Identifying the characteristics of usability that Encourage prolonged use of An Activity Monitor

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A thesis submitted to
Auckland University of Technology
in partial fulfillment of the requirements for the degree of
Master of Computer and Information Sciences (MCIS)

2016

School of Computer and Mathematical Sciences

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ABSTRACT

Together with the use of rapid prototyping techniques and efforts to reduce the production cost, wearable and mobile electronic devices brought to the market faster than ever, with less time spent on actual usability testing of these devices for prolonged use. Due to this, the usability lifespan of such electronic devices has reduced significantly where consumers might be moving or upgrading on to using newer electronic devices more often than they really need to. Therefore, this paper focuses on identifying key characteristics of usability that may encourage prolonged use of an activity-monitoring device. Secondary goal was to observe and record any user acceptance and/or usability issues that may arise from using an activity monitor over a prolonged period.

In this research, an intensive study was undertaken using ethnographic methods of enquiry to improve the rigor of the study. In general, ethnography rests upon participant observation, a methodology whereby the researcher spends considerable time observing and interacting with a social group. The researcher analyzed the face-to-face interviews' video recordings and collected field notes repeatedly according to the coding rules devised using open-coding methodology. Later on, the researcher formed a generic thematic analysis based schema to analyze the coded data.

In this thesis, the researcher has successfully conducted the research and identified six usability characteristics that played crucial role in encouraging prolonged use of an activity-monitoring device among adult users in New Zealand. These six identified characteristics of usability were display screen, lightweight, long battery life, multipurpose, social engagement and easy to carry/wear. In addition, this thesis covers the observed user acceptance and usability issues that may have arisen from using an activity monitor over a prolonged period.

Acknowledgement

This research has been the biggest academic effort that I have undertaken in my life so far. I could not complete this research successfully by myself, and hence I would like to acknowledge the help I received from some of the people during this process.

First and most importantly, I would like to convey my sincere thanks and gratitude to my supervisor Dr. Robert Wellington. He has been the best supervisor who not only gave me unconditional support but also guided me at times, when everything seemed to be impossible to achieve.

I would like to thank AUT's Ethics Committee (AUTEC) for approving my ethics application, reference number 14/252 dated 19 March 2015, which allowed me to carry out the research.

I would like to thank the academic staff and student's office at the AUT for all the help they provided me during my study.

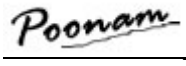
I would like to thank all the participants who contributed immensely in this study with their participation and invaluable feedback. This study would not have been possible without your kind and generous participation.

I would like to thank my parents for their continued support to make my dream of doing a Masters in New Zealand come true.

Last but not the least I would like to thank my loving husband, Pushkar Dhawale, for his continued support, care and affection, without which finishing the thesis would have seemed like climbing Mount Everest.

Attestation of Authorship

I, Poonam Pushkar Dhawale, hereby declare that this submission is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person (except where explicitly defined in the acknowledgements), nor material which to a substantial extent has been submitted for the award of any other degree or diploma of a university or other institution of higher learning.

Signed: 

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Date: 12 July 2016

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1. Introduction

1.1 Introduction

This research thesis outlines a thesis undertaken for 120 points as part of a two-year Master's degree majoring in Computer and Information Science. This research primarily focuses on identifying key characteristics of usability that may encourage prolonged use of activity-monitoring devices. The secondary focus of this research was to observe and note down the user acceptance and usability issues arising from prolonged use of such devices. I have used the smartphone and smart wearable devices as activity-monitoring devices for this thesis. An intensive study over a small group of adult users in New Zealand was undertaken, who used activity-monitoring devices over prolonged period. The researcher met the participants during this time and collected data that helped achieve the research objectives. This document discusses the entire procedure undertaken by the researcher to accomplish the research goal.

To begin, the research discusses "Wearable Activity-Monitoring Devices" to explain the background and inspiration for this study. Then a brief discussion on the formation of the research objectives and consequentially, proposed research question is stated. Then a brief discussion on the adopted data collection method is given. Then the limitations of the scope of this study are stated. Finally, this chapter concludes with an outline for the entire thesis.

1.2 Wearable Activity-Monitoring Devices

In recent years, we have witnessed significant development in mobile and wearable devices. The user interaction with mobile and wearable devices is more intimate than any other electronic device. Due to such intimate nature of mobile devices and their increasing effectiveness, customers are choosing a device that not only satisfies their needs but also their senses (Didem & Ergün, 2014). Hence, the usability of mobile devices has become an important decision making factor for designers and developers during the mobile device development lifecycle. However, the popularity of rapid prototyping techniques has shortened the development lifecycle of mobile devices. Thus, increasing the risk of user acceptance issues arising from inadequate time spent on diagnosing the usability issues in mobile devices especially over a prolonged period.

As stated in (Ryu, 2005), the usability aspects of mobile devices significantly differs from that of software products. The mobile device's usability study depends on both hardware and software components along with emotional appeal and aesthetic integrity of the design. Hence, mobile and wearable devices are becoming a very interesting area of study among HCI communities. The evaluation of mobile devices poses many challenges in testing their usability without constraining users in unnatural ways of motion-limited laboratory settings. Wearable mobile devices can be used in a large variety of contexts (Lyons & Starner, 2001), that could influence the user interaction over a prolonged period. This makes understanding the usability factors of mobile devices over a prolonged period an interesting topic. Many research studies conducted focused on devising new ways of performing usability testing of wearable mobile devices (Alred et al., 2009; Lyons & Starner, 2001; Babu, 2011; Ryu, 2005; Didem & Ergün, 2014). However, most of these researches made lesser efforts to identify the characteristics of usability that encourage prolonged use of mobile devices such as activity-monitoring devices (AMDs).

In this research, a small number of NZ adult users were studied intensively using ethnographic methods of enquiry to improve the rigor of the study (Schensul, Schensul, & LeCompte, 1999; Jones, 2006). In general, Ethnography rests upon the participant observation, a methodology whereby the researcher spends considerable time observing and interacting with a social group (Herbert, 2000; Flick, 2006). The outcomes from this study may have implications on the methods used to improve the usability of mobile devices for prolonged use as AMDs.

1.3 Research Objectives

The primary focus of this research is to identify the characteristics of usability that may encourage the prolonged use of mobile and wearable devices. As outlined earlier, the existing research is inclined more towards devising new ways of performing usability testing of wearable devices. During literature review, the researcher observed the need for finding the usability factors that could encourage prolonged use of AMDs, thus formed three research objectives for this research.

Research Objective 1: Identify Usability Characteristics that encourage prolonged use of an activity monitor

The purpose of this research objective is to focus on the usability characteristics of the AMDs that may encourage or discourage the prolonged use of the device. The outcome would help to understand how important such usability factors are to the users to engage more with the AMDs. To understand what impact would such usability factors have on the user's lifestyle when used during performing physical activity.

Research Objective 2: Identify user acceptance issues arising from prolonged use of activity monitor devices

When used over a prolonged period, it is interesting to find out how well the AMD can blend into the user's lifestyle. Does it pose any issues while being used? Does the device help to improve the user's lifestyle with its adoption over a prolonged period? Hence, the

second research objective of this study is to identify user acceptance issues arising from prolonged use of AMDs.

Research Objective 3: Identify usability issues arising from prolonged use of activity monitor devices

The third and last objective of this study is to identify if there are any usability issues arising from prolonged use of AMDs. This includes the usability factors that are not helpful to users and discourage them from using the device over a prolonged period. In other words, our aim is to identify the usability issues related to the device that could restrict the use of AMD in certain situations such as during physical activities.

1.4 Research Question

After a thorough literature review, formation of the research objectives and the selection of Activity-Monitoring Devices (AMDs), a definitive research question would be as follows:

> *"What are the characteristics of usability that could encourage prolonged use of an activity-monitoring device?"*

The aim of this research question is to find answers at the end of the study and consequentially, to address research objectives outlined earlier including the usability issues and user acceptance issues adversely affecting prolonged use of AMDs.

1.5 Data Collection Method

In this study, the data collection done is through conversational face-to-face video-recorded interviews with the participants. Such an approach helped the researcher to guide the interview discussions as the research was for a Master's thesis that posed constraints on time. This allowed the researcher to maintain the research relatively focused on the topic.

At the same time, the interviews designed were open-ended and free flowing to allow the participants to comfortably report on their user experience with the AMDs. In addition to this, the researcher took field notes during these interview sessions and casual meetings to capture the participant's expressions and important moments of them using the device. This rich collection of data was then analysed using a generic thematic analysis in order to draw meaningful findings from the data analysis to help answer the research question.

1.6 Limitations of the Scope

This study addresses the question on how improved AMDs could further support users to continue to engage with them. However, the restrictive time constraints were main factors limiting the scope of this study. The research carried out was on a smaller group available from the general population of AUT students. The data collected from this group and generic thematic analysis done in ethnographic styles of research was sufficient to draw meaningful conclusion from the study. The need to search for candidates to participate in the study, conduct the research, analyse data and draw conclusion from the findings within a short span of one year has restricted the scope of this study to smaller group of participants. With this in kind consideration, the thesis findings were satisfactorily meeting the time constraints and the research objectives outlined earlier.

1.7 Outline of the Thesis

This document presents the research done, from the initiation of the idea, until the results were drawn and reported. The summary of this research thesis is as below.

This research thesis has begun with the introduction to the research topic, research objectives and research question posed by this research in the *Introduction Chapter*. Then an in-depth view of the research / literature studied for this research and its shortcoming for the research objectives are in the *Literature Review Chapter*. Following this is a chapter on *Research Methods* that discusses on the research methodology and the research methods used in the study.

Then the chapter on *Data Collection and Analysis* gives an in-depth discussion on the data collection procedures and data analysis techniques used in the study. This followed by a chapter on *Findings and Discussion* to draw conclusions from the data collected. Then the research thesis concludes with overall summary of research and conclusion drawn from the study in the *Conclusion chapter*.

1.8 Chapter Summary

This chapter gives an overview of the research background, the research topic, research objectives and research question. It has also briefly touched upon the research methodology, data collection and analysis techniques adopted for this study. This chapter concluded with an outline of the entire research thesis. The next chapter discusses the literature review conducted for the study in detail.

2. Literature Review

2.1 Introduction

The previous chapter gave an overview of the thesis as well as of the literature that forms the basis of this study. As part of this research, literature review performed on research articles focusing mainly on topics such as usability aspects in mobile devices, wearable devices and various applications used to improve adoption of mobile devices during the performing of physical activity. This chapter discusses the findings from the conducted literature review.

2.2 Activity-Monitoring Devices

There are various types of unobtrusive wearable devices that exist in the market that have been either developed or evaluated by various research teams such as

- Shoe-mounted system for the assessment of foot and ankle dynamics (Schepers, Koopman & Veltink, 2007)
- Glove-based photonic textiles as a wearable pulse oximeter (Rothmaier, Selm, Spichtig, Haenss & Wolf, 2009)
- The watch-type Blood Pressure (BP) device (Poon, Wong & Zhang, 2006)

- H-Shirt for heart rate and BP measurement (Gu, Poon, Sy, Leung, Liang & Zhang, 2009)
- Ear-worn activity and gait monitoring device (Lo, Yang & Pansiot, 2009)
- ECG necklace for long-term cardiac activity-monitoring (Penders, Molengraft, Altini, Yazicioglu, & Van Hoof, 2011)
- Ring-type device for heart rate and temperature measurement (Wu, Chang, Sawaguchi, Yu, Chen, Lin, Liu, Han & Liang, 2011)
- Strain sensor assembled on a stocking for motion monitoring (Yamada, Hayamizu, Yamamoto, Yomogida, Izadi-Najafabadi, Futaba & Hata, 2011)
- The clip-free eyeglasses-based device for heart rate and PTT measurement (Zheng, Leung, Sy, Zhang & Poon, 2012)

These wearable devices can record measurements ubiquitously. However, most of these devices have posed challenges such as being uncomfortable to wear the device, the bulkiness of the processing electronics and inertial measurement units (IMUs). Such disadvantages could limit the technology acceptance level for long-term and continuous monitoring.

The technological advances in the mobile and wearable devices have been tremendous in the last two decades. These devices have become smaller, compact and easier to carry. Mobile phones have turned into smartphones with sophisticated processing power and various capabilities such as email, wireless internet and specialized smart applications (or "apps") (Kirwan, Duncan, Vandelanotte & Mummery, 2012). The desirability of the smartphone app (a. k. a mobile app) depends heavily on its capability to store information, save critical data, perform complex tasks, access real-time location based services, play audio and video recordings, etc. The user interaction with such smart devices becomes more intimate than any other electronic devices and more convenient to carry most places by the user (Verkasalo, 2010). Due to their high processing power, multi-tasking, multi-

functionality yet smaller size, these devices are termed as "Smart" devices. These smartphones and smart wearable devices comes packed with many activity-monitoring features such as pedometer, heart rate measurement, blood pressure, monitoring sleeping patterns etc. (Kirwan et al., 2012; Zheng, Ding, Poon, Lo, Zhang, Zhou, Yang, Zhao & Zhang, 2014).

Considering the user's mobility, the user's behaviour changes as per their environment and thus, the user interaction with the wearable devices can differ depending on the context of the user. Such a variety of contexts could influence the user interaction over a prolonged period (Lyons & Starner, 2001). Hence, understanding the usability characteristics of mobile devices observed over a prolonged period and examining the context in which the interaction takes place is very important. It is also found that the level of user interaction offered by such mobile and wearable devices encourage more engagement with the device, eventually increasing the likelihood of technology acceptance by the user (Conroy, Yang, Elci, Gabriel, Styn, Wang & Burke, 2010; Neve, Morgan, & Collins, 2011).

In a separate study (Park & Chen, 2007), it is shown that perceived usefulness and ease of use of a smartphone device can significantly influence the attitude of the user towards the device and hence adopting the device. Furthermore, the consumers are now choosing products that satisfy their 'needs' such as price, effectiveness, efficiency, and interestingly satisfy their 'senses' too, such as physical design and user satisfaction (Didem & Ergün, 2014). Hence, the usability of mobile devices has become an important aspect for designers and developers in decision making during the mobile device development cycle.

2.3 Self-monitoring Physical Activities

Physical inactivity is a modifiable risk factor for many diseases such as cardiovascular disease, diabetes mellitus, cancer (colon and breast), obesity, hypertension, bone and joint diseases and depression (Warburton, Nicol, & Bredin, 2006). The research (Warburton, Nicol, & Bredin, 2006) further states, the prevalence of physical inactivity is significantly higher than that of all other modifiable risk factors. Performing physical activity plays a crucial role in the prevention of chronic diseases and premature health issues. However, assessing physical activities of a large population over a prolonged period in a controlled environment such as a hospital and laboratory is often not feasible. Therefore, from a public health perspective it is more preferable to 'encourage' people in becoming more aware to be physically active to help reduce the sedentary behaviour and improve their lifestyle (Blair, Cheng & Holder, 2001).

(Warburton et al., 2006) reviewed the role of physical inactivity in the development of chronic diseases and premature death and found that regular physical activity has shown to reduce the risks of diabetes and heart diseases, control blood pressure and improve psychological well-being. Hence, the benefits of performing regular physical activities found to be contributing directly or indirectly towards the reduced incidence of chronic disease and premature death among adults who are physically active. This is where the role of smartphones and smart wearable devices becomes vital in monitoring the physical activities and reporting the assessment regularly. The smartphone and smart wearable devices offer self-monitoring capabilities to encourage the user to perform their physical activities for a healthier life.

2.4 Usability of Mobile Devices

Like any other digital device, the success of mobile devices depends on their usability. The needs of the mobile user, the characteristics of the mobile applications, the usage context of the device and physical limitations of the device to be considered in designing the device as well as in performing usability evaluations of the device (Betiol & Cybis, 2005). The user can use mobile devices in different environments where he/she is not always stationery. Therefore, it becomes difficult to setup all type of environments in laboratory settings. Thus, we should conduct mobile devices' usability testing both inside and outside laboratory settings. Due to these factors, the usability context of mobile devices could get as dynamic and diversified as that of the user, which may significantly influence the user interaction (Johnson, 1998). The user interaction with the mobile application may vary in different contexts, for example, the user could access the calendar on the mobile device differently if performing physical activity than sitting at a table drinking coffee. Therefore, context-awareness becomes an important usability characteristic for a mobile device and creates a challenge in designing usability studies for mobile devices (Lyons & Starner, 2001). (Zhang & Adipat, 2005) found that along with varied context, mobile devices pose many other significant challenges in terms of designing usability evaluations such as multimodality, connectivity, varied screen sizes, different display resolutions, various processing capabilities, power consumption, and data-entry methods.

2.5 Current Challenges

The popularity of rapid prototyping techniques has shortened the development cycle of mobile devices (Ryu, 2005). A shortened development period increases the risk of user acceptance issues arising from lack of time spent on diagnosing the usability issues in mobile devices. As stated in (Ryu, 2005), the usability aspects of mobile devices significantly differs from that of software products. The research (Ryu, 2005) furthermore states, the mobile device's usability study depends on both hardware and software components along with emotional appeal and the aesthetic integrity of the design. Hence, mobile and wearable devices are a very interesting area of study among HCI communities.

Evaluating mobile and wearable devices pose many challenges in testing their usability without constraining the users in old, unnatural ways of motion-limited laboratory settings. Most of the recent studies conducted (Lyons & Starner, 2001; Babu, 2011; Ryu, 2005; Didem & Ergün, 2014) focus on devising new ways of performing usability testing of wearable mobile devices in a variety of contexts. However, most of the researchers have made lesser efforts to identify the characteristics of usability that may encourage prolonged use of mobile devices such as activity monitors. Hence, the goal of this research was to explore such area of usability research where the use of mobile and wearable devices over a prolonged period is studied.

2.6 Research Benefits

The findings of this research would contribute towards the future design and development of smartphones and smart wearable devices with better usability to promote prolonged use of the device and to benefit the user in improving their lifestyle through physical activities. The benefit to the parties involved in this research will be as follows,

2.6.1 Benefits for the participants

The participants have been provided with individual feedback forms that summarize the data collected using the activity-monitoring devices. They have also learned how they could use an activity-monitoring device in the future to help them improve and monitor their physical activity. The researcher gave summary report of the findings of this study to the participants.

2.6.2 Benefits for the researcher

The primary researcher will complete her Masters' thesis and gain a Masters' qualification. One co-authored research paper have resulted from this project and successfully published in CHINZ 2015, 15th New Zealand Conference on Human-Computer Interaction, 3-4 September 2015 – Hamilton, New Zealand. The primary researcher has also presented the findings from the research, in this conference.

2.6.3 Benefits for the wider community

This research focuses on identifying the usability characteristics that encourage prolonged use of activity-monitoring devices in the NZ adults (and young adults) to monitor their physical activities and improve their health, to understand the consequences of different actions or inactions with respect to their health, and how to overcome the barriers to changing their behaviour to a healthier one.

2.7 Chapter Summary

The chapter explained in detail the literature reviewed for smartphones and wearable devices used to monitor the physical activities of the user. It also discussed the current challenges faced in usability studies of mobile and wearable devices. In the end, the benefits of this research are stated. The next chapter discusses the research methodology and data analysis techniques used for this study in detail.

3. Research Methodology

3.1 Introduction

The selection of an appropriate research method and a precise data collection method are the foundation of a good research study. This chapter discusses the research design adopted for the study in detail. This chapter shows adoption of an ethnographic methodological approach for interacting with and observing the participants using AMDs over a prolonged period. Then, the researcher discusses the procedure of data collection in detail. Later, the researcher discusses the data analysis procedure. Finally, the chapter concludes with the research ethics considerations undertaken for this study.

3.2 Research Design

This research uses an ethnographic methodological approach. Ethnography is an approach for discovering and investigating social and cultural patterns and meaning in communities, institutions and other social settings. One primary difference between social and behavioural science methods of investigation is that ethnographers discover what people do before they assign meaning to behaviours and beliefs (Schensul, Schensul, & LeCompte, 1999). According to (Herbert, 2000), ethnography is a uniquely useful method for uncovering the processes and meanings that undergird sociospatial life. In general, Ethnography rests upon the participant observation, a methodology whereby the researcher

spends considerable time observing and interacting with a social group. These observations and interactions enable the ethnographer to understand how the group develops a flow of relations and cultural constructions that tie it together.

The advantage of using ethnography for this study is that it offers flexibility to use any method for data collection, collecting any type of data rather than focusing on particular phenomenon of investigation. Using an ethnographic methodological approach, the researcher can focus more on participation in the research and writing the research rather than data collection methods (Flick, 2006). As stated in (Jones, 2006), the advantage of ethnography over other methods is that the researcher can compose their own observations as field notes that can then be used in the research as data. (Jones, 2006) further states that, ethnography allows for empirical data collection, is holistic in nature and provides for better understanding of the phenomena under observation and allows for direct observations rather than relying on second-hand information as compared to other methods. With these benefits in consideration, an ethnographic methodology allowed the researcher to accomplish the objectives of this study and to obtain feedback on the characteristics of usability.

3.3 Procedures

This section will detail the process of recruiting the participants and interview setup along with the inclusion and exclusion criteria for sampling the target population.

3.3.1 Recruitment

The recruitment process began by placing research invitations (Appendix C) on various notice boards across the AUT city campus. The researcher had discussed this process with and received an approval from the primary supervisor. In addition, the researcher has made call for research invitation on relevant student discussion groups in an organisational course management system such as AUTonline. The participants were encouraged to contact the researcher by phone if they were keen to participate in the research. After their initial contact, the researcher gave the information sheet (Appendix A) and consent form

(Appendix B) to the participants to read and complete. The researcher collected signed consent forms before the orientation interview. During the orientation interview, the researcher showed three types of activity-monitoring devices to the participant. If the participant showed interested in at least one of these devices then the researcher conducted further interviews with the participant.

3.3.2 Trial Period

The trial period of using an activity-monitoring device varied from two weeks to 6 months. This length of the trial period was sufficiently long to collect relatively focused data for this study. In addition, the researcher considered this trial period was long enough to encourage the participants to perform physical activity.

3.3.3 Inclusion criteria

The researcher selected participants from a target population in consideration to important factors such as balanced gender distribution, specific age group, and user experience with wearable smart devices. The final research sample consisted of four NZ adult participants aged between 18 - 35 years. The participants were male and female, comprising more than one ethnic background and resided in Auckland. The adults in this age group of 18 - 35 years are likely to own a mobile phone or a smart phone. Therefore, it was relatively easy for them to carry and use an activity-monitoring device. Thus, the final inclusion criteria adopted for this research were as below:

- Male Participants
- Female Participants
- Living locally
- Between the age of 18 - 35 years
- Participants who have used activity-monitoring devices
- Participants who have not used activity-monitoring devices

3.3.4 Exclusion criteria

This research had considered exclusion criteria such as the participants younger than 18 years old; not living locally. The researcher performed participant sampling until data saturation was achieved and the research question was addressed appropriately. As stated in (Breakwell, Hammond, Fife-Schaw, & Smith, 2006), data saturation is achieved at a point when insights into a phenomenon are satisfied and further contributions are unnecessary. (Breakwell et al, 2006) further states that interview questions need relevance to all participants, achieving purposeful sampling of the research population. The final exclusion criteria adopted for this research were as below:

- The targeted sample size and composition has been achieved;
- The sampling may not be completed but the researcher has achieved the number of the prospective eligible participant profiles.
- Participants younger than 18 years
- Participants not living in Auckland

3.3.5 Interview set up

The researcher has considered the use of 'interview' loosely here, as there were many opportunities to meet with the participants over the course of the study, and data about usability may have arisen at any of these occasions. The interviews were either structured (i.e. an orientation session, a debrief session) or informal conversations occurring through casual meetings or visits by the participants during their use of the devices.

The researcher met with each participant at the HCI Lab in AUT where audio/visual equipment (i.e. video camera or audio recorder) was setup to record the interviews. The researcher designed face-to-face interview sessions to be open-ended and free flowing so that participants could report their experience with the activity-monitoring devices. Then the researcher composed field notes that recorded highlights of the interview session and user impressions. The participants were free to leave the interview site at any time and did not need to justify their reason for leaving.

3.4 Instruments

In this research, three instruments were selected for data collection: the researcher as instrument, the qualitative interview, and the researcher's field notes that are consistent with qualitative investigations as stated in (Patton, M., 2002). This research employed generic qualitative thematic analysis as a research method to find answers to the research question of this study, to identify the usability characteristics that encourage prolonged use of an activity monitor.

3.4.1 Researcher as Instrument

In this study, the researcher is an instrument where the researcher remained objective, open to exploration to understand the user experience of activity-monitoring devices. During interviews, the researcher was careful about personal body language and using appropriate sentences to avoid influencing the participant's conversation. The researcher stayed unbiased while recording the participant's expressions and reactions towards activity-monitoring device. The researcher avoided any preconceptions or pre-understanding to remain uninhibited with respect to the participant's organic expressions. The researcher treated the participant's interview with appropriate sensitivity as required and allowed the participant to present him or herself as they intended to, without any interruptions.

3.4.2 Qualitative Interview

The researcher used open ended and free flowing interview sessions as a second instrument to enable participants to express their user experience with activity-monitoring devices without judgment or interruption by the researcher. Some participants were very expressive and the researcher had to ask few or no questions to gather their experiences with the activity-monitoring devices. However, some participants were shy and required a few guiding questions from the researcher to start expressing their user experiences. Please refer to appendix E for the indicative interview question protocol.

3.4.3 Research Field Notes

The research field notes were the third instrument in this study. The field notes were descriptive and captured appropriate information relevant to this study to be helpful as a chronological summary or as reflective notes later used for thematic development (Creswell, 2007). The field notes mainly focused on the participants' impressions and expressions towards activity-monitoring devices; their comments, utterances, physical movements, body language that seemed relevant and appropriate for this study. The field notes also recorded the researcher's feelings, reactions, and interpretations. The researcher stored copies of the recorded interviews (i.e. video and/or audio) in a secure file cabinet in the HCI Lab at AUT.

3.5 Data Analysis and Synthesis

In this study, the researcher conducted a qualitative generic thematic analysis as part of the data analysis and synthesis. As stated in (Caelli, Ray & Mill, 2003), a qualitative generic thematic analysis needs to be contiguous with the positions and assumptions that led to the research question, it is only through these elements that a study may be evaluated. The researcher has covered the foundational research of using wearable smart devices as activity monitors in the literature review that allowed in forming basis for an inductive analysis. The aim of the thematic analysis is to identify commonalities, codes and themes of usability characteristics that encourage prolonged use of activity-monitoring devices. As part of conducting the thematic analysis, the following procedures were undertaken (Caelli et al., 2003):

1. Familiarize with the data
2. Generate initial codes
3. Search for themes
4. Review themes
5. Define and name themes
6. Produce report

The researcher started the thematic analysis process by becoming familiar with the data, by watching recorded interviews. The researcher studied the recorded videos carefully to understand the participant's experiences with the monitoring devices. The researcher created the initial codes by extracting the interesting information from the interviews into a table. The researcher searched through the coded data to identify the commonalities of meaning and developed themes from collated codes. Finally, the researcher created the table containing established themes and implemented all codes within the related theme. The next chapter will discuss the data analysis undertaken for this study in further detail.

3.6 Ethical Considerations

The most important ethical consideration in all forms of research is to ensure that no human being or other creatures were harmed during the research process. The investigation conducted in this research comprised of ethical, respectful, professional and safe procedures. The researcher handed each participant with an information sheet that detailed the purpose and process of the study. The researcher obtained approval from all of the participants to video / audio record their interview sessions. The researcher did no harm to the participants and others. The researcher was conscious about her personal mental and physical health during the research process. The researcher always performed the research procedures with full professionalism and respect. The researcher ensured to remove any personal bias and advocate true respect. The researcher respects for people's right and dignity. The researcher abided by the rights of individuals to privacy, confidentiality, and self-determination.

3.7 Chapter Summary

This chapter focused on research methodology and the research design adopted for this study. It has briefly mentioned the data collection and data analysis process undertaken. This chapter explained how the researcher selected the target population and performed participant sampling, the procedures performed, various research instruments used, how collected data was analysed and synthesized. In addition, the researcher discussed the ethical considerations taken for this research. The next chapter discusses the data collection and analysis undertaken in detail.

4. Data Collection and Analysis

4.1 Introduction

The previous chapter discussed the research design and research method adopted for this study. In this chapter, the researcher discusses the application of the selected research methods for the purpose of data collection and analysis in detail. The researcher has explained how she collected data through usability study, face-to-face interviews and research field notes in detail. This chapter concludes with the discussion on generic thematic analysis performed on the data collected.

4.2 Data Collection

This study used three activity-monitoring devices (AMD): smartphone (SP), smart watch (SW) and smart wristband (SWB) to give a suitable variety of usability characteristics. In Particular, the researcher used Samsung Galaxy S5 smartphone, Samsung Galaxy Gear smart watch and Jawbone UP24 smart wristband as AMDs. The researcher recruited a small group of four young NZ adult participants that included two male and two female subjects aged between 18 - 35 years as per the inclusion and exclusion criteria explained in previous chapter. The participants were encouraged to select any device of their interest from the devices available during the study.

To collect the moments when the participants were exposed to the AMD for the first time, the researcher conducted user orientation sessions. These user orientations sessions were video recorded. This helped the researcher to study the usability of the device from their perspective.

The researcher requested the participants to use AMDs over a prolonged period. The trial period of using an AMD was sufficiently long (varying from two weeks to 6 months) enough to allow them to spend considerable time with the device in their regular life. The participants were encouraged to use AMDs during their everyday activities as much as they could, especially during performing physical activities. However, the researcher did not ask the participants to perform any specific tasks when using AMDs. This study collected data in two ways: face-to-face interviews and field notes.

4.2.1 Face to Face Interviews

The researcher collected qualitative data from the participants during and after they had finished using the monitor device, by conducting face-to-face interviews. Denzin and Lincoln (2005) suggested that qualitative analysis provides the opportunity to observe, step inside, make sense of, interpret, and gain understanding of the world of another, that has the ability to change an individual and, collectively, the world. Using Qualitative methodology, the researcher can extracts the data obtained directly from the participants through semi-guided interviews that provide free and open dialogue to address the research question (Reed-Klein, 2014)

The researcher designed the face-to-face interviews to collect data about participant's perceptions and experience related to acceptability of AMD. The researcher considered the use of 'interview' loosely, as there may be many opportunities to meet with the participants over the course of the study, and the usability data may arise at any of these occasions. The interviews were either structured (i.e. an orientation session, a debrief session) or informal conversations occurring through casual meetings or visits by the participants during their use of the devices. This helped the researcher in understanding different usability characteristics that could encourage the prolonged use of AMD in young NZ adults.

The researcher met with each participant at the HCI Lab in AUT where audio/visual equipment (i.e. video camera or audio recorder) was set-up to record the interviews (Patton, 2002). The researcher designed the interview sessions to be open-ended and free flowing so that the participant could comfortably report their user experience with the AMDs.

4.2.2 Field Notes

During interaction with the participant, the researcher composed quality field notes (Patton, 2002) to record highlights and lowlights of the participant's experience using the AMDs. The researcher recorded the participants' impressions of the interview sessions and their expressions. The field notes were descriptive and captured appropriate information relevant to this study to be helpful as a chronological summary or as reflective notes later used for thematic development (Creswell, 2007).

4.3 Data Analysis

In this study, the researcher conducted conversational face-to-face interviews with four participants with pseudonyms: Anna, Bella, Jack and Sam. The researcher has used pseudonyms to protect participant's confidentiality in this research (Kaiser, 2009). This study has undertaken a qualitative generic thematic analysis (Braun & Clarke, 2006; Caelli, Ray & Mill, 2003) for analysing the data collected through interview recordings and field notes. Since there are no specific steps outlined for data analysis within qualitative generic thematic analysis, the researcher extrapolated purposeful processes from other qualitative methods that the researcher deemed appropriate (Patton, 2002). This section focuses on the process designed specifically to analyse the data using generic thematic analysis.

4.3.1 Familiarize with the Data

The initial step was to familiarize with the data collected. The researcher went through all the video recordings and field notes to collate them for data analysis. Total 14 face-to-face interview sessions had taken place. The researcher video recorded all these sessions using facilities in HCI Lab at AUT. The collected video recordings had a total duration of over

200 minutes. A total of 14 pages with around 1000 words of field notes were taken by the researcher during the interview session to mainly capture the participants' impressions and expressions towards AMDs; comments, body language that seemed relevant and important for this study.

Table 1 shows the details of device selection and usage (in weeks) by each participant. Jack had used all three devices for most prolonged period. Bella was the candidate who used the SWB for least period among other participants. Bella and Sam only used one device out of three available. Anna used two devices for total of 28 weeks. Jack had used all three devices for a total of 40 weeks. The usage of these devices by all participants varied between 5 – 20 weeks that is considered a sufficiently long period to be qualified as prolonged period of use. Furthermore, three participants chose the smartphone and the smart wristband devices to use. However, only one participant showed interest in using the smart watch device.

4.3.2 Generate Coding Procedure

This study required an approach that could ground the coding procedure within the research context. Thus, the researcher established a set of coding rules to form a basis for entire coding procedure as listed in Table 2.

4.3.3 Iteration One

The video recordings and field notes were analysed repeatedly to extract key sentences from the participant feedback and transcribed accordingly as per Step 1 of the coding rules depicted in Table 2. The researcher extracted 488 key responses in the first round to form individual nodes. Then the researcher performed the Step 2 of coding rules to identify and code distinguishable 280 free nodes with varied context.

Participants	Devices		
	SP	**SW**	**SWB**
Anna	✓	-	✓
	18 weeks	N/A	10 weeks
Bella	-	-	✓
	N/A	N/A	5 weeks
Jack	✓	✓	✓
	20 weeks	12 weeks	8 weeks
Sam	✓	-	-
	16 weeks	N/A	N/A

Table 1: Device Selection and Usage by the Participants

4.3.4 Iteration Two

In iteration 2, the researcher repeatedly applied Steps 3 - 5 of the coding rules outlined in Table 2. The aim was to truncate the words in the 280 free nodes to become 2 - 4 words on average in each node. The researcher again attempted to compress any nodes that were longer than four words into four or less. The researcher scanned the free nodes for having more than two meanings. The nodes were to split into two nodes, where the original node had more than two meanings. Then the researcher scanned the nodes for similar meaning and removed the repeated nodes. This way the list of nodes shrunk down to final 125 nodes

that were unique and had at most two meanings attached to them. At this point, the researcher achieved a degree of uniqueness in the list of nodes. Figure 1 shows these 125 unique nodes.

4.3.5 Iteration Three

In iteration 3, the researcher aimed to group the final list of 125 nodes based on their similarity. As shown in Table 3, the nodes were grouped in three categories: 'Physical Appeal' (i.e. Design Aesthetics), 'Features', and 'Activities'. Then the researcher further divided the nodes to two common sub-groups namely, positive feedback (i.e. likes) (+) and negative feedback (i.e. dislikes) (-). The Table 3 outlines these groups as below.

CODING RULES	
Step Number	**Description**
1.	Extract the key responses from the participant's interviews and transcribed in a listed format.
2.	Fairly distinguishable free nodes with varied context to be coded based on the key responses identified in Step 1
3.	Truncate the newly created free nodes to 2 - 4 words to be precise and generic as possible.
4.	Scan the nodes repeatedly to identify any duplicates. Then combine the repeated nodes as per the common context shared between them. Then delete the repeated nodes.
5.	The aim is for nodes to have 1 - 2 meanings. If a node covered more than two meanings then it was broken in to two nodes.

6.	Repeat steps 3 to 5 until no further changes possible.
7.	Group the individual node together to tree nodes that share some similarity among them. Attach meaning to the themes. In each group, separate the nodes as positive and negative impacts.
8.	Repeat Step 7 until you have assigned all nodes to tree nodes.
9.	Keep repeating Step 8 until no sub-groups could be formed

Table 2: Set of Coding Rules established for the data analysis

Devices	Physical Appeal	Features	Activities
SP	12 (+)	18 (+)	7 (+)
	4 (-)	9 (-)	3 (-)
SW	9 (+)	5 (+)	3 (+)
	3 (-)	5 (-)	2 (-)
SWB	9 (+)	6 (+)	12 (+)
	8 (-)	9 (-)	1 (-)

Table 3: Grouping of final nodes after applying the Coding Rules

As you can see in Table 3, smartphone received 37 positive feedbacks and 16 negative feedbacks from 3 participants. Smart watch received 17 positive feedbacks and 10 negative feedbacks from 1 participant. Smart wristband received 27 positive feedbacks and 18 negative feedbacks from 3 participants.

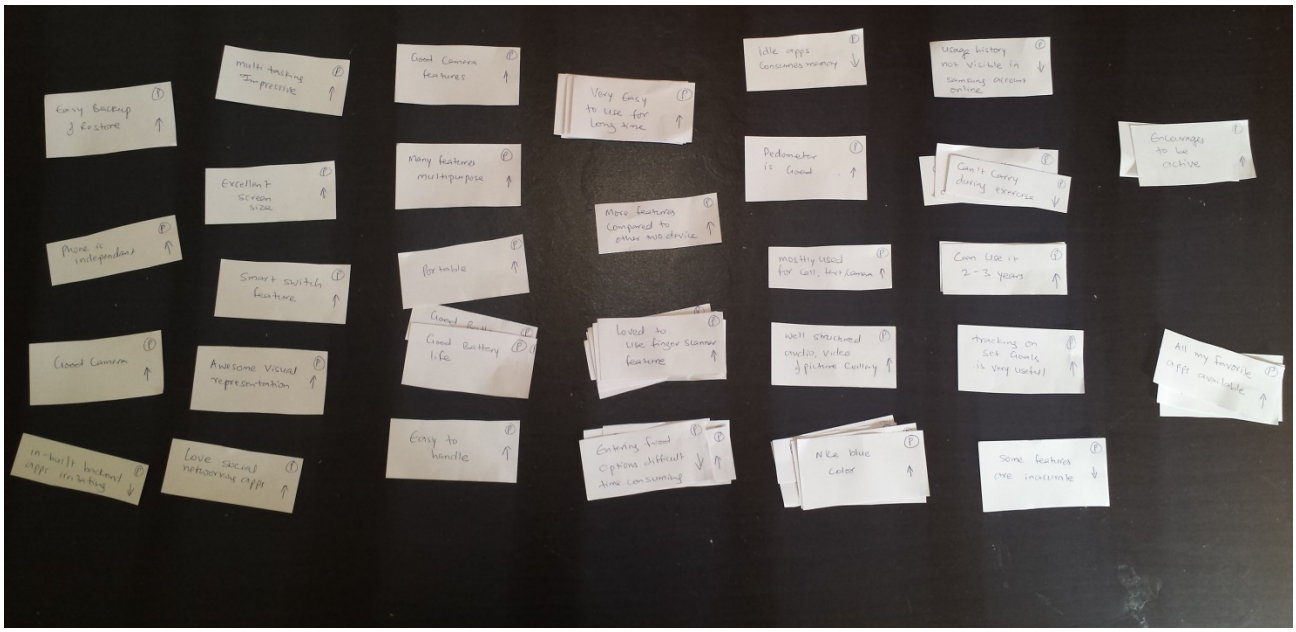

Figure 1: Sorting the 14 pages of around 1000 words of the field notes into 125 unique nodes

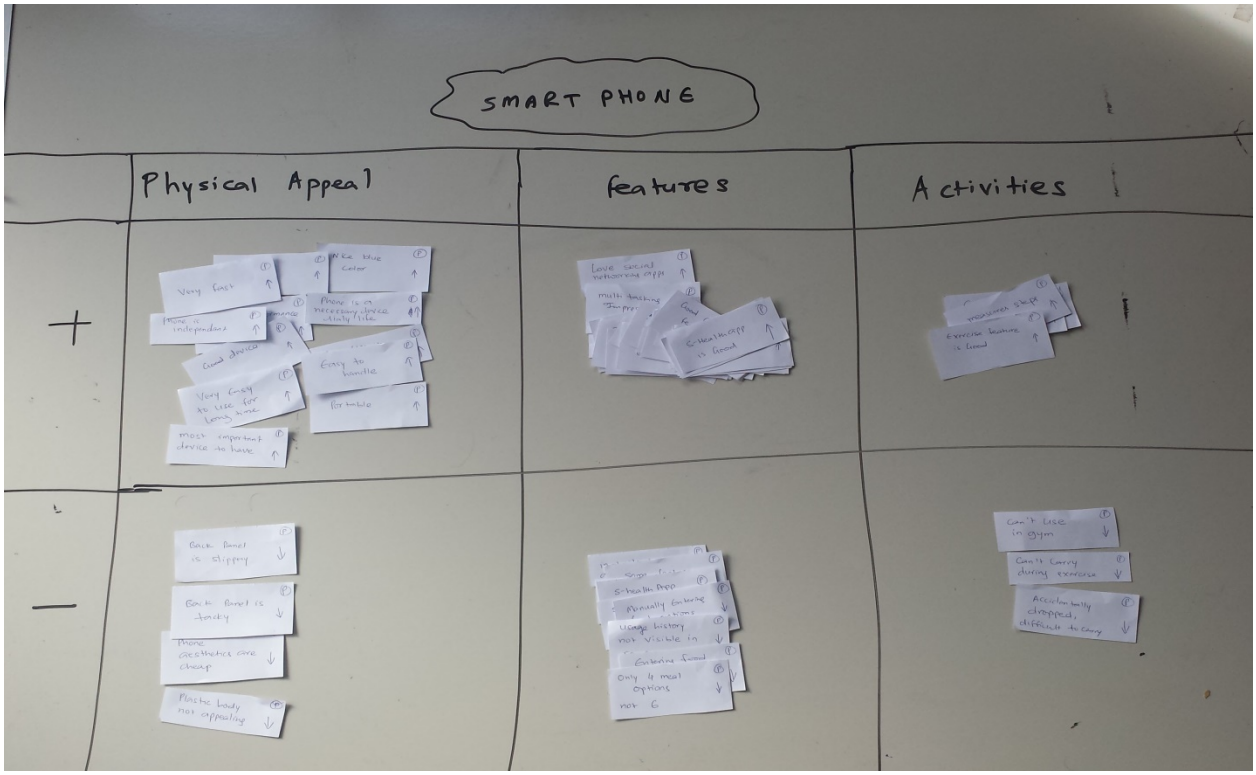

Figure 2: Grouped nodes for the smartphone

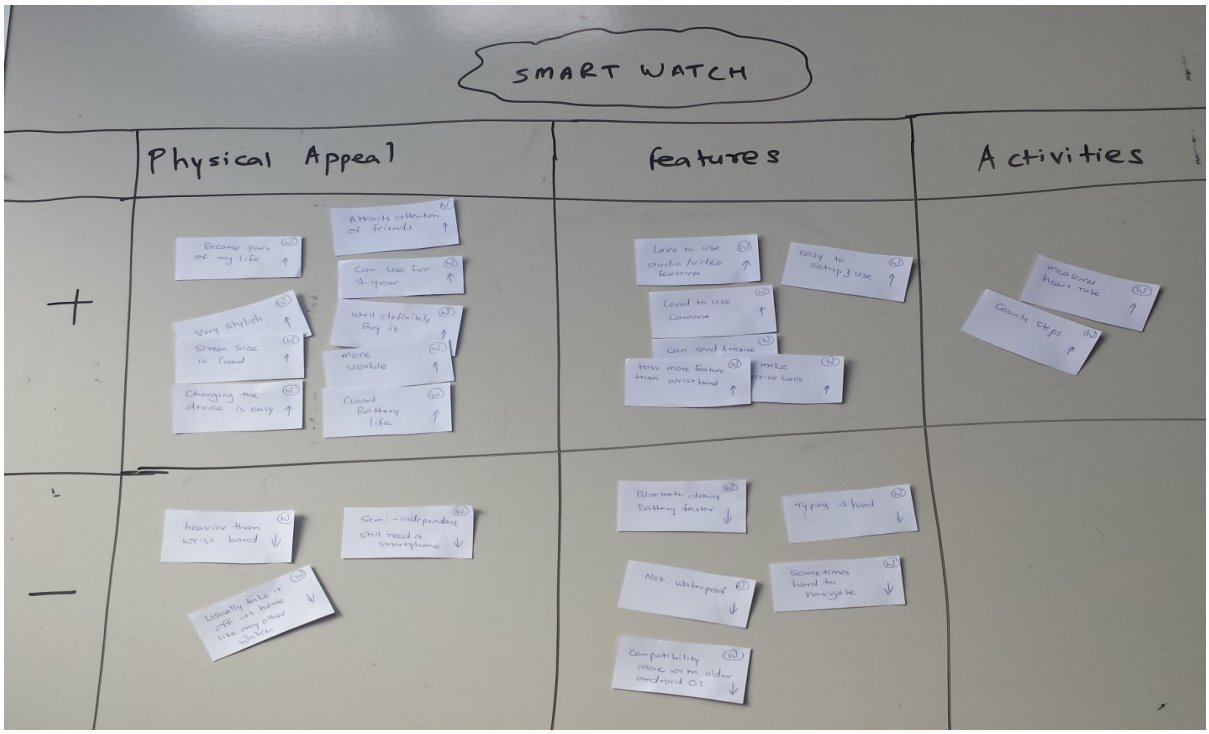

Figure 3: Grouped Nodes for the smart watch

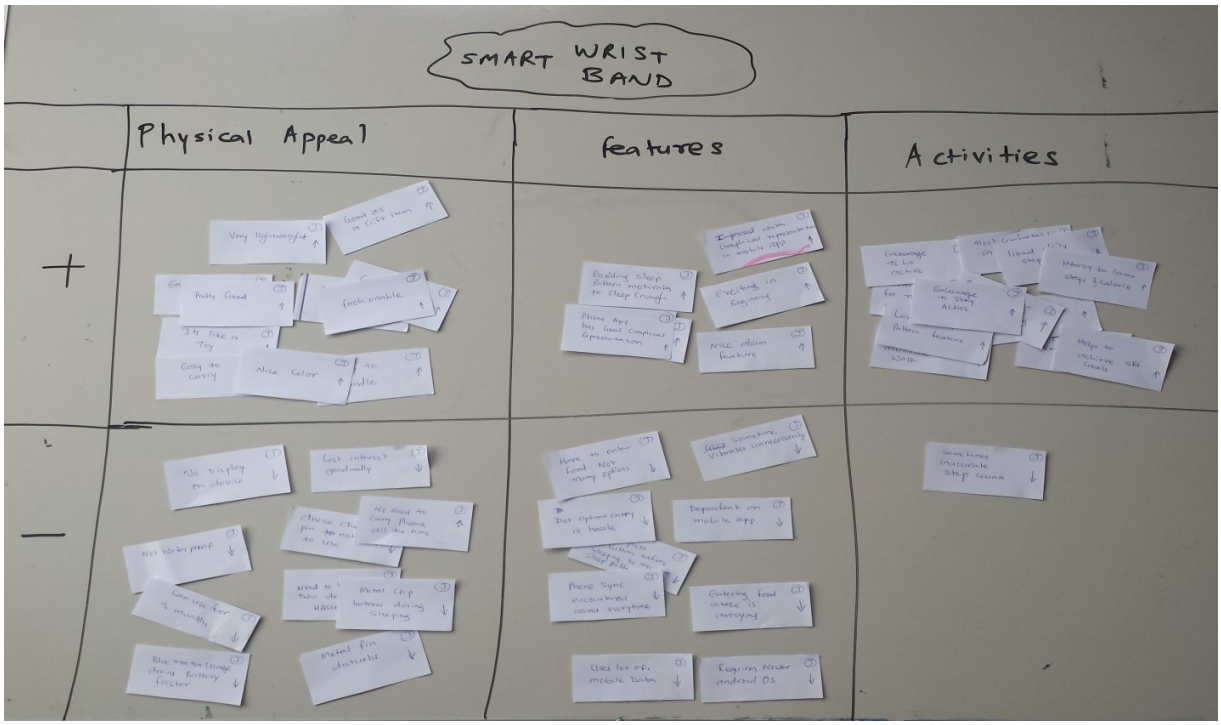

Figure 4: Grouped nodes for the smart wristband

The Figure 1 shows how 14 pages of around 1000 words of field notes were systematically broken down into 125 unique codes using the generic thematic analysis technique. In Figure 2 shows, the unique nodes grouped for the smartphone. Figure 3 shows, the unique nodes grouped for the smart watch. Figure 4 displays, the unique nodes grouped by smart wristband. The researcher has grouped all these nodes by three groups: Physical Appeal, Features and Activities offered in these devices.

4.4 Chapter Summary

This chapter focused on Data Analysis and Collection procedure undertaken in this study. This chapter explained how the researcher used face-to-face interviews and field notes to collect the data. The researcher has outlined the systematic discussion on developing the theme using generic thematic analysis on data collected. The researcher collated hundreds of key responses and refined successfully, then grouped into three final groups: Physical Appeal, Features and Activities offered by the AMDs. In the next chapter, the researcher discusses about the findings from this data analysis.

5. Findings and Discussion

5.1 Introduction

The previous chapter explained how the researcher collected data for this study. The researcher discussed the coding schema developed using generic thematic analysis in previous chapter. The subsequent groups, sub-groups of unique free nodes are now analysed in this chapter. The researcher presents the findings from data analysis in this chapter. This will form the basis for the subsequent discussion. During data analysis process, the researcher also noticed some usability issues and user acceptance issues that arose from using the AMDs over a prolonged period.

5.2 Findings

The findings comprise of data analysis conducted on more than 200 minutes of video recordings and over 14 pages with around 1000 words of field notes. The researcher have grouped the factors found from the data analysis relevant to the research objectives into three main aspects of AMD's: design aesthetics, features and activities offered by the device.

5.2.1 Design Aesthetic Related factors

During data analysis, the researcher found many design aesthetic related factors such as physical design, battery performance, portability, device's weight, the ease of physically handling the device, and screen size to be significant factors to decide on the device's usability and the user's decision making to continue using the device over a prolonged period. All of the participants expressed the need for a screen display. According to the participants, a bigger screen size is important to them as it makes user interaction with the device easier, smoother and more engaging. Conversely, the participants reported that the wearable devices such as SW and SWB were easier to wear and carry. One of the participants said,

> *"When you are doing some exercise or doing some other activity. Usually, I don't carry it [SP]. So, if you want to record the activity, for me it's not convenient to carry the phone. But for the band [SWB], it is really convenient. You just need to put on your wrist and just go. "* ***- Anna***

The participants found the SW to be most attractive to family and friends. They reported that the SWB to be blending really well with clothes and other accessories, making it a fashionable device to wear in parties and social gathering. One of the participants said,

> *"I like the band because I found it fashionable and I am on a weight-loss regime so I thought I would use it."* ***- Bella***

This shows that "being fashionable" encouraged prolonged use of the device. The most interesting finding relating to design aesthetics was that due to an excellent ease of wearing the SWB the participants were comfortably motivated to keep using it even while sleeping. There is a paradoxical duality here. The participants displayed behaviour and made explicit statements that support prolonged use in both the highly interactive multi use system (SP), and the minimally interactive SWB.

5.2.2 Features Related Factors

The studied AMDs were offering different capabilities in the form of various applications designed for performing certain tasks. For example, sending / receiving phone calls and text messages, camera for taking photos, playing games, watching movies, pedometer, heart rate monitor, health app etc. The researcher regards such applications offering various capabilities as “Features” in this study. These features constitute an important group of factors that encourages user for the prolonged use of the AMDs.

One of the participants said,

> *"Feature-wise it [SP] does offer quite good capabilities, it offers multitasking also. For example, pedometer keeps running in background with S-health perspective. While I was trying to respond to an email while walking or listening to music or something, it [SP] did not interfere with the background applications. That was a good feature. I could do simple things like taking a snap. Or respond to a message. Or respond on whatsapp while S-health application was running in background. I liked that!"* ***- Sam***

Hence, the "Multipurpose" features offered by SP encouraged the participants to use SP over a prolonged period. The SP also offered social networking feature that the participants found very engaging to stay connected with family and friends easily on various social networking sites. SW offered another socially engaging feature to measure heart rate. One participant said,

> *"The good thing is that it [SW] can measure the heart-rate. Yeah. So, I can measure it when I am bored. We had kind of game when I had many friends. [A game to find out] Who has the highest heart rate? Yeah"* ***- Jack***

This shows that the participant actually used "measuring heart rate" as a feature to engage with friends. They even played the game to find who has the highest heart rate at that time. The participant reported that the SWB offers the most surprising feature to measure sleep

patterns. The participants reported that this 'measuring sleep pattern' feature made them feel satisfied to know how their sleeping pattern was and how sound sleep they had in the night. This feature encouraged them to use the SWB device more.

The participant, Jack, made a remarkable comment as follows,

> *"I dropped my friend at his home. Then I was driving home. my friend texted me. And I could check it [text message] from the watch [SW] [while] I was driving. Ooh. I left my bag at his house. And I called him [through SW] and said I am coming. [laughter]. I felt like you know. James Bond! [laughter continues..]"* ***- Jack***

As you can see, Jack had a great moment using the SW device that made him feel like a super spy, James Bond, from the movies. This shows how well a user could connect with the device and being able to feel extraordinary. This feeling of exhilaration made Jack use the device [SW] more frequently and made him more intimate with the device. The socially engaging features such as heart-rate measuring, ability to make phone calls, check text messages, etc. offered by SW made the participant use it enjoyably more often. He expressed this enjoyment as follows,

> *"It [SW] just becomes part of my life. It feels little bit weird if I don't have the watch [SW]. It's really useful. Because I can get notifications, read texts easily. Very good!"* ***– Jack***

Another salient feature that played major role in allowing user an uninterrupted interaction with the device was its battery life. The participants reported SWB to have longest battery life, making it more likely and trustworthy to wear the device during physical activities. One of the participants kept using the SWB device for more than a week, almost forgetting to charge it again, he said,

> *"And the battery [of SWB] lasts for about a week. It's quite good! I kept using it, without realizing to recharge again for some time."* ***- Jack***

Even the SW offered the participants good battery life that lasted for almost a week. The participants noticed that the SP has average battery life considering the number of multi-tasking features it offers. On one side, the participants were happy with so many features offered by SP. However, they were not so much impressed with its battery life when used over a prolonged period.

One of the participants said,

> *"Battery life [of SP] is good. umm. In terms of, if I am on Wi-Fi then battery life was not that good. I had to recharge it at least at the end of the day... but if I am not on Wi-Fi then the battery life was better."* - ***Sam***

The participants reported that the feature to record eating habits and keep track of calorie intake in SP and SWB were interesting and helpful but too tedious and difficult to use. Hence, the participants eventually lost interest in using this feature. Thus, indicates that ease of use is a very important characteristic to decide the success of a device over prolonged period.

5.2.3 Activities Related Factors

The third and final group of factors was the "Activities" encouraged by the device such as pedometer, heart rate monitor, measuring calorie burnt etc. All three devices offered activity-monitoring features in the form of mobile applications. The activity-monitoring applications such as S-health and UP24 Fitness Tracker helped the participants set goals and actively track to help them achieve the goals in a set time. The real-time monitoring and notifications capabilities really helped the participants to stay physically active and healthy. Initially, the researcher noticed that the pedometer feature encouraged the participants to stay physically active in regular timed intervals. However, later the participants reported intermittent inaccuracies in step counts done by the pedometer raising trust issues. This eventually discouraged the participants from using pedometer feature. The heart rate monitoring feature offered by SW was most interesting and useful when performing physical activity. These activity-based features encouraged the participant to

stay focused on physical activity and to get the most out of it by tracking set goals. It also encouraged the participants to use the devices more during physical activities.

The participants were comfortable to use SWB more during physical activity than the other two devices due to its simplicity, ease of use and lightweight characteristics. The participants reported that the SP was difficult device to use during performing physical activity and posed risk of damaging its screen due to accidental falls.

One of the participants said,

> *"For the first week, I tried to carry the phone [SP] with me all the time. I had put it in the pocket or somewhere and ummm. I had some accident. Because when I put it [SP] in my pocket and I was doing some gardening. May be because the pocket was too shallow. So, it fell out. It cracked on the edge and even the back cover came out. So after that accident. I just don't carry the phone [SP] with me all the time."* ***- Anna***

Due to this risk of damage, the participants were discouraged to use SP during performing physical activities. Due to no screen display on the SWB, the participants perceived it to be safer device to use during performing physical activities. One of the participants said,

> *"So this is most important! As you can see, I dropped it [SP] it got scratches. I dropped it on concrete. The reason is that this [SP] is big and I cannot wear it on my body. But this one [SW] doesn't fall right. [shakes hand to show SW does not fall]. So this is one of the disadvantages [of SP] and wrist band [SWB] doesn't have screen. So it's safer. "* ***- Jack***

This indicates that the participant's decision to use device during performing physical activities relates to user's perception of risk associated with the device's screen safety during such activities. In addition, the participant reported SWB to have better battery life than other two devices when used during performing physical activities.

This shows natural inclination towards using SWB during physical activities due to its activity friendly features such as easy to wear, longer battery life and no screen display.

5.3 Discussion

The interesting findings from this study led the researcher to meaningful observations and helped to identify the usability characteristics that encourage prolonged use of an AMD. The researcher discusses these usability characteristics along with observed usability issues and user acceptance issues as follows.

5.3.1 Usability Characteristics

In this study, the researcher identified six major usability characteristics that encouraged prolonged use of AMD:

5.3.1.1 Display Screen

All the participants unanimously expressed the need for a display screen. The size of the screen also mattered in some cases such as they wanted to type messages into them or see notifications. The participants felt more engaged with the devices that had Display Screen while using them. Secondly, users preferred to have a screen of any size to interact with the device and did not care much of the size of the screen. With better screen size, comes the opportunity to have visually stunning user interactions. Having a good-sized display screen promotes better user acceptance.

While being important to have screen, the participants also reported concerns about the risks of screen damage during the physical activity. Screen less devices seemed to have increased user's perception of its robustness and safe incorporation into daily life, especially during performing physical activity, and therefore prolonged their usage period.

Thus, depending on the user activity, screen display size becomes an important usability characteristic. It is important to have big screen display when user wishes to interact with

the device itself for activities such as sending text messages, watching photos, videos etc. On the other hand, it is still useful to have no-display device when the user is performing physical activities and the user does not constantly interact with the device itself.

5.3.1.2 Lightweight

The participants were encouraged to use the device while performing physical activities that may include exercise. The researcher did this to observe the role of device's weight in its adoption during physical activity. The participants stated that they would not prefer to carry heavy device during physical activity as the device would restrict their movement and they may get tired carrying its weight. In this aspect, SWB was very lightweight compared to other AMDs studied in this research. Therefore, due to its lightweight, the participants preferred using SWB over others during physical activities. The SP was very bulky due to large screen size and thus less preferred by the participant to carry in hand. Instead, they were placing the SP on a table nearby or in their trouser pockets while carrying out physical activities. This limitation hindered their opportunity to prolong use of SP. Even though SW was a little heavier than SWB, it was wearable. So the participant could use SW during physical activities. This way, SWB and SW offered uninterrupted prolonged use period whether the participants were performing physical activity or not. Thus, the researcher found the weight of the device to be a crucial usability characteristic. The participants had expressed that the device that is most light in weight would be their preferred choice for prolonged use especially during performing physical activities.

5.3.1.3 Battery Life

It was evident from the findings that better battery life enabled the user to perform activities over a prolonged period. The user reported that long lasting battery life gives them opportunity to use device continuously without worrying about charging them often. One of the participants said,

> *"SWB has the longest [battery life], may be one week. Maybe sometimes more than one week. 10 days or something. Very good. This watch [SW] is about 5 days. Maybe 7 days. That's not bad. Because I expected it to be 2 or 3 days. So 5 days is good. Very good. This one [SP]. Maybe one day. I think it is because of bigger screen. It uses more energy."* ***– Jack***

Longer battery life means the user can do many tasks using the device for longer uninterrupted period. Therefore, it becomes an important usability characteristic for an AMD to have long battery life, to be able to offer an uninterrupted prolonged usage time.

5.3.1.4 Multipurpose

The participants reported SP device to be difficult to carry during physical activity. However, the participants desired the Multipurpose and multitasking features offered by SP device and made the device more interesting to them to keep them engaged. Hence, such multipurpose capability encouraged their prolonged use when users are not performing physical activities. The multipurpose features require better hardware support to perform various tasks smoothly such as sending text, receiving calls, taking pictures, checking emails, watching videos all at once. The participants reportedly spent longest amount of time interacting with the SP device itself than other two devices, enjoyably using all the features offered by this device. Such continuous interactions with the device found to be encouraging the participants for prolonged use of SP. The SW offered lesser multitasking features compared to SP, however SP was not wearable. So, offering multiple features and the flexibility to be wearable at the same time made SW a very appealing device. This encouraged the participant to use the device over a prolonged period, even during performing physical activities.

5.3.1.5 Social Engagement

The need of socially engaging with family and friends seemed to influence the decision to use the AMD more often. The researcher made an interesting finding in this study. The features like social networking applications on SP helped the participants stay connected

with their family and friends even when they were on the move. One participant to his family and friends keenly demonstrated the features such as the heart rate monitor on SW during social gatherings. The participants liked the stylish factor offered by SWB device and found it to be very fashionable and socially acceptable. This encouraged them to use the device during social gathering comfortably. This show that "being fashionable" is a desirable usability characteristic that encouraged device's incorporation into social events, and therefore, prolonged the use of the device.

5.3.1.6 Ease of carry/wear

The researcher found the ease to carry/wear the device to be a crucial factor for prolonged use of AMDs. The participants said that they could not perform most of the physical activities while holding the SP in hand, as it restricted their physical activity. Hence, they used to keep SP either in their pockets or on a table nearby while performing physical activity. This disadvantage of being difficult to carry SP discouraged its use during physical activity. The SW and the SWB are wearable devices hence are easy to wear on wrist and did not disturb users while carrying out their physical activities. However, the participants would take off SW when they go home or go to bed, as they found SW to be slightly distracting and felt bit heavier after a long day of wearing it. The SWB demonstrated a light and slim design that interfered lesser with user's actions during physical activities and hence was preferred for longer everyday use. The participants found SWB lightweight and easy to wear with least obtrusiveness as compared to other two devices. They enjoyed wearing the SWB not only during the day but also at night to measure their sleep patterns. They felt encouraged to use the SWB during exercise to measure their step counts, calorie burnt, and heart rate.

It is interesting to notice here that factors such as having good-sized screen, better battery life, being lightweight, multitasking, and ease of use motivated better user acceptance of the device. Whereas, factors such as having no screen, easy to wear, lightweight, fashionable accessory encouraged prolonged use of the device mainly during physical activities. Some of the factors such as ease of use, battery life, and lightweight were common factors in

improving user acceptance and encouraging prolonged use of the device both at the same time. This finding could be useful towards improving AMDs to improve continuous engagement with the users. Some of these factors found to relate to each other such as better battery life and being fashionable lead to using the device during social engagements, hence encouraging prolonged use of the device. In addition, factors such as having no screen, being lightweight and easy to wear, increased the perception of robustness, safety and adoption of the device in daily life, therefore encouraging the prolonged use of the device.

5.3.2 Usability Issues

In the beginning of the usability study, the participants faced incompatibility issues between SWB applications and older version of SP's Operating Systems. It was later resolved by using the latest Android smart phone for the study. The SWB device has a vibration feature that makes SWB vibrate when user receives a notification, but sometimes it seemed to vibrate for no reason. Therefore, the user tried to see if any information was available on SWB's mobile app interface to display some sort of notification visually. However, they did not find any notification displayed in the mobile app interface for when SWB vibrated suddenly. Hence, the participant found such random vibrations to be confusing and annoying when busy in some other activities. During the usability study, the participants reported many usability issues with the devices that were affecting their user experience with the device. The participants observed the SP to have many applications running in background, taking up most of the processing power and battery life. The participants found it irritating. The participants told S-health app in SP to be an average app involving tedious process to enter food options into the app interface. The participants reported the pedometer application intermittently shows inaccurate results for step counts.

Sometimes, the participants found navigating in SW's interface difficult due to smaller screen size leaving less room for navigation. In addition, typing text messages on small screen of SW was found to be hard or limitation for the participants. The participant found Bluetooth used by SW and SWB to synchronize the data with SP to be draining the battery

life faster than the normal use of the device. Surprisingly, the battery life of both wearable devices was unaffected during Bluetooth usage. Only the SP device had experienced shortened battery life when used along with a wearable device. Hence, the participants had reported issues with Bluetooth usage draining the battery (of the SP) faster. One of the participants said,

> *"Because [SW] using Bluetooth [to communicate with SP], before I was using this [SW]. After work, the battery life [of SP] was 50% or 40% left. But now I am using it [SW]. Its [SP's battery life] is 20% [left]. So it is consuming more battery of [SP]" -* ***Jack***

As mentioned above, Jack observed that the SP's battery was draining much faster when he was using SW or SWB device via Bluetooth. On other occasions, the SP battery was lasting longer. This shows that SW and SWB's dependency factor on SP was affecting the battery life of SP, causing it to be charged more often than needed and hence affecting device's opportunity for prolong usage. This could be a valid scenario to reassess the Bluetooth usage techniques of SW and SWB to minimize such battery draining issues observed in SP. Such usability issue could affect ability to prolong usage of SW/SWB device due to concerns over reduced battery life of SP.

5.3.3 User Acceptance Issues

User acceptance plays a crucial role in adoption of an AMD for prolonged use. In this study, the researcher aimed at finding user acceptance issues with the AMDs that could affect the prolonged use of the device. Interestingly, the researcher found many factors that the participants did not like about the devices. More than one participant mentioned about SP's plastic back cover to be tacky and less appealing. The back cover made SP look 'cheap' to them. The back cover also found to be slippery enough to slip-off the hand and fell on ground during physical activity such as gardening. One of the participants said,

> *"I don't like the texture of this back [SP]. Yeah its kinda plastic texture, bit cheap like material. I prefer more metallic finish."* ***- Anna***

The SW was nice and easy to wear, but tend to feel heavier towards the end of the day and one participant always felt to take off the SW when he went home. The participant reported that the metal pin at the end of SWB was obtrusive and distracting while the participant sat on the desk to study or use laptop's keyboard. Neither SW nor SWB are waterproof. The participants suggested that smaller or no display makes SW and SWB dependent on the SP device. The participants reported the SP is an independent device that they could use over a prolonged period. However, they noticed the SP to be hungry for mobile data while on the move.

One of the participants found SP to be a fully independent, SW to be a semi-dependent and SWB to be a fully dependent device. He said,

> *"Phone [SP] can be used by itself. Independently. So I don't need any other device to use this. All the features. But this [SW] requires phone to connect and it requires android 4.0 or more. Yeah. But without connection [with SP]. I can still use [SW] to see the time and pedometer, heart rate, but I cannot get any notification [such as text messages] or call [on SW]. Oh, I can use camera [on SW]. For SWB, I don't [always] need SP because it [SWB] does not have screen. So I need phone [SP] to transfer data from the device [SWB] and see the data on the phone [SP]. But without phone [SP] I cannot use it [SWB]. But, this [SW], I can use half features. So [SW is] half independent"* ***– Jack***

The features related factors were one of prominent findings of the research process that encouraged prolonged use of AMDs. The researcher noticed that more the features offered by the device, the more the users attached to the device emotionally. During the analysis, it is also found that easy to wear and long battery life of the device were the most prevalent factors in choosing the device especially for use during physical activity.

5.4 Chapter Summary

As per the findings and discussion explained in this chapter, following the generic thematic analysis on data collected helped the researcher to identify the factors that encourage prolonged use of AMDs. The field notes and comments from interview recordings support these findings. The analysis also showed the inter-relationship between different factors within each group and across groups as well. Some of the factors such as ease of use, battery life, and lightweight were common factors in improving user acceptance and encouraging prolonged use of the device both at the same time.

This finding could be useful towards improving AMDs to improve continuous engagement with the users. Some of these factors relate to each other such as better battery life and being fashionable led to using the device during social engagements, hence encouraging prolonged use of the device. In addition, factors such as having no screen, being lightweight and easy to wear, increased the perception of robustness, safety and adoption of the device in daily life, thus encouraging the prolonged use of the device.

Six usability characteristics were successfully identified that played crucial role in encouraging the participant for prolonged use of the AMDs. The researcher noticed few usability issues and user acceptance issues during this discussion and outlined in this chapter. The research has been successful in providing direction to further this research on bigger group to fortify the findings from the study and identify new usability factors that could improve or affect prolonged use of AMDs.

6. Conclusion

6.1 Introduction

This chapter summarizes the conducted research along with the suitability of the findings to the research question and objectives as identified at the start of this research. To begin with, the research background and the literature review to equivocate the research objectives and research question are stated. This then led to the search for candidate who would like to participate in the research for the usability study. This chapter discusses the data collected from the research, the systematic analysis and the findings in detail. This chapter then discusses the overall finding in the context of the literature and research methodology. The chapter concludes with how this research inspires the future work in similar area.

6.2 Research Summary

This study started with the literature review of recent work conducted in the field of mobile devices, especially activity-monitoring devices. The researcher had performed the formative part of the literature review before the research started, with an aim to identify the gaps in the current research and related work done. The understanding gained from this initial literature review led the researcher to define the goal for and to conduct the research. Later on, the researcher performed further research to fortify the research topic for this study. This effort led the researcher to form the definitive research objectives that

eventually sparked the most appropriate research question for this study. The researcher chose ethnography as a research methodology for this study. The ethnographic methodological approach allowed for affluent data collection and deeper understanding of the participant's perspective towards using AMDs over a prolonged period.

The researcher gave the participants their choice of AMD from the available devices for the study. The participants used the devices with much needed enthusiasm, curiosity and commitment to give invaluable feedback of using the AMDs over a prolonged period. The researcher had actively been observing the user emotions and expressions right from the user orientation session until the final debriefing sessions, to collect quality data records in the form of field notes. The video recordings from the user interviews and the field notes taken by the researcher were then analysed rigorously to apply generic thematic analysis. The thematic analysis also helped to develop coding techniques that would form meaningful themes from the data collected from significant usability study performed on a small group of NZ Adults. This followed by task of drawing findings from the data analysis that would address the research objectives for the study. The researcher conducted a meaningful discussion on the findings from the study to answer the research question.

6.3 Result Summary

The research conducted identified the usability factors that encourage prolonged use of AMDs by performing generic thematic analysis on the data collected through face-to-face interviews and field notes. This research thesis successfully identified six usability characteristics that played crucial role in encouraging the participant for prolonged use of the AMDs. These six identified characteristics of usability were display screen, lightweight, battery life, multipurpose, social engagement and easy to carry/wear. The data analysis also showed the cross-relationship between different factors within each group and across groups as well. Some of the usability factors such as ease of use, battery life, and lightweight found to be common factors in improving user acceptance and encouraging prolonged use of the device both at the same time. This finding could be useful towards improving AMDs to improve continuous engagement with the users.

Some of these usability factors also found to work with each other such as better battery life and being fashionable lead to using the device during social engagements, hence encouraging prolonged use of the device. In addition, factors such as having no screen, being lightweight and easy to wear, increased the perception of robustness, safety and adoption of the device in daily life, therefore encouraging the prolonged use of the device.

This research thesis has observed and recorded some of the usability issues and user acceptance issues faced by the participants during prolonged use of the AMDs. Bluetooth communication feature of the SP found to be draining too much battery life when paired with SW or SWB for synchronizing the data between devices. Wearable devices found to be dependent on smartphone sometimes for data synchronization and other times for relaying notifications onto the SP for user to read it. Some of the apps in SP found to be continuously running in background raising concerns of unnecessary battery consumption. The participants also reported their annoyance about the meal entering options in SP to keep track of calorie intake of the participant due to tedious data entry involved in recording food options in the device. Random vibrations from screen-less SWB were found to be confusing and irritating enough to often distract the user and question the purpose behind those vibrations as they were not even shown on their respective mobile app in SP.

6.4 Research Objectives met

At the start of this research, the researcher defined three research objectives. This section discusses the appropriateness of the findings to each of these research objectives,

6.4.1 Research Objective 1: Identify Usability Characteristics that encourage prolonged use of an activity monitor

As discussed earlier in the result summary, the study successfully found six usability characteristics of an AMD that could improve its adoption over a prolonged period. The researcher successfully captured and analysed the participant's feedback in varied user context to give in-depth understanding of relevance of usability characteristics to different type of physical activities. The influence of certain usability characteristics in particular

context such as using screen-less SWB observed to be more preferred for physical activities.

6.4.2 Research Objective 2: Identify User acceptance issues arising from prolonged use of activity monitor devices

As stated in the result summary, the researcher has successfully met the objective to identify any user acceptance issue that may arise from prolonged use of an AMD. This study successfully recorded user acceptance issues such as plastic body of SP was not liked by the participants, SP was found to be slippery; even though SW was easy to wear, it felt heavier by the end of the day; SW and SWB were dependent on the SP for data synchronization and notifications purposes;

6.4.3 Research Objective 3: Identify Usability issues arising from prolonged use of activity monitor devices

As mentioned in the result summary, the researcher has successfully recorded the usability issues arising from prolonged use of an AMD in this research. The researcher has successfully identified major identified usability issues such as,

- Random vibrations on SWB
- Too many idle applications consuming battery life of SP
- Meal entering options in SWB mobile app
- S-health mobile app reported to be irritating and tedious
- The pedometer application intermittently recorded inaccurate step counts
- Bluetooth was draining too much battery life of SP when paired with SW and / or SWB.

6.5 Research Question met

The research conducted has been successful in finding answers to the research question "What are the characteristics of usability that encourage prolonged use of an activity-monitoring device?"

As stated in the result summary, the study has successfully identified the characteristics of usability that encouraged prolonged use of AMDs and outlined its influence on technology acceptance level by user. The research approach used was ethnographical methodology that gave opportunity to collect rich data for performing generic thematic analysis and to draw relevant conclusion in the study. The findings of this study are more appropriate to AMDs selected and the specified target population used for this research.

To appropriately answer the research question, six characteristics of usability are identified such as display screen, lightweight, battery life, multi-purpose, social engagement and easy to carry/wear. These characteristics of usability of AMD found to affect user's decision towards its prolonged use. Further data analysis also showed the cross-relationship between different usability factors within each group and across groups as well. The researcher successfully found the user acceptance issues and usability issues arising from the prolonged use of the AMDs negatively influences the user's inclination towards using the device for a prolonged period.

6.6 Future Work

The research has been successful in providing a list of characteristics of usability that encourage prolonged use of AMDs. However, this study was conducted on a smaller group of 4 NZ adults over short span of one year. Hence, future work as an extension to this study would be to conduct the research on bigger group of at least 20 – 40 participants. Such extensive usability study could be beneficial to fortify the findings from the study and possibly identify new characteristics of usability that could improve or affect prolonged use of AMDs during performing physical activities.

In this study, only three types of AMDs were used. Therefore, more variety in the type of AMDs would be interesting to study over a prolonged period as part of future work.

6.7 Chapter Summary

This chapter has summarized the literature review done for this study, and then briefly stated the results of the research. Then the chapter explained the appropriateness of the findings from the study to the research objectives and research question. This chapter also gives future direction of work to expand the findings from this study and extend research over a bigger group with more types of AMDs. As noted in this chapter, the study has been successful in satisfying the research question and meeting the research objectives to identify the characteristics of usability that encourage prolonged use of an activity-monitoring device. The study has successfully recorded and outlined the usability and user acceptance issues arising from prolonged use of an activity-monitoring device.

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Appendix A - Participant Information Sheet

Participant Information Sheet

Date Information Sheet Produced: 30th July 2014

Project Title

Identifying the characteristics of usability that encourage prolonged use of an activity monitor.

An Invitation

My name is Poonam Pushkar Dhawale. I am currently undertaking my Master of Computer and Information Sciences (MCIS) thesis at the Auckland University of Technology (AUT). I would like to invite you to participate in my research. I believe that you could help me to collect data that will allow me to evaluate how useful activity-monitoring devices can be. Your participation in this research is

entirely voluntary and you may withdraw at any time, prior to the completion of data collection, without any adverse consequences.

What is the purpose of this research?

The purpose of this research is to identify the characteristics of usability that encourage prolonged use of an activity monitor. The outcomes from this study may have significant implications on the methods we use to improve the usability of mobile devices. The study will also be helpful to understand various usability and user acceptance issues that could discourage prolonged use of activity monitors, and avoid them in the future, to improve the usability of such devices.

How was I identified and why am I being invited to participate in this research?

You are being invited to participate in this study because you responded to a flyer and you fit the selection criteria of the participants that are needed. You may be a student of the supervisor and participate in this research only if you are not conducting this research.

What will happen in this research?

In the research, you will be given three types of monitoring devices (to use) that are smartphone, smart watch and smart wristband for a period of time. You can choose to use your own smartphone, if it is similar to the smartphone used in this study. You will be asked to carry the monitoring device with you, so that it can monitor your physical activity. The study data will be collected periodically and at the end of the study. During the trial of the monitoring device, we would appreciate it if you could come in and talk about your experiences with the technology. These talks would be conducted in the AUT HCI Lab.

What are the discomforts and risks?

There is no perceivable risk in participating in this research beyond that which is associated with carrying a cell phone. The only discomfort is that you will be asked to carry the monitoring device you were given and follow the instructions to the best of your ability.

What are the benefits?

You will be provided with feedback from the trial and you will learn how a monitoring device may be used in the future to help improve your health through physical activity.

How will my privacy be protected?

To protect confidentiality of the participants all records will be stored in a secure location for a period of 6 years after the completion of this study and only the primary researcher and the applicant will be able to access them. Furthermore, the personal data that identify the participants will be known to the researcher only. No sensitive data will be released in any report based on the research.

What are the costs of participating in this research?

The only cost to you will be the time that you can give to the study. This involves using the device and the time that you can commit to talking to us about the device.

What happens if a student loses or damages a phone/devices?

The Monitoring devices are the property of AUT. You are not going to be held liable for any unintentional damage or loss; however, we do expect you to handle the device with care.

What opportunity do I have to consider this invitation?

Your participation is entirely voluntary. It would be appreciated if you could contact the primary researcher within 2 weeks of receiving the invitation.

How do I agree to participate in this research?

By signing and returning the consent form.

Will I receive feedback on the results of this research?

The results will be first published in the form of a thesis. If you wish to, you will be sent an email with the thesis URL once it is available online. We will also provide you the data from the device that you have been wearing.

What do I do if I have concerns about this research?

Any concerns regarding the nature of this project should be notified in the first instance to the Project Supervisor, Dr. Robert Wellington, Email Address: robert.wellington@aut.ac.nz, Work phone number: +64 9 921 9999 ext 5432.

Concerns regarding the conduct of the research should be notified to the Executive Secretary, AUTEC, Kate O'Connor, Email Address: ethics@aut.ac.nz , Work phone number: +61 9 921 9999 ext 6038.

Whom do I contact for further information about this research?

Researcher Contact Details:

Poonam Pushkar Dhawale,

MCIS student,

School of Computing and Mathematical Sciences

Auckland University of Technology

Email: poonam.p.dhawale@gmail.com

Project Supervisor Contact Details:

Dr. Robert Wellington,

School of Computing and Mathematical Sciences

Auckland University of Technology

Email: robert.wellington@aut.ac.nz

Work phone number: +64 9 921 9999 Extension: 5432

Approved by the Auckland University of Technology Ethics Committee on 19th March 2015, AUTEC Reference number 14/252.

Appendix B - Participant Consent Form

Participant Consent Form

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Project Title

Identifying the characteristics of usability that encourage prolonged use of an activity monitor.

Project Supervisor

Dr. Robert Wellington

Researcher

Poonam Pushkar Dhawale

- ○ I have read and understood the information provided about this research project in the Information Sheet dated 30th July 2014.
- ○ I have had an opportunity to ask questions and to have them answered.
- ○ I agree to carry with me and use as instructed the monitoring devices provided.
- ○ I understand that notes will be taken during the interviews and that they will also be video/audio-taped and transcribed.
- ○ I understand that I may withdraw myself or any information that I have provided for this project at any time prior to completion of data collection, without being disadvantaged in any way.

- ○ If I withdraw, I understand that all relevant information including electronic records, tapes and transcripts, or parts thereof, will be destroyed.
- ○ I agree to take part in this research.
- ○ I wish to receive a copy of the report from the research (please tick one):

  Yes○ No○

Participant's signature: _____

Participant's name: _____

Participant's Contact Details (if appropriate):

_____
_____
_____

Date: _____

Approved by the Auckland University of Technology Ethics Committee on 19th March 2015, AUTEC Reference number 14/252.

Note: The Participant should retain a copy of this form.

Appendix C - Recruitment Flyer

Do you want to get active?

Are you more than 18 years old?

Hello, my name is Poonam Pushkar Dhawale. I am currently undertaking research for my master's thesis at AUT. I would like to invite you to participate in my research. I believe that you could help me to collect data that will allow me to evaluate how useful activity-monitoring devices can be.

Your participation would entail using an activity monitor for a while and talking to me every week about how you use it. The activity monitor could be software on your own cell phone, a wrist device, or another type of cell phone. If you are interested please send me an email and I'll send you more information.

Researcher Contact Details:

Poonam Pushkar Dhawale,

MCIS student,

School of Computer and Mathematical Sciences,

Auckland University of Technology

Email: poonam.p.dhawale@gmail.com

Appendix D – Video Protocol

Date Video Protocol Produced

28th Jan 2015

Project Title

Identifying the characteristics of usability that encourage prolonged use of an activity monitor.

Project Supervisor

Dr. Robert Wellington

Researcher

Poonam Pushkar Dhawale

Version: 2

Video Protocol

In this document, the video protocol used for the study is explained.

- Regular interviews will be taken during the period of study to capture user feedback
- The interviews will be video recorded each time pending participant's agreement.
- If participant is not comfortable with video recording his session then the researcher will request for audio recording.
- The interviews will be conducted in the AUT HCI lab

- All records will be stored securely at AUT/WT 136, in a locked cabinet for a period of 6 years after the completion of this study and only the primary researcher and the applicant will be able to access them.
- Furthermore, the personal data that identify the participants will be known to the researcher only. No sensitive data will be released in any report based on the research.
- Participants will be requested to come to AUT HCI lab for interviews.

Seating arrangement for the Interview

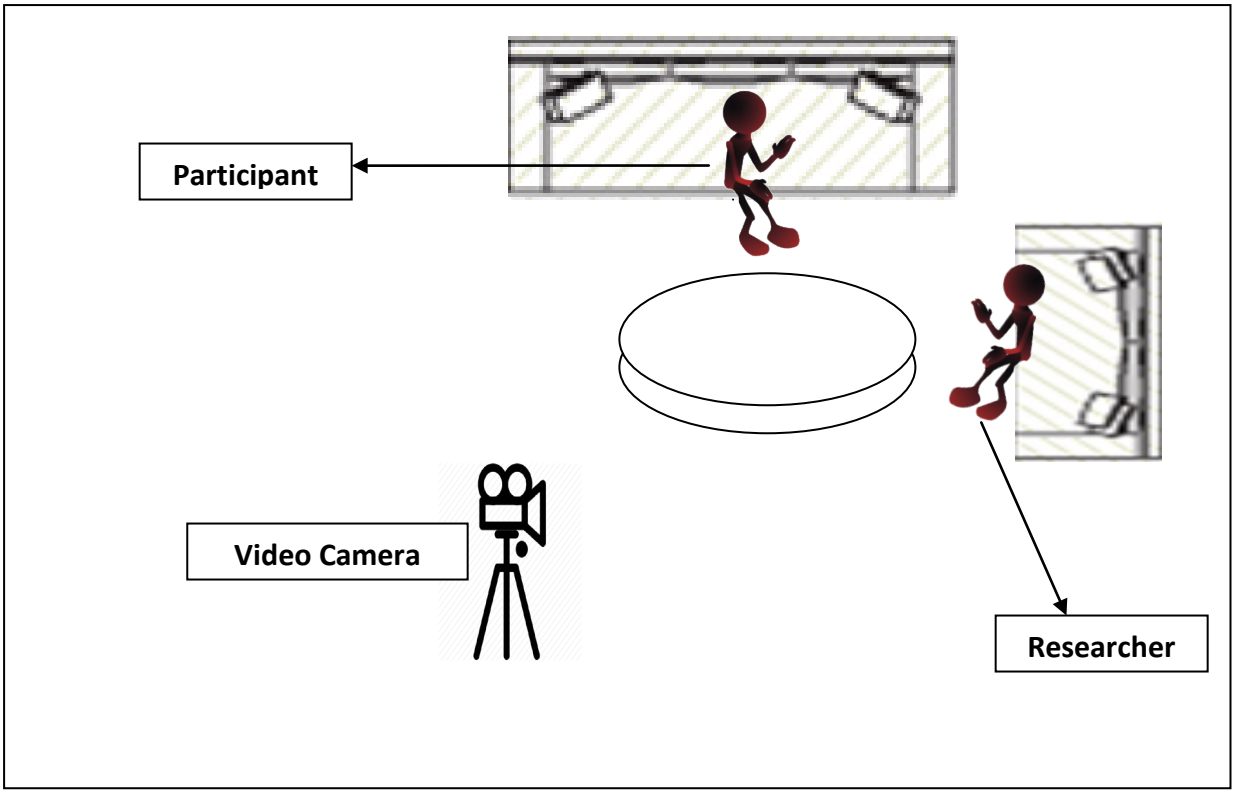

Figure 5: Seating arrangement for the interview

The sitting arrangement for the interview session is shown in Figure 5 above.

- The participants will seat on Sofa (as shown in Figure 5) during the interview.

- The Interviewer will seat on the adjacent sofa/chair (as shown in Figure 5) to have a conversation with the participants.
- All the Monitoring devices used for the study will be placed on the table in front of the sofa. So that the participant can have a look at on all the devices and choose the devices that they want.
- Camera will be arranged diagonally opposite of the sofa so that the participant's facial expressions and body gestures could be captured properly.
- Downloading video files (from video camera), file management, archiving of raw data etc. will be done on computer provided by AUT HCI lab.

Appendix E - Indicative Interview Question

The use of 'Interview' here is considered loosely, as there may be many opportunities to meet with the participants over the course of the study, and data about usability may arise at any of these occasions, be they structured (ie. an orientation session, a debrief session) or informal conversations occurring through casual meetings or visits by the participants during their use of the devices.

Orientation Session

In the Orientation session, the researcher will greet the participant and explain the study undertaken. The information sheet will be handed to the participant and completed consent form will be collected accordingly. Then the researcher will show the three devices used for the study. The participant will be asked to chose from these devices based on his liking at that moment. The researcher will explain few little instructions on how to get started with using the device. The researcher will give further assistance to the participant in using the device upon the participant's request. Following type of questions will be asked in the orientation session:

1. How are you doing?
2. Which device would you like to use?
3. Do you know how to use the device?
4. Do you need any guidance to know how to use the device?

Casual Meeting

The casual meetings will be conducted every 2 - 4 weeks depending upon the participant's availability. In the casual meeting, the participant will be encouraged to talk as much as they could about their experience using the device. Following type of questions may be asked to get feedback from the participants.

1. How did your week go?
2. What is your first impression about this device?
3. How did you feel using this device?
4. Did you face any problem using this device?
5. Which feature do you find useful?
6. Was it difficult to wear/hold this device for your daily routines or physical activity?

Debrief Session

Debrief session will be conducted as the last interview with the participant when he/she finishes using the devices and hands over to the researcher. Following type of questions may be asked during the debrief sessions:

Usability issues

1. How easy is it to use this device?
2. How reliable is this device when used over a long period?
3. What did you dislike about the device?
4. What stopped you using this device?

Design aesthetics of Device

1. Which device did you find more appealing?
2. How do you find the screen layout / size on device?

Acceptance issues

1. How easy was it to use this device over prolonged period of time?
2. Do you think this device will make you look cool and classy in front of your family and friends?
3. Did you use this device while doing your physical activity?
4. How did it help you in improving your physical activity?

FORM PGR15 DEPOSIT OF THESIS/EXEGESIS/DISSERTATION IN THE AUT LIBRARY

PLEASE NOTE	• *This form must be typed. Handwritten forms will not be accepted.* • *The completed and signed form should be bound into the copy of the thesis/exegesis intended for the AUT University Library* • *If the work is to be treated as confidential or is embargoed for a specified time, form PGR16 must also be completed and bound into the thesis/exegesis.*

Student ID No	1120051	**Name**	Poonam Pushkar Dhawale
Faculty	Design and Creative Technologies	**School/Dept**	School of Computer and Mathematical Sciences
Programme	MCIS	**Year of submission** (for examination)	2016
Research Output	**Thesis** ☒ **Exegesis** ☐	**Dissertation** ☐	**Points Value** 120
Thesis Title	Identifying the characteristics of usability that encourage prolonged use of an activity monitor.		

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