worthless, or I am losing my mind and getting old. I also fear it could be a sign of a brain tumour."*

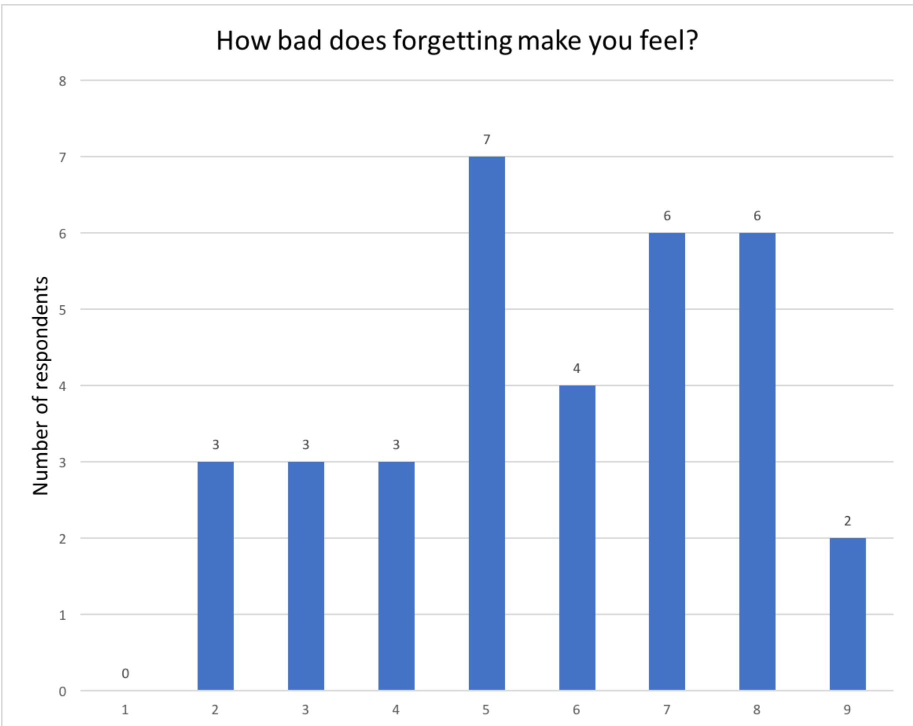


Figure 7.25 There were 18 (53%) participants who felt a range of 6 (shown on 'x' axis) or higher for how bad they felt.

When asked to grade that 'bad' feeling, the question, 'how bad does forgetting make you feel', where '1' indicates not bad at all and '9' is extremely bad shown in Figure 7.25.

Strategies to use

I also asked what types of strategies people put into place to help them remember. This was an open-ended question leaving the respondents free to type what they used. Only 2 of 34 said they used nothing, others (94%) replied that they use calendars, apps on their smartphones, voice memos, asking others to remind them, to do lists (electronic and paper based), Post-it notes, "*Ridiculous amounts of lists!*", they '*physically put things in the way*', by leaving things by the front door and try to keep things in the same place. One individual commented that they would put an unusual item in a weird place to trigger a memory, maybe leaving a bottle of washing up liquid by the front door. None of the respondents used any stand-alone or electronic memory aid devices or devices similar to the proposed bag.

One respondent wrote (quotes copied directly from their response):

> *"I write to do lists daily, put post it notes on my laptop, use the calendar on my phone, try to always put things in the same place so I can find them again."*

and another respondent wrote:

> *"I write lists on my phone. But usually i forget to look at them…"*

Summary

This questionnaire was used to establish two main points as well as be a selection tool for recruiting the participants for the single user study (SU2). The questionnaire revealed how the respondents feel when they forget, which was very negatively. It also demonstrated their regular usage of a bag in their day to day. From the 34 responses there were six individuals chosen to take the study further. They were chosen based on a few factors. If they replied to my email requesting participation, if they could commit to the extended trial amount and their general amount of participation in the questionnaire then they were invited to take part.

7.5 Field-testing: Comparative single user walk out (SU2)

An in-the-wild study was chosen as it is essential to obtain a participant's response and opinion to the device on an 'everyday' basis. This would not be achievable if they were in a restricted lab setting. As the user's opinion is paramount, the devices need to be used as they would use their own bag, in a very real setting. The in-the-wild testing allows this They can use it as part of their daily lives and the responses will be more accurate. My aim to improve the innovation of smart devices relies on accurate and real world feedback, as previous studies using in-the-wild techniques demonstrate (Bird, 2011; Johnson et al., 2012; Liu & Clemmensen, 2011; Ståhlbröst, Sällström, & Holst, 2009).

7.5.1 Study Design

This study is a comparison from high-fidelity prototypes that include an embedded style, so the device is a part of the bag, a stand-alone style, so the device can be attached to their own bag, and a low technology version. There were six individuals chosen who would then use each of the devices. These high-fidelity prototypes look to gather results from the study looking to answer two main questions:

1) Could technology embedding into an everyday item be effective to reduce worries about forgetting?

2) What recommendations are appropriate for designing a smart object for the domain of forgetfulness?

This leads to two sub-questions:

1) Will a contactless system meet the challenges of a smart system?

2) Is an embedded design the most appropriate design?

There are six people that participated in the study, 2 Male and 4 Female and they are all adults aged under 45 years old. They all live in England and are from a variety of backgrounds: for example; homemaker, researcher, creative professional, designer.

None of the participants had any prior experience of using any of the devices nor any similar devices. However, they all have experience with technologies such as smartphones. The only exclusion for participants in this study was if they had a previously medically diagnosed memory condition. Participants were recruited via a website that posts calls for participants, as well as social media sites. The participants replied to calls for participation predominantly online through Twitter, Facebook, Google+, my personal researcher website http://christinefarion.com, Gumtree and, http://callforparticipants.com. Respondents who were interested filled in an initial online questionnaire on Google Forms. This form included an 'information for participants' section noting the ethical approval from Queen Mary University of London for my study as well as disclosure / consent information. All participants agreed to take part in the study.

Participant Requirements: Participants were asked if they could use each device for a period of 5-10 working days in their daily life as a replacement or addition to their current bag.

These six chosen participants were from an original 34 that responded to the initial questionnaire showing interest in participating in the study.

Due to the number of devices (and spare devices) available, only six testers eventually participated completely. Initially it was anticipated that 8 participants would be testers for the devices but unforeseen events meant that 6 users completed the testing.

The time allocated of 5-10 days was established as some individuals would have many trips and others would have fewer. It gives a participant enough scope to be able to try the devices for at least a few trips. If an individual was selected and invited to take part, they were given information that outlined the tasks they would need to undertake including: to fill in an initial questionnaire to help with the study; to use the device and report back for a period of 2 weeks; to use an alternative device also for around 2 weeks and report back; to keep simple notes (online or paper) about the experiences with the device; to fill in a questionnaire after each device about your experience (around 10 minutes); to post the device back in the pre-paid box provided; to participate in a 5 minute one to one interview at the end of the study.

Tasks

The tasks for participants were: to pack their daily items as they normally would with the device currently in use. Each prototype was to be used as part of their daily routine. They were asked to: report daily on their experiences and make any notes; have a follow-up 5-10-minute one to one interview, over Skype; complete an end of study comparison paper survey for each device. The 'in use' tasks are representative of the actual usage for the bag, which improves external validity. Each participant was given a tester number, an A4 size information sheet, also available online, per device as well as a link to a video online demonstrating how to use each system if needed.

Participants were each given:

- 1 Stand-alone (SA)
- 1 Embedded (Either EM1, EM2, or EM3) Message Bag
- 1 LED Only (LED)
- Charging cable
- Paper copy instruction set per device
- Online link to instructional videos and information about using the devices should they need it, Figure 7.26
- One paper copy questionnaire form for each device
- There were 5 items tagged in this system so each participant was given; x2 card, x1 sticker and, x2 key fob style RFID tags to place on their personal items.

Questionnaires

Each participant was asked to fill in an online questionnaire at the start of the study. Once they completed using all the devices there was a final paper based questionnaire that compared the three devices. The respondents were asked to fill this in and to post it back to the researcher along with the device(s). The users were asked to include their respondent number, the device they just finished using and their opinion on a linear scale for several opposing terms.

Figure 7.26 A video still from one of the demonstration videos to use the devices.

7.5.2 Data recording

Data was collected several ways. Audio was collected after a short interview varying from 10 minutes to 15, with participants. This was through conversations over Skype recorded through an iMac using Audacity. These files were then exported as .mp3 format. Ethics considerations were adhered to and participants first gave their permission to be recorded which was recorded at the start of each interview. Paper based questionnaires were mailed back with the devices. Electronic questionnaires were accessed online once completed as well as throughout the study, to check if they were being completed. Some participants did not want to participate in an interview, and one did not complete the paper based questionnaire. The ‘in situ’ nature of this study, being carried out in real world conditions and in peoples’ homes and daily lives meant the frequency with which they used the device was dependent on outside factors as was the number of times they used a device.

Email for distribution: Correspondence with the participants was done through email, providing links to questionnaires, reminders, responses to any questions and arranging the interview. This was decided after initial testing of the best distribution methods flagged up that the instructions, as attachments for example, were large due to the images. This meant that I would have to rely on a users’ connection, data and space to save the document. A link to an online questionnaire was preferable. If the questionnaires were supplied as documents to download, they would have to download them, fill them in, and upload them back to me which would be cumbersome for a user and might discourage them doing this. If the respondent requested the file as a download, it could easily be attached any file they needed so it was not an issue.

7.5.3 Data analysis

The conversations were documented through notes written in my research journal both at the time of the session and immediately after the session. The initial notes were very messy and required transcribing immediately after the session to preserve the data captured. When it was possible direct words spoken from some of the participants were recorded and these became some of the direct quotes used to report the data captured. Later in the day my entries were read again and I elaborated with memory of the experience. This included comments on how many people spoke over each other as well as their reactions and emotions expressed and observed at the time.

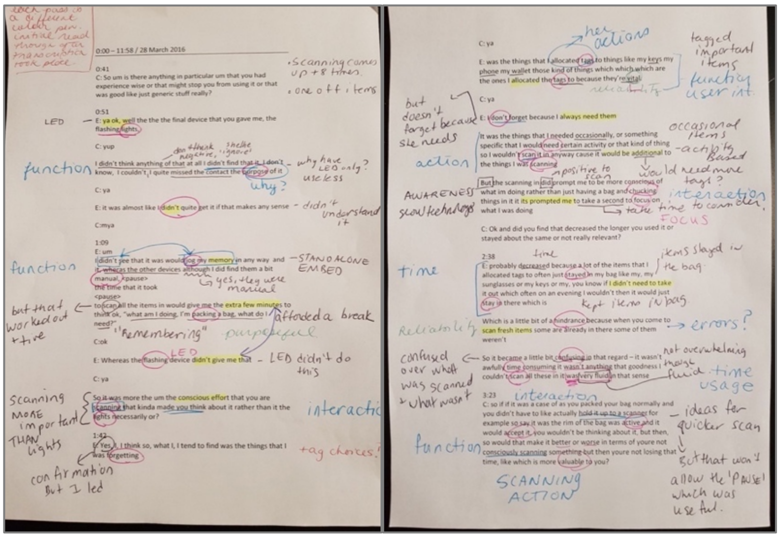
For comments from individuals, a Descriptive Code was applied to capture the theme of what that individual is describing. A Descriptive Code summarises the topic of the excerpt (Saldaña, 2015). For questionnaires and single user studies, I have pre-coded terms that I anticipated discovering information and results that will be a part of that classification. For example, 'types of faults' was used as a category for early testing, and from there I looked to break this down into software, hardware and design or form errors. Based on the type of research that was conducted and the experimental nature of the device, it was not possible to pre-code all the terms to apply to the data for classification. Words such as 'scanning, action, time, and awareness' emerged after re-reading the transcriptions at least five times over.

One of the transcribed interviews from a participant is in Appendix N, this was an eleven minute interview that was recorded on Skype and I then transcribed myself afterwards. Initially I listened to each interview that took place and then did the transcription on the second listening. This took place over several attempts as some words can be difficult to understand, or we may have talked over each other at certain points.

Afterwards this interview is then coded and themes emerged. The thoughts of the participant are mapped and this is then used to form a picture of their experiences coupled with the paper surveys handed back to me. A sample initial transcribed interview is in Appendix N.

Several passes through the transcriptions for the emergence of themes and supporting codes.

Initially in-vivo codes were highlighted to best represent exactly how the participant felt, in their own words.



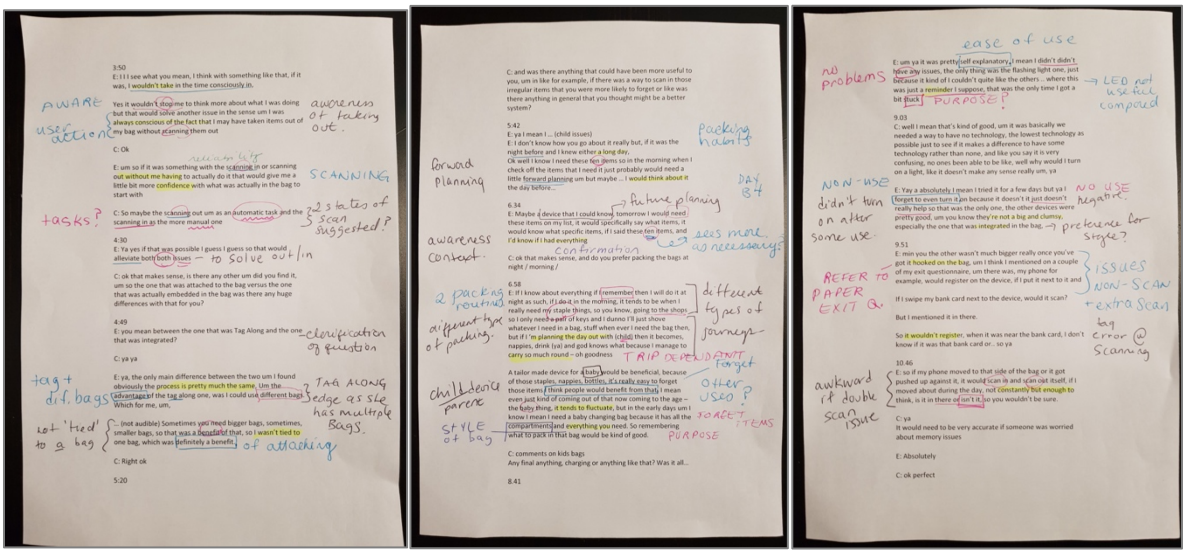


Figure 7.27 Transcriptions and reading through the interviews.

7.5.4 Addressing anticipated problems

Due to the nature of the study which included people and real world devices, I had to rely on them to get back in touch and to fill in the forms. Here I address some of the limitations of the study as well as how potential problems were addressed.

Pragmatic Challenges

A range of pragmatic challenges emerged from the study, these included:

- Difficulty in obtaining users for the study: This was an issue that was anticipated at the start of the study. When I had recruited sufficient participants and the study was about to begin, one left before starting due to holidays and another for various personal reasons. This resulted in a final number of 6 participants completing the study. There was a specific number of devices made, and if they were broken or returned late it was difficult to start all areas of the study to a schedule.

- Study set up issues: decide which device to be used first; and should the devices be sent all at once or on an individual basis. Initially devices were sent out one-by-one but the return and re-distribution of these devices became an issue. Some would not return the first device in a timely manner so it would be very late to the next participant. Do they return them as they were finished with them? If so, the user would have to post back 3 single items, or do they wait until all prototypes were used and return all three at once.

- Data collection and ensuring the daily questionnaire was filled in: Part of the study required a participant to fill in a daily questionnaire about using a device or not but it was difficult to have people remember to fill it in. With hindsight, there may have been a more effective way to control this. I resorted to emailing participants on a regular basis with the link to the online questionnaires.

A few limitations to the research study surfaced.

Location: Some participants voiced concerns that they did not live in or near the same location to myself. They felt worried that this would make it more difficult and some hesitated about having to post an item. Additionally, this study was based in the UK. There may be cultural differences in approaches to wearables or smart objects as well as temperature considerations in other countries and it would be of value to conduct similar studies in other regions.

Device Return: Other timescale issues involved some participants having to wait for a device to be posted to them. Some devices that are with testers, might not be returned in a timely fashion. In one case a new device had to be created due to the uncertainty it would be returned at all. One device was returned not working which created problems.

Age: The device was tested with adults under 50 years old. However, the device potentially has application in other fields or for people with memory conditions and as such it would need to also be tested on a generation that potentially has less technological awareness. Many memory conditions pertain to individuals who are 70+ years of age.

To address users responding and completing questionnaires; providing gentle email reminders asking if they had any questions and to remind them to fill in the online survey. The interview at the end of the study was a useful way to get more detailed information and more anecdotal style information about their experiences that would have been limited by typing a response alone.

The return of the device was an issue that was both anticipated and happened, and it was an awkward situation. One respondent, post-study, was difficult to contact and the device was held up for an extraordinarily long time. They would not respond to many attempts over several weeks to return the device. Postage and packaging was included with the prototypes as was an offer of courier or personal pick up to avoid any stress for participants. One device needed picking up from near where the participant lived.

Damage to prototypes; damage occurred to some of the switches on the devices, and tags broken. Additionally, one device was returned in such a damaged state that it had to be rebuilt (detailed in Chapters 6 and 7).

7.6 Findings for in-the-wild comparison study (SU2)

During this study, it was observed that there is a clear interest in the device from observers and testers, and people believe there is a useful ‘purpose’ for the devices sampled. The current research contributes towards the understanding of; could technology embedding into an everyday item be effective in the domain of forgetfulness?, and, what specific factors are critical to the design of a smart object?.

Feedback received was that respondents reported a more relaxed “weight lifted” feeling once they have packed a bag. However, users would like assurance that the device will not stop working and that they can “trust” it. These early positive results suggest there would be benefit from conducting a longitudinal study with more users; to focus on the effects of the scanning and the device usage. Following on from the study it could be beneficial to understand the effects of the visual reminder, that the bag itself has a purpose, as well as the scanning action itself. Although at several points in the research, the general public at events and in-the-wild had voiced concern that they would worry about having trust in the system, this did not factor largely in these trials. Additionally, none of the participants voiced that they were worried about their safety or that they were more likely to have their bag taken as a result of having lights on it. Although these imagined worries were mentioned from people who had not used the bag.

When a user is operating the system, to achieve their goal of successfully packing their bag, they have several tasks and actions that need to be completed. There are some overall design concerns that affect system level issues, and operational level design that will affect how they achieve their goals.

System level discoveries: The system level discoveries include that a novice user requires no training and it is essential to consider subjective factors such as fun, motivation and aesthetics. There are also considerations of power requirements with low hassle charging, and having a form factor that suits their style. The style has a big impact on usage, and an understanding of the range of items that could be packed in this type of system. What are the items that can be remembered, what are the limitations?

Operation level issues: The operational level issues concerns the user's ability to easily understand what items of theirs are missing; that it operates on a positive feedback system; feedback when an item is or is not packed is communicated to the user; and, the system needs to work in a variety of environments and conditions. These user matters are issues that can be discovered through participant feedback.

Table 7-4 Themes, Codes and Descriptors

Theme	Codes	Descriptors
Critical Issues	Ease of Use	Information on the ability to achieve their goal
	Interactivity: Reminder	Information on scanning as a reminder
	Usefulness: Reminder	Information on the usefulness of the device to the user, in the domain of forgetfulness
	Reliability	Information on reliability of the device
User Variants	Wearability	Information on the styling
	Novelty: Confirmation	Information concerning a novelty aspect
	Aesthetics	Information on appeal of the device
	Pleasure in Use	Information on positivity regarding the use
Additional Qualities	Comprehension	Information on the prototype being easy to understand
	Portability	Information on the ease to carry it or use it due to the size
	Familiarity	Information on prolonged use, the familiarity of the object

Data from the study conducted contained; notes, observations, experiences, recordings, semi-structured interviews and questionnaires. Categorization of the data through similar words, ideals and expressions emerged from respondent's interviews and surveys. Table 7-4 details the themes, codes and descriptors that became apparent when reading through the data, the notes of observations, interview transcripts and questionnaire data. The main themes of critical issues, user variants and additional qualities were built up from the coded interviews. These interviews were transcribed and then reread four times to have memos written up for the overarching themes, the sentences were given main coded words, and words highlighted from these words that formed groupings of similar thoughts.

7.6.1 Critical Issues

Ease of Use

User experience is a focal interest in interaction textbooks, achieving what the user wants easily. There was a 100% reply of 'yes' from the online questionnaire that asked, "Did the device you just used operate in an obvious way. Is it easy to use with no training / explaining?". One user answered that, "*I didn't really need the information sheet, once I'd figured out where to position the tags*" and an individual also mentioned they were surprised that there weren't more '*steps*' to use it.

These initial positive results indicate that the system has achieved the goal of being easy to use with little to no instruction for users under 50 years of age of mixed technical abilities.

Interactivity: Reminder

At this stage, there is a divided result concerning the interaction of scanning an item. The scanning action was mentioned by all respondents. There was a variety of opinions indicating that the scanning action needs to be investigated further.

Negative comments varied from, "scanning is irritating", "felt laborious" and they wanted the bag to just scan it for them. However, two individuals (of the 6) who found it irritating saw a positive side to this, one said;

> *"the manual process required to pack the bag forced me to take more care and time to remember crucial items."* [- SU2 P4]

and the other;

> *"I felt the process was too manual (having to scan items in and out)", adding, "But the scanning in did prompt me to be more conscious of what I'm doing rather than just having a bag and chucking things in it, its prompted me to take a second to focus on what I was doing."* [- SU2 P1]

These quotes were selected as it highlighted an opposing view between the two. One participant felt that having to be forced to scan could actually help with forgetfulness, ‘to remember crucial items’, while the other was bored by it. Consequently, even though the initial comments are negative about scanning an item, the user seemed to turn it into a positive that could be helpful to them. Some respondents [- SU2 P3] found this to be a positive experience from the start and attributed scanning to the reason for not forgetting their items,

> “[…] *just the act of scanning the items like I was physically able to remember, ‘oh ya I scanned my phone so it’s definitely in my bag’ and ‘ya I scanned my keys so I know I’ve got those’ so it was kind of confirmation of the act of scanning my items and seeing everything lit up (pause) so I found that really helpful.*”.

Another respondent [- SU2 P1],

> “*So it was more the um the conscious effort that you are scanning that kind a made you think about it rather than it the lights necessarily*” and another said, *“…although I did find them a bit manual, (pause) the time that it took (pause) to scan all the items in, would give me the extra few minutes to think ok, ‘what am I doing, I’m packing a bag, what do I need?’*”.

Usefulness: Reminder

There were some comments from testers on the usefulness of the devices. This was echoed among the participants and this quote from a one to one interview was selected as it encompassed the feelings of the testers; Particularly positive was a respondent saying,

> *“Yes! I’m not spending an extra time in the morning, looking at what I’ve packed.”* [- SU2 P5]

Others were equally positive,

> “*I found this really useful and um helped me to remember my items.*” and, “*but ya, it was kind of, I sort of checked if I had everything packed, but normally I will check about like 5 times before I leave the house and when I get in the car if I have everything, whereas when I scanned all my items, I did check once, but I was happy with that. I didn’t feel the need to constantly keep checking. Um so ya, it*

definitely (emphasis) did make a big difference to me, being reassured that I've got everything.". [- SU2 P3]

Reliability

Unfortunately, there were issues with the tags themselves not working on certain items which was not anticipated, two (33.3%) of the testers reported that the sticker tags would not scan when the tags were on their smart phone.

"(…) *the 2 or 3 major items, that I need to carry with me are metal like my water bottle ironically, um a mac an iPad, they all seem to, I wondered if it's the radio, like maybe radio or Wi-Fi, the antennas? but even the water bottle. But like I'm guessing the metal?* (…) *if that kind of worked better I probably would have gotten a lot more out of it, and I think the second set of tags that you sent me was a definite improvement* (…) *I don't know if it was just the plastic ID card style ones*" [- SU2 P2]

The user remarked in regards to the tags not working on metal objects that the user had. This is an issue that needs resolving as there should be no limitations as to what items can be tagged.

Another user mentioned they had issues when tagging their mobile phone with a sticker and that they would physically remove the sticker, scan their item and then put the sticker back on – which is not ideal,

"*the only problem I sort of had was, um one of the stickers that I put on my phone it wouldn't scan when it was on my phone so I had to actually peel it off my phone and then scan it and then stick it back on my phone so that's kind of the only problem I had really*" [- SU2 P3]

Further research is needed into the RFID reliability, sensitivity and range. Additionally, one user noted that the Stand-alone version could potentially move around and may have resulted in inadvertently scanning an object,

"*so if my phone moved to that side of the bag or it got pushed up against it, it would scan in and scan out itself, if I moved about during the day, not constantly but enough to think, is it in there or isn't it, so you wouldn't be sure.*". [- SU2 P1]

This too would be a principal area to research further as the reliability of the device would be one of the most vital aspects. An interesting point was raised that the testers tagged the items they deemed essential. However, because of this, one user mentioned that they would rarely forget those items due to this importance (unable to function in their day), whereas the user was highly likely to forget items that were one-off items. As the items were less likely to be needed, the user did not tag them.

> "*It was the things that I needed occasionally, or something specific that I would need (for a) certain activity or that kind of thing, so I wouldn't scan it in anyway 'cause it would be additional to the things I was scanning*". [- SU2 P5]

7.6.2 User Variants

Wearability

When creating an embedded bag, it is difficult to account for everyone's personal style and needs, we can see this through the sheer number of bags available on the market today. Although we tried to account for a generic use case scenario, the bag size was not sufficient for testers. One found the handbag version too small for their needs and commented,

> "(if) *I was somehow able to integrate it into my own bag I would have found it (emphasis) really useful so the concept I thought was really good, it was just unfortunately the bag's a little bit too small for me to use for work.*" [- SU2 P4]

> "*Sometimes you need bigger bags, sometimes, smaller bag's, so that was a benefit of that, so I was not tied to one bag, which was definitely a benefit*".

Novelty: Confirmation

The implementation for this type of system is new and some comments towards the novelty of it surfaced,

> "*I was kind of sceptical that like, would I find this useful, I'm generally not a forgetful person, um but, even still, just knowing, the assurity*[22] *of having it there, um actually works really well for me.*"

22 [*Researcher assumed 'assurance' is meant by the word this tester used.*]

One tester remarked in the online questionnaire when asked about any benefits to using the embedded device the user mentioned,

"*Yeh, for sure - it's a great conversation piece, but also a good at-a-glance status of contents*". [- SU2 P2]

Aesthetically pleasing

Information collected about the embedded version comparing to the stand-alone from a user who anticipated they would prefer the stand-alone system said,

"…*I was surprised by that and I think probably because that first bag was a pretty good design* (…) *that kind a suited me, but with the stand-alone one, I'd forget that it was actually there, I was less likely to forget or to check something in or out, but more likely to forget to do it at all. Whereas the first bag (Embedded) I guess it was kind of obvious, the affordances were all sort of there. Looking at it, you knew, right like this isn't just a regular bag, it does something* (…) *there's lights, so it explains itself to you visually, whereas, the stand-alone, one because I'd kind of put it inside my existing bag um about half the time I'd forget that it was actually there*.". [- SU2 P2]

Also,

"(…) *a lot of it was actually really surprising um which is good, you know like, you know, really nicely designed."*

Responses from the questionnaire online in regards to aesthetics include: '*the electronics were discrete enough not to interfere with the image of the bag*', and, '*I loved that you can use it either with lights on or with lights off to indicate status*'. Aesthetics for the Stand-alone device were mixed, some liking the look of seeing components but saying that it could be smaller still. Comments through the online questionnaire included, '*The size and look of the item is fairly discreet which is preferable. I guess I would like it to be even smaller ideally and maybe encased better. Less of the circuit board showing and a little tidier around the switch and charge point*'.

Pleasure in Use

Some users loved the lights to be on and found having the lights illuminated to be a real perk of the bag, so used it in the opposite way to the designer's intentions (to have the status lights turned off when the items were packed). Instead of the LEDs going off when items were packed, the user had them go on, thus the bag would have all lights lit when it was packed. This did mean however that there was a slightly larger energy need on the bag than anticipated so would need to be taken into future consideration.

7.6.3 Additional Qualities

Comprehensibility: Although all testers found the devices easy to understand, "*it sort of reveals itself to you rather than you having to figure it out*", [- SU2 P3] there was one who later commented that the area of where to scan the tag could have been better highlighted. The user knew to scan the tag, but there was some confusion as to where exactly to do it (right intention, wrong action).

One comment that provided a starting point for potential future implementation, would be including a battery status indicator on a device. One tester noted that having a battery status when it's running low would be useful, "*Would be useful to see remaining battery life, so it's clear when to think about leaving it on charge.*" [- SU2 P4]

Portability: One tester found the battery unit in their device to be too heavy,

> "*it weighed a (expletive) tonne*" and, "*I mean it wasn't large, but like it was dense man, it was heavy, I mean I was like, I'm carrying this thing, why is this heavy hmmmm?*". [- SU2 P5]

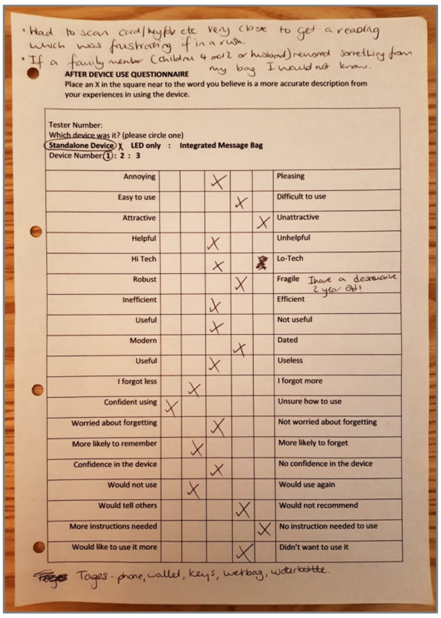
This issue was isolated to the embedded version that was repaired. This was because the charging USB facility broke at the last moment so was swapped for a 4 x AA battery pack. Another commented, "[…] they're not big and clumsy, especially the one that was integrated in the bag". [- SU2 P3]

Familiarity: A comment from a tester regarding the scanning action suggested that it became familiar over the course of using the device,

> "*when I sort of told myself it was like checking things in and out, using that kind of vocabulary, rather than memory, that made more sense to me, like checking your bags in or checking your bags out um so became more of a ritual.*" [- SU2 P1]

7.6.4 End of use (EofU), paper-based questionnaire

Respondents were asked to mark an ‘X’ into the box nearer to the word they felt best described their opinion of the device just used. Responses are from 5 respondents as one did not return any paper questionnaires. In the information below, the users’ marks were collated, and presented as a graphical representation. The questionnaire is in Appendix K. Some respondents also annotated their forms. This respondent felt the stand-alone device was fragile but commented that they have a destructive two-year old, so they may have felt that was the reason.



• Had to scan card/keyfob etc very close to get a reading which was frustrating if in a rush.
• If a family member (children 4 and 2 or husband) removed something from my bag I would not know.

AFTER DEVICE USE QUESTIONNAIRE
Place an X in the square near to the word you believe is a more accurate description from your experiences in using the device.

Tester Number:
Which device was it? (please circle one)
Standalone Device X **LED only : Integrated Message Bag**
Device Number 1 : 2 : 3

Annoying			X			Pleasing
Easy to use				X		Difficult to use
Attractive					X	Unattractive
Helpful			X			Unhelpful
Hi Tech			X			Lo-Tech
Robust				X		Fragile I have a destructive 2 year old!
Inefficient			X			Efficient
Useful			X			Not useful
Modern				X		Dated
Useful			X			Useless
I forgot less		X				I forgot more
Confident using	X					Unsure how to use
Worried about forgetting			X			Not worried about forgetting
More likely to remember		X				More likely to forget
Confidence in the device			X			No confidence in the device
Would not use		X				Would use again
Would tell others				X		Would not recommend
More instructions needed					X	No instruction needed to use
Would like to use it more				X		Didn’t want to use it

~~Tags~~ Tages - phone, wallet, keys, wetbag, waterbottle.

Figure 7.28 One respondent’s replies to the end of device usage survey with textual information as well.

The data for these surveys was translated to a numerical scale. For each of the opposing terms, ‘annoying – pleasing’ the positive terms were selected and given a numerical value. This was determined by where they placed their ‘x’ on the form. For example, in Figure 7.28, the respondent has selected the middle column to place their ‘x’. That will allocate ‘annoying’ with a value of 3. Any ‘x’ marks place in the column immediately next to the term will be allocated a value of 5 and a value of 1 is recorded for the furthest column to the term.

All the questionnaire for the of use survey were collated in the same way. All marks were recorded and then entered into a spreadsheet where they could be better analysed and compared. The tables represent the numerical values collected (Tables 7-5, 7-6 and 7-7) and Figure 7.29 shows the three prototypes average values collected as a comparison.

Table 7-5 Paper questionnaire post-device usage, Embedded bag, Scale 1 (negative response) – 5 (positive response).

	Embedded (EM1, EM2, EM3)					*AVERAGE*
	R1	R2	R3	R4	R5	
Pleasing	3	4	4	4	3	4
Easy to use	5	4	5	5	4	5
Attractive	1	4	4	4	3	3
Helpful	4	5	4	4	4	4
Hi-tech	4	5	5	4	4	4
Robust	3	5	5	5	4	4
Efficient	3	5	4	4	3	4
Useful	4	5	4	4	5	4
Modern	4	5	3	3	4	4
I forgot less	4	5	4	4	4	4
Confident using	4	5	4	4	4	4
Not worried about forgetting	4	4	4	4	4	4
More likely to remember	4	5	4	5	4	4
Confident in the device	3	5	4	5	4	4
Would use again	3	5	4	4	4	4
Would recommend	3	5	1	4	3	3
No instructions needed	4	3	5	3	4	4
Would like to use it more	3	5	5	4	3	4

Embedded Bag: The respondents all felt this was an easy to use device, which from previous research we know this to be an important factor. The device was helpful, and although 4 users found it at the top of the scale for attractive, one user was at the opposite end of the scale and thought it was unattractive. The device was useful and they were confident in using it. They were not so worried about forgetting when they used it and they felt they were more likely to remember. Even so, although 3 or the respondents were pretty sure they would use it again, these results were also a little mixed as we see two users selecting the mid points.

Highlighted in 'would recommend' part of the response is a '1' for R3's selection. Based on the other positive feedback that R3 entered, almost all '4' or '5', this was highlighted as a possible entry error from the respondent. This is based on the feedback that they would use the device again, they were confident in the device and they would like to use it more. Regardless, it is highlighted as a potential anomaly in their responses.

Responses for the stand-alone device were equally as positive as the data collected for the embedded version. The responses are shown in Table 7-6.

Table 7-6 Paper questionnaire post-device usage, Stand-alone.

	STAND-ALONE (SA TA)					AVERAGE
	R1	R2	R3	R4	R5	
Pleasing	4	4	3	3	3	3
Easy to use	5	5	4	4	4	4
Attractive	3	4	1	3	2	3
Helpful	5	5	3	4	5	4
Hi-tech	5	4	3	4	4	4
Robust	5	4	4	4	4	4
Efficient	5	5	3	3	4	4
Useful	4	4	3	4	4	4
Modern	4	5	4	4	4	4
I forgot less	4	3	4	4	4	4
Confident using	5	5	5	5	4	5
Not worried about forgetting	3	4	3	4	4	4
More likely to remember	3	4	4	3	4	4
Confident in the device	5	5	3	5	4	4
Would use again	4	5	2	4	4	4
Would recommend	1	5	2	3	4	3
No instructions needed	4	4	5	4	4	4
Would like to use it more	4	5	2	4	4	4

Stand-Alone: The stand-alone device results are very similar to with the embedded device. They are both consistently 4 or better with only a few 3 in their responses. There are some less positive markings for 'attractive', with users showing a preference for the embedded styling. Also, 'useful' has a mark of 5 for the embedded and the SA has a highest score of 4, so potentially users were finding more use from an embedded version. Again, there is a mark of 1 for 'would recommend' this time from respondent R1. They too marked it highly in other areas, robust, efficient, and useful, so it is unclear why they 'would use it again', 'would like to use it more', yet would not recommend it to others. Lastly, if we look to R3, they did not find the device attractive at all, giving it the lowest possible mark, 1. They also marked low amounts for would use again (2), would recommend (2), and would like to use it more (2). This could indicate that the styling of the device influenced their decisions. That same device they mark as confident in using, easy to use and that they forgot less and were more likely to remember. So even though they were more likely to remember – was it the styling that prevented them from wanting to use it more?

The LED device (results in Table 7-7) helped to establish that simply having 'some' technology is not enough. This simple device that only had lights as a memory system is not enough to inspire the user to use it more and to help with their memory.

Table 7-7 Paper questionnaire post-device usage, LED only.

	LED Only (LED)					*AVERAGE*
	R1	R2	R3	R4	R5	
Pleasing	3	2	3	1	2	2
Easy to use	5	1	5	2	4	3
Attractive	3	4	3	1	3	3
Helpful	1	1	3	2	2	2
Hi-tech	2	3	1	1	1	2
Robust	2	2	3	1	2	2
Efficient	1	3	3	2	2	2
Useful	1	2	3	1	3	2
Modern	3	4	3	2	3	3
I forgot less	1	3	3	2	3	2
Confident using	5	1	5	3	4	4
Not worried about forgetting	3	3	3	5	3	3
More likely to remember	3	3	3	4	3	3
Confident in the device	5	5	3	3	5	4
Would use again	1	3	1	1	1	1
Would recommend	1	2	2	1	1	2
No instructions needed	4	1	3	1	1	2
Would like to use it more	1	3	3	1	2	2

There appears to be confusion as to whether the device does anything for them at all as all 5 respondents choose the middle option ‘3’ that they did not feel they forgot more – or less. Also, the opinions for ‘would use again’ and ‘would recommend’ are all near the ‘1’ mark indicating this is not a device they want to pursue. This is in stark contrast with the high 4’s and 5’s for both the embedded and stand-alone devices.

Overlaying the results obtained from the five respondents on all three devices we can see that there are clear preferences for the smart object devices. From looking at Figure 7.29 although there are parallels for the users feeling confident in using all three devices they found the other two devices made them ‘more likely to remember’, they ‘forgot less’ and they were ‘useful’. These results were far lower in the LED version of prototype. They had the most confidence in using the stand-alone version, but they were more likely to remember with the embedded device and found it more useful.

From the results it appears that the participants are not going to use the LED device, but not because they lacked confidence in using it, they were confident how to use it – but they did not find it helpful, they found it too low tech, and overall not useful.

7.6.5 Overall Observations

The other results obtained were not conclusive as it was a spread between the issues, such as 'would not use' and 'would use again' or the opinion on attractive versus not attractive. There was not any strong feeling one way or another. Users did have confidence in the device and they were confident using it. This particular paper-based feedback would be well suited to running the study again with a larger number of users to see if a more definitive pattern emerges. This aspect of the study would benefit from having a larger sample.

Conclusions are that the embedded and stand-alone have only subtle differences of opinion between them and that there is a clear dislike of the LED only version. It could be interesting to drill deeper into the nuances of the designs and usage to get more refined feedback for future iterations.

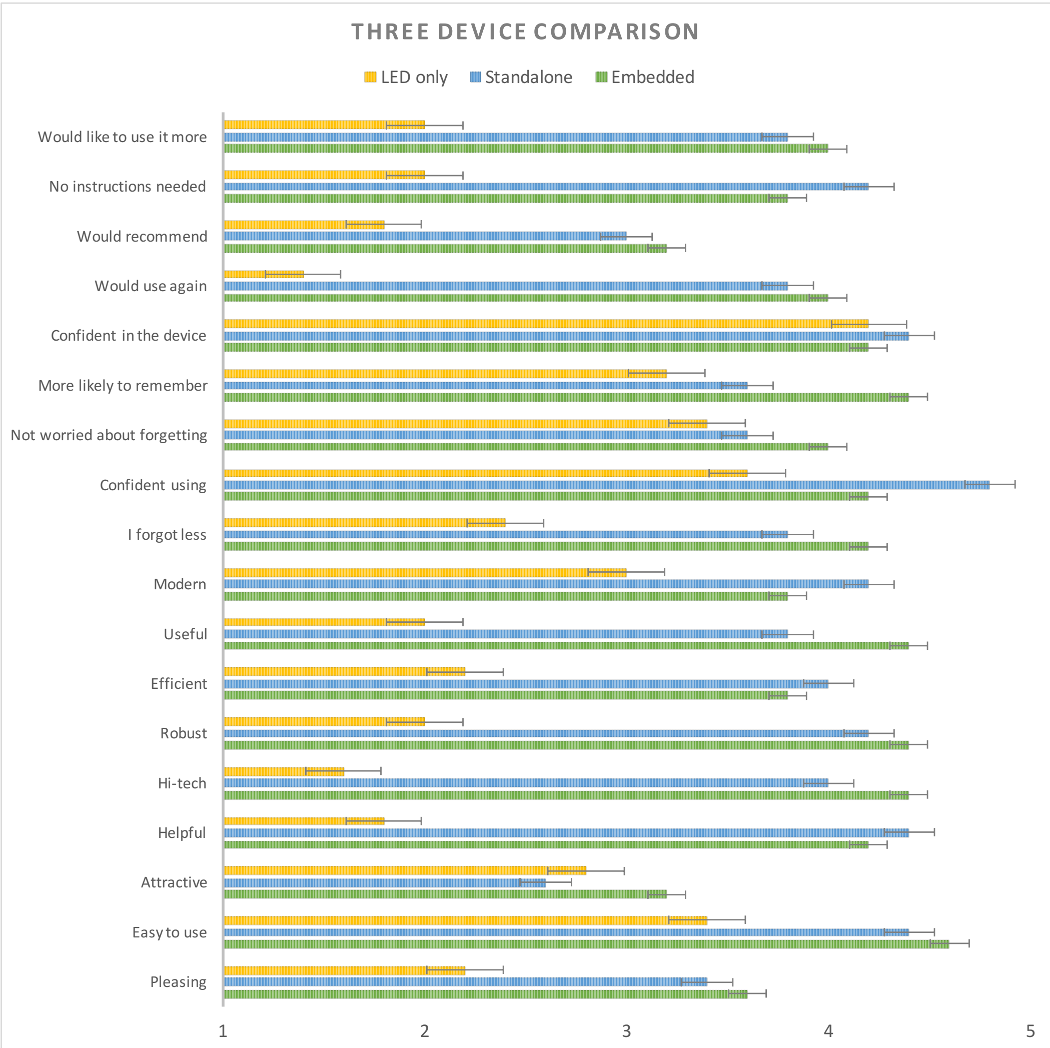


Figure 7.29 Averages of all three of the devices used by five participants and their feedback.

Both the embedded design (EM1, EM2, EM3) and the Stand-alone (SA) have positive results when compared with a low technology version. The users of these devices on average worried less about forgetting, were confident using the devices, and felt more likely to remember. They did also feel confident using the LED only version but they did not record that it was helpful. These results support the findings from the one to one interviews. Respondents commented on the helpfulness and ease of use of the devices and these paper based surveys help to quantify their comments. Side by side comparisons for the three devices indicate the LED performed poorly compared with the other two. The embedded and stand-alone are very closely matched with the embedded version having slightly higher results for helping people remember.

7.6.6 Unexpected Findings

1) Possibly a Slow Technology device?

Slow Technology, designing for reflection (Hallnäs & Redström, 2001), is "a design agenda for technology aimed at reflection and moments of mental rest rather than efficiency in performance." An indirect potential link with slow technology emerged. The interface allowed a user time to pause and think, to have the space of time to make a connection about what they are doing. When conducting the short voice interviews, there was an observation by some of the users that when scanning the items, they had to 'pause'. This moment of pause also gave them a chance to reflect that they typically do not have. It was when this pause occurred that the user realized they had a missing item or needed to pack something else. This observation has similar notions to the Slow Technology movement whereby the goal of using the technology is in some way enhancing to a lifestyle or environment. The users reported that this was a positive point to using the device. Could this be a potential area where the device could be created with a Slow Technology ethos behind it? The ethos from Hallnäs & Redström (2001) is that, "interaction design may have to change – from creating only fast and efficient tools to be used during a limited time in specific situations, to creating technology that surrounds us and therefore is a part of our activities for long periods of time."

2) Tag breakage or improper use?

Some of the items that users chose to tag resulted in the tags breaking, (through force) or not working due to interference. This resulted in frustration for the user so issues with tags – either explaining their use better or having a more robust tag – would need to be addressed.

3) Form Factor served as a reminder.

Respondents said that having a bag that was of a 'special nature' served as a reminder itself – that there was a 'purpose' to it. This was not predicted as an advantage for the embedded bag.

7.6.7 Overview from the in-the-wild study

The overview from the single user study (SU2) has highlighted some of the following documented in Table 7-8:

Table 7-8 Overview of discoveries from in-the-wild evaluations of the devices final designs.

7-8.1 form factor is appropriate	The smaller discreet devices are preferred by some but the aesthetics of the embedded version - appears to afford the advantage of recognition and recall. Respondents looking at a bag that was 'special' served as a reminder that it has a 'purpose', so became a reminder due to its form.
7-8.2 'scanning' may need further investigating	For some users, it became cumbersome and users want scanning seamless. However, a by-product of that scanning motion was that it forced users to think about exactly what was being packed for the journey; this slowing down of packing echoes some of the ethos of Slow Technology. (*more details in Section 7.5.1*)
7-8.3 one-off items	A system that could track one-off items could be researched, as these one-offs' were forgotten more often.
7-8.4 tag reliability and compatibility	The tags did not work on all items. Some issues when using tags on metal items, and an iPhone.
7-8.5 purposeful	Study participants believe that there is a purpose to the devices, even if they do not see a need for themselves. They saw a need for others in their lives (partners, siblings, friends, etc.).
7-8.6 'weight lifted'	Users describe a feeling of 'weight lifted' when they know the items are in the bag and have visual confirmation through the lights.

7.6.8 Discussion

The design of a smart device for individuals who believe they are forgetful can achieve a potential reduction in everyday anxiety about forgetfulness. Initial findings indicate that there was benefit to users when using the device – both the embedded and the stand-alone versions. Qualitative feedback received highlighted that users (a) enjoyed using the device, (b) found it part of their everyday routines and that through using it, they (c) lowered anxiety felt when packing for their day ahead. When unravelling the different components to this issue I ask;

- What design styles and changes are needed for a smart object to be effective? (in the field of forgetfulness)
- What changes did I make to a device (smart object) that is different from current research?

Conclusions at this stage are that there is a clear interest and purpose for the devices sampled. Due to the results being positive at this stage, I believe it would benefit from a longitudinal study with more users to focus on the effects the scanning and the device usage has. The current findings are a principal contribution for this stage, to understand how and why the technology works and what would benefit from improvements.

Incremental changes to the device would further enhance the usability and frequency with which they were able to use it for a user's everyday journeys. The implementation of the current smart object developed has formed a solid basis for this and future research. The research is useful for discovering what is effective and required to not burden someone with additional cognitive load (thus defeating the purpose of a device), but to enhance their lives over time. The findings presented, build upon knowledge in HCI and wearables and takes this work further to contribute to best practice for embedded systems based around anxiety. The form factor of the embedded Message Bag is novel, coupled with the immediacy of such a system makes it a unique device. Although initial perceptions are of complexity, this is quickly debunked when a user sees how easy it is to operate.

In summary, the study has shown initial findings that a purpose-built device, done with the user's needs in mind can reduce anxiety about forgetfulness in the everyday. However, reliability issues would need to be addressed as a user needs confidence in the device. The research shows through users' comments and observations that extreme ease of use and the styling become essential factors for consideration when using a device daily in this domain.

7.6.9 Implications

The indications of the work presented in this thesis are that an everyday object can be modified to assist an individual in a chosen domain. Currently studies regarding an everyday object used and modified in this way are in the minority and the distinction with my work, using a bag, has provided an opening for further research to take place.

The ease of use has enabled individuals to embrace using Message Bag as a daily object, and the styling will encourage this to continue to be the case. This confirms the inference that the styling of an object becomes paramount in its acceptance. I echo research that a device being useful and usable are paramount, the other factors; aesthetically pleasing, age appropriate, fashionable, and culturally and socially acceptable are of just as much importance. (Karahanoğlu & Erbuğ 2011; Starner 2015; Starner 2001; Kintsch & DePaula 2002) As mentioned in earlier literature presentation, devices that look "handicapped" are not adopted (King 2001). My research establishes that taking an existing object and repurposing it can alter the user's perception of it - and their thinking when using it.

7.7 Chapter Summary

Although there are some limitations with our current prototype such as power and charging requirements, tags not working as expected, or breaking, and mixed views on the scanning action, the early implications are positive. Users reported that they found the smart object devices helpful, easy to use, 'I forgot less', efficient, and made them more likely to remember. The scanning action did allow a pause in the packing of their bag which afforded them space to reflect. This reflection resulted in thinking about the day ahead and respondents reported forgetting less. The other side however to that pausing action, the views were mixed if this was a positive thing or a delay in their day that they did not want to have.

Even with the moderate delay of packing, respondents commented on gaining time back in their day through the simple action of viewing the lights on the bag, and knowing they have packed their keys. This eliminated the need for that user to continually check their bag, as they had done previously. This reinforces the early ideas of distributed cognition; off-loading; that the bag can be a memory aid through reducing that cognitive load for the user through sharing it. Unfortunately, there were some issues with tags, breakage and improper placement, and one-off items being an issue that would need further investigation. These items would be items typically forgotten and the current system use does not address that issue.

Additionally, due to continued improvement of hardware, the device components have become smaller and more discreet, fitting in better with a person's style universe, which is a key component to a user having a device on the throughout the day.

Chapter 8 follows with conclusions and recommendations for research to be built upon the findings.

Chapter 8 Conclusions and Future Work

The main contribution of this thesis is that it gives an extensive account of a specific contactless RFID reminder system that provided reminders 'in situ', on ten prototypes created and used in-the-wild. This object-based memory aid prompted users as to what essential items they needed to pack, communicated via LED lights on a bag. The work presented in this thesis aspired to solve real world problems that affect individuals, while also contributing to further research. An extended rigorous approach was followed through multiple tests, studies and observations to inform device developments. The design-led research resulted in a large body of work of prototypes, redesigned iteratively and deployed in several stages with a series of users. The approach coupled with extensive and varied testing methods led to the conclusions presented in this chapter regarding the research questions: Could technology embedding into an everyday item be effective in the domain of forgetfulness?, and; What specific factors are critical to the design of a smart object?

This thesis presented autoethnography studies using prototypes designed for the domain of forgetfulness. The experience-centred approach and the researcher's own anxieties and negativity regarding forgetfulness allowed an extensive array of devices to be created. The regular use of the devices allowed a rich collection of data over an extended period of time in a variety of real world settings.

8.1 Summary of Contributions

Chapter 4 questioned if a device for the domain of forgetfulness could be constructed; with reference to wearables, smart objects and contactless systems. In the chapter, it highlighted that RFID is an appropriate system to use for this implementation. This confirmed previous work in the field (presented in Chapter 2) where contactless systems have been used; *a smart toolbox*, *caretag surgical* and *smart medicine cabinet*. Those previous RFID systems had success, but they were implemented in an alternative way to the in-situ device I describe. Although this success is consistent with research in RFID technology for tagging systems (as described in Chapter 2), the research pushes the use of RFID to an alternative 'alongside the body' form, so the user is transporting it with them in a constant and discreet manner. The benefits of such a device are theorized based on previous literature. That literature detailed systems that were successfully using RFID as a communication method; though in an alternative form factor to my proposal.

Additionally, the initial questionnaire Survey of Needs (NEEDS 1) was used to establish how people felt when they experienced forgetfulness (Section 4.1). It was to discover information about the nature and impact of forgetfulness as well as systems people put into practice to help them remember. There were 91 respondents for the questionnaire. It revealed that people had many methods put into place to remember, including using apps – which they did not find effective. Almost 75 % of the respondents said yes, they still forget things even when using their system. This questionnaire also established that people forget small important items such as keys (95.6%) and wallets (93.3%), and so using a bag as the item to augment became an important choice. We also learnt that 100% of the respondents experienced very strong negative emotions when they forgot. Words used to describe these feelings included, '*dumb*', '*disappointed*', '*frustrated*', and '*failure*'.

The design concept (Section 4.2) was presented which discussed the implementation of the initial prototype, Proof of Concept (PoC). The design and build reference in Section 4.3.1 is recommended as an initial guide to be followed. Section 4.4.4 presented the first autoethnography study that recorded a single journey, in this case to fix any errors with the device. Initial fixes included better securing of the device parts (AU1 issue 1) and it was observed that the device was too bulky (AU1 issue 3). It did hold up in the weather (AU1 issue 2) however and lasted for the journey.

The public engagement event (EV1) highlighted issues with the LEDs, including a lack of understanding why they were placed on the reverse side of the bag (Table item 4-5.2a), what significance the colour and flashing had and what their direct relation to the system was (Table item 4-5.2b). However, people commented that it was nice to have feedback on the outside of the bag (Table item 4-5.2c). It was at this event that people commented on the concept and that it was interesting (Table item 4-5.1a). Twenty of the 30 individuals spoken with could envision a use and application for it for either themselves or someone in their lives (Table item 4-5.1b). It was felt that the styling was too feminine for users (Table item 4-5.8) with this current style, but the 'tech' styling of the bag made it attractive to them (Table item 4-5.3). This event also highlighted many issues that would be addressed in future iterations of the smart object including the LEDs (Table items 4-6.1, 4-6.2, 4-7.1) and how the understanding of them could be improved, and the weight of the device (4-6.5) and battery bulk reduced (Table items 4-6.8, 4-7.4).

Chapter 5 focused on experiential prototyping and a first higher fidelity prototype was created in direct response to the feedback obtained from AU1 and EV1. The device was used extensively for autoethnography study (AU2), and a residential weekend with potential users (RW1).

Data gathered from the residential weekend was separated into four main themes, features, scanning action, communication and aesthetics. Some participants focused on what the bag didn’t do for them and could features be added to tell them where their missing items were (Table item 5-3.1c). The scanning action was unclear to some and their intuition was to scan over the circuit board area of the bag (Table items 5-3.2b; 5-3.2c). This provided useful information for future builds of the device and how users interpret where the active are is located. Their observations regarding communication were mixed, some finding the sound too loud and others too quiet (Table item 5-3.3a). There was also confusion about the lights, not being sure what on or off signalled (Table item 5-3.4a), or which five lights were for which five items(Table item 5-3.4b). Lastly the aesthetics were positive comments, they enjoyed the unique (Table item 5-3.5a) appearance of the bag from a fashion perspective. Also general information that echoed similar comments previously regarded the battery and when it would need replacing (Table item 5-4.3) a lack of information leaflet with instructions (Table item 5-4.2) and wanting the lights for aesthetic purposes, keeping them on (Table item 5-4.4a). This study also uncovered some awkward behaviour with the prototype, when the bag turned off, the system reset and so memory regarding the lights was lost (Table item 5-4.4b). This was an issue that was fixed when discovered as it would prevent proper operation of the device.

Comments had been recorded during previous testing (Table items 4-5.9; 4-7.6; 5-7.7; 5-8.7) regarding concerns about travel with the device. The autoethnography work done in Chapter 5 aimed to address these concerns. The themes that emerged from the extended autoethnographic study were, device use location, device assumptions and functionality. From the six air travel journeys made, including domestic and international, there were no interruptions to travel or concerns (Table item 5-8.7) with actual use of the device. The device was not obtrusive in a user’s lifestyle (Table item 5-8.7) and it can go unnoticed. Some of the issues observed that would need addressing included that the number of objects would have to be reduced (Table item 5-8.1) ten items are too many and the paper reminders were abandoned during use (Table item 5-7.14). Some battery issues still remain, too bulky and charging issues (Table item 5-8.2). The placement of the scanning area could be confusing; it was not near the main circuit board (Table item 5-7.4). Some damage occurred to clothing during use, snagging on the exposed circuit board (Table item 5-8.8).

Chapter 6 detailed three new prototypes that were the direct result from the data analysed in the previous studies. A unisex messenger bag (UNI), an upcycled style (UpA), and a new stand-alone (SA PoC) version were created. The unisex messenger and upcycled prototypes were used for the first single user walk out study (SU1). These prototypes needed to be high-fidelity to enable people to use them in-the-wild. Feedback from those devices resulted in a radical design of a stand-alone proof of concept device (SA PoC). There were also five events that these smart objects were showcased at.

Feedback (Table items 4-6.4; 4-7.5) about men using the same system integrated with a bag but in a less feminine way was mentioned. The Unisex messenger (Uni) looked to answer this concern. Additionally, the 10 light system was overwhelming for users (Table items 5-3.4b; 5-6.2; 5-6.14; 5-7.1) so the LEDs were reduced to five. Results indicated that the respondent would still like to use their own bag (Table items 6-3.1, 6-3.2) as they had very large and specific items, such as a laptop. The respondent also found the bag lights too feminine a feature (Table item 6-3.3) and could they be obscured when in use (Table item 6-3.4). Lastly, they were unsure about being able to 'trust' the bag (Table item 6-3.5). Participants using the upcycled versions (UpB and UpC) reported that the styling encouraged daily use (Table items 6-5.1; 6-7.1b) and they would like the lights on all the time (Table item 6-5.4). Other observations were battery issues, being unsure when to charge (Table item 6-6.2), that the scanning became irritating (Table item 6-6.3) and a concern that there needs to be supporting documentation as a tag was broken and the participant was unsure how to use it (Table item 6-6.4). Also, an external device for using with their own bag was mentioned again (Table items 6-6.5, 6-7.2f).

Observations from events (EV2) included concerns about the bag drawing attention to 'their stuff' because of the lights (Table item 6-8.2b) but equally could it be seen as a deterrent, similar to an alarm system (Table item 6-8.2c)? Questions regarding all weather usage (6-8.3a) and if it would function in extreme cold or heat were asked. Also, alternative usages were discussed, would the device help with Obsessive Compulsive Disorder (OCD) (Table item 6-8.4a), could it be applied to other styles of bags (Table item 6-8.4c) such as a photographer's, or baby bag, or sports such as skiing.

Lastly, a new radical design device was presented, Stand-alone Proof of Concept (SA PoC) which was used for several journeys, documented in Section 6.6.4. These observations noted mostly that many aspects of the device were not appropriate. This included having to pre-program all the items beforehand (Section 6.6.4) and the screen being tedious to wait for the items to scroll through (Section 6.6.4).

Chapter 7 detailed high-fidelity prototypes that were the result of the research undertaken throughout the Ph.D. and these were used for a single user in-the-wild study (SU2). A final version of the Stand-alone device (SA) and an Embedded bag (EM) were used in comparison with an LED only (LED) device. Themes were critical issues, user variants and additional qualities. Users noted that one-off items were the items they were now likely to forget. Those items would not be tagged and so were hard to remember (Table item 7-8.3). Study participants believed the devices had a useful purpose for themselves and for others (Table item 7-8.5).

Information from the end of use questionnaire (Section 7.6.4) highlighted some limitations with the prototypes such as; power and charging requirements, tags not working as expected, or breaking, and mixed views on the scanning action, even so, the early implications are positive. Users reported that they found the smart object devices helpful, easy to use, 'I forgot less', efficient, and made them more likely to remember (Tables 7-5; 7-6). The scanning action did allow a pause in the packing of their bag which afforded them space to reflect. This reflection resulted in thinking about the day ahead and respondents reported forgetting less.

There were also unexpected findings (Section 7.6.5) including that this possibly has links with Slow Technology as the device afforded people the time to pause while they pack. They felt this 'pause' allowed reflection on their day and they were less likely to forget their items (Table item 7-8.2). There was also a tag break and the participant was unsure if it was not functioning or if they had broken it. Lastly, that the form factor served as a reminder itself (Table item 7-8.1).

8.2 Key Concepts

On the face of it, the final study would suggest that these augmented bags (the smart objects) are an effective way to reassure an individual that their items are packed for their day. This device appears to be an effective object-based memory aid. The ritualistic scanning and moments of pause in the system allows the user a space for reflection. This made remembering their items for the day more likely. Additionally, the styling of the bag holds huge influence as to whether a user will use and take the bag out. In some ways, this becomes the overriding factor in smart object design; if the user will not take the object out, it cannot perform its job.

The construction of a device that was part of an item that they used daily could become part of a routine which has the potential to aid memory. Essential aspects that such a device would need to be successful, such as the battery life to last for long periods of time and the reliability of tags, have now been exposed and research can be built upon from the work presented in this thesis.

7.7.1 Results of Investigations

During the testing there were positive aspects that surfaced indicating that embedded technology to an everyday item can be effective. The observations and data collected in response to the research question, ‘Could technology embedding into an everyday item be effective in the domain of forgetfulness?’ is yes, that users of the final prototypes worried less about forgetting, were confident using the devices, and felt more likely to remember. The data collected through observations, questionnaires and interviews revealed that people were confident when using the device, they forgot less and came to rely on it (Section 7.6.5). Participants reported feeling like a ‘weight was lifted’ (Table items 6-6.6; 7-8.6) when using the device.

Through the studies with users in real world environments we discovered: the form factor of an ‘in-situ everyday item device’ reduces feeling that they may forget through using a non-typical memory aid. Respondents noted that the form itself became a trigger to remembering, i.e. the object was ‘special’, so has a special purpose (Table item 7-8.1). Based on the feedback from the users, pausing to pack gave them a space to contemplate (Section 7.6.6), therefore remember. The low learning curve of using the designed smart object enabled immediate use. Users were confident using the device, and they would use it again. This ease of use allowed continued use, if a prototype had not been used before or was left for some time, a user would still be able to use it effectively. Many of the participants wanted to continue using the device after the trails (Section 7.6.5). Overall, the data revealed users found the devices helpful, they forgot less, and they would recommend the device (Section 7.6.4).

During the testing there were some negative aspects that surfaced. The lack of knowledge about how other individuals may react to a smart object whilst travelling could pose an anxiety risk was voiced (Table items 4-5.9; 4-7.6). Although comments and questions regarding anxieties for security when using the device were recorded while out with the prototypes and at critique events, it was discovered that these worries were not echoed by the participants in the single user walk outs. The participants were confident using the device and no travel or security issues were reported. Additionally, to ensure there were no claims to travel risks, the devices were used extensively including journeys to airports for example and the observations documented (Section 5.4.4). However, not a single negative issues presented itself at any of the locations. If there is a perception that the device may pose a security risk then potentially understanding of what it is about the device concerns people.

Another negative issue raised was a apprehension for usage in bad weather, however the device was successfully used by participants and throughout the autoethnographic studies in rain and wind and harsh weather (Table item 6-8.3a). Throughout this usage no unfavourable reactions were recorded, the users found the devices robust (Section 7.6.4) . Additional issues including the ability to ensure the device was working correctly, or that the battery was charging or needed charging were voiced. These concerns regarding the correct operation of the device had not been directly addressed as they mostly surfaced during the last study. This would be an area for further development. Nevertheless, even with those worries recorded, the final single user study reveals respondent's described being confident in the device (Section 7.6.4).

8.3 Guidelines: Smart Objects in the domain of forgetfulness

One aspect of the research was to gather data to understand what specific factors are critical to the design of a smart object. The Design Cycle as presented in Chapter 3, Section 3.9, guided the development of the prototypes through a framework developed, Everyday items into Effective Smart Objects. This involved a system of three main areas, a creation process, a build procedure and performance activity. This proved very useful in the early stages of the prototype development however, as the research continued and more data was gathered the system became less useful. This was due to many incremental changes being made at a rapid pace to develop higher fidelity prototypes to be used by people in-the-wild.

Through in-depth and extended autoethnographic studies of several prototypes at different developmental stages, a variety of detailed design information was collected alongside the data from users at events, conferences, and single user studies. This included the discovery of desirable characteristics for a smart ubiquitous device in the domain of forgetfulness: to include; a discreet system (not bulky); an easy power solution; little to no learning curve; extreme ease of use; reliability and; appropriate styling as essential.

Overall users found the devices robust and attractive, some users commented that the appearance of the device was so attractive they would use it even if it had no function. However, early on in the research some users regarded the device as too 'girly' or not the right size, which would prevent them from using it. These issues were addressed and tested through later prototypes. These later devices confirmed styling issues and it is clear that without appropriate styling, for example perception that the bag is for women only, or it is not the right size, the item becomes useless, an individual will not use it. The illuminated lights provide instant visual feedback from afar that allows a user to feel calmer knowing the item is packed, audio and haptic cues also signal confirmation.

Positive design Features for a smart object:

1. Appropriate styling is essential. Styling issues featured throughout the research. Styling is important, so much so, it will inhibit a user from using the device even if it is helping them. Additionally a user who likes the styling or feels it reflects them will encourage regular use (Table items 6-5.1; 6-7.1a; 6-7.1b). Many comments towards the 'tech' look of the bags being a positive thing, (Table item 4-5.3) supported them wanting to use it. Particularly if the item was a fashionable item (Table item 5-3.a). However, negative styling indicated they would not use it, (Table items 4-5.8; 4-6.4; 4-7.5, 6-3.3) in this instance it was the opinion it was too feminine.
2. Fun is an important aspect in the design. When observing people using the prototypes, typically they are engaged with it and find the interaction 'fun', (Table items 4-5.6; 6-5.5; 6-7.2b) this supports continued use.
3. Clarity of features is needed. The features or main uses of the device need to be explicit to avoid any user confusion. Observations concerning the main communication system – the lights – were initially confusing for the users (Table items 4-5.2a; 4-5.2b; 4-6.1; 4-6.2; 4-7.1, 5-3.4a; 5-3.4b). In the prototypes presented in the thesis a clear mapping of 'blue' keyfob to 'blue' light was made for the user. This removed an additional step of potential confusion for the user. Confusing features need to be examined and potentially removed (Table items 4-6.8; 5-6.14), which happened when paper card reminders had been used for the system. These were too confusing for users and so was removed. Also, confusion over the scanning action was observed, so this was redesigned when it was observed that users natural mappings were to scan over the circuit board (Table items 5-3.2a; 5-3.2b; 5-3.2c; 5-3.2d). Observing the users in action is essential in order to receive essential feedback on the use of the device.

Undesirable design issues:

1. The size and weight of the device needs to be appropriate, not wanting a 'bulky' system. Initial prototypes had a lack of space (Table items 4-5.4; 4-6.3; 4-7.2; 5-6.7) which was questioned along with the weight of the device (Table items 4-5.7; 4-6.5; 4-6.7; 4-7.4). The size and weight needs to be appropriate (portability, Section 7.6.3) for the everyday item you are designing for. If this was a large backpack then typically this observation would allow slightly more bulk and weight than a small handbag, for example.

2. Clear direction to using components of the device is needed. Feedback from respondents indicated that at times there was a lack of understanding for how or when to charge the battery. The battery is needed on a basic level for the operation of the device so this is an essential aspect to address (Table items 5-4.3; 5-6.3; 5-6.5; 5-6.6; 6-6.2; 6-7.4d, 6-8.1a; 6-8.1b).
3. Confounding potentially embarrassing or negative feelings for a user. Some of the respondents voiced concern at the ‘beep’ when in a quiet environment and being unable to turn this off (Table item 5-5.2).
4. Usage concerns, travelling safety, for example would need addressing. Concerns about the usage of the device need to be eliminated. Concerns regarding travelling with the device were voiced. If there are concerns, the device may not be used (Table item 5-7.7).

8.4 Future research and alternative applications

Developments from this research can be applied to other fields and uses, and not just for individuals in this domain. As highlighted in Chapters 4, 5, 6, and 7, many individuals offered their own interpretations of situations whereby they too would find the device useful – such as; to account for items in a doctor’s bag before visiting a patient, to ensure all necessary items were packed; or a photographer looking to not lose expensive lenses or lens caps when out on a job; or, a parents’ style of bag where there are multiple items needed by different family members at different times.

My research focused on individuals who had no medically diagnosed memory issues. Early questionnaires highlighted that many of us feel forgetful which affects our daily lives. However, there is potential application in the medical field for individuals with diagnosed memory conditions. Could the research be adapted into the medical field and what adaptions would need to be considered to ensure the success of a user fulfilling their goals?

Three further areas to investigate from the research currently done includes the adaption of the smart object for other fields, adapting it for medical purposes (table item 6-8.4a questions use for OCD), and addressing issues that were not fulfilled from the research, including confusion if the device is working (Table items 6-3.5; 6-7.2d concerns forgetting to scan an item), power issues and comprehension with charging (Table items 5-7.3; 5-7.5; 6-6.2; 6-7.4d; 6-8.1a; 6-8.1b), and unusual items being forgotten (Table items 6-8.4e; 7-8.3).

(1) Adaption of the smart object, RFID based system, for other fields.

This would be a fascinating area to research as it would potentially provide interesting contrasts in designing these augmented objects, to respond to different needs. Would the proposal of an adapted smart object be designed the exact same way as the object addressing an issue with weight loss or punctuality for example? If using these objects in different domains, would they have similar features? What aspects would need a redesign, or can we pull together a resource that would provide a base smart object 'module'? For instance, could modules be built depending on the domain in which we are using it? Would using the proposed framework, *Everyday Items into Effective Smart Objects* help to define the domain and the focus for the design?

Many people offered suggestions and ideas about how they would like to use the device and in what other forms. This could be for other bag styles such as a baby bag. There was an excitement about the notions of having a portable RFID system 'on-person' and people wanted to adapt it. After completing this research, there is scope to apply this 'adaption' to future development and create a system for use in other ways. Maybe the technology becomes a small reminder system an individual can have on their desk, on a shopping cart, or wear around their neck. Potentially it could even be used as a belt as some people have asked. As the components continue to become smaller and less expensive these other areas to explore become possible. Research would be needed regarding the domain to be adapted, and the specific user goals.

(2) Could the device be adapted for use in a medical situation?

How would these devices need to be adapted to be successful or would they be widely useful regardless of medical diagnosis or not? Through the testing and observation of the devices, many people who did not have a medical diagnosis for forgetfulness wondered if the device would be efficient for an individual who did have a medically diagnosed condition. At one event someone enquired about work towards the field of OCD study. Could further research be drawn out for different medical issues? Potentially, is there scope for use for individuals with a visual impairment, for example? My personal work in the field of sight loss has afforded me an insight into using technology to make everyday life a little easier. Tagging many items that are essential for the day and having a tactile system focusing on the vibration motor and less so on the lights as the visual feedback. How could this device be adapted? How could it be carried? Would this be an in-house system that was also activated as an individual was leaving the house? Potentially a wider system use could have benefit.

(3) Addressing issues not fulfilled: including uncertainty if the device is working, power issues and questions about one-off items. During the research, there were observations and data that noted some usability concerns. This included uncertainty if an item had been scanned, or how the device would cope if an item was removed if it was not actively scanned. During my own use of the bag, there was an incident where a tagged item fell out of my bag, (Section 6.3.5, Field Notes from Journey 3) and it did scan as it fell. Potentially there could be a wider antenna area on the outside only of the bag to aid with this issue? The solution warrants more work as it could potentially make the device more useful.

Additionally, power issues and concerns were mentioned in almost every study conducted. Table items 5-7.3; 5-7.5; 6-6.2; 6-7.4d; 6-8.1a; 6-8.1b listed several battery issues, "Charging is not functioning correctly", "Battery life", "Is the battery able to be charged, does charging work?", "Solar charging capabilities". Throughout the prototype development, although the battery did change from larger, heavier 9V plugged in, to a replaceable LiPoly rechargeable, people were still concerned with the battery. The effectiveness of communicating when it would need charging and when it was fully charged needs to be better addressed. Also suggestions regarding solar power, or contactless charging should be investigated.

Lastly, one-off items did pose an issue for the prototype. Short of people requesting additional tags to use, the one-off or unusual items (Table items 6-8.4e; 7-8.3) were not addressed in the studies. Primarily this was due to the issues surfacing during the last single user testing. There was an issue with those items being forgotten so this too would be an appropriate area for further research.

8.5 Final Word

The research in the thesis demonstrated extensive autoethnography studies, and a design-led approach that resulted in ten working smart bags. These prototypes were used in many varied studies to discover if technology embedding into an everyday item be effective in the domain of forgetfulness, and what specific factors are critical to the design of a smart object.

From these studies, it was discovered that the styling of a device becomes essential to its success. Also, the scanning action that is required of a user when tracking items in an RFID system allows a user moments of reflection. This reflection resulted in thinking about the day ahead and respondents reported forgetting less. Illuminated lights provide instant visual feedback from afar that allows a user to know if an item is missing. The visual feedback provides comfort to the user because they no longer check their bag obsessively for items, which can lead to a user having more time in their day. Implications are that when all the components are designed with the user's needs and goals at the forefront, that the device can be made in a way to ensure the users success with achieving their goals.

The data collected through observations, questionnaires and interviews from in-the-wild studies revealed that people were confident when using the device, they forgot less and came to rely on it. Users were not worried about forgetting and would choose to continue to use the device after the study. Even though limitations appeared including power and charging requirements, tags not working as expected or breaking, and mixed views on the scanning action, the implications are positive. Users reported that they found the smart object devices helpful, easy to use, 'I forgot less', efficient, and made them more likely to remember.

Regarding specific factors that are critical to the design of a smart object, the studies uncovered that appropriate styling is essential, the aspect of fun and interaction plays a role in its use, and clarity of features is needed. Also, the size and weight of the device embedded needs to be appropriate for the object, a clear direction to using components of the device is needed, elimination of potentially embarrassing or negative feelings for a user would need to be addressed as well as usage concerns reduced. Lastly, the unique form factor became a reminder itself and usability coupled with the intuitive nature of the system was shown to be essential. When creating a smart object, usability and an intuitive nature is even more important than in a standard system. While dealing within the domain of forgetfulness, this is paramount.

This research provided a solid foundation for discovering design constraints in the domain of forgetfulness, and provides a solid basis for future work. The thesis presented the understanding of what components would be effective to use when building a device, to not burden someone with additional cognitive load - with an ultimate goal to enhance a user's life over time. It is anticipated that these fundamental characteristics will be of interest to fields of dementia, Alzheimer's, brain injury and hypothetically obsessive compulsive disorders. The work will also be of interest and could be built upon by HCI, Wearables and Cognitive Science communities.

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Appendix A: Ethics Approval

Ethics approval for all message bag related testing.

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Queen Mary Research Ethics Committee
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Dr Matthew Purver
CS 403
Department of Computer Science
Queen Mary University of London
Mile End Road
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13th March 2013

To Whom It May Concern:

Re: QMREC1159 – Combating Forgetfulness; TagBag

I can confirm that Ms Christine Farion has completed a Research Ethics Questionnaire with regard to the above research.

The result of which was the conclusion that her proposed work does not present any ethical concerns; is extremely low risk; and thus does not require the scrutiny of the full Research Ethics Committee.

Yours faithfully

Ms Hazel Covill
Research Ethics Committee Administrator

Appendix B: Needs Survey Questionnaire

Full NEEDS 1 questionnaire.

Memory Questionnaire

INFORMATION: Designing a smart device to alleviate negative emotions that happen when we forget.

I'm currently studying embedded technology, distributed cognition and forgetfulness.

I'm trying to find out about memory to be able to improve a device that could help to reduce those negative feelings we have when we forget an item. If you have the time to answer my survey it would be very helpful and appreciated.

PARTICIPATION
This is a short 20-question survey, which should take around 5 minutes to complete.

At the end of the survey there is a document "Information for Participants", which explains privacy, data protection and how your responses will be used.

NEXT

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Never submit passwords through Google Forms.

Memory Questionnaire

SELF PERCEPTION & MEMORY

Do you think of yourself as a forgetful person?
(or consider yourself to be forgetful)

- ○ YES
- ○ NO

How often do you feel you forget things

- ☐ Daily
- ☐ Every Other / Few Days
- ☐ Once a Week
- ☐ A Few Times a Month
- ☐ Not Very Often

How do you feel when you forget something?
Write what you like here, any emotions experienced, your psychological state at the time etc...

Your answer

Do you typically forget:
tick all that apply

- ☐ Items you need
- ☐ Appointments
- ☐ Locations
- ☐ Things you'e supposed to do
- ☐ Train of thought
- ☐ Other:

Does this impact the rest of your day when you forget something, how?

Your answer

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Memory Questionnaire

SPECIFICS OF MEMORY

Do you carry any of these items with you on a regular basis?

- [ ] Keys
- [ ] Wallet / Change
- [ ] Pens
- [ ] Phone
- [ ] Kindle
- [ ] Other Tablet
- [ ] Makeup
- [ ] Note Pad
- [ ] Business Cards
- [ ] Book(s)
- [ ] Phone / Other Charger
- [ ] Laptop
- [ ] Glasses
- [ ] Other cards i.e Travel Card...
- [ ] Chewing Gum
- [ ] Tissues
- [ ] Personal Products
- [ ] Other:

Which items do you think of as ESSENTIAL, (or difficult / awkward to carry on with your day) without the item(s)?

Your answer

What items do you / have you forgotten?

Your answer

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Memory Questionnaire

SYSTEMS

Do you have any systems in place to help you remember? i.e Post-It Notes or things you do to help you remember?

You may leave items in certain places etc...

Your answer

Have you tried / do you currently use software solutions, such as To Do Lists or Reminders?

- ○ YES
- ○ NO

If you use Reminders / To Do Lists, how effective do you think they are?

	1	2	3	4	5	6	7	8	9	
Not Effective	○	○	○	○	○	○	○	○	○	Very Effective

Do you still forget things, even when using your "systems"?

The things you do to try to remember, or Reminders / To Do Lists etc...

- ○ YES
- ○ NO

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Never submit passwords through Google Forms.

Memory Questionnaire

INFORMATION FOR PARTICIPANTS

Research study [smart devices to alleviate negative emotions experienced when we forget]

We would like to invite you to be part of this research study, and would like to ask for your consent. You should only agree to take part if you want to, it is entirely up to you. If you choose not to give consent to take part there won't be any disadvantages for you and you will hear no more about it. Please read the following information carefully before you decide to give consent; this will tell you why the research is being done and what participants will be asked to do if they take part. Please ask if there is anything that is not clear or if you would like more information.

You are free to withdraw your consent at any time and without giving a reason.
You have been asked to take part in a research project run in conjunction with Queen Mary University of London: Christine Farion is a research student at Queen Mary University of London. Her research is studying forgetfulness, which can be a cause for concern when it begins affecting our daily lives. Forgetfulness is associated with feelings of embarrassment and shame and yet there is little attention given to forgetfulness in a healthy population. Forgetfulness is a lived experience and something that happens in our day to day. Therefore we propose the "message bag", which will be carried throughout regular daily activities, with an aim to alleviate the cognitive load, in an effort to eliminate forgetfulness.

Confidentiality, anonymity, and data storage:All video-recordings will be destroyed within 7 years, unless material acquired is acknowledged to have value and potential for subsequent analysis to enable further publication of findings. Survey questionnaires will be stored for 7 years, and everything will be anonymised. The data used in papers or for further research will not have any identities associated with it, it is only your responses that we are interested.

All identities' will be anonymised in any subsequent publications.
During the analysis period, only the principal investigator, supervisors and the supporting institutions will have access to the data. All non-digital data gathered as a part of the study (consent forms, data obtained through informal conversation and written observation notes) will be stored in secure location in the University. All digital data (video-recordings and photographs) will be stored in encrypted files on password protected digital format on a computer located in the University and one of the investigators' laptops.

Digital and non-digital data resulting from the study will only be used as:
• A part of this research study will appear in presentations and publications relating to this research.

Contact: c.farion@eecs.qmul.ac.uk

Thank you.

Any comments / anything you would like to add:

Your answer

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Appendix C: Survey of Needs

All unedited responses to: How do you feel when you forget something?

Frustrated (2)
Embarrassed, generally. Apologetic. That's when the thing I've forgotten is important to someone else, which makes it much worse. (2)
Stupid, low self-esteem, inadequate, sometimes depressed if the forgetfulness had major/important consequences. An awareness of advancing years compared to my youth.
Annoyed when I was supposed to do something that I didn't.
Frustrated Annoyed Angry at my brain
It annoys me. I don't like feeling like I'm not in control of what's going on up there.
Nothing really. I remember my granddad being the same. While we are both considered by others to be intellectual people, short term memory loss has always been a given.
Foolish
dumb, upset,
Panicked, angry, stressed.
Irritated, but used to it.
I feel ashamed, especially if the thing I've forgotten is something told to me by someone important to me.
Stupid, dumb, annoyed at myself. Even angry
Frustrated, sometimes embarrassed. In extreme cases, annoyed or worried that my forgetfulness will get worse.
Mildly frustrated that I misinterpreted the value of the thing to remember (and consequently forgot it).
Frustrated annoyed fearful
I can suddenly be thinking of something and then quickly get side tracked and forget what I was thinking about. It can be frustrating as I find myself racking my brain trying to recall, whether that be tasks that need carrying out or ideas, train of though. I find I have to go over things that I can remember thinking about and then retrace the steps psychologically in order to remember what I had forgot which sometimes works.
Stupid, angry
Annoyed, mostly. Sometimes shameful if someone was relying on my ability to remember something.
Annoyed, confused, scared that I'm getting old.
Annoyed..
Anxious
stupid, frustrated, angry
Frustrated - it's become somewhat of a norm. Except with numbers... I'm really good with remembering numbers (not just phone numbers either).
I rarely forget items, and when I do, they aren't essential. I quickly become frustrated if I do forget something important. I am more likely to be unable to find something, which often results when I put it in a different place than I usually keep it.
I was supposed to do something. but what again... ? (Can be 5 seconds after I had the thought of doing it) Or: I feel that I forget something, but have no utter clue what
Guilt, irritation, sadness
Aggravation
Irritated. I forget mostly important things, so it is really irritating. Bu I am making progress!

disappointed with myself
Lost & silly.
Annoyed, frustrated, realise that I'm getting old.
Insomnia and working on multiple projects
Confused mostly. Then annoyed. Then I try to concentrate on what I've forgotten.
Silly, stupid, Parent
apathetic
I do not enjoy forgetting anything, and when I do, I try my best to recover the memory before doing anything else.
Disappointed in myself, and surprised at what I have forgotten, but not surprised that I have forgotten something.
Harried
I'm used to it. My emotion is pretty consistent with whatever it was before.
Sometimes a feeling of sudden panic when i realise I have forgotten something but normally just a mild frustration. It depends on the importance of the thing forgotten.
Annoyed/angry with myself, sometimes angry at the person who pointed out that I forgot something.
A bit dumb.
I feel I'm letting people down by failing to recall what I've been asked to do. I've usually been busy concentrating. Being a developer I focus intensely on coding to the exclusion of things important to others.
Daft
Often when tired. Feel frustrated, like I'm trying to bully my brain into remembering.
I tend to forget things more when I'm stressed, or focussed on getting something done
Normally only forget simple things like shopping etc
Often like I'm not living up to my expectations. If forgetting something that I was asked to do whilst working I feel as though I'm not as good a worker as I could be. Fairly often I feel like I'm letting the other person down, and I sometimes feel like I'm losing points with them.
Panicked! Throws me off my stride, makes me realise I'm stressed!
anxious, a failure. too rushed, too disorganised. a mess. not taken seriously. too vague, scatty, flaky.
annoyed, need to find it (it's usually something misplaced
Irritation with myself, sometimes embarrasment if I was trying to make a point and lost my train of thought.
stupid
Bit stupid - I tend to put pressure on myself to remember stuff.
Annoyed.
It usually something my wife has asked me to do... I just seem to switch off when she's speaking but I'll remember when it's too late that I was supposed to do something so generally I feel dread at the ear bashing I'll get on my return home
like a twat
Depends on what it is I've forgotten. If it involves someone else (a meeting, a birthday or their belongings for instance) I feel guilty and irresponsible, like I've let them down. If it's my own stuff I feel resigned! If it's something unimportant that can be replaced or fetched later I don't worry anymore (aside from mild frustration).
Bit pissed off with myself, to be honest.
Recognition. Sometimes complete denial... fear
Silly and at times frustrated.
disappointed frustrated
Frustrated, that I didn't make a note to remind myself.

Ashamed.

Frustrated and angry at myself for being so stupid. Get annoyed that I will often have to go back and get the thing I am missing which then makes me late. When I turn up flustered that I am late I get embrassed.

no

It depends what I have forgotten - it's usually small silly things. e.g. I go into the bedroom to get something when I get there I cant ' remember what I went for. I have to go back to the room I came from and it usually comes back to me. I am better at the big things but everything is on my calendar. I would be mortified if I forgot something important and would feel 'old'! I think I am more forgetful if I have a lot on my mind. I do forget peoples names, place names etc. They come back to me eventually.

dumb

Annoyed usually. I can usually remember stuff of zero importance, but can't remember something was talk I needed to do a day ago.

Am I getting old... is this forgetfulness getting worse?

Normally annoyed.

Distressed

Irritated with myself for not remembering

Par for the course. It'll come back to me.

Frustrated with myself.

Frusrated

I tend to feel a bit stupid, frustrated or annoyed with myself - particularly if this happens at work.

Very annoyed and frustrated.

annoyed and frustrated

curiosity on what the potential causes are for the forgetfulness

Annoyed, embarrassed, silly. Sometimes like others may think I do not know what I am talking about/doing.

Always frustrated and upset with myself. Guilty or angry with myself when I forget things for my family.

It frustrates me. I do not like forgetting things

If it's something that I have promised to someone else, I beat myself very badly because of it. I feel very guilty and very, very sorry for the person I let down because of my forgetfulness. I feel like a failure. I beat myself because of it and I find it hard to focus on anything else. My thoughts come back to the forgetfulness all the time.

Appendix D: Survey of Needs

All unedited responses to: Does this impact the rest of your day when you forget something, how?

No (3)
No. (2)
Yes, but only in the sense that I have to compensate for whatever it is. I don't worry about the actual forgetting. (2)
Self recrimination, constant re-evaluation of the circumstances leading to what I forgot & it's implications
Can mess up the rest of the day, and affect what I've planned to do
Only if the thing I forget was something to do WITH my day.
Not really. I typically get reminded about what it was I was supposed to do :)
Lowers mood
yes I feel I'm having an off day
Yes. I am upset and agitated the rest of the day. Just an "off" feeling.
Sometimes.
It can impact my day, especially if I forget an appointment and double-book. I almost never just stand someone up, but I might have to cancel one of the appointments, which can be embarrassing.
Sorta kinda...makes me late for work sometimes... Lowers self esteem
Usually it's not serious but the frustration & anger with myself can affect my mood and temperament for a while aft the incident.
Sometimes if its something that I needed and have gone out of the house then very much so! But otherwise it's just annoying
Not so much, it will for a good few minutes, 5 - 10 mins depending on what I was thinking about and if I knew it had importance. Not more than that usually before it then comes back to me.
If it's something my wife has asked me to do that's important, and I forgot - it sometimes can if she gets angry that I've forgotten
Not generally. The way I see it, if I forget something and miss an appointment for example, it's done, there's nothing I can do to change the past, so I make a new appointment, apologise and try better to remember it. Using a calendar/diary helps.
Can be distracting while I try to remember things, usually it's the more trivial things that bug me the most.
Annoys me and certain people around me.
hard to buy something if you've spaced your wallet. tough to take the call if you can't find the phone. have to make apologies when the meeting is missed.
Yes, but luckily I have Google at my finger tips most of my day. My wife gets *very* frustrated with me and it sometimes causes tension.
Sometimes it causes me to lose focus, but I am generally able to find a workaround.
Yes sometimes in case of deadlines, forgetting items on trips
Only if there isn't time to rectify the situation. Otherwise I feel bad because it upsets my wife, so I feel guilty.
sometimes, when i forget something really important to someone else

Yes, most often when I am forgetful it will impact try schedule as now I have to shuffle thing to fit what was forgot in.
Yes. Deadlines are not kept.
If I have forgotten to do something important, it can have a knock on effect, as I then have to drop what i'm doing and go back to doing the forgotten task. This can sometimes delay delivery of a different project.
There may be a loss of confidence if I dwell on it.
Only if its something important that I need to do / bring
No.
Maybe not the rest of the day but it will stay on my mind until I've worked out what it was. Either by remembering (if it was train of thought / doing something) or by searching online for the piece of information I'd forgotten
Not really. I try to mitigate with tools like lists, routines, etc...
forget things and have to go back and get them, late for appointments I forget.
Missed meetings can have repercussions.
The people around me usually expect me to forget and remind me if it's essential. The effect is usually that I have more work to do than I thought.
Not really
it affects nearly everything. the biggest impact, i think, is that i have a problem learning how to correct mistakes. I might come to a conclusion that would be helpful next time, but i don't retain it. :(
Not usually but yes if I have forgotten something like an important appointment
I sometimes forget my lunch and snacks, which disrupts my workday as I have to go out to buy stuff. I sometimes forget minor tasks coworkers have asked me to do, leading to a rush and stress when they remind me last minute.
Yes, I get behind in daily tasks easily.
It make me feel stupid or uncaring. It can take a few hours to recover from that feeling.
Its frustrating but thats about it.
Not usually. I rarely forget the "big" things.
Sometimes it means redoing things, or wasting time because I'm doing the wrong thing.
No it doesn't. When I forget, it's simply a "damn" and then I carry on with my day.
No it doesn't, it just makes me wish I could develop a way of not forgetting things to begin with.
Not really, I usually work around it, but it would be a disaster if the thing I'd forgotten was my iPhone.
yes, feel guilty. need to apologise. makes me late, makes me look stupid or disinterested
I spend a sidisproportionate time trying to find the thing rather than doing without I am very dissatified that the thing is missing, yet don't feel proportioately elated when it finally reappears
Not really. Sometimes I get a late start if I can't find my glasses.
yes, by not having something I need at the right time or by confusing the time for an appointment.
No, I move on pretty quickly.
Sometimes, depends on what I'm supposed to do or items I need.
yeah, I'll probably end up sleeping on the sofa!
just annoying tbh
Again, it's context dependant. If I forget my swimming kit I can't swim. An important forget will ruin my day as I'll feel guilty, and will take action to make amends. If I forget my keys I'll be slightly worried all day that I won't be able to get in my house later.
Not really.
Yes, even now I've just remembered that I've forgotten to pay the plumber.
Sometimes

If I forget something for my baby for example then it may result in needing to return home prematurely which is frustrating.

Usually just a niggling frustration and dealing with how consequences affect others.

It's embarrassing.

Being late leading to being embrassed that I'm late. I have two young children so if I forget my daughters waterbottle/reading book etc she gets upset and I feel like a bad mum. Usually last to leave as I have to find the things I have put down around other people's houses which makes me look like a fool.

no

If it's a name I spend most of the day trying to recall it or if it's a place name I look on a map. It annoys me until I find/recall it. I don't think I have ever forgotten an appointment. I have been known to go out without my glasses but it's more that I think they are in my bag and then they are not!

yes I get lost a lot

It depends. If I'm reminded of the thing I forgot I usually pick up the thread quickly. I seem to lose the index to the memory, not the memory itself.

Not so much - generally I work around any forgetfulness.

When travelling, I sometimes forget to pack an important item which I don't realise until I am at my destination and cannot return to collect it.

I usually remember what I forgot, but if I can't remember it annoys me.

Not much.

It depends what was forgotten really. If I can manage without it, I get over it within the hour or so.

For me, I'm just annoyed that I *should've* remembered. This feeling probably lasts for a couple of hours.

It does not really impact it, except the thing I need is very important and I forget it.

makes ne stressed

sometimes, it largely depends on what I have going on that day; deadlines, appointments, etc...

Sometimes it makes me feel like I need to prove myself when in a work/academic situation, for the rest of the day (if I forget what I am talking about or forget something when asked in a meeting)

No. I go shopping to get the item I need and get over it. If I left my lunch in the microwave I later realise I'm hungry and "Oh yeah, I have food in there!" I just reheat it and go on about my day. I'm too used to it to let it bother me for too long.

n/a

Yes, my thoughts come back to the thing I forget over and over again. It makes focusing very hard and I can't really put 100% energy to anything else.

Appendix E: Survey of Needs

All unedited responses to: Do you have any systems in place to help you remember? i.e Post-It Notes or things you do to help you remember?

87 responses

no (3)

No (2)

No. (2)

Yes, i leave things in predictable places where I'll see them, or automatically have them (in bag for example) (2)

yes, I use a GTD system on my phone

Notes in iPhone Lists on scraps of paper At work a post it to remind of anything in the fridge!

Reminders on iphone, also calendar reminders. Notepads at work.

I use google tasks a lot and/or calendar reminders.

Google Tasks

writing a lot of notes, leaving post it notes, reminders on my computer

Yes- memo app on iPhone.

(1) Say to myself just before leaving home, while at the same time touching the places where the items shld be (to make sure they're there): "Phone...wallet..tissue...keys..." (2) Reminders app on my iPhone

I'm a visual person, so if I need to remember something I put it somewhere where I'll see it. Another strategy is to put things where I will have to deal with them. I.e. I sometimes put the rubbish in front of the front door so the next time I leave I need to deal with it on my way out.

Try to leave keys and items above in the same place... Have key hook at home

I use Onnifocus & reminders on the iPhone to remind myself of tasks that need to be done but I'm not consistent enough with the regular reviews to completely rely on it and keep falling off the wagon. Find my phone is useful for finding the phone but just wish I had a similar solution for my keys & wallet.

I keep a very brief daily journal of topics I worked on, or discussed. The brief entries in the daily journal point me to project notes in a separate journal. Its all digital and synced via evernote, so its always available if I have my phone with me.

The thing that gets me every time I leave the house is remembering that I've locked the door and sometimes I've had to go back like 5 times to check its locked! I think because it's such a non conscious mundane task I do everyday I don't trust myself that I've done it. I've never not locked the door or forgotten to turn the oven off but still check check and double check

A large amount of post-it-notes usually helps, stuck to monitors and on books.

Try to leave items in bowl in hallway

I try to use calendars/diaries to keep track of appointments. I try to use notes apps to keep track of lists (like shopping) and things to do.

A few iPhone apps eg calendar, password app, lists

I try to use reminders on my phone, but doesn't really work, as they always seems to something a little more important to do at the time.

Leave purse and diaper bag in same location, write lists for myself at my desk

same place to put keys, wallet and phone when not on me

To do apps.

I generally keep everything in my coat pockets or purse. To keep up with my schedule, I use Google Calendar and phone reminders.

Used to leave my keys and wallet ALWAYS on my desk after a day, but now just leave them in my coat

I always put my keys, phone and wallet in the same pockets in my coat.

add it to smartphone agenda write it in the note pad

More of a routine.

Always carry certain things in certain pockets of trousers and others in certain pockets of my coat.

Pat my pockets when starting a journey

I use my phone calendar with alerts to remind me of things I need to do/ appointments. If I have several chores to do in a day I write them down in a list, ether on paper or on my phone.

My important things are always kept in specific jacket and trouser pockets

I leave everything in my jeans or my coat. Always in the same pockets. To try and remember things to do, I tend to use post-it notes.

Post it

Always put things in the same place

sometimes set alarm

I keep everything in a specific place and have a routine before I leave the house to ensure that I don't forget something important.

Use Lotus Notes to give reminders about meetings.

I ask my wife :)

Same place for keys, phone each night Same pocket for both during day Something unusual I might forget, I will hang a note on my door over the doorknob

nothing heavy. i didnt try memory palace. i use workflowy as a todo system which also tracks things to remember. i will almost always forget anything i dont write down

I use my google calender on my phone and laptop for important events

Keys, wallets and phone go into my pants pockets every night, so that they will be with me when I get dressed in the morning. Tasks are assigned reminder alerts in my Outlook calendar, so that they pop up to notify me several hours before the task is due.

No, I just assume I won't forget it again, until I do.

Unconsciously, my phone, keys and wallet are always in the same place. I write notes on a pad on my desk to emphasise things I need to do.

I leave things in my bag so i remember to take them.

I have a travel list on my iPhone for when I work away.

I sometimes leave things I need to take tomorrow by the door.

Everything I take out with me I leave in my bag, I will use it I'm the evening and then put it all back in my bag before going to sleep. I do a general check at the door, like the wallet, phone and keys etc.

I often use a To-Do list to remember little jobs I need to do, though I never have a problem taking items with me.

I use the 'Errands' app on iPhone

keys by the door. Calendar on phone,iPad and work synced. notes on the floor by the front door

yes

Phones and my wallet have a desk they live on. I use grocery lists for shopping.

linking things with actions

I put each item I need to carry with me (keys (car and house), wallet and phone) into separate pockets then tap each pocket to check for bulk before leaving the house. I also write notes on my hand a lot.

Nope.
wallet and keys are always in my jacket, phone in my pocket glasses are on my face. at night, all these thing are on my bedside table
nope
I leave things in my bag. I repeat the "phone, wallet, keys" mantra on leaving my house. Sometimes I'll leave a hand written note to self (rare).
I use the reminders app on iOS.
Yes. Leave it out. Put it away and it's gone forever. I even wish my fridge had a glass door.
Will leave some items in bag permenently like purse and sunglasses as I never need these whilst in the house. I will sometimes pack back night before so I have more time to remember anything I've forgotten. Will leave items in plain sight in the hope I don't miss them.
Usually just leaving things in places where I know I'll notice and force me to remember why I left it there.
Post it notes for the win. I use scrum specifically. I do the "wallet, keys, cellphone" ritual. I use an app to help me remember where I parked my car.
Mental check list before leaving the house. The kids remove post it notes or they fall off after a while!
Yes - most of it is left in my handbag Appointment etc. on calendar I always have a shopping list but have sometimes left this at home!
notes reminders, lists tonnes of lists
I sometimes use the reminders app on my phone to remember things.
Keeping things in the same place, using reminders on my iPhone.
Google calendar Google keep
I put everything into one spot, so I'm not as likely to forget something
Basket for my pocket stuff at home, drawer at office. Keep wallet in right front and keys in left front pocket.
My reminders list in my phone.
Reminders on the phone
I put everything in Google Calendar.
I have a diary. And I I have post its inside to make lists. I also have lists on my phone.
To do list, calendar on my phone, post it notes, alarms on my phone, leaving items where I can see them, always wearing my ID card or putting it straight in my bag when I take it off
I place the same four items in the same four pockets
I keep my wallet on top of my bag so I have to physically put in inside my bag before leaving. And I keep my keys hanging on the doorslide so I have to physically touch them when opening the door. (I still forget them sometimes...)

Appendix F: Software and Flowchart

Software: Arduino version 1.0.5 is used to write and upload the code to the boards. Needed are; the main IDE and FTDI drivers; as well as libraries <SoftwareSerial.h> for when the ID-12 RFID reader was used <Wire.h>, <EEPROM.h>, <avr/pgmspace.h> and <data.h>. Additionally, I needed the Teensy app when coding with the much smaller Teensy board, and at points I used Sublime Text app for coding Arduino as the interface is friendlier and with a Stino plugin it has all the Arduino menus to choose the port, monitor, boards etc. the same as with Arduino software.

Pseudo code for both devices > if the device is turned on:

```
1 Read data stored in Electrically Erasable Programmable Read-Only Memory
(EEPROM)

2 Any saved data? (scanned items / tags)

       YES? >
              light the corresponding LED(s), goto 3
       NO? >

              3 Wait for a tag to be scanned

                     Tag present? NO > LOOP 3 until tag presented

                     Tag presented YES>

                                   Read tag ID

                                          Is it recognized?

                                          YES >
                                             Save data: tag scanned
                                             Turn off LED if on
                                             Turn on LED if off
                                   Sound piezo
                                   Vibration motor activated

                                          NO >
                                             goto 3

              4 Are all tags scanned?

                     Yes >
                            Execute sequence of all tags scanned
                     No >
                            Wait for tag to be scanned, goto 5

       5 LOOP: wait for a tag to be scanned (goto 3)
```

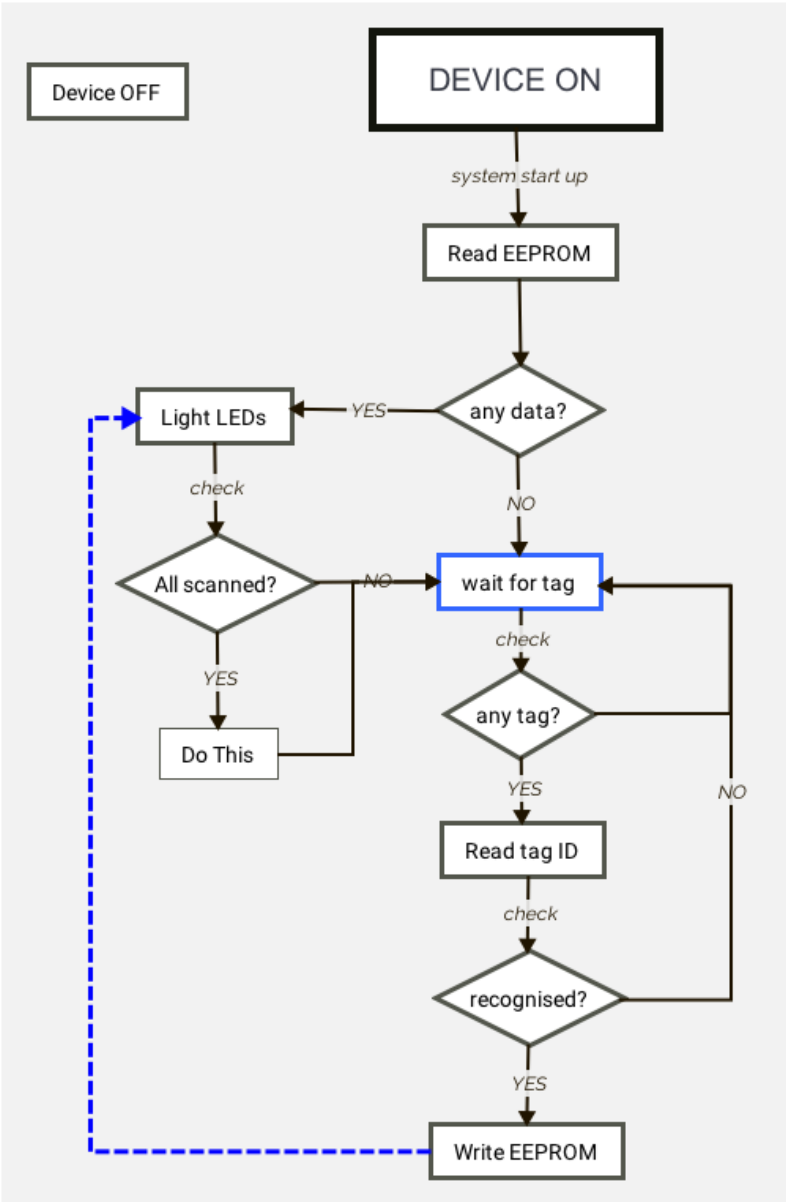


Figure Appendix F-0.1 Flowchart of the system.

Appendix G: Proof of Concept

Materials and Build reference for the Proof of Concept prototype

This is a guide to the Proof of Concept bag as it was implemented. This prototype is an initial rudimentary system consisting of 5 flashing LEDs on the rear of the bag. Beside those LEDs is a blank paper card label area. This is where a user can write with a pen or pencil, what object each light represents. Before they use the bag, they choose items and they 'tag' each item with individual **RFID tags**. These tags interact with the RFID reader system embedded in the bag, which also activates lights. The lights on the back exterior of the bag enable a user to see that the item tagged was packed (or not packed) even from across the room, using bright LEDs.

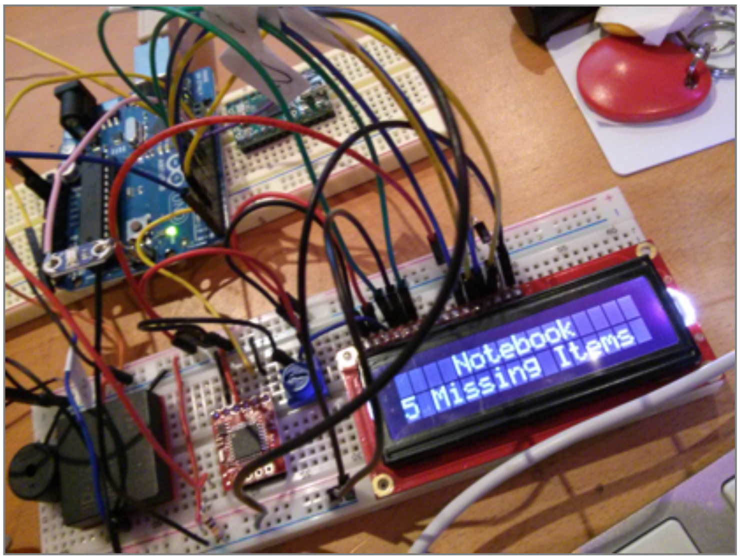


Figure Appendix G.0.1 Prototyping with Arduino and an LCD screen, components on a breadboard for programming and initial testing of code and how / if the RFID system works.

The materials list consists of the following hardware components which were chosen for several reasons including their size, availability, cost and 'off-the-shelf' nature.

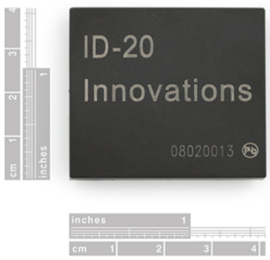
List of Components
Arduino Uno
ID-12 RFID Reader & 125 kHz tags
Breakout Board for RFID reader
Piezo / speaker
Through hole LEDs
LCD Screen
Wires / Resistors / potentiometer

Breadboard for initial testing the system, shown in Figure 5-5
Power source

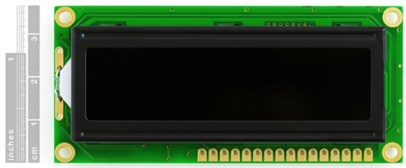
Arduino Uno

The Arduino Uno[23] is a microcontroller board that was chosen for its adaptability, low cost and availability. It has enough input/output (I/O) ports to be able to adapt and change requirements as needed. The board has both a digital and analogue system as needed, with ports appropriate to both. Technical details regarding clock speeds, processors and pin capabilities can be found online.

(a)



(b)



(c)

Figure Appendix G-0.2 Arduino Uno board (a)
Figure Appendix G -0.3 RFID reader used in the system ID-20 (b)
Figure Appendix G -0.4 LCD Screen. Note these are not shown to relative scale (c)

RFID Reader, Breakout board, and tags

The RFID reader used in this system is the ID-20[24] shown in Figure Appendix B-2(a) which is short range. (Note at the time of writing this board has since been discontinued and replaced by an ID-20LA which has a lower voltage input.) One negative issue with this reader is that it needs to be disconnected from the Arduino board to program it, as both the Arduino and RFID reader use the same data line. The ID-20 has an internal antenna which is better for a system that people would carry with them. If there was an external antenna it might be knocked or damaged. The reading distance of the tags is determined by the gain of the antenna. In this scenario, the size of the tag antenna alters this scanning distance. The larger card style tags (9cm x 6cm) which have a larger antenna inside are activated from the furthest distance away (~ 10cm) and the smaller tags, a button style (1.5cm diameter) for example to glue on to the bottom of a lipstick or sew into clothes have a very short distance where the tag must almost be placed directly on top of the reader to activate the system. Tags have a fundamental role in

[23] Arduino board image in Figure Appendix G-2. Retrieved May 2016 from http://sparkfun.com
[24] ID-20 RFID image. Retrieved May 2016 from http://sparkfun.com

the system; providing the capability to store a series of digits to which the RFID reader can decode and send to the Arduino. The tags used for this prototype are 125 kHz frequency and do not store any other information and have no additional memory. Because the tag is an essential part of the complete system, it must be large enough to ensure that the does not cause delays in the system, which could be frustrating for a user. Selecting an ideal tag size to ensure that this is not the weakest link in the system, is essential, described by Foster, "To overcome this, the ideal tag should be small in size, inexpensive, mechanically durable, should provide long operation range and should be possible to be attached into various objects, without any significant effects on its performance." (Foster & Burberry, 1999) It is this observation that determined which tags would be ideal to test, taking into consideration the types of personal items the user would want to tag.

When users were asked about their essential items for their day (described in Section 4.1) typical items that surfaced were keys, phones, wallets and so on. Lastly to mention, the ID-20 RFID reader has a pin spacing that make it difficult to directly map into an Arduino system, and so an additional *breakout board* is needed to correct the pin spacing to use the reader with a breadboard to program it through the Arduino system.

LCD Screen

The LCD Screen[25] used for this prototype is 16x2 character with LED blue backlight with white text. It uses a parallel interface and uses 11 pins to the Arduino board to operate.

LEDs & Piezo

I decided to use LEDs for the system due to their high-brightness, long life expectancy, high tolerance to humidity, low power consumption and minimal heat generation. Equally concerning was the aesthetic value it offered. One colour is used in this system, pink flashing 3mm LEDs. Implementing a piezo element to the bag enables audio feedback. When an item is successfully scanned, there is a 'beep' sound to accompany it. The lights, sounds and vibrations are a way of continually informing the user of items being scanned successfully, and whether it is in or out of the bag. Immediate feedback is a critical usability consideration, providing results from actions (Norman, 1988).

[25] Similar LCD is shown in Figure 5-9. Retrieved May 2016 from http://proto-pic.com

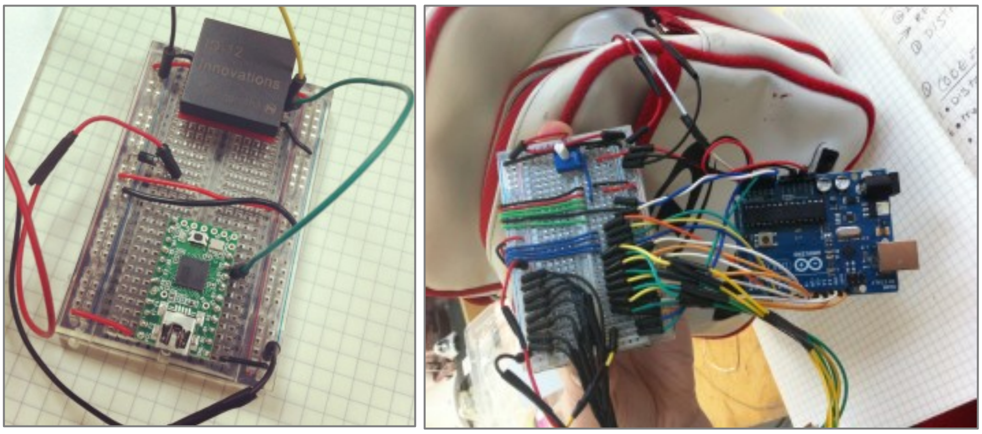


Figure Appendix G-0.5 Initial explorations with an RFID reader, ID-20.

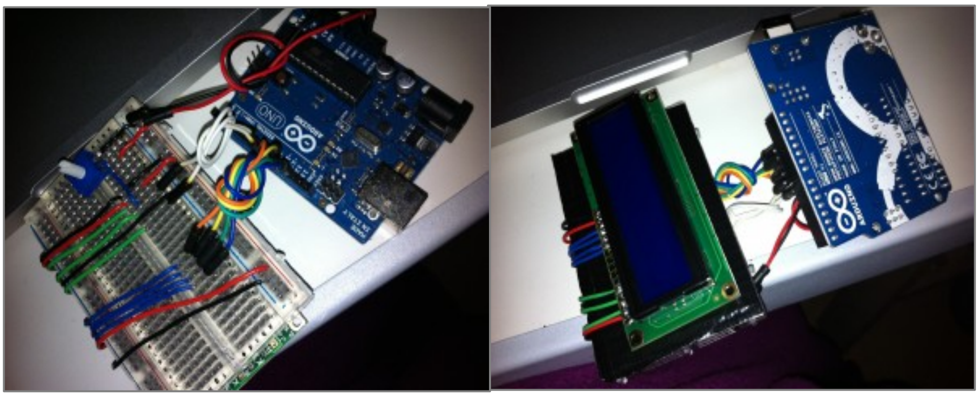


Figure Appendix G-0.6 Hooking up the LCD screen for embedding in the bag.

Various Hardware

The generic hardware for the performance and operation of the device includes; resistors, 10K potentiometer, jumper wires, breadboard and a 9V power source battery. This is the initial prototyping with temporary jumper wires to establish a working system. This is needed to be done before embedding it into a bag as errors are easier to find and fix. The ID-20 RFID reader at the top and a smaller microcontroller board is the Teensey (not described here as it was used to check the workings of the RFID only and not used for the system). The image on the right side shows the system ready to be placed inside the bag and the jumper wires and Arduino Uno board can be seen. On the underside is the LCD screen.

Software

The functionality of the RFID interaction System, is programmed with Arduino version 1.0.5 and then uploaded to the Arduino circuit board.

Appendix H: Message Bag 1.0

Materials and Build reference for Message Bag 1.0 prototype (MB1)

This Messenger Bag prototype is a modified Crumpler brand bag MB1. This bag was chosen for its styling, size, pockets, durability and materials. This styling was decided after comments for the previous version noted that the device occupied a large amount of space in the bag. A larger bag would be needed to accommodate both the system and the users' items. There was a need to design the device appropriate to the bag being used. The optimum configuration chosen for this bag would need to accommodate an embedded RFID system with 10 LEDs; 5 to be used for item memos / tasks and 5 for objects that are tagged. From the materials and components researched appropriate hardware changes were made.

Materials list for the design and development of Messenger Bag 1.0 are:

- Lilypad (ATMega328) Main Board (sewable)
- Mifare SLO18 RFID Reader & 13.56 MHz tags
- Sewable Piezo
- Sewable LEDs
- Charging unit
- Wires / Conductive Thread / Resistors / breadboard / power source

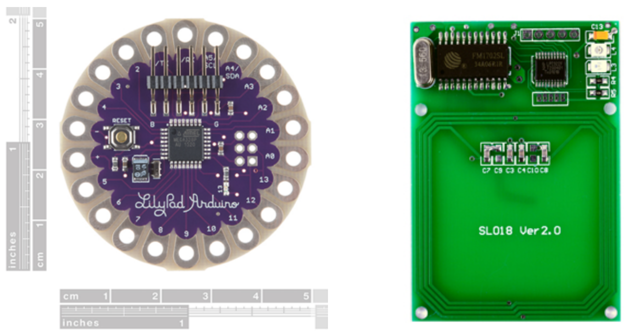


Figure Appendix H-0.1 Lilypad Main Board (left) and SLO18 RFID reader (right).

Lilypad (ATMega328) Main Board This system uses a Lilypad[26] circuit board designed specifically to be sewn. It is a similar board to the Arduino and is programmed with the same Arduino software. The Lilypad has more I/O ports than other Lilypad boards, these ports are needed for LEDs, piezo and RFID reader connection.

The board operates at 5v so for ease of system creation, the RFID reader ideally should also be 5v operation. Lilypad Main Board is a good match for this version because it can be placed anywhere on the bag, it is robust enough to withstand weather conditions such as rain and is more discreet than a typical circuit board. Additionally, it is very lightweight; it will

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26 Lilypad circuit board shown in Figure Appendix H-1. Retrieved July 2016 from http://sparkfun.com

not add a noticeable amount of extra weight to the bag. This weight issue is serious as it was highlighted from prior testing; too much weight could be a factor preventing people from using it.

RFID SLO18

The SLO18 is a thin RFID circuit board that is appropriate for use in a bag because it doesn't add much bulk to the overall system. It integrates all necessary components and antenna in one PCB: an important design decision for the system, as an external antenna would not be as sturdy and could be easily broken through everyday use. The SLO18 is a reader / writer board that can be used for contactless communication needed for this system (as described in Chapter 3 Design Concept). The SLO18 has corner holes which make it easy to sew into the top flap interior of the bag. The inside flap of the bag was opened by unstitching the bag and this was sewn inside. The two top flap pieces were then sewn back together again so it was a hidden, discreet object.

The reader uses a variation on Mifare standard tags with a frequency of 13.56MHz, the Ultralight, or 1K tag, 1K referring to its memory size. This reader operates at 5V which makes it compatible with the Lilypad circuit board selected. The tags provided are for the user to choose what items they want to track. These are RFID passive tags of MIFARE 1K specification that have no power requirements and can store a number (a 12-byte unique id) that is used for identification. These tags have additional capabilities as they can store up to 1K of information on non-volatile memory. Although this is also useful for NFC devices to read them, in this instance we are only needing the number to identify the corresponding item that will activate a light. Each tag is assigned to one LED colour and will always activate that same colour light. In this case, there was no need to use a 13.56MHz frequency in place of the 125-kHz system used previously other than this RFID reader reads only those tags. It does also provide an option to modify the device if needed in the future with an NFC system that can also read these tags.

Sewable Lilypad Buzzer & LEDs: This is a small buzzer that uses 2 I/O pins on the Lilypad main board which can create different basic sounds. The buzzer is loud enough to be heard inside a pocket but not obtrusively noisy. This is sewable, which fits in well with this system design, again reducing weight and bulk compared to the previous design. The LEDs are sewable to also fit with this system and are a variety of colours that do not flash, as this was a cause for confusion. Sewable items are sewn with conductive thread to enable communication with the processing board.

Charging Unit & Battery: The *proof of concept* prototype did not have charging capabilities and relied on batteries (a square 9V) being changed when it was no longer usable. The charging unit was added when feedback for the previous system established that charging would be preferred to change and buy batteries when they wear down. The charging unit requires a USB mini cable to charge the battery. Due to a charging unit being added, the 9V battery was changed. This system uses a Lithium Polymer rechargeable battery which addresses the desire for charging in preference over swapping batteries. A positive side effect to that is the battery also has a much slimmer form, so the weight was reduced when compared with the 9V battery.

Note: this battery change was implemented, then a wiring issue resulted in component breakage, so battery and recharge module were replaced with a 4xAA plastic case that had its own on/off switch.

Wires: Single core wire was used in the first system, and it was a good option for a device that was partially housed on a breadboard. The single core is a stable wire to bend and hold its shape and pushes easily into the breadboard because it is so stiff. However, the components of the Messenger Bag device has its main device components placed both on the outside of the bag and along the inside against the material. Because of this, using single core wire makes the bag too stiff and wires could be prone to breaking and snapping with repeated use. Replacing the wires with multicore wire of a similar gauge means the wire is a lot more pliable and better suited for this use, as it is less prone to breaking under strain or movement. There is also conductive thread used to sew electronic components.

Appendix I: Upcycled Handbags

Materials and Build reference for Upcycled Handbags prototype

There *were 3 styles made* (to be able to have enough devices for testers in the study) and they all use: a Lilypad USB; Sewable Vibration Motor; Lithium Polymer 3.7V Battery, 1000mAh; and various materials for crafting.

Lilypad USB

This is very similar to the previous Lilypad board listed, however this one has less input/output ports and the large programming connector on the surface of the board is removed. It is programmable through USB, meaning that my earlier complaint about the processor unit snagging on clothing can now be rectified. This board also operates with a lower voltage running at 3.3V so the RFID board was swapped with a lower voltage module.

Besides the styling modification, there is also a reduction in the number and use of the LEDs. Message Bag 1.0 originally presented with a 10-light system, where comments and questions surfaced whether a user could then remember what all the lights were for. This seemed counter intuitive to a system that is easy to use and requires no additional cognitive load or learning a new system to operate. Scaling down the number of lights was the resolution so there are 5 lights on this system. Additionally, the lights on the previous system were deployed as half for physical items and half for general task-based reminders. This has also been changed, as mixing up different systems seemed to introduce questions about how to remember which colour is for which? The lights now correspond to physical items only, which all receive their own tag. Additional to that, there is other feedback alongside the sound of the piezo; a vibration motor provides haptic feedback and confirms the scans success, so it has been added. This is particularly useful in situations when it is noisy.

The form and weight of this system is a lot smaller and lighter than the previous design. A further modification is presented in the next section; it is a unisex version that is larger. That unisex smart device and the 1950’s styled bags will be tested in-the-wild with participants.

Appendix J

Letter given to participants for the single user walk outs, Chapter 7.

Hello!

Thank you for your participation.

Your tester number is:
Please use it whenever you are filling in a questionnaire.

You have been sent **3 devices**.
Each device should be tested for a period of at least 5 days and up to 10 working days if possible, according to your schedule and daily activities.

Use the devices **in the order numbered** on them.
For example, Device One, use that device for 5-10 days and fill in the daily questionnaires for that device. Then when you have used it for the amount of time that works with your schedule, take Device Two and then repeat, repeat again with Device Three.

After using a device for the 5-10 days, please fill in the form included.

When the testing has finished, please mail them back in the packaging provided using the postage and return label included.

Any questions might be answered on the site http://messagebag.christinefarion.com/current-testers/

Appendix K

AFTER DEVICE USE QUESTIONNAIRE
Place an X in the square near to the word you believe is a more accurate description from your experiences in using the device.

Tester Number:
Which device was it? (please circle one)
Standalone Device : LED only : Integrated Message Bag
Device Number: **1 : 2 : 3**

Annoying						Pleasing
Easy to use						Difficult to use
Attractive						Unattractive
Helpful						Unhelpful
Hi Tech						Lo-Tech
Robust						Fragile
Inefficient						Efficient
Useful						Not useful
Modern						Dated
Useful						Useless
I forgot less						I forgot more
Confident using						Unsure how to use
Worried about forgetting						Not worried about forgetting
More likely to remember						More likely to forget
Confidence in the device						No confidence in the device
Would not use						Would use again
Would tell others						Would not recommend
More instructions needed						No instruction needed to use
Would like to use it more						Didn’t want to use it

Appendix L

Consent information and questionnaire to recruit participants.

Message Bag, participants wanted.

We are looking to test 3 devices. Each device would have a 2 week use period where you would report as and when you used the device. This is a short survey that will take around 5 minutes and can be done online or on paper.

* Required

Consent Information

You are invited to participate in our study for Message Bag. It will take under 5 minutes to complete the questionnaire.

Your participation in this study is completely voluntary. There are no foreseeable risks associated with this project. However, if you feel uncomfortable answering any questions, you can withdraw from the survey at any point. It is very important for us to learn your opinions.

Your survey responses will be strictly confidential and data from this research will be reported only in the aggregate. Your information will be coded and will remain confidential. If you have questions at any time about the survey or the procedures, you may contact Christine Farion at QMUL (Queen Mary University of London) by email at the email address below.

Confidentiality, anonymity, and data storage: All recordings will be destroyed within 7 years, unless material acquired is acknowledged to have value and potential for subsequent analysis to enable further publication of findings. Survey questionnaires will be stored for 7 years, and everything will be anonymised. The data used in papers or for further research will not have any identities associated with it, it is only your responses that we are interested. All identities' will be anonymised in any subsequent publications. During the analysis period, only the principal investigator, supervisors and the supporting institutions will have access to the data. All non-digital data gathered as a part of the study (consent forms, data obtained through informal conversation and written observation notes) will be stored in secure location in the University. All digital data (video-recordings and photographs) will be stored in encrypted files on password protected digital format on a computer located in the University and one of the investigators' laptops. Digital and non-digital data resulting from the study will only be used as:
• A part of this research study will appear in presentations and publications relating to this research.

Contact: christine.farion@qmul.ac.uk

Thank you.

1. **Continue** *
   Check all that apply.
   - [ ] Yes

Skip to question 2.

Questionnaire

These are questions that are about the logistics if you are selected to be a tester. If you can not meet these criteria or are not comfortable with any of these questions then thank you for your time and I hope you may help us in the future!

2. **Do you use a bag / backpack / carrier / purse etc? If so, how often?**
Mark only one oval.

- more than two times a day
- once or twice a day
- a few times a week
- once a week
- less
- I don't use a bag / carrier

3. **Will you be able to reply to a short questionnaire daily about your experiences?**
Mark only one oval.

- Yes
- No

4. **Do you have access to the internet to be able to post your responses online?**
(A questionnaire could be printed out for the daily responses if preferred.)
Mark only one oval.

- Yes
- No
- Paper based is preferred.

5. **Would you be able to do a short (10-15 minute) verbal interview after the study is complete about your experiences throughout the study?**
Mark only one oval.

- Yes
- No

Forgetfulness

6. **Have you been diagnosed with a medical condition relating to memory in any way or have any medical memory issues that you are aware of?**
Mark only one oval.

- Yes
- No

7. **How forgetful do you think you are?**
Mark only one oval.

	1	2	3	4	5	6	7	8	9	
Not very forgetful										Extremely forgetful

8. **How often do you think you forget things?**
Mark only one oval.

- several times a day
- at least once a day
- a few times a week
- about once a week
- a few times a month
- around once a month

9. **How often do you experience negative feelings e.g. stress or panic when forgetfulness happens?**
Mark only one oval.

	1	2	3	4	5	6	7	8	9	
rarely										every time I forget

10. **How negative an 'experience' is it when you forget?**
This is in terms of location / consequences / situation aspects of forgetting.
Mark only one oval.

	1	2	3	4	5	6	7	8	9	
not very										extremely

11. **How bad does forgetting things make you feel?**
Mark only one oval.

	1	2	3	4	5	6	7	8	9	
not bad at all / I don't mind										extremely bad

12. **Please describe how you feel when you forget things.**
Any words or sentences that come to mind when you have forgotten?

....

....

....

....

....

13. **What current strategies do you use to remember things now?**
    do you write lists? post-it notes? place things in locations? etc

Participants

14. **Which items are the most important to be put in your bag for your daily routine?**
    Please list at least 5, in order of importance to your day / successful function of your day / journey

15. **Please provide your email address so we can contact you about participating in the study.**
    If you are selected then we will need to get in contact with you.

16. **Can this email address also be used to send you a reminder / link to a short questionnaire?**
    Note, this will only be used for the duration and purpose of this study and will be removed afterwards.
    Mark only one oval.

    - Yes
    - No

17. **Could you provide a mobile phone number so a text reminder can be sent daily for the questionnaire? (If you are selected and agree to being a participant)**
    Leave blank if you would prefer to not receive a text reminder.

Appendix M

All responses to “how bad does forgetting make you feel”

Please describe how you feel when you forget things.
Depending on what it is, it can make me feel stressed or unhappy. The act of wondering whether I've forgotten or lost the item can also be an issue.
Silly, disorganised, predictable
Usually bad though I learned to live with this. But if I forget things about something I promised to someone I feel really frustrated
No! No! No! Please, no! Stupid. Again. Do I have dementia/Alzheimer's disease?
Guilty, cross with myself, should have remembered.
Frustration, the fact that a little piece of information is inaccessible in my mind makes me upset at the limits of our biology, and therefore excited about potential ways technology can help augment memory. Running around the house trying to remember where x item is is such wasted time.
I think: I should have made better note of this (calendar, to-do list, etc.). How could I forget - as I've learned my lesson before!? (I disapprove of repeated "mistakes," and feel like: how could I have possibly forgotten?
Usually i forget to do things around the house like dishes and laundry. So that gives troubles with my partner. Also forgetting appointments makes me anxious. Because i have agorafobia i have to prepare before leaving the house. If i don't have the time to prepare i get anxiety attacks. (Hyperventilating and throwing up or loosing consciousness)
Irritated and frustrated but I've worked to get rid of this - mostly it's to do with guilt and feeling stupid, which I don't like and don't need to feel!
Sometimes I feel really stupid; sometimes I just tell myself it's ok or it's happened before and try to continue with my activities.
Guilty, stupid, insufficient, inattentive
Frustrated annoyed disappointed
Irritated that I didn't plan ahead or note something down.
Depends on what it I've forgotten but typically I'm annoyed at myself. I might worry that it will impact what I had planned for the day and need to rethink...or try to remember the details of whatever was in/on the thing I'd forgotten. It's rare that I would forget essentials like my keys, wallet or phone but things like my notepad, laptop charger, various cables, books etc - because they are often between a couple of bags. I most often forget headphones...and that irks me a lot!
"Damn!", "Oh nooooo!!", "How silly..."

I would usually forgot something when in a rush, so I would feel frustrated and annoyed with myself for then having to take more time out to return home and collect the item I forgot!
Generally just annoyed at myself for not remembering something
i wonder if i am losing my marbles so to speak (i suffer bouts of depression so when i forget stuff, i panic i am relapsing)
I often feel like I should have done better. Like I have let myself down by forgetting simple items that I am aware that I need on a daily basis.
I hate forgetting things, so have developed a lot of systems so my awful memory doesn't impact my life. However it still happens and I feel like an incompetent. Utterly embarrassing.
noen
Annoyed at myself and frustrated, anxious that by having forgotten the item something will go wrong or I will desperately be in need of the forgotten item.
It worries me when I forget things because I don't normally do it so I really dwell on it.
Mostly curse words
Mild annoyance because my day-to-day activities don't much require set things - at worst, I forget to take my lunch to work. All my keys and things are kept in my bag, so never forget them. I often forget things when I go shopping, and it is also an inconvenience, but I don't think too much into it - I generally have a laissez-faire attitude, and realise it is not the end of the world.
It depends on where I lost that thing. I mean, in a place which is far away--angry, not far away--don't care; could be found back--don't care, couldn't be fund back--shocked.
Silly, Can't believe I forgot!
Shocked at first, then relieved cause nothing could be changed then.
Shocked at first, then relieved cause nothing could be changed then.
Stupid, ineffective and lazy
Feel anxious and stressed.
Stupid, forgetful, incompetent .
I feel worthless, or I am losing my mind and getting old. I also fear it could be a sign of a brain tumour.
I feel frustrated with myself and at times I feel quite thick for forgetting a simple thing.

Appendix N

Transcription from participant in SU2.

This transcription did not include the pleasantries exchanged at the start of the interview nor the voiced confirmation that the interview was recorded and the participant has agreed to be recorded.

0:00 – 11:58 / 28 March 2016

0:41
C: So um is there anything in particular um that you had experience wise or that might stop you from using it or that was good like just generic stuff really?

0:51
E: ya ok, well the the the final device that you gave me, the flashing lights,

C: yup

I didn't think anything of that at all I didn't find that it, I don't know, I couldn't I quite missed the contact the purpose of it

C: ya

E: it was almost like I didn't quite get it if that makes any sense

C:mya

1:09
E: um
I didn't see that it was would jog my memory in any way and it, wheras the other devices although I did find them a bit manual, <pause>
the time that it took
<pause>
to scan all the items in would give me the extra few minutes to think ok, "what am I doing, I'm packing a bag, what do I need?"

C:ok

E: Whereas the flashing device didn't give me that

C: ya

So it was more the um the conscious effort that you are scanning that kinda made you think about it rather than it the lights necessarily or?

1:42
E: Yes, I, I think so, what I, I tend to find was the things that I was forgetting

C: ya

E: was the things that I allocated tags to things like my keys my phone my wallet those kind of things which which which are the ones I allocated the tags to because they're vital.

C: ya

E: I don't forget because I always need them

It was the things that I needed occasionally, or something specific that I would need certain activity or that kind of thing so I wouldn't scan it in anyway cause it would be additional to the things I was scanning

But the scanning in did prompt me to be more conscious of what im doing rather than just having a bag and chucking things in it it its prompted me to take a second to focus on what I was doing

C: Ok and did you find that decreased the longer you used it or stayed about the same or not really relevant?

2:38
E: probably decreased because a lot of the items that I allocated tags to often just stayed in my bag like my, my sunglasses or my keys or my, you know if I didn't need to take it out which often on an evening I wouldn't then it would just stay in there which is

Which is a little bit of a hindrance because when you come to scan fresh items some are already in there some of them weren't

So it became a little bit confusing in that regard – it wasn't awfully time consuming it wasn't anything that goodness I couldn't scan all these in it was very fluid in that sense

3:23
C: so if if it was a case of as you packed your bag normally and you didn't have to like actually hold it up to a scanner for example so say it was the rim of the bag was active and it would accept it, you wouldn't be thinking about it, but then, so would that make it better or worse in terms of youre not consciously scanning something but then youre not losing that time, like which is more valuable to you?

3:50
E: I I I see what you mean, I think with something like that, if it was, I wouldn't take in the time consciously in,

Yes it wouldn't stop me to think more about what I was doing but that would solve another issue in the sense um I was always conscious of the fact that I may have taken items out of my bag without scanning them out

C: Ok

E: um so if it was something with the scanning in or scanning out without me having to actually do it that would give me a little bit more confidence with what was actually in the bag to start with

C: So maybe the scanning out um as an automatic task and the scanning in as the more manual one

4:30
E: Ya yes if that was possible I guess I guess so that would alleviate both both issues

C: ok that makes sense, is there any other um did you find it, um so the one that was attached to the bag versus the one that was actually embedded in the bag was there any huge differences with that for you?

4:49
E: you mean between the one that was Tag Along and the one that was integrated?

C: ya ya

E: ya, the only main difference between the two um I found obviously the process is pretty much the same, Um the advantage of the tag along one, was I could use different bags. Which for me, um,

… (not audible) Sometimes you need bigger bags, sometimes, smaller bags, so that was a benefit of that, so I wasn't tied to one bag, which was definitely a benefit.

C: Right ok

5:20
C: and was there anything that could have been more useful to you, um in like for example, if there was a way to scan in those irregular items that you were more likely to forget or like was there anything in general that you thought might be a better system?

5:42
E: ya I mean I … (child issues)
E: I don't know how you go about it really but, if it was the night before and I knew either a long day, Ok well I know I need these ten items so in the morning when I check off the items that I need it just probably would need a little forward planning um but maybe … I would think about it the day before…

6.34
E: Maybe a device that I could know, tomorrow I would need these items on my list, it would specifically say what items, it would know what specific items, if I said these ten items, and I'd know if I had everything

C: ok that makes sense, and do you prefer packing the bags at night / morning /

6.58
E: If I know about everything if I remember then I will do it at night as such, if I do it in the morning, it tends to be when I really need my staple things, so you know, going to the shops so I only need a pair of keys and I dunno I'll just shove whatever I need in a bag, stuff when ever I need the bag then, but if I 'm planning the day out with (child) then it becomes, nappies, drink (ya) and god knows what because I manage to carry so much round – oh goodness

A tailor made device for a baby would be beneficial, because of those staples, nappies, bottles, it's really easy to forget those items I think people would benefit from that, I mean even just kind of coming out of that now coming to the age – the baby thing, it tends to fluctuate, but in the early days um I know I mean I need a baby changing bag because it has all the compartments and everything you need. So remembering what to pack in that bag would be kind of good.

C: comments on kids bags
Any final anything, charging or anything like that? Was it all…

8.41

E: um ya it was pretty self explanatory, I mean I didn't didn't have any issues, the only thing was the flashing light one, just because it kind of I couldn't quite like the others .. where this was just a reminder I suppose, that was the only time I got a bit stuck

9.03
C: well I mean that's kind of good, um it was basically we needed a way to have no technology, the lowest technology as possible just to see if it makes a difference to have some technology rather than none, and like you say it is very confusing, no ones been able to be like, well why would I turn on a light, like it doesn't make any sense really um, ya

E: Yay a absolutely I mean I tried it for a few days but ya I forget to even turn it on because it doesn't it just doesn't really help so that was the only one, the other devices were pretty good, um you know they're not a big and clumsy, especially the one that was integrated in the bag,

9.51
E: min you the other wasn't much bigger really once you've got it hooked on the bag, um I think I mentioned on a couple of my exit questionnaire, um there was, my phone for example, would register on the device, if I put it next to it and

If I swipe my bank card next to the device, would it scan?

But I mentioned it in there.

So it wouldn't register, when it was near the bank card, I don't know if it was that bank card or.. so ya

10.46
E: so if my phone moved to that side of the bag or it got pushed up against it, it would scan in and scan out itself, if I moved about during the day, not constantly but enough to think, is it in there or isn't it, so you wouldn't be sure.

C: ya
It would need to be very accurate if someone was worried about memory issues

E: Absolutely

C: ok perfect

11.14
C: thank you for your help… (discussion about returning the devices back etc)