DECISION MAKING WITHIN MISSING PERSON INCIDENTS

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ABSTRACT

Every year the police receive around a quarter of a million reports of missing people in England and Wales alone. Missing Incidents are not only traumatic and potentially dangerous for those involved, but are also likely to contribute to overall public spending; both with respect to the resources required for Missing Person searches, but also due to the increased likelihood of the breakdown of familial care following difficult to manage behaviours. Effective responses to these incidents are imperative, but there is little understanding of how missing person incidents unfold from the perspective of carers and parents.

The thesis draws together several disparate research areas, alongside original research, which helps to elucidate how those responsible for a person with care and support needs search, navigate and make decisions under stress and lays a framework of understanding for future research. The work described in this thesis takes a three stage approach; description, prediction and intervention, in order to develop a systematic understanding of how missing incidents unfold, how decision-making within missing incidents can be predicated, and ultimately how technology could be used to address the problem.

An initial interview study describes how missing incidents unfold and identifies the important decisions made by carers and search and rescue volunteers. Using this understanding, a vignette study was conducted which led to the development of a predictive model of behaviour during missing person search and the identification of factors which influence decision-making under these conditions. Effective communication is a crucial requirement for carers conducting Missing Person searches; both for material assistance and emotional support. Based on these findings, the final study of this thesis tested a novel prototype technology using an experimental design in a naturally occurring environment. Several evidence-based recommendations were produced as a result of this work which are intended to inform the design of new technologies for supporting missing person searches and may be of use to technology developers, policy-makers, care providers and other stakeholders.

PUBLICATIONS

The following publications have been written within the timescale of this PhD research:

Conference Proceedings

Harrington, K., Fulton, P., Brown, M., Pinchin, J., & Sharples, S. (2015). Digital Wellbeing Assessments for People Affected by Dementia. In M. Kurosu (Ed.), *Human-Computer Interaction: Users and Contexts: 17th International Conference, HCI International 2015, Los Angeles, CA, USA, August 2-7, 2015, Proceedings, Part III* (pp. 409-418). Cham: Springer International Publishing.

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1 INTRODUCTION

1.1 OVERVIEW

This introductory chapter will demonstrate the real-world need for research within the area of missing person search, highlighting briefly the economic and human costs associated with missing incidents. Of particular importance to this thesis will be an investigation of "informal" missing person searches for people at risk (including those with care and support needs) conducted by carers and guardians for the purposes of developing a series of design recommendations which may assist technology developers in creating effective solutions based on human need and observed behaviours. This chapter will describe a three-stage approach to addressing the problem (description/prediction/intervention) and declare the aims and objectives of the research, which will serve as a framework for the thesis.

1.2 BACKGROUND

Informal and familial carers are estimated to have an economic contribution in the UK of £132B a year, which is approximately the total annual spend on the NHS (Buckner & Yeandle, 2015). The main factor in the breakdown of care and subsequent institutionalisation of those with care and support needs is carer burden caused by difficult to manage behaviours. Missing incidents are one of the main stressors responsible for both carer burden and subsequent institutionalisation (Rowe et al., 2011).

Therefore, it is imperative that guardians and care givers are equipped with the tools and strategies to deal quickly and effectively with these situations as and when they occur; both to minimise the immediate risk of the care recipient and to reduce the long-term likelihood of the breakdown of care.

Every year the police receive around a quarter of a million reports of missing people in England and Wales alone (Bureau, 2016). Furthermore, it is thought that many missing person incidents may go unreported. Whilst the vast majority of missing people return home safely, missing incidents present a serious risk to both children (Biehal, Sinclair, & Wade, 2015; Lampinen, Peters, Gier, &

Sweeney, 2012) and adults (Ali et al., 2016). It is estimated that up to 80% of adults who go missing also have mental health issues, thus increasing the risk to their own safety (Missing Persons Data Report 2014-2015). People with care and support needs and others who could be considered 'vulnerable' are much more likely to go missing than the general population and are at much greater risk of injury or fatality if they do. (Perkins, 2013; D. Perkins, P. Roberts, G. Feeney, & M. Penrith, 2011a).

Dementia patients alone constitute over 15% of all search and rescue operations in the England and Wales (Perkins, 2013; Perkins et al., 2011a), yet only represent around one percent of the population. Not only is the prevalence of vulnerable adults who go missing disconcerting, but so too are the associated risks. Koester & Stooksbury (R. Koester & Stooksbury, 1992; R. J. Koester & Stooksbury, 1995) report that those adults living with dementia who were not found within twenty-four hours have a mortality rate of around fifty percent. Whilst much has changed in the intervening years since the work of Koester & Stooksbury, Bantry White and Montgomery (2016) note that there is a dearth of literature which investigates the risks of vulnerable adults who are missing. Additionally, there is great variability of the survival rates of missing individuals in more recent studies. In a retrospective observational study, Bantry White and Montgomery (2015) report that incidents of harm were relatively rare amongst missing people, and indicate that in their study people only sustained harm in 15 of the 281 incidents, and that only two of whom were found deceased. Contrastingly, a similar study conducted by Hunt, Brown, and Gilman (2010) indicates a mortality rate of around 15% for vulnerable adults who become missing. It is suggested by Bantry White and Montgomery (2015) that this variability may be due to differences in climate and environment and that even in their study, there was still considerable risk to missing persons. Similarly, the survival rates of other vulnerable adults who go missing (including 'despondents', those with cognitive impairments, mental illness and/or drug dependencies) are reported to be much higher than that of the general public (Perkins et al., 2011a).

People living with dementia (PWD) represent a special case within missing person search activities. Not only are they overrepresented in search and rescue

operations, they are also particularly vulnerable to falls and environmental variation due to their average age and cognitive impairment. PWD are also prone to 'Wandering Behaviours', which may exhibit themselves in a variety of complex ambulatory patterns (Hope et al., 1994; Lai & Arthur, 2003). Certain neurological differences also indicate that those who are elderly or suffer from Mild Cognitive impairment find navigation tasks significantly more difficult (Moffat, Elkins, & Resnick, 2006). PWD and their carers are also important to consider in terms of their specific user-requirements for assistive technologies in light of the fact that people over 65 are reported to be the lowest demographic of internet users (Age.co.uk). Additionally, certain cognitive difficulties such as language processing, reasoning and complex task completion present additional barriers to technological inclusion.

Whilst there is a wealth of research into laboratory-based visual search tasks (Ellison, Schindler, Pattison, & Milner, 2004; Kiss et al., 2007), other research into the experience of families of the missing, and some Human Factors research into Search and Rescue operations (Julie A. Adams et al., 2007; Julie A Adams et al., 2009; Plant & Stanton, 2016), very little research has systematically addressed missing person incidents prior to police involvement. Recently, however more research has evaluated the impact of technology designed to help with missing person incidents, but this area of research is within its infancy (Megges, Freiesleben, Jankowski, Haas, & Peters, 2017).

1.3 RESEARCH QUESTION AND APPROACH

1.3.1 Research Question

"How can technology be used to support guardians and carers during missing incidents?"

This thesis will focus on the behaviour of caregivers as they conduct missing person searches prior to police involvement. Specifically, this work will investigate the decision-making strategies employed by caregivers as they attempt to find people with care and support needs. The aim of the thesis will be to discover the challenges and constraints faced by carers and parents in

"real-world" missing person searches, to predict the likely behaviour of people engaged in missing person search and to suggest guidelines for possible technological interventions based on a knowledge of likely behaviours and psychological needs.

In order to answer this question adequately, this thesis will adopt a three-stage approach consisting of description, prediction, intervention. Each of the stages builds upon the findings in the last in order to create effective interventions based on an understanding observed behaviours during missing incidents. This approach enables technologies to be designed which fit the needs of users as they currently occur, rather than developing technologies which may not necessarily be compatible with the naturally occurring behaviours. It is hoped that recommendations which are based on a comprehensive understanding of naturally occurring behaviours will assist in the management of missing incidents, improving outcomes and reduce carer burden.

The three stage approach outlined, broadly lines up with the three goals of scientific research, as defined by Hale (2011) and McBurney and White (2009); description, prediction and control, where each stage of understanding builds upon the findings of the last. This approach is particularly relevant to behavioural and cognitive science, where we may wish to change the behaviours and/or cognitions of groups and individuals by developing an understanding of how situations unfold, the factors which effect behaviours and interventions based upon those understandings.

Description

Description is the act of defining, classifying and categorizing naturally occurring phenomena and consists of a collection of facts about observed events. It entails a preliminary understanding of the problem in its full context. McBurney and White (2009) define description as a crucial first step in any new field of scientific research. In the descriptive stage, events and entities under consideration must be documented and categorised. This initial step allows a consensus to form around the field of inquiry under investigation. Descriptions of events or phenomena may be based on a relatively small number of examples and can be entirely qualitative and at this stage. McBurney and White (2009)

draw parallels between the necessary descriptive stages of cognitive science and the pioneering work of the early naturalists who attempted to document and classify all living forms. Not only is description the collection of data and understanding of the current state of affairs, "its focus is on the discovery of meaning" (Ololube & Kpolovie, 2012). Descriptive studies therefore, are appropriate when the subject of consideration is little understood and lacks consensus of even basic definitions, often descriptive work may take the form of observational studies, case studies or surveys (Hale, 2011). At this stage, preliminary hypotheses can be formed, but the central focus is about discovery, classification and consensus building around definitions. Description is crucially important because it defines the subject matter for which the laws are sought (McBurney & White, 2009).

This thesis will begin by describing missing person incidents involving people who could be broadly considered to be at risk. These include children, people with mental health problems, adults with care and support needs, and in particular, elderly people with dementia. A literature review will detail existing research related to this area, and an in-depth analysis of a series of semi-structured interviews will explore decision-making during missing incidents and provide additional context to the problem. These chapters taken together will be the descriptive framework upon which the subsequent work will be informed.

Prediction

Predictions are based on repeated observations and detail the relative probability that one even will proceed (or not proceed) another, or that a particular event will occur given a certain set of conditions. At the predictive stage of research, causal relationships are not fully defined, but correlations between variables are established. In practice, this means that we are able to demonstrate one event is likely to occur after another, without fully understanding why. At the predictive stage of research, theories can be generated about the relationships between two or more variables. Such theories entail empirical predictions which are a necessary component of all scientific research (McBurney & White, 2009). At the predictive stage, predictions must

be operationalised in such a way that they can be verified and tested in an unambiguous and repeatable fashion; but moreover, they must be capable of being falsified (Popper, 2014). At the predictive stage of scientific exploration, theories should entail real-world consequences about the relationships between the variables of interest which have been identified during the description stage. Further, the closeness of the theories predictions can be tested against the observed outcomes in order to see how well these predictions perform; which may give some indication of the predictive power of the underlying theory.

The predictive aspect of this thesis will be a predictive model of decision-making during missing person incidents and will be presented from data elicited from a pool of 272 participants, described in chapter 4. The model will illustrate 'typical' missing person incidents, and explore other factors which influence people's actions during missing incidents; including differences between parents and carers, the role of emotion in decision-making and how the mobility independence of care recipient affects carer-giver behaviour in missing incidents.

Control / Intervention

The final stage of scientific explanation is control/intervention (McBurney & White, 2009) which is the third aspect of the goal of discovering regularities of behaviour. At this stage, predictions have been formalised and expressed in terms of laws. Individual facts which pertain to the subject matter can be shown to be instances of general laws, and laws themselves are explained in turn by their relations to an overarching theory. At such a level of explanation, it becomes possible to suggest new modes of operation, to develop new technologies and to propose interventions which are based on this more comprehensive understanding. For example, an understanding of the germ theory of disease, facilitates disease prevention which is based upon hygiene and anti-biotics.

In the current context, based on an understanding of a predictive model, it becomes possible to suggest interventions that seek to change the behaviour of individuals to behaviours that are more likely to lead to more favorable outcomes, to reduce stress, or to increase efficiency.

Methods of Control / Intervention will be proposed in the later part of the thesis, these will be devised based on a thorough understanding of how people behave during missing incidents. A specific technological intervention designed to help teams conduct missing person searches will be developed and tested in a field trial. Moreover, general lessons will be drawn from the research in order to form the basis of a series of design recommendations for the development of assistive technologies aimed at facilitating better outcomes in missing incidents.

1.3.2 Aims

The three aims of this thesis each represent one of the stages of prediction, descriptions and intervention.

1. **To establish a descriptive framework for understanding Missing Incidents, based upon a synthesis of relevant existing research and an investigation into "real-life" missing person searches.**

   To determine typical decision-making sequences within "real-life" missing person searches prior to police involvement and to identify challenges and constraints faced by searchers. The initial aim of the thesis is to discover typical strategies employed by those searching for vulnerable people and the context in which missing person search typically occurs. Additionally, the work will aim to explore the key stages of missing person search from the period immediately following a noticed absence to the missing person being reported to the police.

This aim was addressed in detail in study 1 (Chapter 3) and explored again in study 2 (Chapter 4). Chapter 3 details a series of interviews with both Search and Rescue experts and the carers of adults with care and support needs, all interviewees had experience in searching for an adult who could be considered at risk. It is hoped that by interviewing two different groups, different search strategies can be examined and evaluated and by describing current best practice, lessons may be learnt which are applicable to the carer population. One of the purposes of these interviews was to establish "Critical Decisions" made by searchers during missing person incidents, the challenges that they faced and the larger context in which these incidents typically occur. The context here, denoting not only the environmental factors and the specific circumstances of a search activity but, more generally, the emotional and cognitive backdrop to the

situation, as well as the particular constraints of policy. The study detailed in Chapter 4, revisits this exploration and asks respondents to choose from a fixed series of choices and seeks to probe their levels of worry and confidence in their decisions at each stage of the incident.

2. **To form the basis of a predictive model of human behaviour during missing person search, including the identification of factors which affect carer search strategies.**

   There is a great deal of variability in carers' responses to periods of noticed absence and the strategies they employ to find their care recipients. One of the key aims of this research will be to identify which factors affect decision-making in this context. For example, do the specific health, psychological and physical conditions of the care recipient determine the search strategy employed by searchers? Do people search for adults in a different manner than they search for children? Further to discovering 'typical' decision-making sequences during missing person incidents and the identification of factors which influence these decision strategies an aim of this research will be to form a probabilistic predictive model of human behaviour. This model will assist in determining likely decision sequences and could be of use to both policymakers and those looking to develop technological interventions.

Study 2 (Chapter 4) addresses this aim by modelling decisions made during in a text-based missing person scenario as a stochastic process, it seeks to discover whether factors such as care recipient mobility, age and independence influence the search strategies employed by searchers.

3. **To develop evidence-based recommendations and guidance for the creation of future assistive technologies designed to help with missing person search.**

   The final part of this thesis will be to develop recommendations for the development and implementation of assistive technologies based on a comprehensive understanding of the typical decision-making strategies

employed by carers and guardians, which may be of use to technology developers and policy-makers.

A series of recommendations for the development of assistive technologies will be presented in chapter 7 based on an analysis of the results of the previous studies. These recommendations will be informed by an understanding of the typical behaviours of carers and guardians during missing incidents and general attitudes towards assistive technologies.

1.4 OBJECTIVES

1. **Review research related to Missing Incidents; including prevalence, outcomes, and at-risk groups and critically appraise literature relevant to "Search" behaviour and decision-making relevant to the research question.**

2. **Capture the perspectives and experiences of individuals who have experience of Missing Incidents.**

3. **Form a model of guardian and carer behaviour during Missing Incidents.**

4. **Measure the extent to which various carer or care recipient circumstances affect search strategies.**

5. **Elicit the general attitudes held by carers about the use and appropriateness of assistive technologies to assist with missing person search.**

6. **Survey currently available technologies designed to help with carers and guardians manage missing incidents.**

7. **Develop and test a technological intervention which could be used during Missing Incidents.**

8. **Explore how the findings may have practical benefit to care recipients and carers, as well as technology developers, policy-makers and other stakeholders.**

1.5 THESIS STRUCTURE

Figure 1.1 illustrates the structure of the thesis. Chapters are indicated by the corresponding numbers, the research question is highlighted in green, and novel data contributions of the thesis are illustrated in orange. Each of the main study chapters (3,4,5 & 6) builds upon the findings and new understanding developed in the chapter that preceded it.

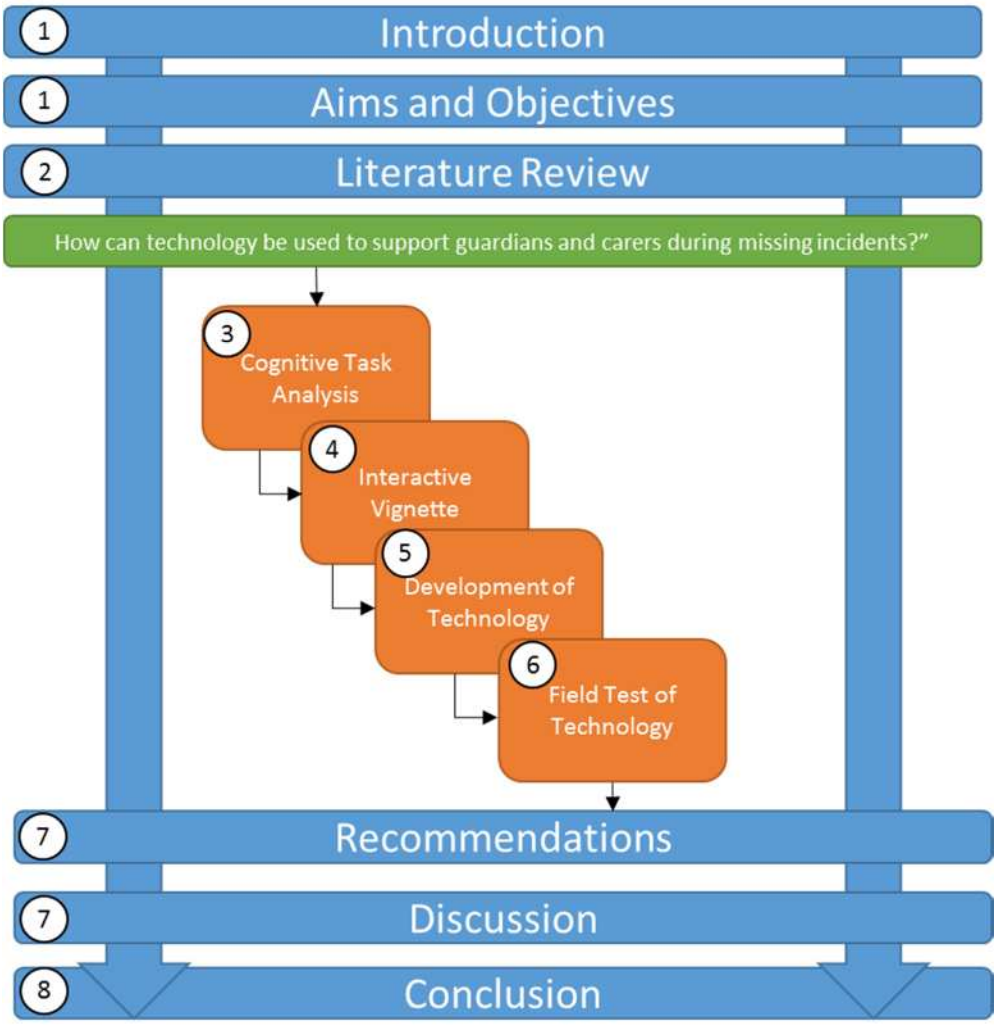


Figure 1.1 Information Flow of Research

Table 1.1 illustrates the objectives which are required to be accomplished in order to achieve the overall aims of the thesis which in turn provide an answer to the research question. The diagram also highlights which chapters accomplish the specified objectives. It should be noted that whilst the chapters and studies described in this thesis broadly align with the objectives specified

in the diagram above, in practice, there is far more overlap between the chapters and objectives than is represented. For example, in order to accomplish objective 8 “Explore how the findings may have practical benefit to care recipients and carers, as well as technology developers, policy-makers and other stakeholders”, all previous work has been considered in the context of the overall question. Similarly, the basis of the predictive model described in chapter 4 was heavily informed by the work which preceded it. Nevertheless, the table below should give the reader a clearer indication of the intentions and motivations for each separate piece of work and moreover provide the reader with a better understanding of how each chapter helps to answer the overall research question.

Table 1.1 Chapter Structure and Objectives

Objective	Aim	Chapter	Description
1	1	2	Literature review to review research related to missing incidents
2	1	3	Interviews with individuals involved in missing incidents
3	1, 2	3, 4	Descriptive and predictive models presented in each chapter
4	1, 2	4	Factors measured as covariates
5	2, 3	5	Questionnaire on technology use and appropriateness discussed
6	3	5	Appropriateness of current technology discussed in chapter
7	3	5, 6	Technological prototype designed and evaluated
8	3	7	Findings discussed in context

1.6 CHAPTER OVERVIEW

2: A Human Factors Approach to Missing Person Incidents

This chapter will introduce the relevant background to the thesis, highlighting not only the prevalence and risks associated with missing incidents involving vulnerable people, but will also introduce relevant theoretical perspectives the thesis will draw from. The first part of the chapter highlight the dangers of missing person incidents through an investigation of relevant statistics. The second part will focus specifically on people living with dementia and their carers, it will give a brief synopsis of so-called ‘wandering’ behaviours sometimes exhibited by persons with dementia and the associated burden this may cause to carers and family members. Finally, the chapter will conclude with

a summary of relevant research paradigms which will be employed in order to answer the main aims of the thesis. In doing so the chapter will attempt to meet objective 1, and go part way to achieving aim 1, a description of Missing Incidents.

3: Understanding Missing Incidents

This chapter will discuss two series of interviews which were conducted at the beginning of the PhD using a task analysis approach. Five search and rescue experts, as well as five careers of adults with care and support needs, each gave retrospective accounts in which they were searching for a person that was considered "vulnerable". The Critical Decision Technique was used in order to identify "Critical Decisions" that were made during each incident. Emergent thematic analysis was then applied to the transcripts of the interviews which yielded more granularity than the typical CDM whilst maintaining the exploratory nature of the interview technique. The findings will be discussed in order to shed light on how missing person searches are currently conducted from the perspectives of those who lose individuals in their care as well as those who are highly trained in such incidents. Carers will be interviewed as they represent a population which would greatly benefit from a technological intervention designed to assist with missing incidents (objective 7), whereas Search and Rescue volunteers represent the current best practice for missing incidents and their role within these incidents helps to put into context the larger context in which these incidents unfold. It is hoped that by better understanding these incidents as they occur, policy based and technology based interventions can be developed in order to better address the needs of those affected. This chapter will meet objective 2, "Capture the perspectives and experiences of individuals who have experience of Missing Incidents." Finally, the chapter will demonstrate the study's novel contribution to these methods and highlight the benefits of the chosen approach.

4: Vignettes for Predicting Behaviours

This chapter will discuss the tailored scenario study which took the form of an interactive online survey. The tailored scenario study was informed by the findings of the CDM interviews. This chapter will discuss the development of

the scenarios in relation to the results of the previous study as well as how this approach fits in with existing literature around vignette and scenario studies. Existing vignette studies are typically either entirely quantitative or entirely qualitative. It will be argued that a mixed methods approach has the advantage of capturing specific concerns and thoughts of those involved whilst the quantitative aspect will lend support to a predictive model of behaviour. The chapter will discuss the results; in particular how they support or contradict the findings of the previous study. The chapter will also draw attention to novel approaches to the analysis performed in this study; such as a unique approach to rank ordering lists of a heterogeneous length and using Markov modelling to analysis the decision-making behaviours of large groups of people.

5: The Design of Assistive Technologies

The chapter will highlight some of the issues around assistive technologies. It will also consist of a brief survey of currently available technology that may assist with informal missing person search and highlight some of the limitations of existing approaches. Reference will also be made to other related work focusing on the necessary considerations of the development inclusive technology; such as developing technology for those living with a variety of physical and cognitive impairments. In particular, specific risks for people living with dementia will be discussed in detail.

Additionally, this chapter will look in more detail at some of the relevant questions asked to participants as part of the previous studies. Both search and rescue experts and carers were asked a series of questions about their attitudes towards assistive technologies that may help with missing person search. In addition, the vignette studies also conclude with a series of open and closed questions about assistive technologies, including which technologies carers think would be most appropriate for their situation and why. The field study also asks about the appropriateness of assistive technology generally and how they think the intervention developed for study 3 might help. These findings will be discussed in unison and general lessons relating to the appropriateness of technological interventions will be addressed.

6: Field Trial of Assistive Technology

Chapter six will report upon an artificial search task experiment assisted by a variety of technological systems. During the study participants will have half an hour to find as many "search targets" as they can around the University of Nottingham University Park Campus. Participants will then be asked a series of factual questions which will act as an objective measure of their situation awareness participants will also be required to fill out a SART questionnaire as a subjective measure of their situation awareness. The final part of the trial will also consist of a small focus group in which participants will be asked about how they felt the technology helped or hindered them and areas in which they think it could be improved. The study consists of four conditions; one to one phone calling only; conference calling only, one on one phone calling and digital map, conference calling and digital map. These four conditions constitute a two-by-two experimental design, testing features designed to enhance situation awareness by presenting information visually and auditorily. It is expected that systems intended to raise situation awareness will also have a positive outcome on the search task, though it is unknown whether audio or visual communication will facilitate a better outcome.

7: Discussion

Chapter seven will discuss the findings obtained in the PhD studies from chapters' three to five and discuss their results with regards to the key research objectives highlighted in the introduction. The findings will also be discussed within their wider context in order to highlight how the PhD studies supplement and contribute to the body of existing work in this area. Finally, a series of key design recommendations will be drawn from the analysis which may help to facilitate the development of assistive technologies to help find missing people.

8: Conclusion

The conclusion of the thesis will summarise the key findings and explicitly address how they achieve the aims of the PhD, reference will be made to the implications of the work and unexplored questions for further research will be identified.

1.7 KEY FINDINGS OF RESEARCH

The thesis begins with a summary of relevant literature, identifying the risks and prevalence of missing incidents. Specific risks for PWD are underscored, as well as the logistical and emotional difficulties caregivers may experience during missing incidents. During the first series of interviews, the decision-making sequences of carers and search and rescue experts are compared and contrasted and two respective models explain the differences between the observed behaviours; typically Search and Rescue Experts engage in proactive planning and time-management, contrastingly, caregivers typically employ reactive decision-making strategies which are opportunistic. Informal missing person search prior to police involvement is often a task often involving multiple people. People will often seek assistance early on after a period of noticed absence and long before calling the police, both for material assistance in the search task, but, additionally, for emotional support and reassurance. It was observed that carers are often reluctant to contact the police, even when it was appropriate to do so. This finding is in concurrence with earlier work conducted by Dodds (1994).

The work also details decision-making differences between carers of adults and carers of children and highlights other differences which may be used as predictors for the decision-making sequences of missing incidents. Mobility and independence of the care recipient are excellent predictors of total choices that will be made before the caregiver calls the police. The level of worry experienced by the caregiver initially following an absence is an excellent predictor of how many actions caregivers will perform prior to calling the police. Three predictive models of caregiver behaviour during missing incidents are proposed; one of the models identifies “rank ordering” of the decisions within a missing incident, and it is thought that these rank orders reflect associated task costs, with decisions which are perceived as less costly (both in terms of time resources and associated guilt) are prioritised during missing incidents. This finding is supported by a correlation between self-reported worry at each decision and rank order.

The thesis also presents a novel technology which is intended for use during missing person incidents. Unlike other technologies designed to help with

missing incidents, the technology put forward in this thesis does not depend upon location tracking technologies (GPS/GNSS), but instead seeks to facilitate communication between teams of searchers. This contrasts with work which depends upon a person wearing or carrying a GPS enabled device (Bulat et al., 2016; Megges et al., 2017) and as such does not depend upon an at-risk person carrying GPS enabled technology. Instead, the technology presented in this thesis could be used in conjunction with GPS enabled solutions. This technology has been tested, and whilst participants were generally approving, the effect on search performance is yet to be demonstrated.

1.8 Novel Contribution(s) to Methodology

The initial study discussed in the thesis (Chapter 3) extends Klein's Critical Decision Method in a number of ways. One of the sets of interviews was conducted with people and who were not necessarily experts in planning and conducting missing incidents. The purpose of these interviews was to discover the general decision-making sequences of carers as well as the cues they depend upon in order to arrive at their decisions and the underlying emotional states people experience when engaged in the activity. According to Klein, experts are individuals who have acquired thousands of patterns which are specific accumulations of direct and vicarious experiences and allow enable them to use these experiences to "intuit" appropriate responses to novel stimuli (Gary Klein, 2015). Whilst carers and informal care givers may have considerable knowledge about their care recipient, it is unlikely that they will have experienced thousands of missing person incidents which would enable them to apply their previous knowledge seamlessly to a new situation. It may certainly be the case that carers can be considered experts in their respective fields, but the carers who were interviewed in this thesis confirmed that they had very little experience in conducting Missing Person Incidents. Thus, the interview approach differs from Klein's original formulation which uses the CDM to specifically elicit the tacit knowledge of experts (Gary A Klein, Calderwood, & Macgregor, 1989) within a particular domain, rather than to understand how non-expert users arrive at their decisions. The study also built upon emergent thematic analysis techniques (Wong & Blandford, 2002; Wong & Blandford, 2004) applied to critical decision method interview transcripts, by performing a

analysing using two separate coding schemes and quantifying the overlap between critical decisions and “global themes”. This allows for an understanding of where decision-makers attention is focused at each stage of the incident.

Chapter 4 presents an original approach to vignette studies, by introducing both customised and interactive elements. The study bears resemblance to traditional experimental vignette approaches but due to the nature of the independent variables (care recipient mobility and independence), it is not possible to manipulate the factors which are likely to influence strategies employed by carers. Therefore, the experimental design more closely resembles that of a naturalistic experiment, whereby key independent variables are identified but not controlled by the researcher. This multi-staged vignette was heavily informed by the interview findings of the previous study. The scenarios participants were presented with in this study were based on real-life missing person incidents and the decision-choices presented to participants were choices which were identified as “Critical Decisions” from retrospective interviews about real-world missing incidents.

Further, the study presented in Chapter 4 also uses a number of novel analysis techniques for understanding decision-making sequences; including a variation of pair-wise ranking to determine the relative order of decisions even in conditions where certain decisions are absent from decision-making sequences. Such a technique could also be used to identify preferences in rank order tasks where rank responses made by participants are of heterogeneous lengths.

Chapter 4 will also discuss the use of Stochastic modelling techniques based on vignette responses in order to form the basis of a predictive model of human behaviour. Stochastic modelling techniques have been used to predict human behaviour in a variety of contexts, including language recognition techniques, driver behaviour and consumption patterns, but to the best of the author’s knowledge, the application of stochastic modelling techniques to vignette data is an original contribution.

Finally, a new Android application was developed specifically for the field trial described in this thesis, with the hopes of enabling better communication

between teams of people engaged in a co-operative search task. There are various other patents that describe similar applications, but nothing in a high-level search on the combination of a messenger app in combination with a location app. The field trial designed for this study adopts a traditional experimental design (two by two) but in a naturally occurring environment. In this way, the study design deviates from more controlled experiments in laboratory environments, but also allows the various aspects of the intervention to be separated and examined in a way in which research "in the wild" does not usually allow for.

Overall, the thesis presents a comprehensive method for exploring under-researched areas of interest, and provides a clear structure of how research can progress through initial exploratory stages, to quantifiable models which identify the influence of operationalised variables and finally, how that understanding can be used to inform the design of a technological intervention.

1.9 CHAPTER SUMMARY

This chapter presented a general background to the problem of missing persons and discussed the approach that will be taken for the research. The aims and objectives of the PhD have been discussed and an explanation has been given of how each of the proposed studies will satisfy these aims. The content of the chapters has been described, briefly and novel contributions of the research have been highlighted. The following chapter will discuss existing research related to the area of missing incidents, search behaviour and decision-making and in so doing attempt to develop descriptive framework for understanding missing incidents.

2 A HUMAN FACTORS APPROACH TO MISSING INCIDENTS

2.1 CHAPTER OVERVIEW

This chapter will describe and critically appraise existing research which may shed light on cognition and behaviours during missing incidents. It will provide an overview of relevant missing person statistics in Great Britain and the associated risks faced by missing persons and their carers. The chapter will also describe specific risks surrounding at risk groups and the technological solutions designed to reduce those risks. The chapter will conclude with a summary of research paradigms; providing a deeper insight into search, navigation and decision-making and providing a theoretical underpinning for the work described in this thesis.

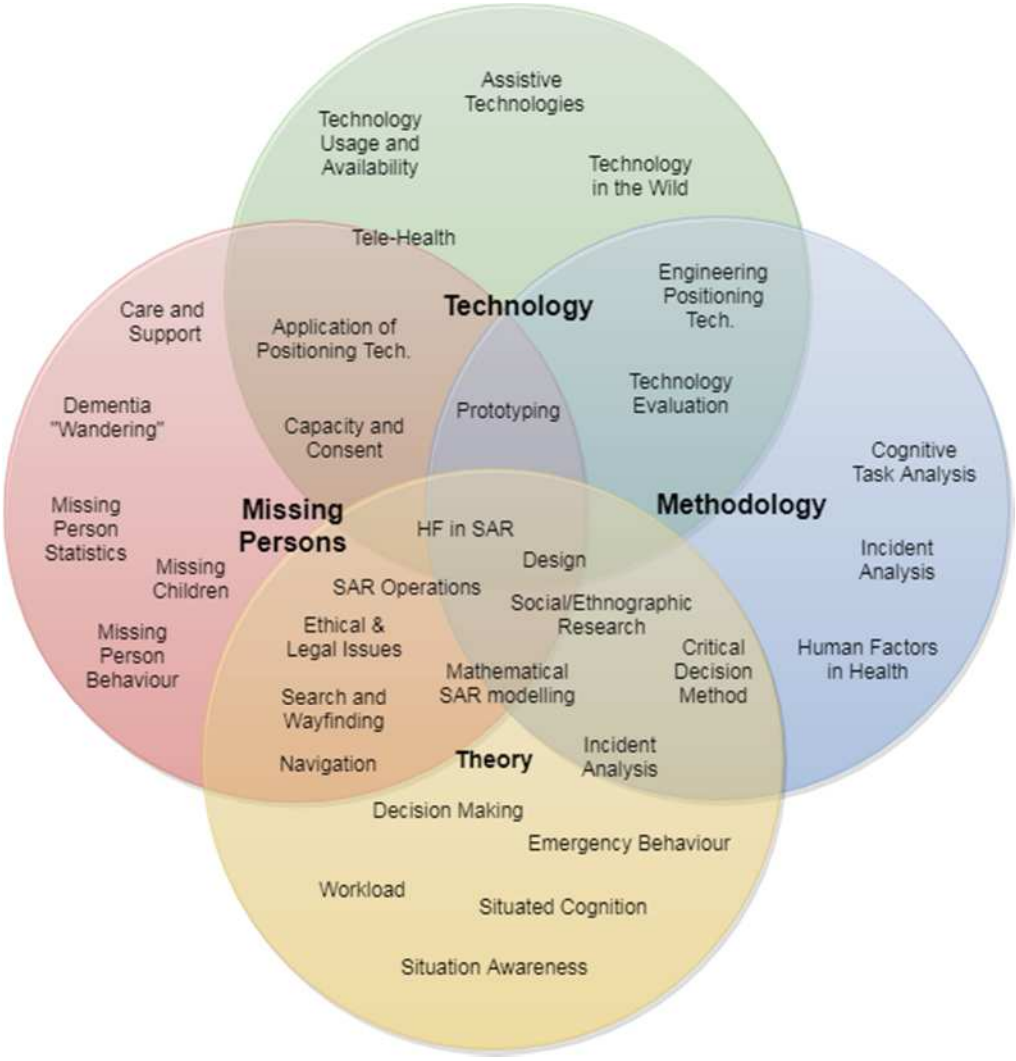


Figure 2.1 Scope of Literature Review

2.2 A HUMAN FACTORS APPROACH TO MISSING PERSON INCIDENTS

Missing incidents are activities which usually involve a wide variety of individuals, institutions and complex socio-technical systems in a time-critical situation. Therefore, a thorough understanding of these incidents depends upon an in-depth analysis not only of individual behaviour and psychology but also an investigation of how people work in teams during missing incidents and a full consideration of the real context in which missing incidents occur; including any organisational, legal or logistical constraints and commonly used technological artefacts. Human Factors is a research discipline which incorporates many aspects of psychology and cognitive science, but unlike its more theoretical cousins, Human Factors does not seek to discover universal truths of human behaviour devoid from the specific context in which they occur.

Instead, Human Factors is an approach that uses the knowledge of human abilities and limitations *in-situ* to inform the design of systems, organisations, tasks and tools in order to facilitate safe, efficient and effective human use. The Chartered Institute for Ergonomics and Human Factors (UK) gives the following definition: "Ergonomics (or Human Factors) is the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimise human well-being and overall system performance".

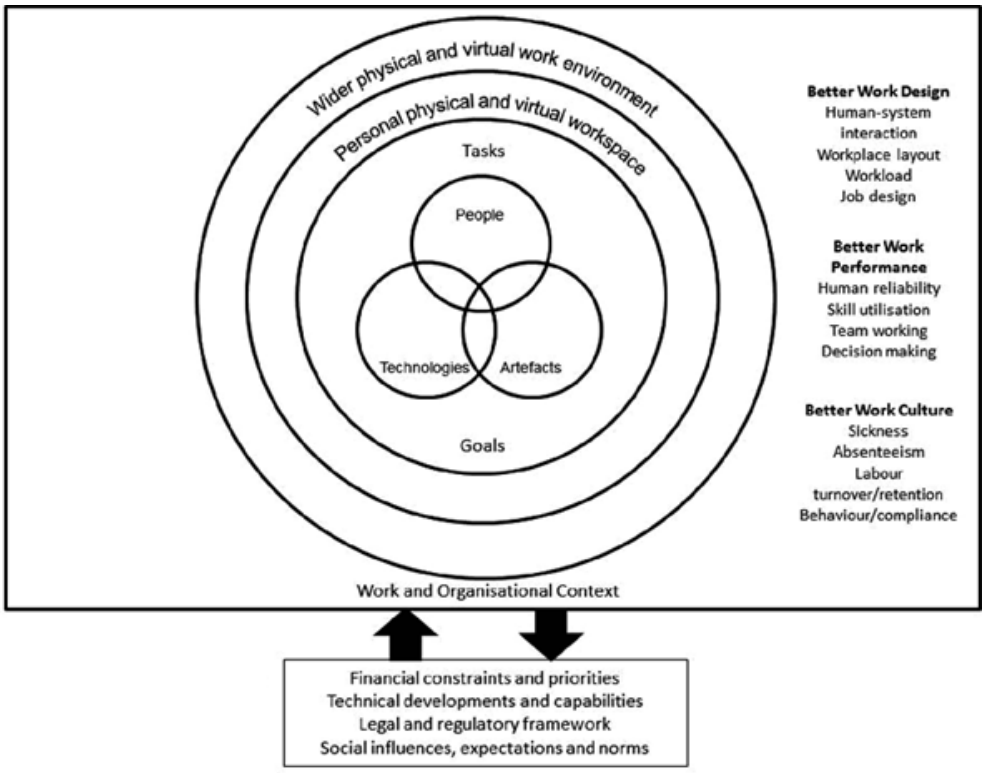


Figure 2.2 The "Onion Model" of Human Factors from (Wilson & Sharples, 2015)

The "Onion Model" depicted in Figure 2.2 (above) describes the scope of Human Factors research for workplace design, and has served as a theoretical framework for numerous studies which seek to understand complex work environments, often depending heavily upon shared work between people and technological artefacts (Sharples et al., 2012; Waterson & Catchpole, 2016). Human Factors has been considered a "bridging discipline" (Wogalter, Hancock, & Dempsey, 1998) which provides a common framework for facilitating numerous aspects of workplace design and investigation. The "Onion Model" metaphor suggests a holistic approach to understand complex

interacting systems and sub-systems of people (Waterson & Catchpole, 2016), and emphasises the importance of end-users and other stakeholders as being central to the investigation. Human Factors professionals are often involved with numerous other experts in a wide variety of collaborative projects, which often means collaborating with people from disciplines who may have differences in their overall approach. Hence, the “Onion Model” does not necessarily prescribe a strict methodology, as it does suggest an overall approach which places the users of the system as the central topic of its investigation (Catchpole, 2013).

The centre of the diagram aptly shows the people, technologies and artefacts under consideration, which is the predominant focus of Human Factors research. The next level out, highlights the tasks under consideration; this may be a particular work task, such as entering data into a spreadsheet or cleaning a house. Also highlighted in the diagram is the personal physical and virtual workspace, which describes the physical and virtual space in the immediate vicinity of an operator and the wider physical and virtual work environment in which these are situated. These aspects are all subsumed by the work and organisational context, which encapsulates the wider business culture, financial constraints and priorities and any social influences which may be in effect. On the right hand side of the diagram, three human factors goals related to the workplace design are given. Whilst it could be argued that Human Factors and Ergonomics have broadened their attention from solely occupational and workplace design, the diagram is still applicable to other contexts in which humans use technology and artefacts to achieve desired goals. Human Factors focuses first and foremost on people, and their interactions with technologies and artefacts in order to perform meaningful tasks. Using “The Onion” model, as a guide, this chapter will attempt to elucidate missing incidents, the people involved in those incidents, and the wider context in which these incidents occur. An exposition of the scale of the problem will be presented in the first part of this chapter (2.3), making reference to the prevalence and risks of missing incidents. The second part of the chapter (2.4) will identify at risk groups who are at a high risk of becoming missing or at a high risk of injury or mortality when they do. Finally, the chapter will draw upon various research

paradigms which are related to missing incidents as well as other cognitive science concepts and theories which facilitate the understanding of likely behaviours and cognitions during search tasks. The intention of this chapter will be to describe missing incidents in detail, the people affected by those incidents and relevant research which may help to explain and understand the behaviours of those involved in the early stages of those incidents.

2.3 MISSING PERSON RESEARCH & STATISTICS

2.3.1 Prevalence of Missing Incidents

Missing incidents in the UK, whilst relatively rare amongst the entire population, pose a serious threat of physical and psychological harm to the missing and can often cause considerable distress to the families of those who affected. The last available data from the UK shows a 5% increase of missing persons reported to the police, and current data shows around 577 missing person incidents are created per day, relating to approximately 350 missing people (Bureau, 2016).

Table 2.1 Missing People in Great Britain per 1000

Table recreated from Missing Persons Data Report 2014-2015

Police	Population estimate 2014	No. of missing-related calls 2014/15	Per 1,000 population
England & Wales	57,408,654	282,066	4.9
Scotland	5,347,600	39,926	7.5
Total	62,756,254	321,992	5.1

Table 2.1 provides an estimate of missing-related calls made in England and Wales, and Scotland respectively. Often the number of missing related calls exceeds the number of missing individuals. A number of reasons are given for this discrepancy, firstly, that numerous repeat calls may related to a single missing incident, or that the missing person is found before the details are entered into a case management system. The Missing Persons' Bureau also suggest that caution should be taken when considering figures provided from

police departments as not all missing people are reported to the police, or reported as missing. Several areas has seen increases of above 50% on previous estimates, but this may be in part due to children's homes being encouraged to report missing incidents early, rather than attempting find the children themselves before contacting the police.

The UK notably keeps comprehensive statistics relating to missing persons, but international statistics relating to the prevalence of missing incidents are hard to come by. However, the FBI recently published statistics pertaining to the total amount of missing person reports and unidentified persons (*2018 NCIC Missing Person and Unidentified Person Statistics*, 2019), which is shown in Table 2.2.

Table 2.2 Missing Person Statistics in the United States

From 2018 NCIC Missing Person and Unidentified Person Statistics

Males under 18	198327
Females under 21	225640
Males over 21	986111
Females over 21	62371

Whilst the FBI do not give these figures in terms of rate per 1,000 population, unlike UK statistics, totalling these values and comparing them to the population of the USA as a whole, gives a figure of 4.50 per 1,000 for the population. Which is comparable, but slightly lower than the UK average. However, comparisons of this kind need to be taken cautiously, as reporting methods and legal definitions vary from country to country.

Similarly, assessing the prevalence of missing incidents across Europe is difficult; Interpol have not made statistics on missing incidents available. There is some limited data on missing children in Europe. The organisation Missing Children Europe, who manage and support a network of hotlines suggest that in 2017, they received calls relating to 5621 Missing Children (Missing Children Europe 2018). In addition, the European Commissioned report (Cancedda, 2014) also provides some statistics relating to the prevalence of missing children across Europe but point out that cross-country comparisons of this kind are fraught with problems. In the last available report covering the timescale from July 2012 until July 2013, there is considerable variability in the

prevalence reported between member states. In the Netherlands, Greece and Cyprus, reports for missing children range from between 0.06 and 0.35 per 1,000 children, conversely, Hungary reported 8.52 missing children per 100,000 and Ireland reported 5.57 missing children per 100,000. Unfortunately, no comparable reports are available for the adult population.

2.3.2 Demography of the Missing

Table 2.3 Demography of Missing Persons in Great Britain

Recreated from Missing Persons Data Report 2014-2015

Age group	Male Incidents	Female Incidents	Total Incidents	Age group percentage of total incidents
0-4yrs	608	479	1,087	0.6%
5-8yrs	1,120	528	1,648	0.9%
9-11yrs	3,540	1,864	5,404	2.9%
12-14yrs	17,812	20,275	38,087	20.3%
15-17yrs	28,804	37,823	66,627	35.4%
18-21yrs	6,370	6,353	12,723	6.8%
22-39yrs	19,169	11,049	30,218	16.1%
40-59yrs	13,240	6,966	20,206	10.8%
60-79yrs	4,928	2,388	7,316	3.9%
80+yrs	1,922	1,212	3,134	1.7%
Unknown	748	749	1,497	0.8
Total	98,261	89,686	187,947	
Total percentage	52.3%	47.7%		

Table 2.3 gives a breakdown of missing incidents by age grouping and gender. According to these figures, teenagers are the group most likely to go missing in Great Britain (England, Wales and Scotland) and males are slightly more likely to go missing than females (52%). Additionally, this gender difference increases with age, with 62% of all adult missing incidents attributed to men.

2.3.3 Missing Person Behaviour and Risks

Table 2.4 Incidents Broken Down by Type of Harm 2014/15

Recreated from Missing Persons Data Report 2014-2015

	Accidental Harm	Emotional Harm	Found Deceased	Physical Injury	Self-Harmed	Sexual Offence Victim	No Harm Suffered	Total
2014/15 Total	223	67	255	795	965	162	59,588	62,055
Percentage	0.3%	0.1%	0.4%	1.4%	1.4%	0.2%	96%	

Whilst the vast majority of missing people return unharmed, the highest risks suggested by the data are physical injury and self-harm. The report also notes that the level of emotional harm may be significantly underestimated due to the difficulty in classifying what constitutes emotional harm.

Table 2.5 Percentage of Incidents by Harm Suffered 2014-15

From Missing Person's Data Report 2014-15

	Child N = 38,450	Adult N = 23,605	Total N = 62,055
No harm suffered	98.1%	92.7%	96.0%
Hurt or harmed	1.6%	6.1%	3.3%
Sexual offence victim	0.3%	0.1%	0.3%
Found deceased	<0.1%	1.1%	0.4%

Table 2.5 demonstrates that adults are significantly more likely to come to some form of harm than children, but missing children are more likely to be the victims of a sexual offense than missing adults.

2.3.4 Wider issues surrounding Missing Persons

A more holistic approach has been adopted by Stevenson, Parr, Woolnough, and Fyfe (2013) who conducted a series of qualitative interviews with families who 'live with' a missing person and identified key aspects of their experiences. They focused particularly on search, communication and the relationship the family had with Police services. From their research, they concluded that the decision to report an adult as missing is fraught with anxiety and this often prevents them from seeking help sooner. Often families conduct significant informal searches prior to seeking professional help. In emergency situations, people often experience potentially overwhelming emotions which can affect their own personal safety (Whalen & Zimmerman, 1998). In an ethnographic study, Lois (2001) observed the extreme emotions experienced by family members during crisis situations and investigated the role of volunteer search and rescue teams in interpersonal emotional management. Rescuers typically managed victims and families extreme emotions during crisis situations. This often led to a lasting emotional bond between family and rescue team.

2.4 AT RISK GROUPS

2.4.1 People Living with Dementia

There are an estimated 50 million people worldwide living with dementia, with that number expecting to approximately double every 20 years as the population ages (2011b). The economic impact of dementia is estimated to rise to approximately $1T by 2018 (Perkins et al., 2011b). These costs include direct medical care costs, formal social care costs (provided by community care professionals), and informal care costs (unpaid care by friends or relatives).

The importance of an effective response to dementia was highlighted by health ministers in the G8 Health summit of Dec 2013, who state that; "We need to provide better and more concrete measures for improving services and support for people with dementia and their carers, to improve their quality of life and wellbeing." The importance of wellbeing and quality of life is also explicitly stated in Scotland's National Dementia Strategy 2013-2016 and the State of the Nation Report on Dementia Care and Support in England.

The term dementia refers to a variety of brain diseases which may cause difficulties with memory loss (Bowen et al., 1997), cognition and language (Choe et al., 2008), as well as a reduction of visuospatial skills (Simard, van Reekum, & Myran, 2003) and difficulties with orientation tasks (L. Liu, Gauthier, & Gauthier, 1991) resulting from brain cell death (Whitehouse et al., 1982). Although dementia can affect people of all ages, it is a condition which disproportionately affects the elderly, with only an estimated 5% of cases occurring in people below 65 in the UK (Prince et al., 2014). Due to dementia's association with age and women's higher life expectancy, most people with dementia are women, consequently, dementia is the leading cause of death among women in the UK (A. s. R. UK, 2015). Whilst some memory loss is often observed as people get older, dementia differs markedly from normal cognitive and memory decline due to aging (Anstey & Low, 2004; Belleville, Peretz, & Malenfant, 1996), which is thought to affect approximately 40% of people over 65 (Canada).

As well as cognitive impairment, dementia significantly impacts people's ability to perform the "Activities of Daily Living" (activities such as cooking, cleaning and shopping). The ability to perform these tasks independently is crucial to maintaining quality of life in people with dementia (Andersen, Wittrup-Jensen, Lolk, Andersen, & Kragh-Sørensen, 2004).

Similarly, dementia is different from Mild Cognitive Impairment (MCI), which is a syndrome defined as cognitive decline greater than would be expected from an individual's age and education level and affects between 3% and 19% of adults over 65 (Gauthier et al., 2006). The wide range of the estimated prevalence of MCI in the adult population is likely to be caused by the difficulty of definition and assessment (Ganguli, Snitz, Saxton, & et al., 2011). MCI may remain relatively constant for a number of years, without progressing to more sever impairment or dementia (Feldman & Woodward, 2005).

Dementia has a variety of underlying neurological causes, including Alzheimer's disease, vascular dementia, Lewy body dementia and frontotemporal dementia. The World Health organisation estimate that

approximately 50 million people have dementia, with Alzheimer's accounting for approximately 60-70% of those cases (Organisation, 2017).

It is also reported that people living with dementia have on average two to eight co-morbidities (additional chronic illnesses) (Sanderson et al., 2002; Schubert et al., 2006), which can often introduce additional difficulties, further reducing their quality of life and increasing the complexity of care that they require. For those people with dementia who become lost, this may substantially increase their risk of an adverse outcome. In addition, there is strong evidence to suggest that comorbidities increase the speed of cognitive decline in patients diagnosed with Alzheimer's (Solomon, Dobranici, Kåreholt, Tudose, & Lăzărescu, 2011). The most frequent comorbidities in people living dementia are hypertension and diabetes, but other significant associations include Parkinson's disease, congestive heart failure, skin ulcers and cerebrovascular disease (Poblador-Plou et al., 2014). Poblador-Plou et al. (2014) also highlight the comorbidity rate of other psychological disorders such as insomnia and anxiety and neurosis, which may make any interventions to prevent wandering behaviours particularly difficult.

2.4.2 Why do people "Wander"?

"Wandering" refers to a variety of behavioural, navigation and ambulatory patterns which can accompany all variations of dementia. Wandering is said to include 'checking', 'aimless walking', 'excessive activity', 'walking towards an inappropriate purpose' and 'wandering off' (Hope et al., 1994). and has been considered one of the most difficult to manage behaviours (Matteson, Linton, & Barnes, 1996; Rowe M et al., 2015). It is also one of the major factors determining the likelihood of institutionalisation (Knopman, Kitto, Deinard, & Heiring, 1988).

However, more recent research into the behaviour based on the experiences of carers challenges the assumption that 'wandering' is 'aimless' (Brittain, Degnen, Gibson, Dickinson, & Robinson, 2017). Brittain et al, analysed qualitative interviews conducted with carers and argue that the prevalent narratives demonstrate there are pronounced links to specific areas and meaningful places which people with dementia will walk *to*, thus suggesting

‘wandering’ may, in fact, be goal-directed behaviour. Similarly, Algase et al (1996) argue that the so-called disruptive behaviours observed in PWD may be an attempt to address unmet psychological needs.

The Algase Wandering Scale was developed in an attempt to categorise the various forms of wandering behaviour and measure their presence and severity. It has been used in a variety of research and clinical contexts and is currently on its first revision, which has itself been translated into many languages (Greiner, Makimoto, Suzuki, & Yamakawa, 2013). Algase (2006) points out that ‘wandering’ and other difficult to manage behaviours have been historically under-researched compared to dementia research within the field of biological sciences. She argues, however, that the research is becoming more rigorous as our understanding increases with much of the research being quantitative and stating an explicit framework for research. Algase considers wandering behaviour to the desire to meet an unfilled need and becoming lost rather than merely “aimless” ambulation (Algase et al., 1996).

However, the definition of “wandering”, still lacks consensus. A literature review conducted by Halek and Bartholomeyczik (2012) concluded by stating, *“At the moment there is no conclusive definition of wandering, there are no obvious causes for it and therefore no clear intervention recommendations”*. The term ‘wandering’, they argue, is too diffuse and too difficult to distinguish from other forms of behaviour, such as agitation and non-anomalous ambulation. In addition, they suggest that much of the literature, taxonomies, interventions and suggested aetiologies are based on older research which lacks scientific rigour.

There is also a dispute between the relationship between ‘wandering’ behaviours and getting lost from a community care home, with some arguing the two are conceptually distinct, and therefore, measures of ‘wandering’ are not sufficient to determine specific risks (Bantry White & Montgomery, 2016). Rowe, et al. (2011) also differentiate ‘wandering’ from missing incident behaviour in terms of frequency, timing and nature.

The Missing Person Conceptual Model posits an interplay between the contextual, situational and neurological antecedents that result in a PWD

leaving a place of safety and becoming missing (Rowe M et al., 2015). Contextual issues include becoming separated from the caregiver whilst out, becoming agitated and leaving home, and most crucially, a gap in the supervision of the PWD. The most notable element of the Missing Person Conceptual Model (Figure 2.3) is the interplay between the antecedent factors which result in a missing incident; these contextual, situational and neurocognitive antecedents cannot be considered in isolation from one another as the specific neurocognitive factors will affect situational factors, such as level of surveillance required, and contextual factors, such as regular behaviours exhibited by the PWD. The model is excellent for sketching the precursors of missing incidents and highlighting some of the consequences of such events, but does little to elucidate missing incidents themselves.

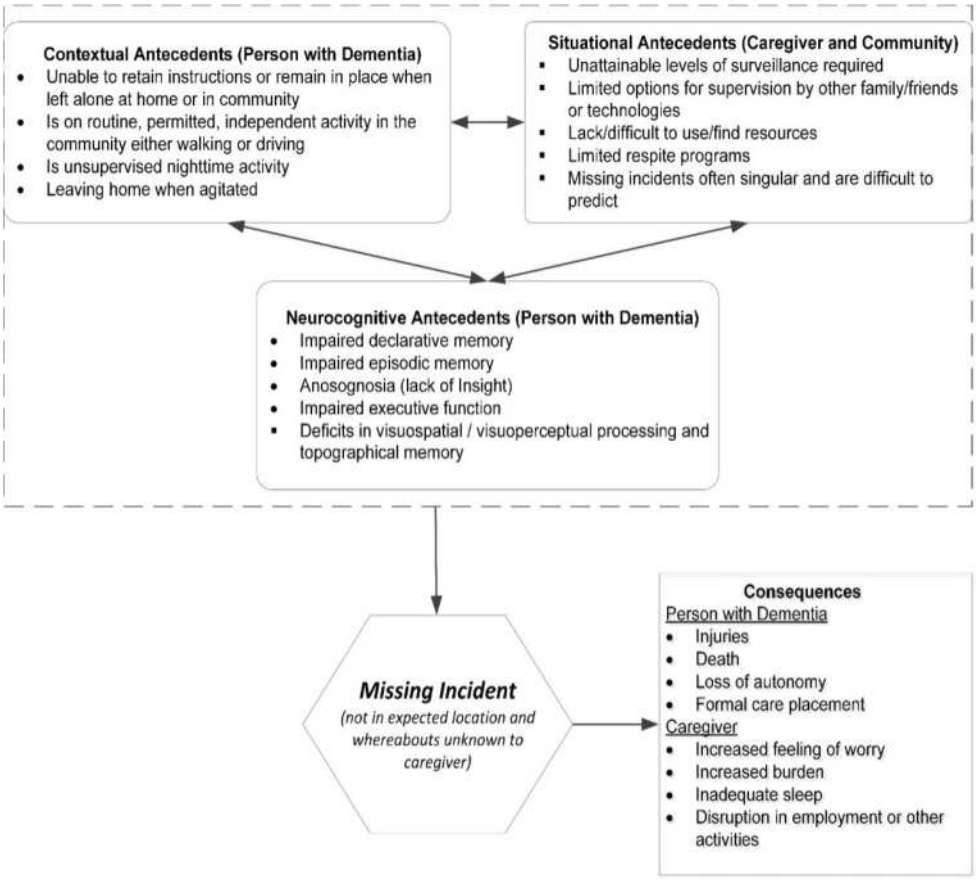


Figure 2.3 Missing Person Conceptual Model

From Rowe et al, 2015

It has also been suggested these behaviours more common in those with Alzheimer's than other forms of dementia, and existing psychopathologies may also increase the risk (D. A. Klein et al., 1999), yet there is a debate surrounding the prevalence of this behaviour, with estimates varying considerably from 17.4% to 63% (Lai & Arthur, 2003). No doubt, this wide discrepancy of estimates is largely down to the difficulty of categorising exactly what constitutes wandering, and exactly how it should be classified. Whilst there is still some controversy surrounding the causes and definition of 'wandering' behaviour, it is often seen to be one of the biggest concerns for PWD and their carers (Dodds, 1994).

2.4.3 Risks and Behaviour

When elderly individuals suffering from cognitive impairments go missing, there are many potential risks. In a retrospective analysis of 62 elopement incidents, Aud (2004) identified several risks that eloping individuals encountered which included; roads, lakes, woods, construction sites, railway lines and outdoor temperature. They identified 4 incidents of serious risk from hyperthermia and 13 of risk from hypothermia. Of those in the study, 32% suffered injuries and 7 of the 62 were admitted to hospital, one woman later died from injuries sustained whilst leaving a care home unescorted. Clearly, when vulnerable people become lost and confused in unfamiliar environments they pose a great risk to their own personal safety. Finding people who abscond in a timely fashion is critical and may even save lives. McShane (2013) points out that 40% of all people who have dementia will at some point get lost, and 5% will get lost repeatedly. It is this 5 % he suggests that are an ideal candidate for assistive walking technology.

In a retrospective study, R. J. Koester and Stooksbury (1995) analysed the database of the Virginia Department of emergency services records of SAR. It was discovered that people with dementia who go missing will usually be found within a mile of the position they were last seen (PLS), (89% within a mile, mean 0.6 miles, median 0.6 miles, range 2 miles). All the people in the study that were found within twenty-four hours survived, but mortality rates increased to fifty-four percent after this critical period. In around half of all cases, caregivers conducted extensive searches themselves without informing the

police. In the cases when the patient was found uninjured, those who did contact the police in the study did so after a mean time of around ten hours. The carers of those who were found deceased only contacted the police after a mean time of 3.5 days. There was some evidence to support the notion that people living with dementia take the path of least resistance, with most of those found on or close to roads, many in large bushes or briars and a significant number also in creeks or drainage systems next to roads. It is also reported that many with dementia who go missing will wander across roads, are generally unresponsive (even when uninjured) and will rarely leave physical clues as to their location.

Ali et al (2016), also highlight the adverse consequences of wandering in community care settings. Of the 143 participants in their study with mild dementia, 49% had falls, fractures or other injuries due to wandering behaviour and around 43.7% demonstrated eloping/abscondment behaviours. They also note that whilst persistent walking and poor gait were significant predictors of risk, there were no correlations between the participants' demographics (age, sex, ethnicity, education) and health, and their risk from wandering-related adversity.

2.4.4 Children at Risk

Children who are aged 15-17 are the highest group to be reported missing to the police, both in terms of gross figures, but also as percentage of the population. Missing incidents involving children are also far more likely to be attributable to repeated missing cases, with repeat missing cases accounting for 59% of all missing children incidents as opposed to 20% of adult incidents (Bureau, 2016). Fortunately, over 98% of missing children return unharmed and less than 0.1% are found deceased (Table 2.5 Percentage of Incidents by Harm Suffered 2014-15) and approximately three quarters of children are returned in less than 24 hours (Bureau, 2016). Whilst these figures are somewhat encouraging, distress caused to both children and parents during missing incidents as well as the social and financial costs associated present clear and pressing problems which need addressing.

When children are missing for the long-term, not only is this a tragedy for the child, but likely also to cause immeasurable distress to parents and family

members, that may in some cases be far more difficult to manage than even the confirmation of the death of a child (DeYoung & Buzzi, 2003). Parents of long-term missing children find it difficult to begin bereavement when there is still ambiguity about their child, and also reported poor experiences with therapy and support groups, which can in some circumstances lead to depression (DeYoung & Buzzi, 2003). In the case of children, the fear of abduction is much more prevalent (Woolnough & Gibb, 2016), despite the fact that criminal abductions only account for 0.2% of all missing children cases across Europe (Missing Children Europe, 2018). More worrying still for the parents of missing children it has been estimated that there is between a three to six hour window from the time of abduction to the time of murder (K. M. Brown, Keppel, Weis, & Skeen, 2006).

Children who are intentionally missing tend to be older than children who are considered unintentionally missing (Woolnough & Gibb, 2016) and there is considerable concern that these older children will become victims of child sexual exploitation (Sharp, 2012). It has been reported that there are other considerable risks faced by missing children, such as drug use, poor health and being the victims of crimes (Shalev, 2011). It has been suggested that predicting risk is extremely difficult in the case of missing children because of the highly individualistic nature of missing incidents and the rarity with which these events occur (Tarling & Burrows, 2004).

Additionally, not only are missing children more likely to be the victims of crime, repeat missing children are also likely to become involved in crime themselves (Shalev, 2011). In a study which examined all solved cases where a child under the age of 18 had gone missing repeatedly in the area of Oxford, it was discovered that 82% of repeat missing children were also involved with crime and arrested on at least one occasion, with the most common offences being GBH, assault, theft, shoplifting and criminal damage (Shalev, 2011). Where data was available, the study indicates that in 36% of cases, children went missing from a care home environment and 5% went missing from foster care. This finding is supported by more recent work conducted by Hayden and Goodship (2013), who note the high volume of children who were missing were within care of missing person reports involving children. In their study, they

ascertained that children in care represented 44.9% of all incidents, which means they are heavily overrepresented. However, when incidents were analysed on a per child basis, this figure dropped to 28.7% which may suggest that children in care are much more likely to be missing on multiple occasions.

2.4.5 The Role of a Carer

The importance of adequate care provision in an aging population cannot be overstated. Informal and familial carers were are estimated to have an economic contribution in the UK of £132B a year, which is approximately the total annual spend of healthcare (Buckner & Yeandle, 2015). This figure is up from previous estimates for two main reasons; firstly, the number of people over 85 has increased by 38% since 2011 and secondly, a reduction in homecare support provided by local government (Buckner & Yeandle, 2015). The number of people acting as unpaid carers is increasing faster than the rate of population growth in the UK and more people than ever before are involved in the provision of care for another person. As of 2015, approximately 6.8 million people were acting as informal carers. That figure is up from 2001 by approximately 16.5%, with the largest real increase being in those carers that provide fulltime care (50+ hours) (Buckner & Yeandle, 2015). Whilst the population of carers is growing, it is important to remember that the population is not static, with an estimated 2.1 million adults taking on caring roles a year, and almost as many seeing their caring responsibilities come to an end (Addison, 2014). This rapid turnover means that most people will take on caring responsibilities at some point in their lives. An estimate from CarersUK suggests that as many as three in five people will provide unpaid care for a friend or relative (George, 2001). Supporting carers to manage difficult behaviours will not only improve the lives of those affected, but is likely to reduce dependency on public services.

Carers not only provide practical help for those who are sick, infirm or disabled, but they also provide emotional support. The affected person is dependent upon the carer, and as such their well-being is directly related to the nature and quality of care they receive (Shah, Wadoo, & Latoo, 2010). These demands can often place considerable strain on carers, impacting every aspect of their lives, from socialising and relationships to work life. In a UK survey conducted in 2015, 84% of carers report high levels of stress, 78% report high levels of anxiety and

55% of carers reported feeling depressed (Carers UK's annual survey 2015), Caring can often raise difficult personal issues, such as duty, responsibility, adequacy and guilt (Oyebode, 2005). It has also been shown that these depressive symptoms in carers are highly correlated with the severity of functional impairments and intensity of problematic behaviours (such as wandering) in care recipients (Corcoran et al., 2002; Molyneux, McCarthy, McEniff, Cryan, & Conroy, 2008). Dementia in particular, is likely to cause anger, grief, loneliness and resentment of the carer (Cohen, Colantonio, & Vernich, 2002).

Carer burden is defined as a context-specific negative affective outcome that occurs as a result of a perceived inability to contend with the role demands of caring, often resulting in feelings of hopelessness or futility (Park et al., 2017). It has been argued however, that carer burden is ill-defined, and often contradictory within the academic literature, thus making it difficult to demonstrate its relevance to clinicians and policy makers (Bastawrous, 2013).

Despite this, the Zarit Burden Interview (Zarit, Reever, & Bach-Peterson, 1980) is believed to be the most commonly used measure of carer burden (Bachner & O'Rourke, 2007). This is a widely administered self-report measure is usually conducted in the form of a closed-response interview. It was originally developed for use with informal caregivers of community dwelling PWD, but since its development over 30 years ago, has subsequently been administered to a broad range of patient-carer populations (Akpan-Idiok & Anarado, 2014; Tang et al., 2017), formal and informal carers (Nakanishi et al., 2017) and translated into many languages (Goncalves-Pereira & Zarit, 2014; Taub, Andreoli, & Bertolucci, 2004). Despite this fact, the Zarit Burden Interview has a demonstrated good internal consistency, as well as high validity and reliability across numerous divergent populations (Bachner & O'Rourke, 2007). Some have criticised purely quantitative measures of carer burden for failing to capture relevant contextual issues (such as culture) that are related to caregiving outcomes, and subsequently these measures are inadequate for expressing the breadth of carer burden (Bastawrous, 2013). Nevertheless, the Zarit Burden interview has a proven track record, high internal consistency and validity, and a wide-ranging application.

Pearlin, Mullan, Semple, and Skaff (1990) argued that much of the research into carer burden lacked a theoretical framework, and proposed a multi-dimensional model of caregiver burden based upon previous research that would allow the direct relationships between constructs of interests and outcomes to be modelled, as well as the indirect effects between intervening constructs. They proposed a model that would be incorporated literature from both the geriatric and paediatric literature in order to provide a more comprehensive picture of caregiver burden than would otherwise be provided by any overly specific model. The model proposed by Pearlin et al. (1990), was also designed to be generalizable to formal, as well as informal caregivers, and thus provides on of the most inclusive models of carer burden to date.

Figure 2.4 (below) elucidates the main factors affecting carer burden and well-being, and highlights some of the potential outcomes of high levels of carer burden. Whilst this model has been altered by Shah et al. (2010) since its original formulation, the general picture remains the same; the arrows in Figure 2.4 denote not only associations between constructs, but causal relationships observed by clear evidence in the literature. As in Figure 2.4, Pearlin et al. (1990) propose five factors which have been shown affect the physical and mental health of care givers, and are likely to affect support outcomes, such as the breakdown of homecare and subsequent institutionalisation of the person with care and support needs.

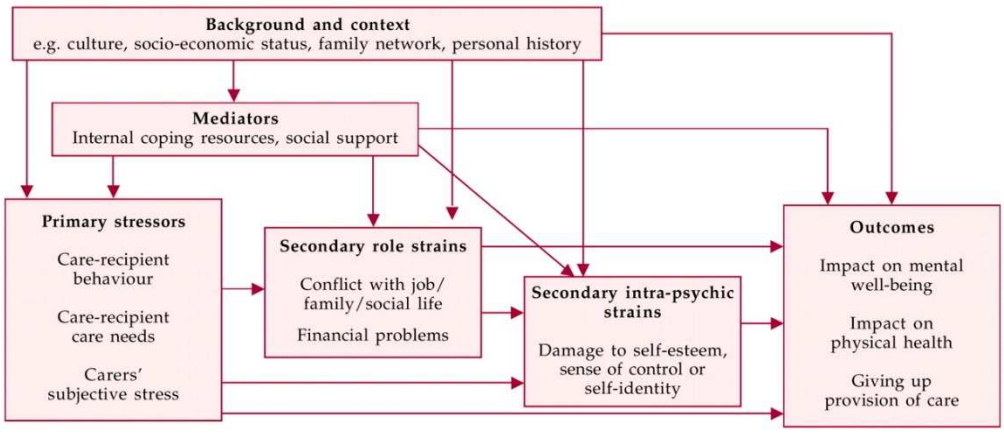


Figure 2.4 Pearlin's stress-process model of stress in carers

Adapted from (Pearlin et al., 1990) in (Shah et al., 2010).

Difficult to manage behaviours, such as wandering, aggression and wandering have been shown to increase carer burden for those carers of mobile PWD (Miyamoto, Ito, Otsuka, & Kurita, 2002). This finding has also been supported by other research which confirms behavioural disturbances as a significant predictor of carer burden (Allegri et al., 2006).

Often, when attempting to manage wandering behaviours, informal carers describe using several potentially inappropriate coping strategies to mitigate these behaviours. In an interview study investigating the perception of wandering from the perspectives of familial carers, Dodds (1994) identified several such strategies, including; physical restraints, alcohol, aggression and lying in order to prevent incidents of wandering. Some have suggested that the use of dysfunctional strategies such as these are associated with high levels of carer anxiety (C. Cooper, Katona, Orrell, & Livingston, 2006), though the authors caution that their results do not clarify the direction of causality. Thus, it cannot be concluded if anxiety causes inappropriate coping strategies or vice versa. When dealing with incidents of wandering in PWD, Dodds (1994) notes that, "While caregivers were willing to contact neighbours when their loved one became lost, they were reluctant to call the police" (Dodds, 1994, p. 754). As this research occurred over 20 years ago, the thesis will explore whether people are still reluctant to call the police, or whether attitudes have changed in the intervening years.

Ultimately, behavioural disturbances and carer burden both contribute significantly to the likelihood of institutionalisation of PWD (Eska et al., 2013), therefore it is imperative that strategies are in place that allow carers to deal with difficult to manage behaviours, thus reducing burden and consequently institutionalisation; improving quality of life and reducing public spending.

2.4.6 The Potential of Transformative Technologies

Technology is becoming increasingly ubiquitous in society, and the rapid development of assistive technologies present a radical alternative to the future of healthcare and risk management. These developing technologies afford new possibilities in the monitoring, delivery and efficiency of healthcare systems and have been the result of various movements, such as the exponential increase

in computing power, an urgent need to address the rising burden of chronic illness resulting from increased life expectancy and the paradigm of patient-centric healthcare (Bhavnani, Narula, & Sengupta, 2016). “Digital Health”, often involves the development of various connected health systems, smart devices and computational techniques to achieve positive health outcomes and improve overall wellbeing. The American FDA state that digital health has the potential to reduce inefficiencies, improve access, reduce costs, increase quality and make medicine more personalised for patients (FDA). Many Digital Health systems involve self-monitoring, often through wearable or portable devices. Harrington et al. (2015), suggest one such use of digital health and wellbeing systems in monitoring the wellbeing of people living with dementia and their carers, using digitised versions of well-established measures (such as the Zarit Burden Interview) allowing assessments to occur in the comfort of their home; reducing the time costs and personal discomfort associated with assessment.

It is hoped that by recording and reporting information about behaviours and physiological measurements devices can educate and motivate individuals towards better habits and positive behavioural changes. Yet, whilst the use of connected digital health devices and applications is becoming increasingly popular, there is little evidence to suggest that the monitoring and recording of patients results in the behavioural changes required to improve overall public health (Patel, Asch, & Volpp, 2015).

Currently, technological solutions to either a person becoming missing or to assist in finding them have already been developed and in a few cases even implemented by local police departments (for example Sussex Police department), charitable organisations (such as St Banados) and private companies (for a summary see http://www.alzheimers.net/8-8-14-location-devices-dementia). The forerunner for these technologies is GNSS capable devices which whilst certainly effective, remain controversial (McShane, 2013; O’Neill, 2013).

A possible solution to reducing the amount of vulnerable adults going missing is the use of electronic tagging technology. This system usually involves placing a device such as a bracelet around a person’s wrist containing some short-range

indoor tracking technology and placing several sensors throughout the residence to detect movement between zones. This has the potential to alert carers when the person they care for has moved beyond some designated point but does not allow for tracking outside of these set locations. Miskelly developed one such system for preventing dementia wandering and reports high reliability and compliance (Miskelly, 2004). Other systems have used tagging devices such as these to identify those who are at high risk of wandering (Kearns & Fozard, 2008; Kim, Hassan, Na, & Huh, 2009).

Tracking devices differ from generic tagging systems in that they have the ability to locate a person outside predefined areas. They are therefore the most useful tool to find people who have absconded from a domestic environment. The ability of technological tracking devices to assist in the search for vulnerable adults who go missing has been demonstrated since the turn of the century (Shimizu, Kawamura, & Yamamoto, 2000).

White et al, conducted a series of interviews with familial carers and concluded that tracking devices were found to be preferable to locked doors or carer supervision as a means for allowing people to maintain a certain level of independence where the risk of elopement is low (White, Montgomery, & McShane, 2010). Whilst some studies into the acceptability into tracking devices have shown that tracking is preferable to locked doors, no studies have directly reported the views of those living with dementia (O'Neill, 2013). Further, whilst this technology is available, little has been researched into the typical end-users needs in this context or into any intervention designed to control absconding behaviours outside of an institutional setting (Hermans, Htay, & Cooley, 2007; Robinson et al., 2006). It is reported that whilst tracking methods have demonstrated usefulness in uncontrolled trials, more studies are needed to validate its effectiveness (O'Neil, Freeman, & Portland, 2011). A further exposition of technological interventions will be discussed in chapter 5.

More recently, comprehensive testing of location technology designed to help people when they become lost has taken place. For instance, Bulat et al. (2016) examined seven commercially available tracking devices (3 radio frequency and 4 based on GPS). They ran a series of trails which were based on simulated

missing person incidents and measured time to discovery, and degree of deviation from a straight intercept course. They discovered that whilst radio frequency methods performed reasonably well at close proximity, GPS devices performed well at any range. They also noted that the ranges which radio frequency device manufacturers claimed were not attainable in the particular location settings in which the trails were run and that the use of radio frequency location devices required aimless walking before a signal was found. Conversely, they note that the GPS devices typically worked very well and provided highly accurate location tracking, which resulted in efficiency twice as great as the radio frequency devices.

In a longitudinal study, Milne et al. (2014) also conducted a study which examined the acceptability, effectiveness and cost-effectiveness of location technologies to assist with missing people with the intention of collecting information pertaining to broader outcome measures relating to the use of location technologies (such as quality of life assessments, diary studies, resource use, anxiety and depression). Unfortunately, they note numerous difficulties which made the quantitative outcome measures difficult to appraise, thus highlighting serious challenges for any randomised control trial wishing to investigate real-world outcome measures. These difficulties included an enthusiasm for location-based technologies from the social care staff, which suggests that some would be unwilling to randomise people to a control group. They also indicate that substantial variability existed in the time spent searching for care recipients, but "time spent searching" was difficult for carers to operationalise. However, more recently, a separate study has also investigated the acceptability of GPS devices using a mixed methods approach (L. Liu, Miguel Cruz, Ruptash, Barnard, & Juzwishin, 2017). In their study, forty-five client-caregiver dyads were issued GPS devices for an overage of 5.8 months over a 1 year period. Their approach utilised focus groups, questionnaires and observed behaviours. According to their research, the acceptability of GPS tracking devices among clients and caregivers was surprisingly high and that performance expectancy (perceptions of usefulness) was the ley determinate in the acceptability of the technology. However, these findings contrast with the work of Megges et al. (2017) who also used client-carer dyads in a longitudinal

evaluation of GPS technologies. They discovered that usability ratings significantly decreased after around four weeks of testing. They also discovered that ratings of self-efficacy were negatively correlated with the willingness to purchase the prototype, which may indicate that individuals who perceive themselves as having a greater degree of autonomy may be less likely to purchase these devices. It is also mentioned from their research despite reasonably fair ratings by participants, the device was used infrequently, which they suggest may be an artefact of inadequate training.

Location-based technologies for missing people have been in development for around two-decades, but work which documents the real-world outcomes of using such devices is sparse (Megges et al., 2017) and results often conflicting. Whilst these technologies appear to have gained acceptability amongst carers, the real-world impact of technologies over a longer period is not fully understood. The deployment of new digital alternative systems is not always a unanimous good. Beynon-Davies (1995) cites the rollout of the London Ambulance Service Computer Aided Dispatch System (LASCAD) as one example of critical system failure, resulting in loss of life. In addition to a small error in the software, Beynon-Davies also highlights the overall carelessness with which the system was developed and deployed, which failed to take into account the system requirements, partial information and likely repeated calls to the same incident. Subsequently, operators were unable to keep track of the status of the ambulances in their system; sending multiple units to a single location and none to others. The system generated such a vast number of exception messages on the terminals of the dispatchers that it was not possible to process further calls. System developers did not take into account the actual working practices of emergency ambulance dispatchers (one such practice in the paper system was stacking cards which were likely to be calls to the same incident), and subsequently the new system was not fit for purpose, resulting in an estimated 48 avoidable deaths (Beynon-Davies, 1995). The lesson here is clear; system developers and those wishing to replace existing measures with new, digital alternatives, must begin their design process from a thorough understanding of task requirements, user-expectations and likely behaviours. This thesis will take such an approach, by developing a series of design

recommendations for new digital alternatives to existing systems which are based upon a thorough understanding of how missing incidents unfold and the likely behaviours, concerns, and expectations of future end-users.

2.5 Frameworks for Understanding Decision Making in Missing Incidents

Whilst there is some research into the perspectives of families of the missing, (Parr, Stevenson, Fyfe, & Woolnough, 2015), research into the behaviours of the missing (R. J. Koester & Stooksbury, 1995), and research into experienced search and rescue teams (Plant & Stanton, 2016), little research has devoted itself to analysing the behaviours and decisions of carers and guardians of the missing during the critical 24 hour period following a noticed absence. Despite this, various well-established research paradigms and research areas may help to elucidate the decision-making and behaviours of guardians and carers conducting missing person searches following a noticed absence.

2.5.1 Incident Analysis

Incident Analysis constitutes one of the main strands of human factors research and is often used to identify the systemic antecedents of accidents or near misses; for example, incident analysis techniques have been used to improve overall system design in light of large-scale technological system failures, such as Three Mile Island and Chernobyl (Meshkati, 1991). One of the most widely used incident analysis techniques is The Critical Incident Technique (Flanagan, 1954), which is a set of procedures for collecting observations about human behaviour in order to solve practical problems and develop broad psychological principles. Flanagan suggests that the critical incident technique does not consist of a rigid set of procedures to be applied, but instead should be thought of a flexible set of principles which should be adopted and modified to suit the purposes of the current study. The technique relies on simple judgements made by qualified observers which are evaluated based upon the alleged purpose of the activity and research.

The Critical Incident Technique has been used in a wide variety of contexts. Particularly pertinent to this thesis, the Critical Incident technique has been modified to elicit indicators of high and low quality nursing care from patients

and their nurses (I. J. Norman, Redfern, Tomalin, & Oliver, 1992). In a study conducted by I. J. Norman et al. (1992), the Critical Incident Technique was adapted to fit a different set of presuppositions specific to the reports of patients and nurses about quality of care. This technique allowed for patients and nurses to establish 'meaning' of critical happenings within incidents. The authors also highlight that the use of a relational database allows for a 'personal theory' of quality of care to be identified for each respondent. Thus, it is suggested that the critical incident technique allows respondents own personal stories and unique perspectives to be capitalised upon and avoids the loss of information that may occur when highly complex and specific narratives are reduced to descriptive categories.

Another common technique used for understanding complex systems is the Accimap, developed by (Rasmussen, 1997). The Accimap looks specifically at accidents; a sub-category of incidents in which a singular cause or multiple causes all contributed to dangerous and/or undesirable system behaviour. The Accimap technique is an approach which seeks to understand the confluence of forces resulting in undesirable system behaviour at various 'levels', from the immediate physical and behavioural causes, to the managerial and legal frameworks that the task is embedded within. Historically, legislative frameworks, system design and human behaviours are each studied separately by specific academic disciplines, but the Accimap seeks to unify the analysis of system behaviours by identifying the interplay between various 'levels' of understanding.

2.5.2 Human Factors Research in Search and Rescue

Much of the related Human Factors research in this area is focused upon professional search and rescue teams, with a substantial portion of that research devoted to facilitating the development of robotics and drones appropriate for use in Search and Rescue tasks (Julie A. Adams et al., 2007; Burke, Murphy, Coovert, & Riddle, 2004; Gabrecht, 2016; Nourbakhsh et al., 2005; Schlenoff & Messina, 2005). In addition, there is a considerable amount of literature which focuses on search and rescue tasks in emergency situations such as collapsed buildings (e.g. (Hew & Sunshine, 2002) rather than missing incidents per se.

Adams et al conducted a series of cognitive task analyses with Wilderness Search and Rescue Teams (Julie A. Adams et al., 2007; Julie A Adams et al., 2009). They integrated various sources of information including expert interviews and operational manuals in order to form the basis of a goal-directed task analysis and a work domain analysis. This work demonstrates the usefulness of cognitive task analysis techniques for deconstructing the search and rescue task, in particular, cognitive task analysis has been shown to be beneficial in identifying key informational requirements. Despite the extensive nature of the study, the study only analyses the activity of Search and Rescue teams and does not consider the wider context in which the activity occurs, such as the perspectives of other stakeholders, including the families of the missing.

Human Factors work into urban search and rescue tasks typically focuses on the interaction between robotic agents or tools and their human operators. Robots are often to assist emergency teams find survivors in collapsed buildings as the buildings are often unsafe for humans. Search and Rescue robots are often also able to navigate through areas that humans would not be able to, owing to their smaller size. Burke et al. (2004) conducted a communication analysis on data gathered during a 16 hour high fidelity urban search and rescue disaster response drill with remotely operated robots. The findings indicate that operators spent the majority of their time gathering information, both about the state of the environment and the state of the robot and relatively little time navigating the robot. The study also suggests that operators have difficulty integrating the robot's view into their own mental model of the situation, but compensate for this by communicating with other team members on site in order to increase their situation awareness.

2.5.3 Laboratory Experiments in Visual Search Tasks

Perhaps the largest area of research focusing on search behaviour is visual search, which has been developed from a perspective influenced heavily by cognitive psychology (Neisser, 1964). Visual search experiments are typically involve participants attempting to find a target item amongst a complex array of distractor items in a controlled environment (Wolfe, 1994). In these types of experiments, two methods are commonly used; the *present-correct* method and the *reaction-time method.* In regards to the former, participants are briefly

presented with an array of items for a set time (known as an inter-stimulus interval) followed by a mask. The participant is then asked whether the target is present or absent from the stimulus array and the target-absent response and percent correct is measured as a function of the inter-stimulus interval. If a task can be performed with high accuracy under these conditions even with very short inter-stimulus intervals, it is taken to mean that these items have been processed in parallel. Conversely, if larger stimulus arrays require higher inter-stimulus intervals, it is assumed that a process with limited capacity is required for the search task (Bergen & Julesz, 1983). The second type of visual search experiment methodology typically employed uses neither a mask nor an inter-stimulus interval, instead, participants are presented with stimulus array and asked whether the target item is present or absent and their response time is recorded. In this case, if reaction time is independent of the size of the stimulus array, the process is considered to be in parallel (Humphreys, Quinlan, & Riddoch, 1989).

Wolfe (1994), suggests that visual search occurs by a process he calls Guided Search 2.0 (GS2). The GS2 model assumes that input and initial processing of stimuli are carried out in parallel across the entire visual field and independent representations are generated for a limited set of basic features (such as colour, orientation, shape, etc.); he calls these representations, *feature maps*. The GS2 model proposes an interplay between "Bottom-Up" and "Top-Down" activation. Where the former is a measure of how unusual a particular item is compared to neighbouring stimulus, it does not depend upon any preconceived knowledge of what one is looking for, but merely embodies the principles of similarity and difference between an item and its neighbours; as the similarity increases between distractor and target items, 'Bottom-Up' activation decreases (Duncan & Humphreys, 1989). Bottom-Up activation is therefore not sufficient to guide attention if the *featural* properties of a target item are not distinct compared to their neighbours. Conversely, Top-Down activation, is goal-driven, subsequently, beliefs, cognitions and expectations are likely to affect the recognition process. Wolfe (1994) describes the how Bottom-Up and Top-Down processes interact in order to direct attention. The ability to perform visual search tasks therefore, depends upon sufficient difference for bottom-up

processes to distinguish a target item from its neighbour, as well as the correct expectation about what the target *should* look like to direct top-down processes. In the context of missing incidents, this suggests that correct expectations about what the missing person is wearing will help Top-Down processes direct attention to the appropriate aspects of their visual field, whilst Bottom-Up processes will be improved if the missing person is wearing clothes that are in contrast to their environment.

Kiss et al. (2007), highlight additional factors can affect visual search, pertinent to this thesis, they point to numerous studies which demonstrate how the emotional salience of stimuli affects sensory processing (Lang et al., 1998), the allocation of attention (Eastwood, Smilek, & Merikle, 2001) and decision-making (Cacioppo & Gardner, 1999). Kiss et al. (2007), go further and show that this relationship is bi-directional; not only can the emotional salience of stimuli impact the visual search task, but the attentional processes can also impact emotional evaluation. Faces that served as distractors in a visual detection tasks were likely to be rated as less trustworthy than target faces, further demonstrating the interplay between emotion an

Experiments from visual search experiments shed light on an important aspect of search behaviour, and demonstrate the relationship between fundamental neurological processes and higher order cognitive expectations. Evidence from such experiments also shows the role that emotion plays in the visual aspect of search. However, whilst profoundly relevant to missing incidents, they highlight only a very small aspect of the overall task. In addition, visual search experiments take place in extremely controlled and artificial environments that lack the context of missing person search and hence, they have a low ecological validity.

2.5.4 Wayfinding, Navigation and Orientation

Navigation is often described as goal-directed movement through the environment which consists of two distinct aspects; *Wayfinding* and *Locomotion* (Freundshuh, 2001; Montello & Sas, 2006; Verschure, Pennartz, & Pezzulo, 2014). Whilst definitions of Wayfinding and Navigation vary somewhat in the literature, Darken and Peterson (2001) describe ‘Wayfinding’

as the cognitive element of navigation; distinct from movement, it relies upon the development and use of a cognitive map, mental map, or mental model of the environment. Locomotion (or simply, motion) is the real-time aspect of navigation in which an individual traverses through space, maintaining balance, avoiding obstacles and barriers and moving towards an intended location. Golledge (1999) offers a similar description, referring to wayfinding as selecting paths from a network and navigation as both a cognitive and spatial process. Navigation as therefore the aggregation of wayfinding and locomotion, and thus both cognitive and motoric.

A necessary requirement of wayfinding also requires that travellers are aware of their own location relative to their destination, as well as to other salient places or objects en route to their location. This knowledge is called *Orientation* (Montello & Sas, 2006). A full knowledge of one's location with respect to the Earth's surface (*Geographic Orientation*) is not required to complete most navigation tasks, it suffices that travellers merely know enough about their current position relative to their target destination. Disorientation may occur frequently during a navigation task, particularly in individuals that have a poor sense of direction (Kozlowski & Bryant, 1977). Orientation is knowledge which is updated in real-time during a navigation task, either via landmark-based or dead-reckoning processes. Landmark-based orientation involves the presence of salient environmental features known to the traveller, whereas dead-reckoning involves estimating the velocity, duration and acceleration of travel. Dead-reckoning methods are limited, however, as they depend upon a full orientation of a previously located place with respect to the current position, and any errors incurred by dead-reckoning processes are compounded over time (Montello & Sas, 2006).

Spatial knowledge is required for wayfinding tasks, though there is still debate about how exactly spatial knowledge is represented. Following on from a seminal paper investigating the navigational strategies employed by rats, Tolman describes the idea of 'cognitive maps', which are mental representations of spatial information (Tolmon, 1948). Golledge describes cognitive maps as implying "deliberate and motivated encoding of environmental information so that it can be used to determine where one is at

any moment, where specific encoded objects are in the surrounding place, how to get from one place to another, or how to communicate spatial knowledge to others" (p15 (Golledge, 1999)

Perhaps the most supported model of spatial knowledge representation is the Landmark Route Survey (LRS). It not only describes the various levels of representation of spatial knowledge, but also how spatial knowledge develops. Siegel & White (1975) theorise that spatial knowledge is often fragmented, incomplete and may at times be inconsistent. The LRS model suggests that spatial representations are often a series of multiple, sometimes contradictory 'mini-spatial representations'. According to this model, landmarks serve as associative cues (Waller & Lippa, 2007); stimuli that facilitate the recall of appropriate directional responses, but also function as anchor points for organising other spatial information (Golledge, 1999). Waller and Lippa (2007), also lend support for a variation of this theory, and also note the importance of landmarks as 'beacons'; waypoints which indicate progression towards a navigation goal. Landmarks are more likely to be remembered if they have a dominant physical form, are peculiar in some way, or have associated cultural significance (Appleyard, 1970). Therefore, the performance of wayfinding tasks can be improved by providing or enhancing the salience of the visual details of specific locations in the environment (Thorndyke & Goldin, 1983; Thorndyke & Hayes-Roth, 1982). *Landmark knowledge* is often seen as the appropriate conceptual relationships between certain known stimuli and required action, but these cues are often static, orientation dependent and disconnected (Darken & Peterson 2001).

Familiarity with a navigation task can facilitate the acquisition of *route knowledge*; knowledge of paths between landmarks. At this level of representation, travellers can navigate between two or more landmarks, though this navigation may not be optimal. For example, travellers may know how to get from A to B and from A to C, but have no knowledge of how to get from A to C. Route knowledge can facilitate the exchange of spatial information and allows common frames of reference to be established (Golledge, 1999). It is suggested that this type of knowledge is organised in the form of a hierarchy of networks, connecting various locations (Golledge, 1999).

At the highest level of representation, *survey knowledge* (also called configurational knowledge) develops, this involves the ability to estimate relative or absolute distances and directions between two locations, even in unfamiliar routes. Configurations often consist of a hierarchy of locations and routes and the spatial distributions between them. Survey knowledge is often presumed to be the highest level of spatial understanding (Hart & Moore, 1973) and is said to constitute much more formal knowledge of spatial relations, including an understanding of Euclidean distances (Golledge, 1999). Taken together, these aspects represent the total spatial knowledge structure, or cognitive map. However, this hierarchy has been challenged by other research, which suggests that even once survey knowledge is acquired, psychological distance in cognitive maps is primarily dependent upon route distance, rather than Euclidian distance (McNamara, Ratcliff, & McKoon, 1984).

An overall model of navigation is illusive, with some models being too specific to certain environments (hence, not easily generalizable) and others failing to capture the salient aspects of navigational tasks (Darken & Peterson 2001). One model that may be useful in considering how people engage in missing incidents is taken from Jul (1997); Figure 2.5. This model proposes that navigation tasks consist of a hierarchy decisions and integrates goal formation, strategy selection, cognitive maps and other navigation elements into a unified theory. To fit this model to behaviour during missing incidents, goal formation in this case should be considered which *places* carers choose to search, rather than what to search *for* more generally. This model also suggests that there is a reciprocal relationship between wayfinding and locomotion. Goal formation informs strategy selection and together with information from the environment and the travellers cognitive map decisions about locomotion are decided and acted upon. Assessment of the current situation may result in a different strategy being employed, or even a different location being decided upon.

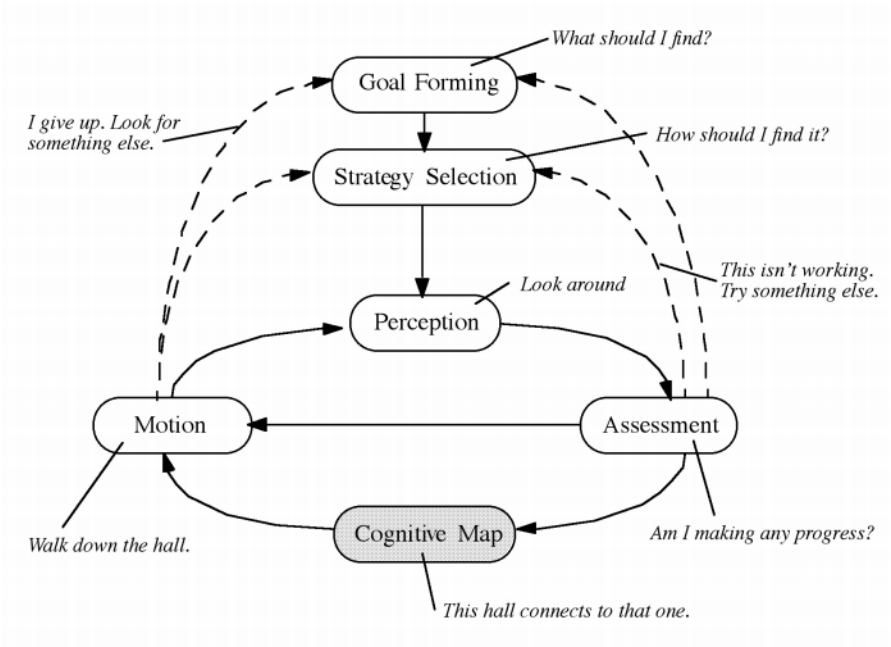


Figure 2.5 A Model of Navigation

Adapted from (Jul, 1997) in (Darken & Peterson 2001)

An obvious limitation of applying this navigation model to missing incidents however, is that it is devoid of the specific context in which missing incidents occur and thus does not adequately capture the salient features which differentiate navigation tasks from missing incidents. In particular, the model does not describe the basis on which these assessments are made in relation to the overall goal, nor does it account for decision-making biases or the high-levels of stress that can be encountered if a traveller becomes disoriented or is otherwise experiencing high levels of emotional arousal. Nevertheless, the relevance to caregiver behaviour during missing incidents is clear and helps to frame the understanding of missing incidents within a wider, better researched academic context.

2.5.5 Optimal Foraging Behaviour

Related to investigations into Wayfinding and Navigation is the research into animal foraging behaviour. According to Kalff, Hills, and Wiener (2010), foraging describes behaviours as diverse as "Picking bananas from banana trees, searching for nebulas in the night sky and hunting for tuna in the open ocean" (p 168). Missing Incidents are tasks which are very closely analogous to "foraging", they both involve the allocation of time and resources in order to

find a specific object in time and space. The modern scientific understanding to foraging behaviours is largely attributed to two papers; MacArthur and Pianka (1966) and Emlen (1966). The first of these such papers (MacArthur & Pianka, 1966), attempts to model "optimum theories" of foraging; that is, the allocation of time and resources in such a way to maximise food gathering whilst minimising energy and time expenditure. Whilst the second (Emlen, 1966), derives a series of predictions about animal behaviour from elementary mathematical assumptions about similar optimal strategies.

According to Kalff et al. (2010) *area-restricted search* (ARS), is one of the most well-studied behavioural patterns in foraging. ARS patterns involve high turning angles following resource encounters, but lower turning angles in their absence. ARS is considered to be an optimally adaptive response when resources are clustered (patched environments) and typically localises animals to where resources are more densely clustered. In addition, this strategy has a minimal informational requirement, depending only that the forager changes their behaviour on encountering a resource. The efficiency and simplicity of ARS has led some to propose that this strategy may have provided the biological building blocks for the subsequent evolution of attention (Hills, Todd, & Goldstone, 2008).

ARS suggests that foragers use *temporal cues* to determine when to leave designated 'patches' of the entire search area. According to predictions made by ARS, foragers will spent more time in resource-rich or dense patches, whilst devoting less time to sparse patches. If a certain temporal threshold passes without encounter, foragers will leave the patch (fewer, shallower turns), whereas encounter with a resource target will increase the total patch residency time incrementally.

Whilst it could be argued that research into the evolutionary foraging behaviours of human and non-human animals has little relevance to missing person search, many of the foraging strategies predicted by MacArthur and Pianka (1966) and Emlen (1966) have been observed in areas as divergent as information foraging on the internet (Pirolli & Card, 1999), consumer behaviour (Donald A. Hantula, Diane DiClemente Brockman, & Smith, 2008) and even

the ways in which humans navigate through their own memories (Hills, 2011). These findings suggest that the control of attention and the control of movement may share a similar evolutionarily optimal control structure. Which lends support to the idea that there may be common 'foraging' strategies, as a vestige of our evolutionary baggage. These strategies (or foraging heuristics) may have been beneficial overall, but may in certain specific circumstances manifest themselves as maladaptive behaviours. It may perhaps be the case that people are prone to stochastic movement patterns when looking for a missing person, but following more prescriptive methods would be more effective.

2.5.6 Prescriptive Search and Rescue Research

Search Theory which was originally developed by the United States military in order to efficiently search for enemy submarines (Koopman). Search Theory attempts to derive proscriptive rules about optimal search strategies, as opposed to describing how humans actually behave during these tasks. Research of this nature involves mathematical modelling of abstract agents searching in space to find a target, where each search agent is considered to have a probability of detection over a certain range, or in the words of Benkoski, Monticino, and Weisinger (1991), Search Theory is "any mathematical framework involving the search for lost or hidden objects" (p469). Search Theory relies upon various probabilistic models which relate both to distribution and detection probabilities in order to inform optimal search strategies. For example, given a certain probability of detection (that is, the probability of an agent or 'detector' to detect a target object in given conditions) the optimal "sweep width estimation" (the distance between two separate search agents or separate passes) can be obtained. Through the use of this modelling technique, various methods for efficiently searching have been developed (Lin, Roscheck, Goodrich, & Morse, 2010; Perkins, 2013; Perkins et al., 2011a) and are often used as the basis for search and rescue operational manuals (D. Cooper, C. et al., 2008). However, these models are entirely prescriptive and do not describe how search and rescue operations are actually conducted as they do not account for human psychology, geographical restrictions and contextual clues which may inform the search parameters. Whilst Search Theory can help to inform search strategy; in

describing how ideal searches *should* be conducted, it does little to elucidate how searches *are* conducted.

2.5.7 Decision-Making

Research into decision-making has a variety of wide-ranging applications. Particularly pertinent to the work in this PhD is an understanding of how people make decisions under pressure or in time-critical situations. In a seminal paper, Klein (1993) proposed the theory of Recognition Primed Decision-Making (RPD) in order to understand the decision-making capabilities of experts. Klein calls his general approach, "Naturalistic Decision Making", (Salas & Klein, 2001; Zsambok & Klein, 1997), which can be broadly characterised as the study of experts making decisions in their full context, rather than in an artificial laboratory environment. Klein describes how he came to study the rapid responses of firefighters and their ability to make rapid and effective decisions in complex environments (G.A. Klein, Calderwood, Clinton-Cirocco, & Laboratory, 1988) which he used to inform his RPD model.

Klein postulates that in time-critical situations, experts do not often have time to deliberate between numerous possible courses of action. Instead, when an expert is confronted with a situation, they rely on their experience and access their memory of similar situations in order to decide on an appropriate course of action. Rather than trying to arrive at optimal solutions, experts, he argues, use cues to arrive at merely satisficing courses of action.

The RPD asserts that expert practitioners will attempt to find examples from their memory which bear resemblance to the current situation in the hopes of choosing a suitable course of action. They will then use mental simulation to evaluate whether the course of action is satisfactory, amending and revising their plans if necessary (Figure 2.6). Klein suggests that the RPD allows for rapid and effectual decision-making in situations where conscious deliberation would be too slow (G.A. Klein, 1993).

A similar suggestion has been made by Gigerenzer and Goldstein (1996), who argue that humans make inferences about their environment under conditions with limited time and knowledge and therefore do not always have unlimited time, knowledge or resources at their disposal to make entirely 'rational'

decisions. Instead, they demonstrate that in many cases merely satisficing solutions outperform multiple regression inferences in terms of speed and accuracy in a computer simulation. This is taken to show that cognitive mechanisms capable of successful performance need not be derived from an exhaustive consideration of all possible options.

If Klein is correct, however this rapid and intuitive method of decision-making would only be available to those with previous experience of multiple different scenarios (i.e. experts) as such, this theory of decision-making is not applicable to novices.

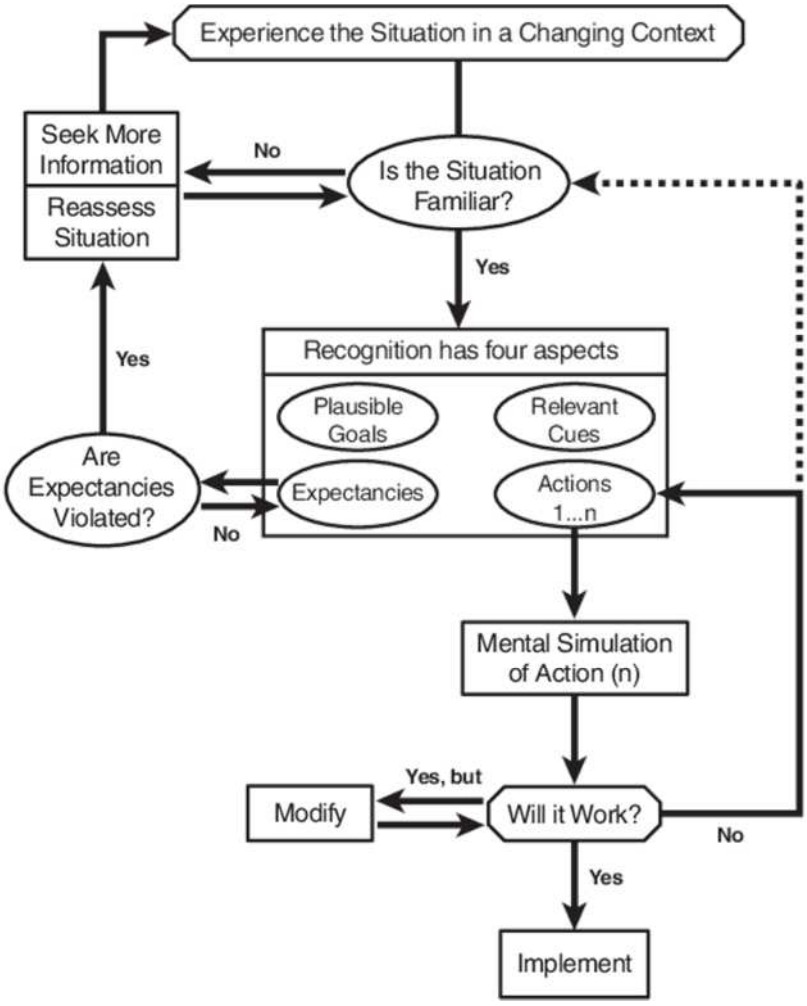


Figure 2.6 Recognition Primed Model of Decision Making

Recognition-primed decision-making model from (G.A. Klein, 1993)

Kahneman has notoriously challenged the assumptions of the alleged authority of experts, and in particular, the approach taken by Klein (Kahneman & Klein, 2009). Kahneman and his late academic partner Tversky are sceptical about intuitive decision-making and point to numerous cognitive errors and biases in decision-making that can occur even in the most experienced practitioner (D. Kahneman & A. Tversky, 1979). However, both Klein and Kahneman insist this is merely a disagreement in approach and not a disagreement on fundamentals per se (Kahneman & Klein, 2009; G. Klein, 2014).

Kahneman outlines a theory on decision-making distinctly different from Klein's, he describes two 'fictional personas' in the brain which are responsible for decision-making, he calls these System 1 and System 2 (Kahneman, 2011). System 1, he argues is fast, automatic, instinctual and subconscious, it often relies on stereotypes and emotional reasoning. System 2, on the other hand, is slow, effortful, logical and deliberate. Kahneman suggests that whilst system 2 is often more accurate due to its logical nature, rapid judgements in time-critical incidents do not often permit lengthy deliberation. Further to this, he notes that due to the effortful required for conscious and logical reasoning, system 2 is active in problem-solving far less frequently. Therefore, he insists, system 1, which depends upon biases and heuristics and is prone to error, is far more frequently employed than system 2. Whilst there are obvious differences in the approaches laid out by Kahneman and Klein, it is interesting to note that Klein too believes that rapid decisions depend upon automatic and instinctual responses as opposed to conscious deliberation (G.A. Klein, 1993).

Kahneman and Tversky suggest that forecasts and predictions are often likely to be wrong, owing to the fact that people often overestimate the probability of particularly salient events, whilst underestimating much more mundane outcomes (Kahneman & Tversky, 1973), this bias, known as the availability heuristic is thought to be pervasive in judgement and decision-making. In a series of studies, Kahneman and Tversky demonstrated that the cognitive availability (the ease at which certain relevant instances come to mind) of a particular item is used as a heuristic to determine its likelihood. For example, when participants are asked to estimate the if they thought the letter "k" appeared more as the first or third letter of a word, they (incorrectly) guessed

that “k” appeared more as the first letter in a word due to the cognitive difficulty of recalling words where the target letter is third in the word (Tversky & Kahneman, 1973). The availability heuristic, they argue, leads to systematic biases and illusory correlations between unrelated phenomena.

Other similar biases identified by Kahneman and Tversky include the representativeness heuristic and a failure to consider the base rate; the average frequency at which an event is likely to occur (Tversky & Kahneman, 1973). The representative heuristic is usually employed when people are asked if one object or event belongs to a particular class or process. However, rather than using prescriptive rules and analytical reasoning to determine whether this is the case, people make their judgements often by considering mere superficial similarity or rely on stereotypes.

Additional research also illustrates that people avoid losses much more than they seek gains, at around twice the rate. ‘Loss aversion’, demonstrates that people are not always strictly judicious when evaluating gains and losses. They do not view forgone gains in the same manner as losses (Thaler, Tversky, Kahneman, & Schwartz, 1997). Such examples call into question the rational nature of decision theories outlined by Klein, and more fundamentally, challenge the idea that decisions are made by fully-informed, self-interested rational agents trying to maximise a certain utility function (Daniel Kahneman & Amos Tversky, 1979).

Related to loss aversion is the notion of sunk-costs, it describes the tendency to persist in unfruitful courses of action on the basis that a large prior investment (time, money or effort) has already been made (Arkes & Blumer, 1985; Daniel Kahneman & Amos Tversky, 1979). This psychological tendency is fallacious because decisions should be evaluated solely on the benefits and costs moving forward, previous investment has no bearing on whether continued investment is prudent. This might manifest itself during missing person incidents if carers continue to follow a course of action long after it becomes clear that it is no longer fruitful.

Another cognitive bias likely to affect the outcome of missing incidents is the well-travelled road effect. It describes the tendency of travellers to

underestimate the length of time of traversing a familiar route whilst overestimating unfamiliar routes (Allan, 1979; Jackson & Jucker, 1982). Potentially, this could lead to sub-optimal searching and errors in the prioritisation of likely search areas.

Acute stress has been shown to significantly detriment decision-making abilities. In an experiment conducted by Wemm and Wulfert (2017), participants were randomly assigned to one of two conditions; stress or control. In the stressor condition, participants were subjected to the Trier Social Stress Test, in order to induce stress and anxiety. Both groups were then presented with an Iowa Gambling Task; where the objective is to maximise winnings in an artificial gambling task. Participants are given a hundred choices and asked to choose between four decks of cards, some decks have higher associated costs, but greater rewards, and in each deck. The probabilistic nature of the Iowa gambling task makes it difficult for participants to make fully informed choices, and as such it has been used in many experiments looking into decision-making. In the study conducted by Wemm and Wulfert (2017), the presence of a stressor has been shown to substantially reduce performance in the Iowa Gambling Task. The authors theorise that stress may generally result in a failure to attend to the full range of possible consequences of a decision, thus reducing task performance. In a similar study, van den Bos, Harteveld, and Stoop (2009) demonstrated that participants subjected to a stress condition typically experienced higher levels of cortisol and that the production of cortisol affected performance in the Iowa Gambling Task. Interestingly, they also observed a different relationship between cortisol and performance between men and women, with men's performance declining as cortisol increases. Contrastingly, female participants the slight increases in cortisol levels actually increased task performance. Whilst there is an observed relationship between stress and decision-making abilities, the study conducted by van den Bos et al. (2009) suggests that there may be sex differences in the way that people respond to stress.

Smith and Kida (1991) have argued that the typical experimental setup in which certain heuristics and cognitive biases are tested are often very artificial and do not adequately represent the context in which expert decision-making occurs,

calling into question the generalisability and ecological validity of such studies. Though the authors confirm that expert practitioners are not immune to cognitive biases, they argue that many of these biases are mitigated or modified in studies which used experts performing familiar tasks. The prevalence of systematic biases resulting from a dependency on heuristics should not necessarily be taken to suggest that heuristics are inherently 'bad' or that they will more often than not result in sub-optimal performance. Heuristics can be considered adaptive strategies which evolved in tandem with other fundamental psychological mechanisms (Goldstein & Gigerenzer, 2002) and therefore must have been selected for. The survivability of such mechanisms demonstrates that heuristics must have been beneficial overall to the species, but it should not be surprising that these generalisations may be sub-optimal in marginal, or otherwise scientifically contrived cases.

When people make decisions in highly emotional and time-critical incidents, they employ a variety of heuristics, which are often prone to bias and systemic errors. This could result in sub-optimal decision-making, which is likely to affect the outcome of missing incidents, even amongst expert practitioners. Yet, that is not to say that the dependency upon heuristics is fundamentally flawed, or that better outcomes could be achieved if more strictly 'rational' models were employed. Gigerenzer and Gaissmaier (2011) point to the fact that the conditions required for a more strictly rational bounded (or indeed Bayesian cf. Savage, 1951) are simply not met in most real-world cases, making any attempts at more formal 'optimal' reasoning strategies inappropriate for all but marginal cases. This may be because there is a high informational dependency of formalised rules, and in 'large-worlds' very slight initial informational discrepancies may multiply in magnitude resulting in strategies far less optimal than those given by heuristics. The consequence of these errors were observed once the heuristics became more formalised and it was demonstrated that, in many large-worlds, heuristics were more accurate than standard statistical models which had the same (or more) information (Gigerenzer & Gaissmaier, 2011). It has been suggested that there is an inverse-U-shaped relationship between the level of accuracy and amount of information available (Gigerenzer & Gaissmaier, 2011). This may result in "less is more" effects, where additional

information actually results in poorer and less optimal decision-making (Gigerenzer & Goldstein, 1996). Whilst research into heuristic decision-making is typically purely descriptive, (e.g. which heuristics do people use and when?) 'less is more' effects suggest that often, heuristics are better suited to many cases of decision-making under uncertainty. This raises the normative question, 'When *should* people rely on heuristics rather than strategies to improve decision-making outcomes?' (Gigerenzer & Gaissmaier, 2011).

2.5.8 Workload

Workload is a human factors construct which is often thought of as the mental effort, or the processing resources required for any given task, given that this mental effort itself can be thought of as a finite resource (Wickens, 1979). According to the original theories of Moray (1967) and Kahneman (1973) workload is associated with a concept of undifferentiated capacity; there is a general pool of processing resources available for all tasks and processing resources are allocated to each task indiscriminately, based only upon the demand of each respective task. Therefore, as the difficulty of demand of a task increases, more resources are required to be allocated in order to maintain task performance. Given there is considered to be a finite pool of processing resources, the difference between the total pool of resources and task demand is referred to as spare capacity. Performance is assumed to remain relatively constant whilst there is spare capacity, but quickly declines once this capacity begins to be exceeded; this rapid decline is referred to as the "precipice of performance" (Wilson & Sharples, 2015, p. 518).

However, the idea that processing resources are finite and undifferentiated has been famously challenged by Wickens (Wickens, 1979, 1991). Wickens gives examples of efficient time-sharing (such as walking whilst talking) and inefficient time-sharing (such as reading whilst talking) (Wickens, 1991), in order to lend support to his idea that the processing resources proposed by Kahneman are not *undifferentiated*. Instead, he argues that two tasks may interfere if they are competing for common processing mechanisms or structures, but tasks that are not competing for common processing mechanisms will have less interference. This is why it is relatively straight forward to talk whilst walking, but not as easy to talk whilst reading. Over the past 60 years,

the concept of ‘time-sharing’ has developed into a well-defined model of “Multiple-Resources” (Wickens, 2008) in which Wickens defines four separate dimensions; stages of processing (perceptual and cognitive), codes of processing (spatial and verbal/linguistic), modalities (auditory and visual) and finally, visual channels (focal and ambient). Whilst Wickens suggests that tasks requiring separate aspects of cognition will be less likely to interfere with each other, he is eager to point out that this does not mean there will be no interference between these tasks as they may both require access to certain common structures. Wickens defends the rationale for defining these four dimensions in two ways; firstly, he suggests that the model has neurophysiological plausibility, and secondly, he also suggests the dimensions of the model coincide with relatively straight forward decisions which could be made by a designer. One might be able to improve task performance or increase the safety of a given system by designing it in such a way as to reduce interference between tasks.

Researchers employ a variety of methods in order to estimate workload. Often, when attempting to assess workload, researchers will conduct experiments which require a participant to conduct a primary task of interest, whilst simultaneously attempting a secondary task. As the demand of the primary task increases, workload subsequently increases and performance on the secondary task deteriorates. The deterioration of the secondary task is often taken to indicate the demand of the primary task.

2.5.9 Situation Awareness

Situation awareness (or situational awareness) describes the knowledge an individual has about their environment, often with respect to a specific task or series of tasks. Situation Awareness however, is far more than awareness of numerous pieces of environmental data. According to Endsley, for an operator to have situation awareness they must have an advanced level of situation understanding and the ability to project the current system state to an unseen future state in light of their pertinent goals (Mica R. Endsley, 1995). Thus, Situation Awareness can be thought of as comprising as three main states, each progressively enhancing the level of situational awareness.

The first is perception (of elements in the environment). This describes an operator's ability to attend to the goal-relevant information in their environment. This could for example, be the ability to read dials, gauges and other displays related to altitude and other important data whilst piloting a plane, or the ability of an automotive driver to know where other vehicles and obstacles are relative to their own.

The second level; comprehension (of the situation), is based on a synthesis of (potentially) disjointed level one elements. It not only involves perceiving relevant informational elements in the environment, but understanding the significance of those elements when taken collectively in light of current operator goals. It may involve integrating various disparate pieces of partial or incomplete information in order to construct a working mental-model of the situation. For example, a fire alarm may sound in an office, but an office worker may have the additional knowledge that there is a fire alarm test due at that time and conclude that this must mean the alarm is part of a test and not a real incident.

The final level of situation awareness is projection (to a future system status). This third and highest level of situational awareness is achieved not only though the knowledge of current system status, but an understanding of the dynamics of that system, and how the system elements interact and change over time. Projection of this kind allows for operators to make appropriate decisions based upon future predicted states. A driver may for example, perform an emergency stop if he sees a ball in the road because he projects that this may mean a child will soon follow.

According to Endsley, Situation Awareness is intrinsically linked to decision-making (Mica R. Endsley, 1995). Firstly, situational awareness forms the *basis* of decision-making; knowledge of important and job-pertinent system elements are the primary basis on which decisions are evaluated (e.g. if an pilot wishes to lower their landing wheels, they will have to ensure the landing wheels are not already lowered and that it is safe to do so). But moreover, the manner of characterising a problem will determine the process chosen to arrive at a solution. In the absence of full system knowledge or an appropriate mental

model of the system under consideration, people will very often fail to solve the problem even if they have solved similar problems in other contexts.

The relationship between task performance and situation awareness is not entirely straight forward and not always direct. Whilst there are numerous studies linking situational awareness to task performance (Durso et al., 1998; Ma & Kaber, 2007), there is not a one to one correspondence between situational awareness and performance in all cases. Although it is suggested that low Situation Awareness will result in poor performance, that does not entail that high situation awareness is sufficient for good performance. In a study investigating the relationship between situation awareness and task performance for air-to-air combat pilots Endsley found that situational awareness was significantly correlated with high performance, but only for individuals who had the technical and operational capabilities to put such knowledge to action. Those with lower technical capabilities could not utilise their knowledge of the situation to their advantage (Mica R Endsley, 1990). Conversely, the same study suggests that poor situation awareness would not necessarily lead to poor performance if subjects realised their lack of situation awareness and modified their behaviour accordingly.

Situation Awareness depends upon, and is affected by many human cognitive abilities, including attention, perception and memory. Attentional resources are required in order to attend to pertinent system attributes, often many processes will have to be attended to in parallel for complex tasks. As attentional resources are limited, often, operators cannot actively attend to all system elements simultaneously and may also depend upon long term memory to portion the relative priorities of each system element and distribute their attention accordingly. Fracker and Wickens (1989) discovered that experienced operators typically focus their attention on environmental elements that were more likely to contribute to task success. Wickens (2002) also suggests a multiple resource model of attention, which identifies which types of information can be most easily attended in parallel. Whilst the attentional resources of human beings are often considered to be fixed, the capacity for attention can be expanded if information is presented in such a way to minimise task interference.

Perception itself can also influence an operator's situational awareness; advanced knowledge about the expected characteristics of system attributes has been shown to significantly increase the speed and accuracy of the perception of information (Jones, 1977), this finding also bares resemblance to the influence of 'top-down' processing within visual perception (Neisser, 1964). Equally, it has been proposed that level 3 situation awareness depends heavily upon working memory, as the operator has to maintain the knowledge of present conditions, the rules of interaction between system elements and the projected future system states (Mica R. Endsley, 1995). System awareness not only depends upon the necessary cognitive capacities of agents, but also the design of systems which facilitate goal-relevant system elements to be perceived, understood and projected to a future state.

Situation awareness is often used to describe the knowledge an individual operator has over his or her environment, but increasingly situation awareness has been considered at the level of teams of agents rather than individual operators. Two paradigms for understanding the situational awareness of teams predominate the literature; shared situation awareness (M.R. Endsley, Bolte, & Jones, 2003; Lipshitz et al., 2006) and distributed situation awareness (N. A. Stanton et al., 2006). Approaches of shared situation awareness seek to understand the informal cooperative strategies that operators develop in order to foster a similar understanding across an entire distributed system. Effective performance depends upon common knowledge of the current system state, knowledge about other team mates and their goals as well as knowledge about future activities and intentions, or '*interpredicatablity*'. This 'shared situation awareness' may be thought of as '*common ground*' (Gary Klein, Feltovich, Bradshaw, & Woods, 2005) and is a coordinating influence, allowing teams to allocate resources appropriately to meet both individual and team goals. Conversely, distributed situation awareness takes the view that in complex systems individual agents may have their own situation awareness that may diverge drastically from that of their teammates. N. A. Stanton et al. (2006) argue that it is neither common nor desirable that complex teams share their situation awareness in the way expressed by those expressing the '*common ground*' paradigm as different agents have different purposes and different

goals. The consequence of this view is that rather than situation awareness within teams being thought of as shared knowledge, situation awareness within teams is dynamic and collaborative, binding individual team members together on a moment-by-moment basis. However, whilst these two paradigms may be at odds, both may be useful to varying degrees in describing and understanding how teams communicate and effectively coordinate tasks in light of multiple operator goals. It may be the case that in some circumstances a 'common ground' understanding of team situation awareness yields analysis more appropriate to the goals of research, whilst in other cases a distributed paradigm is better suited.

Understanding how teams comprised of human and non-human agents work within shared physical or informational environments is often an essential part of Human Factors research. Thus, an informed theoretical understanding of how individual members perceive, understand, communicate and contribute to the task specific environmental knowledge of others should underlie any serious analysis of decision-making within teams.

2.5.10 Situated Cognition

In his landmark book, Hutchins (1995) draws our attention to the significance of culture as a collective human cognitive process, rather than a collection of tangible and intangible things. Hutchins argues that in both cognitive science and anthropology, the role of culture has been marginalised as mere epiphenomena, arising from the aggregate of individual ideation and shared beliefs. Separating cognition from culture in this way is a mistake with unnoticed costs, Hutchens notes, because "it hides the many ways in which cognition is part of the cultural process" (p 354 (Hutchins, 1995)). It is suggested that this reductive individualism privileges abstract properties of isolated individual minds and therefore reinforces an implicit dependency upon Cartesian dualism. This move encourages us to mistake the properties of complex sociocultural systems for the properties of individual minds, hence, "primitive" technological cultures must be such because of the primitive minds which constitute them. The consequence of this mistake leads to an attribution error, namely, that of assuming that complex behaviours necessitate complex individual cognition, and therefore that individual cognitive processes are

sufficient to explain the observed complexity. The theory of Situated Cognition takes the opposite view; namely that knowledge is inseparable from action (J. S. Brown, Collins, & Duguid, 1989), therefore, cognition cannot be separated from context. Under this understanding, it would be a mistake to assume that cognitive processes are merely 'in the head', devoid of the context which gives rise to them. Young, Kulikowich, and Barab (1997) suggest that meaningful cognition is a continuous interaction between a perceiving-acting agent and a dynamic informational field, discretized into meaningful "intentional units" relating to an overall goal or choices made, moment to moment in pursuit of a goal. These "intentional units", they suggest should be the basic unit of analysis for any investigations into cognition. Whilst a theoretical discussion of such nature is beyond the scope of this thesis, the idea that cognition is inseparable from context is an important consideration for any serious investigation of the ways in which people perceive, think and act in real-world settings.

2.6 FINDINGS FROM LITERATURE REVIEW

There is a wealth of literature which relates to many aspects of missing incidents; including statistical treatments of police reports, longitudinal studies, interviews with the families of long-term missing and a vast array of literature which investigates search behaviour, such as; visual search, foraging and operational Search and Rescue guidance. Additionally, theoretical constructs employed within the human factors discipline, such as Decision-Making, Workload and Situation Awareness may help to shed light on the cognitive processes involved in missing person search. Finally, research about social care, such as the impact of carer burden and carer wellbeing help to provide a context for missing incidents amongst vulnerable people. However, very little of this research helps to unify the operational context in which missing incidents unfold, the cognitive demands placed on those involved in decision-making and the emotional burden placed upon of carers, which may lead to further negative outcomes (Zarit et al., 1980). Missing Person Incidents are a complex task which involve a wide variety of institutions, and networks of individuals with wide-ranging responsibilities. Missing Person Incidents present both a risk to the individuals who are missing (Ali et al., 2016; Bantry White & Montgomery, 2015; Hayden & Goodship, 2013) and may contribute to long-term distress of

carers and parents (Park et al., 2017), which may contribute to institutionalisation, and thus increase public spending. Whilst there is literature which investigates the emotional impact of the long-term missing (Stevenson et al., 2013), little is known about the cognitive processes involved of carers and family members of missing people during the initial stages of missing incidents.

2.7 CHAPTER SUMMARY

This chapter gave an overview of issues relevant to the research, including the prevalence, demography and risk of the missing. The chapter adopted a human factors approach to the problem, focusing on people, their interactions, cognitions and behaviours and discussed the specific issues faced by missing at risk groups and their carers. Finally, relevant theories of decision-making in time-critical scenarios were outlined, underscoring the cognitive biases likely to affect decision-making within missing incidents and the importance of considering the context in which these decisions are made. The following chapter will use the paradigm of "Naturalistic Decision Making" in order to discover how individuals make decisions during missing incidents.

3 UNDERSTANDING MISSING INCIDENTS

3.1 CHAPTER OVERVIEW

This chapter reports upon a study which uses the "Naturalistic Decision Making" paradigm to investigate how missing incidents unfold and the decisions which are made by those conducting missing person searches (both carers and expert search and rescue volunteers). Interviews were conducted using the Critical Decision Method in order to elicit specific information about the decisions and challenges faced by participants during missing person search. Results for each group were analysed using Emergent Thematic Analysis in order to identify common themes across various incidents, which were examined using a mixed-methods approach. Finally, the chapter presents various descriptive models of behaviour relating to individuals engaged in missing person searches.

3.2 INTRODUCTION

The purpose of this study was to discover what types of decisions, cues and underlying emotional states people experience when searching for a vulnerable person in order to see how these factors influence the search task. Additionally, this research was conducted in order to define the constraints of the research problem. Whilst there is work into Search and Rescue that takes a Human Factors approach; often the focus of this work is about the adoption of robots and drones within professional search and rescue teams (Julie A. Adams et al., 2007; Burke et al., 2004; Gabrecht, 2016; Nourbakhsh et al., 2005; Schlenoff & Messina, 2005) rather than missing incidents per se. Conversely, much of the work investigating the carers and families of missing people comes from a broader sociological perspective (Lois, 2001; Parr et al., 2015; Stevenson et al., 2013) and aims to capture the perspectives and narratives of families of the missing. To the author's knowledge, no work to date has been conducted investigating the decision-making sequences of the carers of the missing from the period immediately following a noticed absence until an official report. The purpose of this study therefore is not only to understand the experiences and decisions of carers, but to explicitly define the Missing Incident task from the perspective of carers so that it can serve as a foundation for other work in this

area. In addition, the interviews from Search and Rescue volunteers not only provide a means to contrast 'naïve' searchers with those more experienced, but also demonstrate the likely consequences of an official report. The strengths and weaknesses of this approach to incident analysis are discussed. This chapter explicitly addresses objective 2 **"Capture the perspectives and experiences of individuals who have experience of Missing Incidents"** and conjunction with the previous chapter satisfices aim 1, **"…establish a descriptive framework for understanding Missing Incidents, based upon a synthesis of relevant existing research and an investigation into "real-life" missing person searches"**. Finally, the chapter will present various descriptive models of behaviour relating to individuals engaged in missing person searches, whilst some of these will be expanded upon in a later chapter, the work discussed in this chapter will also go part way to addressing objective 3, **"Form a model of guardian and carer behaviour during Missing Incidents"**.

3.3 BACKGROUND

Task analysis refers to a diverse range of tools which are often employed within the Human Factors discipline in order to describe in detail various aspects of operator behaviour and also to provide a comprehensive description of operator tasks. Task analysis techniques are often used to identify sources of error in complex socio-technical systems and ultimately suggest ways in which the system could be improved (Shepherd, 2000; Wilson & Corlett, 2005).

Methods such as these can be used to discover various subtasks as well as the ways in which these are distributed in time and space and between various team member task analysis techniques have also been adopted previously to facilitate the use of unmanned aerial vehicles for search and rescue operations (Julie A. Adams et al., 2007) and to understand the distributed situational awareness of aerial search and rescue operators (Plant & Stanton, 2016).

Traditional hierarchical task analysis techniques tend to be action-oriented approaches and focus on providing a description of the observable aspects of operator behaviour (Neville A. Stanton, 2006). Typically, hierarchical task analysis involves adopting a top-down approach organise tasks and subtasks into appropriate organisational hierarchies. In this way, Hierarchical task

analysis can be used to identify potential sources of error and inefficiency as well as define potential operational constraints to improve future systems or to provide training documents (Shepherd, 2000).

However, hierarchical task analysis techniques are typically focused on the goals of operators and not well suited to elicit underlying cognitive and affective states that give rise to differing courses of action (P. Salmon, Jenkins, Stanton, & Walker, 2010). An alternative set of approaches known collectively as Cognitive Task Analysis, provide methods to overcome some of the traditional shortcomings of hierarchical task analysis "yield information about the knowledge, thought processes and goal structures that underlie observable task performance" (Chipman, Schraagen, & Shalin, 2000, p. 3) and as such can be used to discover descriptions of both overt behaviours and covert cognitive functions for complex tasks that last several hours or days (Clark, Feldon, van Merriënboer, Yates, & Early, 2008). Militello and Hutton (1998) highlight the increasing need for cognitive task analysis particularity in environments which require inference, diagnosis, judgement and decision-making. As such, cognitive task analysis approaches are preferable to more traditional hierarchical task analysis techniques in domains where experts may find the justification for their decisions difficult to verbalise.

The Critical Decision Method (Gary A Klein et al., 1989; Weitzenfeld, Freeman, Riedl, & Klein, 1990) is one such method. It is an incident-based knowledge elicitation technique based on the Critical Incident Technique (Flanagan, 1954) designed to uncover the decision-making processes of experts. The critical decision method allows participants to define the scope of the problem in their own terms and as such not only provides scope for the analysis of the allocation and distribution of subtasks but also allows for the possibility of creating alternative solutions. It consists of semi-structured interviews which require the participant to give an account of a previous incident. After which, the interviewer and participant construct a timeline of events and identify critical decisions. Finally, for each decision point, the interviewer asks a series of probing questions, designed to elicit specific information about each decision within the context in which that decision was made.

Whilst a great deal of research has demonstrated that eye-witness testimony is subject to reconstruction and misremembering (Loftus & Palmer, 1996), it is argued that challenging events of this nature require focused attention and for this reason are also much more likely to be vividly recalled than routine events (Crandall, Klein, & Hoffman, 2006).

Typically, the Critical Decision Method is used to extract tacit information from experts in order to form training manuals, expert systems or to design operator interfaces. One of the suggested applications for knowledge elicitation from this approach is the development of new systems (Crandall et al., 2006; Gary A Klein et al., 1989; O'Hare, Wiggins, Williams, & Wong, 1998). The Critical Decision Method has also been used to identify user-requirements for the development of new technologies in complex socio-technical systems with associated time-critical tasks such as emergency medical dispatch (O'Hare et al., 1998; Wong & Blandford, 2002). Identifying cues and decisions used by experts may also help to discover a deeper understanding of the best current practice of missing person search. The Critical Decision Method is not only an appropriate method for discovering the cognitive processes involved in decision-making within complex, cognitively demanding environments, but due to the fact it involves participants recounting specific incidents it also helps to elucidate the wider context in which these incidents occur. For this reason, the Critical Decision Method is uniquely suited to address objective 2 (Capture the perspectives and experiences of individuals who have experience of Missing Incidents) and objective 3 (form a model of guardian and carer behaviour during Missing Incidents).

3.4 METHOD

3.4.1 Ethics

Participants were fully informed to the purpose and nature of the study and signed consent forms prior to the interviews. Copies of these consent forms can be found in Appendix A.1. Participants were made aware of their right to withdraw at any point and all names and identifying information were removed from the transcripts, to ensure confidentiality. The data was stored securely on a password-protected computer, in accordance with the University of

Nottingham's data policy. Ethical approval for this study was granted by the University of Nottingham's Ethics committee within the faculty of engineering.

3.4.2 Participant Recruitment

Participants were selected on a voluntary and unpaid basis and recruited via word of mouth. In the case of carers recruitment was also conducted via the use of an advertising campaign which consisted of posting flyers in public places and a social media campaign. All participants were required to be over the age of eighteen and have experience of conducting a missing person search for an adult over the age of eighteen with care and support needs.

Five participants were selected from three search and rescue organisations within the United Kingdom, including associated members of Mountain Rescue and Low Land Rescue teams. Potential participants were identified during an initial consultation with a subject matter expert and senior mountain rescue volunteer, this initial consultation also allowed the interviewer to familiarise himself with the general operations, terminology and command structure employed within search and rescue teams. Each participant had at least five years search and rescue experience and was 'team leader' (or higher) within their respected organisation. These participants only represent UK search and rescue teams and it is likely that search and rescue operations in other countries vary in terms of their duties, responsibilities and communications with other organisations. Whilst the sample size in this study is modest and caution should be taken when attempting to draw general conclusions, each participant represents a considerable degree of experience and numerous search and rescue operations.

Five participants were selected who had experience conducting informal missing person searches for adults with care and support needs. All participants were currently employed as professional carers, although one participant reported an incident from her personal life in her role as a familial carer. To be eligible for the study, participants must have been over eighteen and had a legal or implied obligation to call the police during the incident in question they must also have been one of the principle decision makers during the incident. This

was a necessary condition for eligibility as the interview technique seeks to identify critical decisions which occur during incidents.

3.4.3 Interview Technique

Participants were interviewed using the Critical Decision Method (Crandall et al., 2006). The Critical Decision Method was chosen over and above a more exploratory approach such as exploratory interviews (Ryan, Qu, Schock, & Parry, 2011) as the Critical Decision Method provides a suitable structure for investigating discrete incidents and allows for the identification of key decision points, which may shed light on the cognitive processes involved in evaluating possible courses of action. A proposed script for each of the interviews can be found in Appendix A.2, though this did slightly vary between interviews, owing to the semi-structured nature of the method. During the course of the interview participants were asked to recall in detail an incident from personal experience which involved them looking for an adult who could be considered 'vulnerable'. As the participants recalled a particular incident, the interviewer constructed a timeline of events which was then verified with the participant. 'Critical Decisions' were then identified collaboratively between the interviewee and the interviewer. Participants were told that a 'Critical Decision' was a decision that required expertise and/or judgement rather than a routine and standardised operating procedure. Additionally, they were told a 'Critical Decision' might be a point in the incident in which somebody with less experience would have done differently. Once the Critical Decisions had been identified, the researcher asked a series of standardised probing questions for each decision point in an attempt to further understand the decision-making process behind each decision, revisiting and clarifying the incident in the process. Whilst there are some suggested categories and probing questions listed in Chapter 5 of 'Working Minds' (Crandall et al., 2006), it is advised that these should be modified to suit the current purpose of the study. In the current study, the areas of particular interest are affective states, cues, decisions and effects. As such, a series of standardised probing questions were asked during a 'deepening sweep', these were adapted to elicit information about each area of interest. A script was written for the purpose of the interviews, which included a briefing as well as prompts and probing questions see Table 3.1 Probing Questions.

Table 3.1 Probing Questions

Probing questions
For discovering decision cues:
• Did you identify anything from previous experience or knowledge that led you to make this, as opposed to another decision? • What led you to make this decision as opposed to another possible option? • What led you to believe that this decision was the right one to make in this situation?
For identifying emotional states:
• How did you feel at this point? • Would you say that this decision was influenced even in part by emotion? • Do you feel that your emotional state helped or hindered you in coming to this decision?
For discovering the effect:
• What was the overall outcome of this decision? • In hindsight, would you have made this decision again or done something different? • Would a different decision at this point have resulted in a different outcome? • Is there any chance that the effect of this decision could have been different?
For further clarifying the decision:
• Could you explain for me in a little more detail, exactly what this decision was and the procedures involved in executing it? • How exactly was this done, what were the actual things you needed to do to make this happen? • Would you say that this would be a typical response to this situation; would I, for example, find support for this decision in an operating manual?

All search and rescue volunteers were interviewed by the thesis author in face-to-face interviews and lasted between 45 minutes and 1hour and 45 minutes. One interview was conducted at the headquarters of the Edale Search and Rescue team, one interview was conducted at the University of Nottingham, one interview was conducted at the participant's place of work, and the final two were conducted at the private residence of one of the participants.

Interviews with carers varied between one hour and a half, and thirty minutes, with a median interview length of one hour and five minutes. Two interviews were conducted at participants' place of work, and the remaining three were conducted via video conferencing software.

3.4.4 Emergent Thematic Analysis

The Critical Decision Method can elicit knowledge and information about specific incidents and expertise of professionals, but data extracted from the interviews requires further analysis and representation in order to identify commonalities across incidents. Emergent Thematic Analysis (ETA) has been applied to critical decision method interviews to identify overall decision strategies and broad categories of behaviour as well as further describe the context in which the task occurs (Wong & Blandford, 2002; Wong & Blandford, 2004). Emergent Thematic Analysis can be used to distil the critical decision method transcripts, thus enabling broad themes to be identified and analysed without committing oneself to any a priori assumptions. This preserves the exploratory nature of the CDM whilst increasing yield and ensuring analytical rigour.

The interviews and handwritten timelines were transcribed by the author, who also performed the analysis. The Critical Decisions which were identified during the interviews were coded in the transcripts. Identification of common critical decisions, respective to each group was conducted by grouping the Critical Decisions elicited across interviews.

Finally, the data set was coded for "Global Themes", which were higher-level concepts thought to be pervasive throughout the decision-making process. This differs somewhat from the approach adopted by Wong and Blandford (Wong & Blandford, 2002; Wong & Blandford, 2004), as the Critical Decisions themselves were the basis of the initial coding themes. This involved further dividing each of the critical decision excerpts into smaller sub-sets, representing decision-specific themes, and further elucidated the main considerations during each decision. The sub-themes of each critical decision are given in , alongside a figure which indicates the total number of references made that were within the sub-theme.

Additionally, an entirely separate coding scheme was created to identify considerations which were pervasive throughout the datasets. This additional stage of coding allowed for an exploration of where attention was focused throughout the incident and also allowed for a "cross-referencing" technique

which demonstrated the relative importance of each of these factors within incidents. This “cross-referencing” technique was performed in NVivo, using the “Matrix Tabulation” function and identified excerpts from the transcripts which were common to both a given critical decision and a particular global theme.

The two types of coding schemes (critical decisions and global themes), loosely correspond to Braun and Clarke’s distinction between “Inductive and Theoretical Thematic Analysis” (Braun & Clarke, 2006). Where the identification of critical decision points is largely a ‘top-down’ and ‘Theoretical’ process; due to the critical decision points being explicitly identified prior to the analysis. Contrastingly, the identification of ‘Global Themes’ is far more bottom-up, ‘Inductive’ and data-driven, as no themes were identified prior to the analysis nor was coding forced into a pre-existing coding scheme. These two approaches in conjunction allow for operational decision points to be identified which can be clearly understood by practitioners whilst allowing for deeper, often more subtle themes to emerge. Performing the more ‘theoretical/top-down’ method of analysis first also provides some guidance as to what themes are common across multiple decision points and structures the data before a more in-depth coding scheme is generated.

This differs somewhat from the approach adopted by Wong and Blandford (Wong and Blandford 2002, Blandford and Wong 2004), as the critical decisions which were identified during the interviews were the basis of the initial coding themes. The approach taken here also extends upon the ETA approach by identifying various sub-themes for each of the critical decisions, as well as global themes which pervade incidents. A distinct advantage of this approach is that using the cross-referencing technique, the relative importance of specific issues can be identified for each of the critical decisions.

3.4.5 Representation

Once coding was complete, diagrammatic representations of the search task in both conditions were produced in order to show the temporal sequence in which decisions were made. Whilst there are many methods of task representation within incident and accident analysis, none of these seemed wholly appropriate

for representing the data elicited from the interviews. A popular approach to incident analysis is Rasmussen's Accimap (Rasmussen, 1997), which looks at the contributing factors leading to a specific accident. However, this was deemed inappropriate on multiple counts. Firstly, without significant modification, the Accimap is designed to analyse only one specific incident rather than identifying trends across multiple similar incidents (P. M. Salmon, Cornelissen, & Trotter, 2012). Secondly, the Accimap shows how various factors across multiple levels all contribute to an unintended and accidental consequence. This differs from the incidents under investigation in that, the search task is an attempt to mitigate and resolve an unfavourable situation rather than an analysis which seeks to understand why these unfavourable states of affairs arose.

Incident representation diagrams were produced specifically for the purposes of representing the relative importance of themes as they relate to each critical decision. These diagrams resemble the original timelines created during the interviews but use generalised decision themes rather than the specific decisions reported in each interview.

Figure 3.1 illustrates the various stages of analysis that were conducted on the data. The thesis author conducted and transcribed the interviews and performed all stages of the analysis.

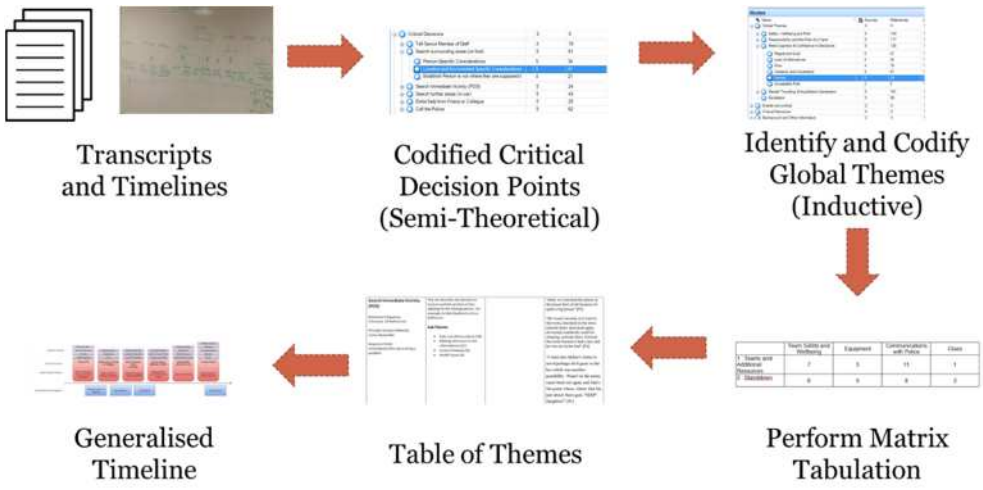


Figure 3.1 Stages of Analysis

3.5 RESULTS

3.5.1 Results Search and Rescue

Decision-making within the Search and Rescue context, whilst dynamic; typically follows an ordered sequence. There is a great deal of variability in the specifics of each decision, for example, 'decide search area' was a decision made in every incident, but the details of where to search were dependent upon environment, context, available resources and knowledge of the missing person. Upon grouping decisions across interviews, seven critical decisions emerged, including 'On-ground decisions' which represents a general grouping of the less frequent and more variable responses to environmental and contextual factors faced by 'on-the-ground' teams. Whilst no particular interviewee identified these specific decisions as 'Critical', it was decided that for completeness these important but less predictable decisions should form part of the task analysis.

Of the five interviews which were conducted, two of the interviewees reported upon missing incidents in which the missing person was found unharmed by the search and rescue teams, whereas in the other three incidents, the missing people were not found by the search and rescue teams. Overall, decision-making within Missing Person Incidents tended to follow a similar trend, however two of the interviewees who were members of a lowland search and rescue team, appeared to have less responsibility for overall decision-making than the three participants who were members of volunteer mountain rescue teams. Participants who were members of the lowland rescue team tended to share responsibility with the local police for overall planning and conduct of the search, however, members of the mountain rescue teams tended to act far more autonomously and decide the overall search strategy based on their own knowledge of the local topography, weather conditions and resources available.

A full description of the inclusion criteria and summary of results for both Critical Decisions and Global Themes can be found in Appendix B.1 and Appendix B.2 respectively.

Figure 3.2 shows the generalised timeline of search and rescue teams which were created after the analysis of the transcripts. Critical Decisions are highlighted in red, typical events and routine procedures in blue and sub-themes for each decisions are highlighted in purple. Search and Rescue volunteers described a methodical process of search, which is typically only revised upon the discovery of new information. Search and Rescue operations were described as ending in one of three ways; the missing person is found (dead or alive), stand-down, where the SAR operation is temporarily suspended overnight and operation abandoned, where a standown is issued but the operation is not resumed.

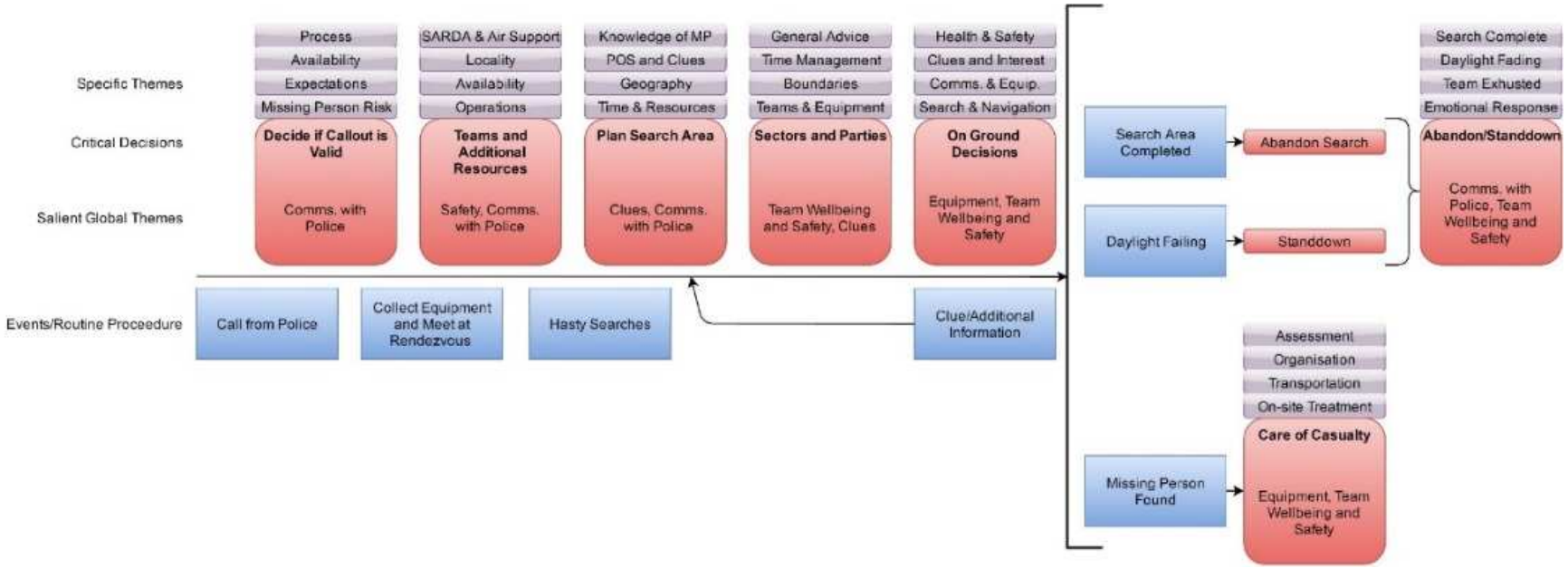


Figure 3.2 Critical Decision Sequence Search and Rescue

3.5.2 Intersection of Global Themes and Critical Decisions (SAR)

This table shows all of the references that were used in both the Critical Decisions and the Global themes (both full and partial matches). This data was produced using two separate coding schemes, “Critical Decisions”, and “Global Themes.

The counts in the Table 3.2 are the result of conducting a Matrix cross-tabulation in NVivo and indicate the total amount of references which are common to both each critical decision and each global theme. This table therefore gives an overall illustration of the relative importance of each global theme within each critical decision and subsequently sheds light on the main point of focus during each stage of the incident.

Table 3.2 Intersection of Global Themes and Critical Decisions Search and Rescue

	Team Safety and Wellbeing	Equipment	Communications with Police	Clues
1 : Is Callout Valid?	6	2	13	0
2 : Teams and Resources	7	5	11	1
3 : Plan Search area	12	2	14	13
4 : Sections and Sectors	7	4	13	7
5 : On-ground decisions	8	4	8	2
5 : Care of casualty	1	9	1	0
6 : Stand-down	8	0	8	2

Table 3.2 shows that communications with police were prevalent throughout all stages of Search and Rescue operations. “Team Safety and Wellbeing” was also a major consideration throughout all stages of incidents reported, but particularly pertinent to the decisions of search area planning, on-ground decisions and the ultimate decision to stand-down. Clues were a consideration during the initial planning stages, but featured little elsewhere.

Search and rescue operations typically followed a standardised and predictable sequence of decisions, though the specific decision outcomes arrived upon were entirely dependent upon the circumstances of the search. Decision makers apply a broad set of heuristics to the search task but often have to improvise depending upon the information they have available to them about the missing person, the environment of the search, and the resources at their disposal. Expert search and rescue practitioners describe their decision-making process as a mixture of ‘Expertise and Judgement’, rather than strict adherence to a rigid protocol. Despite this fact, decision makers largely made the similar decisions in the same order in each case and there was a great deal of commonality in the decision-making process across incidents.

Police involvement was reported to be generally high, though there were differences between respective search and rescue associations and local Police organisations, this was shown to impact both the number and scope of decisions made by Search and Rescue teams. In two of the five interviews conducted, search and rescue volunteers reported that Police effectively managed the overall search plan, decided the search area, and ultimately issued the order to ‘stand-down’ as appropriate. The other three participants reported a much higher degree of autonomy in the decision-making process, although even in these cases they worked very closely with the local Police. In a few cases, this involved the Search and Rescue teams requesting background checks or asking for additional resources (such as support from the Royal Air Force) to be called in. The importance of this communication is reflected in table 4 in which communications with the police features as the most salient global theme in all but the “Care of Casualty” decision point.

There was evidence that search and rescue experts viewed time as a resource which needed to be allocated appropriately and tended to plan their searches with the knowledge that teams may be conducting the search for up to several days. Incident controllers and other decision makers ensured that they and their teams had appropriate provisions prior to the commencement of any given search and acted under the assumption that adequate preparation would lead to more effective searches. Search plans were reported to be informally constructed immediately following the callout. Incident commanders often had a general idea of the overall search plan upon arriving on scene and would continue to revise and clarify their plan dependent upon the resources that were likely to be available up until the moment of deployment.

Areas of high probability or those which required a lower amount of resource commitment were usually searched first during a preliminary "hasty search"; this involved the search teams looking across footpaths and accessible areas before a more formal and structured approach to search began. Hasty Searches are a preliminary sweep of the area which utilises available personnel resources whilst team members are still arriving on scene. Once an initial hasty search had been conducted, teams were split into smaller groups of three to five people and allocated a clearly defined area, preferably with a natural boundary radiating out from the position of last sighting.

Generally, decision makers tended to be forward thinking and strategic but also responded well to new information. Search and rescue organisations have to adapt if their assessment of the situation changes due to external factors such as additional information from the police, or if one of the search teams finds a clue. In this case, teams will usually be asked to hold their position, and may be called back for redeployment whilst the search plan is revived and (if necessary) position of last sighting.

When asked about the effect that emotion might have upon decision-making, interviewees seemed to indicate taking a professional attitude towards the search task and maintained emotional distance from the act of searching (e.g.), "You don't have time to wear your heart on your sleeve" [P3]. This emotional distance may be due to the fact that all of the interviewees had been involved in

numerous cases with negative outcomes, and therefore had realistic expectations.

Managing team expectations was considered to be an important role of incident commanders and team leaders. One incident commander reported not telling his team he thought it was very unlikely the person they were looking for was still alive in order to maintain team morale; “You don’t tell em that, you keep it to yourself. – The lads, they know how many beans make five, but they still keep searching, they don’t pack up until they’re told” [P3].

When asked about the emotional states practitioners experienced during the search (“How were you feeling at this point?”), search practitioners would often report on their hypotheses about the missing person rather than provide any insight on the level of emotional arousal caused by the difficulty and importance of missing person search. Through clarification, practitioners did sometimes state how they were feeling at the time, but this was usually an operational consideration regarding the likelihood of a positive outcome. This suggests that whilst it is possible to discover some of the affective states experienced during a stressful and time-critical incident direct questioning may not be the best approach for expert practitioners. (Luini & Marucci, 2015) used the framework of naturalistic decision-making to develop an approach for understanding the influence of emotions on cognitive processes. However, their approach comprised of a series of experimental trials investigating the reaction times and emotional responses of participants’ performance in a firing range, and therefore, despite the fact the study could broadly be described as “Naturalistic Decision Making”, their methods for discovering the role of emotion in cognition are not applicable here. An alternative approach might involve direct observation of incidents, or the application of discourse analysis techniques on the transcripts.

3.5.3 Carers’ Results

There was a range of diverse incidents reported in the interviews, interviewees described a wide variety of absent people with many complex care and support needs. Despite this fact, informal absenteeism search typically followed a standard and predictable sequence, with each decision viewed by the carer as

an escalation. At each stage of the incident, carers typically chose the decision which could be considered the least disruptive and time-consuming of available options. The incidents reported cover the time period from initially discovering an absence to calling the police, at which point the carers no longer considered themselves to be the principal decision maker in the missing person search. Of the five interviews which were conducted, four of the participants reported upon an incident in which the care recipient was found unharmed, but in one of the reported incidents the care recipient was not found during the initial search. Three of the participants reported upon missing incidents involving adults within a care home setting, one participant reported upon an incident in a specialist college for young adults with disabilities, and a final participant reported upon an incident with her own father (though she herself was also a professional carer). Full descriptions of the Critical Decisions and Global Themes for the carer group can be found in Appendix B.3 and Appendix B.4 respectively.

A generalised timeline of missing incidents from the perspective of carers is illustrated in Figure 3.3. Figure 3.3 shows typical missing person incidents from the perspectives of carers. Highlighted in red are the decisions which carers deemed to be “Critical”, in blue are common events or decisions which were considered to be routine, and in grey are sub-themes which were coded for each decision (discussed further in Appendix B.3).

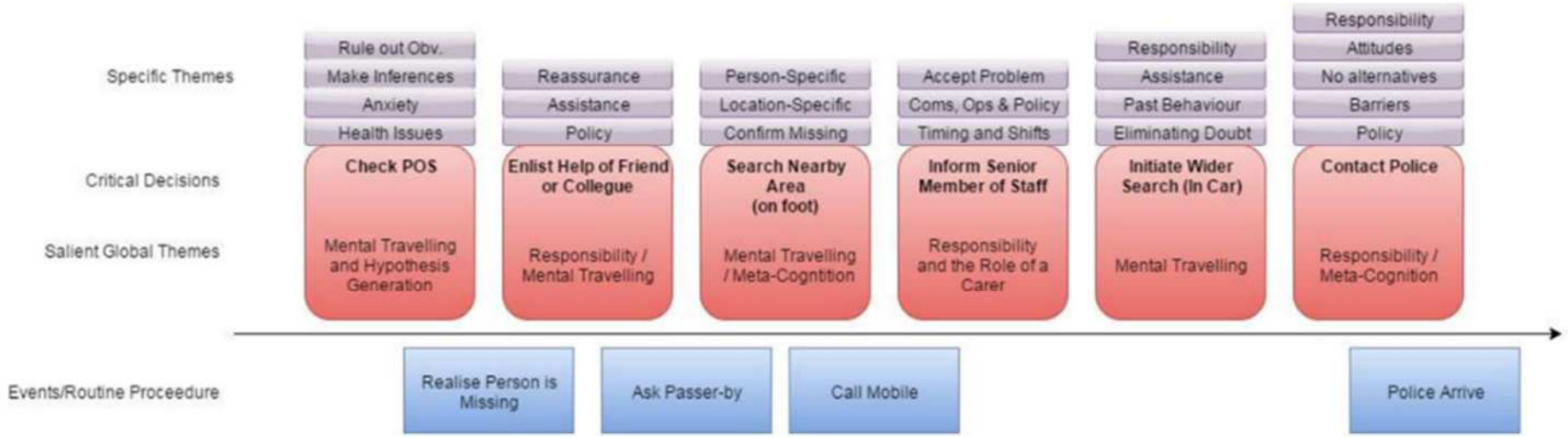


Figure 3.3 Decision Sequence Timeline of Carers

3.5.4 Intersection of Global Themes and Critical Decisions (Carers)

Similar to Table 3.2, this table shows a count all of the references that common to both the Critical Decisions and the Global themes (both full and partial matches) for the transcripts of the carer interviews.

Table 3.3 Intersection of Global Themes and Critical Decisions Carers

	Safety, Wellbeing and Risk	Responsibility and the Role of a Carer	Meta-Cognition & Confidence in Decisions	'Astral Traveling' & Hypothesis Generation
1 : Search Immediate Vicinity (POS)	10	9	14	17
2 : Enlist help from Friend or Colleague	5	17	17	14
3 : Search surrounding areas (on foot)	16	11	43	49
4 : Tell Senior Member of Staff	10	20	13	10
5 : Search further areas (in car)	17	19	23	35
6 : Call the Police	29	38	37	20

Table 3.3 shows the intersection of global themes and critical decisions for the transcripts, which indicates the focus of attention during the incidents. Unsurprisingly, "Astral travelling" and hypothesis generation featured highly during actual search tasks (search surrounding areas, search further areas), indicating that carers try to place themselves 'in the mind' of the missing person in order to make inferences about their location. The category of "Meta-cognition", described the self-reflective aspect of thought, this included the times when participants mentioned that they questioned their own judgement. Meta-cognition was common during the search tasks but particularly referenced when people recalled their feelings towards the police.

Carers reported a high degree of emotional distress when conducting informal missing person searches for their care recipients which increased as the incident progressed. Carers were often reluctant to call the police, fearing that they would be judged for failing in their duty of care and the social stigma attached to calling them. In addition, carers also felt that they had an obligation to conduct a thorough search of the area so they often repeated steps that they had already taken to rule out any possibility of doubt and ensure that when they called the police no obvious places were left unchecked.

As one might expect, search strategies adopted by carers tend to be far less systematic but also involved investigating areas of high probability first. The cues employed by the carers were usually based upon knowledge of the care recipient's history, personal preferences and recent mood rather than in-depth considerations about the environment.

One carer reported panic and a 'sinking feeling' upon discovering the person she cared for was missing, yet later in the interview she reported having an ambivalent attitude towards the possibility of a positive outcome, "a lot of you is thinking, please let him be ok and the other bit of you is thinking, please let him've fallen and broken his neck and he's dead" [P1]. Clearly, the complex relationships that carers have with their care recipients is very individualistic and likely to be a major factor in determining how emotion affects decision-making in this context.

A sub-theme within "Responsibility and the Role of a Carer", called "Respect for Personhood" was identified which pertains to certain conflicts carers feel about their roles as guardians. On the one hand, carers feel they have a duty to protect their care-recipients from physical, psychological and emotional harm, yet also have a responsibility to respect their autonomy and not completely restrict their behaviours, even if those behaviours could have adverse consequences. One carer reported feeling unable to lock the front door, despite the fact that wandering behaviours were common in her care recipient, another reported noticing the care recipient wandering away, but following him, rather than stopping him in an attempt to mitigate undesirable behaviours in the future.

Another key difference identified between the groups so far are the factors affecting the enlisting of additional resources. The carers interviewed reported feeling far more associated stigma when seeking additional help, both from friends and the police. This was due to both a concern about wasting police time and failing in the responsibilities as a carer. Contrastingly, expert practitioners see requesting additional resources as 'part of their job' and have no such associated stigma. It seems likely from the initial interviews that a major difference between carer search and practitioner search is that informal carer search is much more reactive and involves only short-term consideration whereas expert practitioners were typically much more pro-active and sought additional resources very early into the search. This could be due to a combination of factors including; stigma, experience, typical search length and emotional involvement.

3.6 DISCUSSION

3.6.1 Discussion of Findings

Whilst timelines for interviewees within each group were similar (participants typically identified the same critical decisions in the same order), there were considerable differences between the groups. For example, whilst "Astral Travelling" was identified as a Global Theme within the carer group (Appendix B.4), this type of cognitive process was less prevalent within search and rescue volunteers. Search and Rescue teams typically used physical clues or last known locations to decide upon appropriate search areas, rather than an in depth and personal knowledge of the missing person.

Carers and Search and Rescue Experts have radically different approaches to finding missing people. Not only is the focus of attention very different for these groups, but the decision-making strategies employed are vastly different. Search and Rescue Teams typically use the initial stages of an incident to gather information and plan their strategy, formulating a plan and seeing it through.

The teams will not deviate from the plan unless there is additional information, which will cause them to regroup and revise (see Figure 3.4). In this way their search strategy could be described as "pro-active", that is to say that SAR

volunteers anticipate many problems before they arise and plan searches in such a way as to minimise travel distance and redundancy. Search and Rescue volunteers dedicate a portion of their time gathering information and planning before any action is taken.

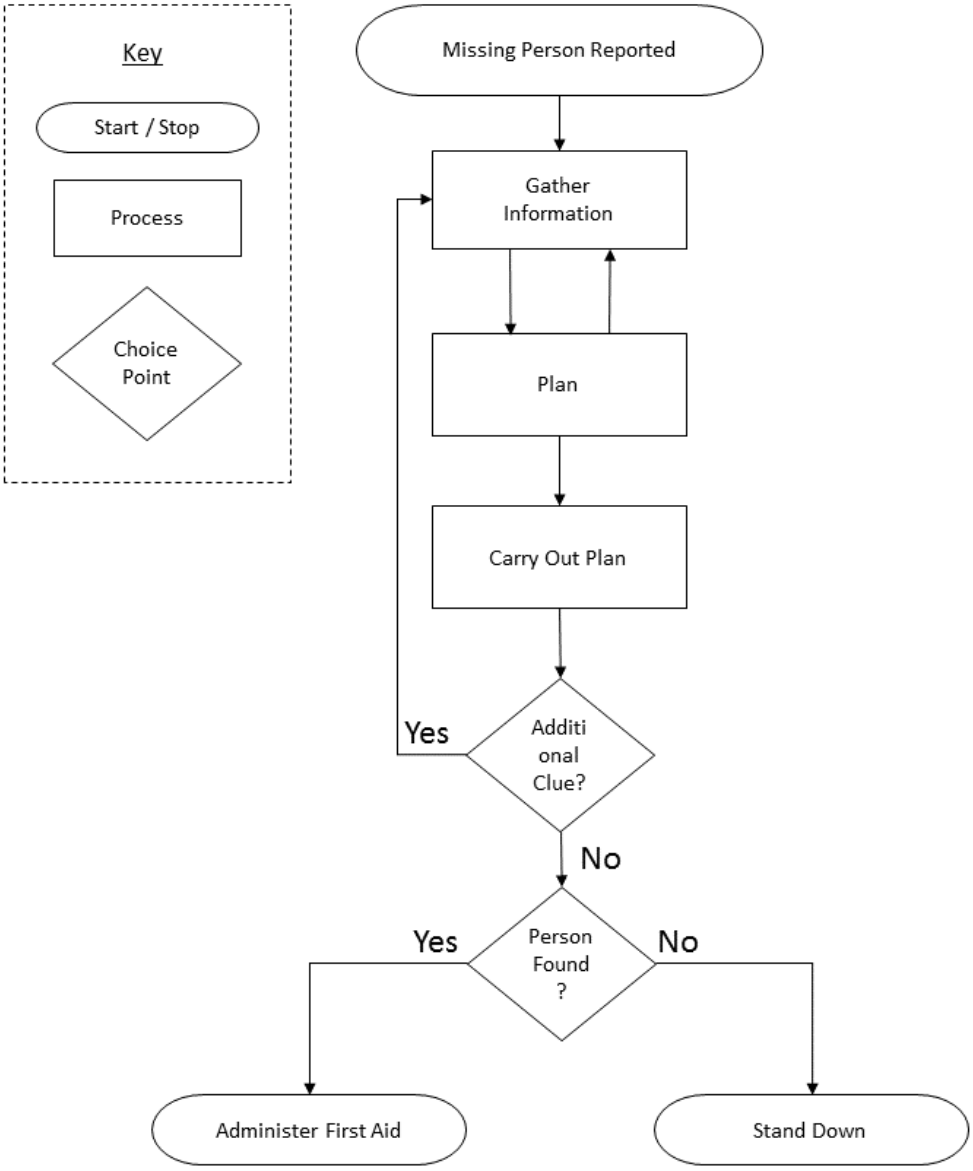


Figure 3.4 Pro-Active Strategies of SAR Teams

A Pro-Active Search Model Based on the interviews of Search and Rescue Teams

Conversely, carers acted in a much more reactive fashion. Figure 3.4 outlines a model intended to describe the reactive decision-making strategies of carers during the search task. Hypotheses were generated immediately after a noticed absence and these are investigated. If the absent person was not found in the expected location, a new hypothesis was generated. Should the carer fail to think of another possible location then they will enlist help from the lowest possible authority they can. This will typically be a friend or colleague, followed by a superior or manager (for professional carers), before finally calling the police. One participant described her search strategy as being akin to "check lists" (P1), although other comments in the interview would lend support to the idea that these "check lists" are generated *on-the-fly*.

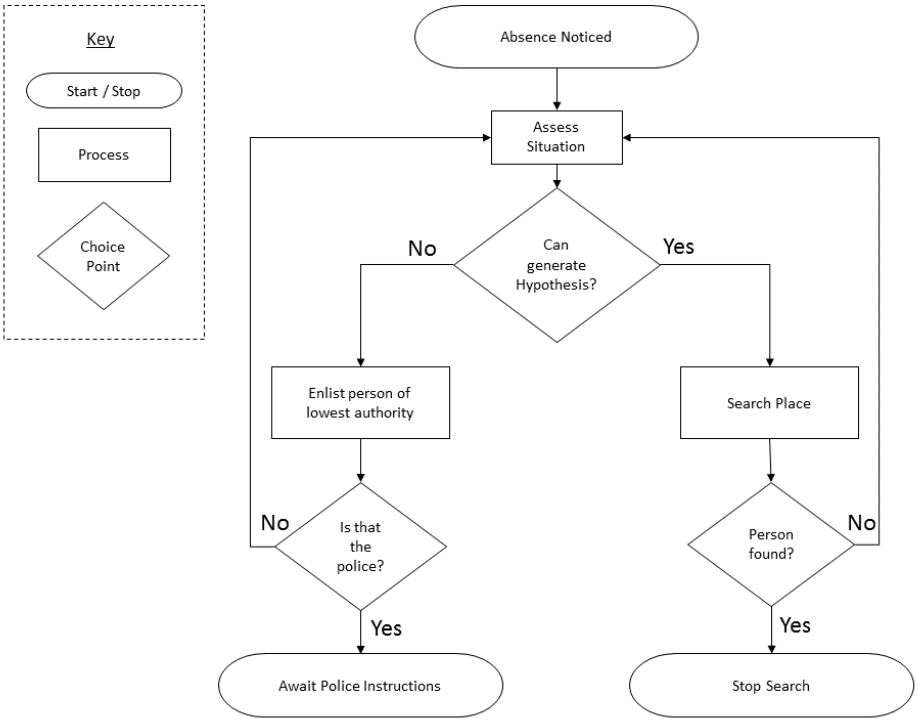


Figure 3.5 Reactive Search Strategies of Carers

A Reactive Search Model Based on the Interviews of Carers

The differences in reactivity and proactivity highlighted by Figure 3.4 & Figure 3.5 may be due to differences in the various levels of expertise and resources available to each group respectively. However, it should also be noted that the

beginning of these activities is radically different for each group. In the case of the search and rescue expert, it is assumed that the missing person is not in an "obvious" place, that there is a high level of risk and that there is no doubt the incident is a legitimate missing person incident. Conversely, in the case of carers, it is unclear when a noticed absence becomes a missing person incident, and hence the perceived seriousness of the incident increases over time and the start of the incident is ambiguous. Other differences between the way in which carers and search and rescue experts approach missing person incidents are summarised in Table 3.4.

Table 3.4 Main Findings from Interview Study

Carers	**Search and Rescue Experts**
Unclear when absence becomes "missing incident".	Receive communication from the police requiring assistance.
Help enlisted for both assistance in search, but also emotional support.	Resources enlisted early in incident, depending upon availability.
No formal plan at the beginning, hypotheses generated and then tested in quick succession.	Plan all activities at beginning.
Conduct search activities usually as part of a group.	Conduct search activities as part of multiple teams.
Anxious about enlisting help or contacting police	Will enlist appropriate assistance if available.
Highly emotional due to knowing the care recipient personally.	Emotionally more distant, focused upon practicalities of search.

The differences observed may be down to a myriad of factors, from different operational considerations, different relationships with the missing person and the perceived social costs of enlisting help and additional resources to the search party.

3.6.2 Discussion of Method

Many previous studies which investigate search and rescue from a human factors perspective, focus specifically on how new and novel robotic and drone

technologies may be integrated into existing search and rescue practice (Beck, Teacy, Rogers, & Jennings, 2016; Macwan, Vilela, Nejat, & Benhabib, 2015; Schlenoff & Messina, 2005). Additionally, much of the focus within this type of research tends to be focused upon urban search and rescue efforts, which typically involve searching buildings for an unknown amount of potential casualties (Hew & Sunshine, 2002; Y. Liu & Nejat, 2016). However, these activities greatly contrasts with missing person searches in which a known individual is lost in an area which is not necessarily constrained to an individual building.

The Critical Decision Method alone provides an excellent framework for understanding expert behaviour across difficult or challenging incidents and provides a clear framework for conducting semi-structured interviews. Additionally, when Emergent Thematic Analysis is performed on interview data greater detail and understanding of the operator task can be obtained. Wong and Blandford highlight the three major strengths of this approach (Wong & Blandford, 2004). Firstly, it "promotes the exploratory nature of the CDM", making it an excellent research methodology for a little-understood problem. Secondly, it "Balances Emergence and Theory", this was particularly true of the study in question, in which critical decisions were identified in conjunction with the interviewees, but 'Global Themes', were only identified through an iterative and emergent process. Finally, this method is fast and practical. Whilst combining the Critical Decision Method with Emergent Thematic Analysis is more time-consuming than the Critical Decision Method alone, it yields a much greater insight and has the flexibility to focus on specific aspects of interest.

Similar to the approach adopted by Wong and Blandford (Wong & Blandford, 2002), sub-themes were also identified within the critical decision points. Coding for the sub-themes was conducted after all the data extracts for the critical decision points had been fully coded in all instances in which they appeared in the data set. Introducing a second level of coding within the critical decision points allowed for a more specific and detailed account of each decision and which aspects practitioners deemed important.

Combining these various approaches across multiple levels of analysis created a sophisticated dataset. Using analysis software such as NVivo allowed for insightful results to be returned when presented with a variety of queries. When coded interview data is formatted in this way, it is possible to return all data items that relate to both a specific decision point and a specific global theme. For example, one may wish to find specific excerpts that relate to "Team Safety and Wellbeing" within the "Plan Search Area" decision in order to understand what safety considerations are made by team leaders when initially planning a search. This may be beneficial to those wishing to understand the focus of attention during various stages of missing person searches and may also help to highlight specific difficulties, constraints or thoughts at relating to each of these intersections. Alternatively, this method could be adapted to highlight the focus of attention during each critical decision for a wide variety of critical incidents.

3.6.3 Limitations

The study facilitated a description of searcher behaviour, cognition and emotion during missing incidents in two separate contexts, but it was not without limitations. Firstly, the sample sizes for both groups were reasonably modest, and as mentioned by many of the SAR volunteers, there is a great deal of variability between incidents. Subsequently, it is unlikely that the incidents described during the interviews represent an exhaustive list of all possible decisions, events, cognitions or outcomes. Relatedly, a small sample size may not be an exhaustive description of individual differences in decision-making strategies. However, (Saunders et al., 2018) suggests that saturation should be operationalised in a way that is consistent with the research question and analytic framework adopted. No new critical decisions were identified after the second series of Search and Rescue interviews, (or after the third interview with carers) which could be taken to indicate data saturation was reached. There was also considerable consistency between the decisions identified and the general order in which decisions were made.

However, there were differences in the levels of responsibilities between different Search and Rescue associations and these differences may vary even more greatly between countries. Whilst the decisions identified for the search and rescue volunteers may be considered broadly reflective of the practices of

search and rescue teams in the United Kingdom, there may be substantial differences in the procedures and considerations of search and rescue teams in different countries with different climates and legal systems. Likewise, all of the carer interviews were conducted in the UK, however, it is likely that practices and cultural norms vary between countries. Therefore the applicability of these findings should be taken with caution when used to apply to non-UK populations.

3.6.4 Discussion of Aims and Objectives

This chapter set out to explicitly to meet objective 2, to "**Capture the perspectives and experiences of individuals who have experience of Missing Incidents**", in conjunction with the previous chapter, two models of carer behaviour were presented, Figure 3.3, which describes "typical" incident sequences and Figure 3.5, which illustrates the reactive decision-making tendencies of carers during missing incidents. These two models, combined with the previous exposition of relevant research could be used as a framework to understand missing incidents from the perspectives of parents and guardians and therefore satisfy aim 1, "**To establish a descriptive framework for understanding Missing Incidents, based upon a synthesis of relevant existing research and an investigation into "real-life" missing person searches".** Additionally, these descriptive models meet objective 3, **"To Form a model of guardian and carer behaviour during Missing Incidents"**, but these models, despite being informative are entirely qualitative. Chapter 4 will expand on these models using a large dataset in order to quantify likely decision-sequences.

3.7 CONCLUSION

The aim of this research was to investigate what decisions are made during search and rescue operations and what factors affect those decisions. The results demonstrate the effectiveness of using the CDM combined with ETA. Furthermore, the introduction of two separate coding schemes during the analysis also highlighted which particular aspects and considerations were important at each stage of the search process and therefore indicated the main focus of practitioners' attention as they conducted a task. This approach expands

upon the Critical Decision Method and has the potential to be applied to a wide variety of other incident analysis studies. This study identified 7 critical decisions made by search and rescue experts during an incident and 6 critical decisions made by carers following a noticed absence. The study also highlighted other considerations of both groups when conducting a missing person search and highlighted the relative importance of each consideration as the incident progressed. However, whilst the interviews were in-depth and elicited a rich dataset, the sample size for each group was relatively low and as such the findings may not necessarily be generalisable to the respective target populations.

3.8 CHAPTER SUMMARY

This chapter outlined a major study of the PhD which used retrospective accounts of real missing incidents in order to form models of missing incident search activities. Using the Critical Decision Technique in conjunction with Emergent Thematic Analysis, several such models were developed which shed insight on the type and order of decisions made during these incidents and the challenges faced by both carers and search and rescue volunteers. A series of "Critical Decisions" were identified for both groups, and specific issues were discussed which pervaded the entirety of these tasks. The next chapter utilises the critical decisions elicited during this study in order to form the basis of a larger scale study which seeks to build on this understanding in order to form the basis of a predictive model.

4 VIGNETTES FOR PREDICTING BEHAVIOURS

4.1 CHAPTER OVERVIEW

This chapter will present a novel approach to experimental vignettes in order to determine likely decision-sequences of carers and parents involved in a missing person search and the factors which affect those decisions. It will build upon the more qualitative study in the previous chapter and assess to what extent the previous findings are applicable to a larger population. The study described in this chapter will devise a series of scenarios which are based upon the interview findings of real missing incidents and invite participants to indicate how they would respond in such a situation themselves. "Critical Decisions" which were identified in the previous study will be used as fixed choice points within the interactive vignette. The more quantitative approach described in this chapter will be used to form the basis of a predictive model of behaviour during missing incidents based upon a large sample of participants answering questions about hypothetical incidents involving real people.

4.2 INTRODUCTION

In order to discover whether the findings from the CDM interviews were applicable to a larger population and to identify key factors and individual differences which affect decision-making strategies during absenteeism search, a "vignette" style study was devised. Whilst the previous study involved in-depth interviews, using interview methods can often be highly time-consuming and interview data does not lend itself easily to quantitative analysis. Nor do interviews facilitate the identification of individual differences and other variables which may affect decision-making within this context.

Whilst the previous study could be described as focusing on depth and quality of information, the focus of this study will be two-fold. Firstly, one of the aims of this study is to see whether the findings from the previous interview studies concur with a much larger dataset. Internet surveys allow for a large pool of participants at relatively little time cost to the researcher, potentially reaching hundreds or even thousands of participants without also incurring associated time scaling costs. Internet surveys also have an additional time-cost advantage

in that the results typically come in a digital format, which saves the researcher considerable time in copying answers to a digital format for later analysis.

Secondly, the use of a large-scale vignette of this type will facilitate quantitative analysis, which will mean that overall trends can be identified for large sections of the target population. Potential factors affecting decision-making will also be able to be identified, such as the missing person's level of mobility and independence. Quantitative data also lends itself to the development of predictive models in a way that qualitative data is unable to.

Finally, the study will make use of the vignette scenarios and ask additional questions about their attitudes towards assistive technologies more generally, these will be explored in more detail, along with additional interview data from the previous study in a later chapter. This work addresses a muchneeded gap in the research literature pertaining to the behaviours, attitudes and decision-making processes of carers and parents involved in missing person search incidents prior to police involvement. Specifically, this work will address aim 3 "**Form a model of guardian and carer behaviour during Missing Incidents"** and aim 4 **"Measure the extent to which various carer or care recipient circumstances affect search strategies"** of this thesis.

4.3 BACKGROUND

Vignettes typically comprise of presenting participants with short descriptions and or pictures of specific scenarios in order to elicit responses. They are particularly useful in exploring issues which are culturally sensitive or otherwise difficult to measure using observational or experimental techniques and allow participants to provide insight into areas where they may have little or no experience. Hill, describes vignettes as "Short scenarios in written or pictorial form, intended to elicit responses to typical scenarios" p3 (Hill, 1997) others offer similar descriptions (Alexander & Becker, 1978; Finch, 1987; Hazel, 1995; Hughes, 1998; Keane, 2012). The vignette method was first proposed by Rossi in his dissertation in which he explored the prestige of households (Alves & Rossi, 1978)Alves and Rossi 1978, Rossi 1979).

Barter and Renold (1999) suggest that Vignettes have three main purposes "to allow actions in context to be explored; to clarify people's judgements; and to

provide a less personal and therefore less threatening way of exploring sensitive topics". Carroll (2000) also points out the usefulness of scenario studies when used in Human-Computer-Interaction research; "Scenarios are a vocabulary for coordinating the central tasks of system development--understanding people's needs, envisioning new activities and technologies, designing effective systems and software, and drawing general lessons" (Carroll, 2003, p. 6)

Evans and Roberts also highlight the usefulness of vignettes when trying to analyse judgements and decision-making, arguing that the results from such studies are highly applicable to real life behaviour, "When vignette studies are well designed to test specific questions about judgments and decision-making, they can be highly generalizable to "real life" behaviour, while overcoming the ethical, practical, and scientific limitations associated with alternative methods" (Evans et al., 2015, p. 43).

4.3.1 Applications of Vignette Research

Vignettes have been used in a wide-variety of contexts and applications and can be used either as a complementary technique to other data collection methods (Hazel 1995; Hughes 1998, Keane et al, Wade 1999), or as a research method in their own right (Sauer et al 2014). In reference to the former, vignettes can be used to form the basis of a focus group (Wilkinson 1998, Keane et al), or during the course of an interview (Wade 1999, Rahman 1996). Vignettes can also be used to elicit information from people who have experience with sensitive topics, by allowing participants to give honest responses based on their experiences with these issues in a non-confrontational way, "As commenting on a story is less personal than talking about direct experience, it is often viewed by participants as being less threatening" p3 (Barter & Renold, 1999). For this reason, they can often be used in highly sensitive or politicised topics, in areas as diverse as healthcare practice (Murray, Özaltin, and Tandon, et al., 2003; and Salomon, Tandon, and Murray, et al., 2003), fairness of wages (Sauer et al 2014) and transgender issues (Bockting, Miner, Swinburne Romine, Hamilton, & Coleman, 2013).

Carroll (2000) identifies the use of scenario in facilitating software development as "the designer focuses first on the activities that need to be supported and then

allows descriptions of those activities to drive everything else" (Carroll 2000, p2), this particular purported quality of vignettes will be valuable in determining exactly how technology might be used to assist in missing person search activities.

4.3.2 Qualitative and Experimental Vignettes

Whilst there are many variations of vignette-based methodology, broadly speaking vignettes fall into two categories; Qualitative and Experimental vignettes. Qualitative vignettes; tend to be conducted via face to face interviews where the interviewer asks a series of broad questions and seeks open responses in an attempt to elicit rich data to identify general attitudes and themes pertaining to specific social and cultural issues.

"Unlike their more experimental counterparts, the aim of qualitative vignette interviewing should not be to arrive at an accurate prediction of an interviewee's behaviour but instead to achieve insight into the social components of the participant's interpretative framework and perceptual processes" (Jenkins, Bloor, Fischer, Berney, & Neale, 2010, p. 178)

On the other hand, experimental vignettes are usually quantitative and follow similar methods to traditional experiments. They typically comprise of three variables; controlled variables, experimental variables and contextual variables. Controlled variables are those aspects of the vignette which remain consistent across experimental groups, experimental variables are those aspects which change dependent upon experimental group, and contextual variables are considered to be incidental aspects of the vignette which are added to give the scenario depth and realism. The vignettes usually take the form of a sentence or short paragraph in which the participants are asked to make a series of judgements. Experimental variables are manipulated by the experimenter to create a variety of different vignettes. If multiple experimental variables are employed in a vignette study, it is possible for the researcher to determine the influence of each individual factor by using factorial analysis methods even in the absence of all permutations being presented.

4.3.3 Interactive and Tailored Scenario Studies

Jenkins et al. (2010) describe a vignette used during the course of the interview in which participants could influence the development of each stage depending upon which course of action they choose from a fixed number of options. This dynamic approach could be used to facilitate the development of a vignette which has multiple stages, relating to the critical decision stages of a missing person incident.

Coughlan, Brown et al (2013) demonstrate the use a vignette based approach in which participants were asked tailored questions regarding members of their families. Using tailored scenarios enabled the study's questions to provoke additional detail without the need to create a fictional character. This overcomes some of the criticisms highlighted earlier, participants don't need to imagine what a fictional persona may do, which could influence their responses, but instead use their knowledge of a family member, thus increasing their engagement with the survey. In addition, using tailored fictional scenarios about real people circumvents the typical trade-off between creating fictional characters that are both representative and rich.

4.3.4 Criticisms and Responses

Finch suggests that "asking about what a third party 'ought' to do in a given situation is not the same thing as asking respondents what they themselves think they ought to do" (Finch, 1987, p. 113). Stolte also raises the concern of the potential for respondent to satisfice in formulating their responses, that is to process the vignette and their responses in a "careless and ineffective way" (Stolte, 1994). He suggests that a way to increase the reliability and reduce the likelihood of participants formulating satisficing responses is to conduct the vignette in a quiet room with few distractions, to tell participants to take their time and to incentivise completion of the study.

Chapman and Milham (2006) point out that as fictional personas are made more specific, they are less easily generalizable to the population at large. This sentiment is also echoed by Schutz, who points out, "Vignettes that enable participants to envisage themselves as the protagonist and in their situation are

likely to yield rich data. Conversely, “the more abstract the interpretation is, the less chance it has of hitting its mark” (Schutz, Walsh, & Lehnert, 1967, p. 175).

Jenkins (2010) highlights the importance of the plausibility of scenarios, so that they can be related to the life of the participant and suggests that making developmental stories interactive can address some of the challenges faced by more traditional vignettes.

However, we will see how some of the objections raised by other commentators do not apply to the proposed methodology, which asks participants what they themselves would do in a given scenario. These scenarios have also been informed by the timelines elicited from carers’ timelines of similar incidents in the previous chapter, potentially lessening to concerns of the plausibility of such scenarios.

4.4 METHOD

Initially, respondents are asked a series of questions relating to their own specific circumstances, a description of a person they are responsible for and their relationship to that person. This information is then used to form the basis of a vignette. Information such as the name of the person they care for is used within the vignette to increase the sense of realism and personal involvement.

Further, the vignettes were interactive and had a branching structure, participants were asked what they would do in a given scenario from a series of fixed choices, the scenario then unfolded dependent upon these choices and participants were then presented with an additional ‘stage’ within the vignette. The fixed options presented to participants were identified in a previous interview study which documented the experiences of real-life missing person cases from the perspective of carers. In addition, the vignettes themselves were heavily based upon the descriptions of real missing person incidents described by carers in the previous study.

At each stage of the vignette respondents were also asked a series of questions about how they were feeling, questions relating to the hypothesis they had about the missing persons’ whereabouts and how confident they were with the decision they had just made. The scenario comes to an end when participants

finally choice “Call the Police”, at this point they are asked further questions about their attitudes towards the police, before finally they are given closure and told that the person they care for has been found by the police. After this, they are asked a few final questions about their views on assistive technologies, and heir appropriateness for use in this situation.

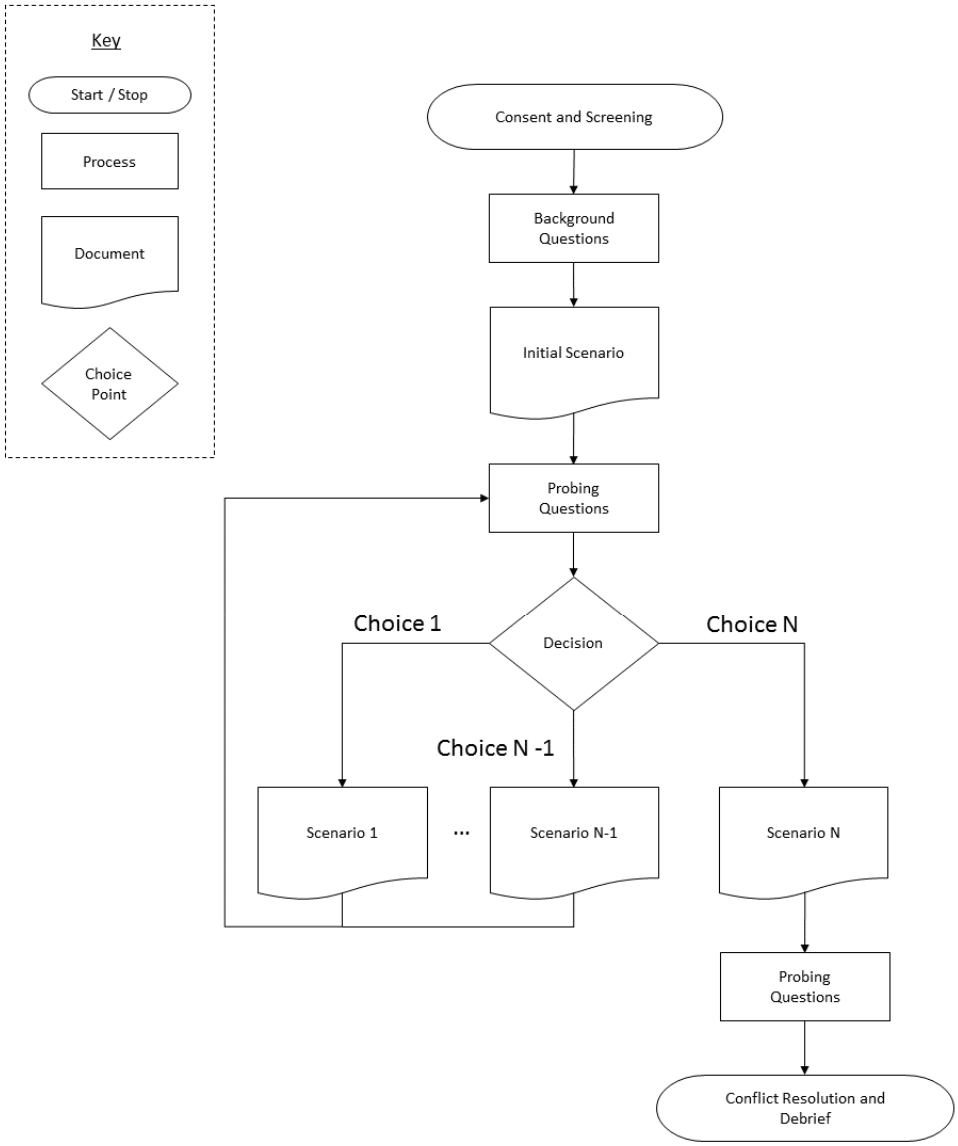


Figure 4.1 The Structure of Interactive Vignettes

Figure 4.1 The Structure of Interactive Vignettes, approximates the methodological structure of the study described in this chapter and proposes a generic method which could be applicable to other studies wishing to use this methodology. Where possible, standard flow diagram conventions were

observed, though, flow diagrams have no standard notation for n possible choices, therefore the symbol "…" was used to denote an undetermined (but finite) amount of possible choice paths. Choice "n" in this case, referred to the decision to "Call the Police", which resulted in the subsequent termination of the interactive vignette. A similar scenario format could be devised for a variety of other emergency situations which would be otherwise difficult to observe (e.g. evacuation of planes and buildings, employee behaviours during natural disasters, etc.).

Two other features present in this study were unable to be adequately represented by the diagram. In this particular study, respondents could not choose the same option more than once, hence as the study progressed, their choices reduced. Additionally, the diagram does not represent the personalisation aspect that the scenario employed, these values were obtained during the background questions stage and pipped into the scenarios. Nevertheless, it is hoped that the diagram may serve both to illustrate the structure of this particular study and serve as a guideline for others wishing to develop similar methodologies.

4.4.1 Natural Experiment Design

Whilst this study protocol more closely resembles that of an experimental vignette, it differs from typical experimental vignette studies in a number of ways. Unlike Rossi's original study in which the experimenter directly controlled the variables of interest, this study will more closely resemble the form of a natural experiment, whereby independent variables are identified but not controlled by the researcher. These independent variables relate to the "experimental variables" in Rossi's original study but in this case, participants will be asked to complete a short questionnaire about their own circumstances relating to their care of the dependent person.

4.4.2 Contextual Variables and Personalisation

Additional taken from the initial form such as care recipient's name and hobbies are used to form the basis of the tailored scenarios with the intention of making the scenarios presented more applicable to the participants. It is hoped that making the scenarios more personal, responses will be more similar to the real-

world responses of participants and the level of emotional arousal will more closely resemble that of a real-life situation. Information such as the name of the person they care for is used within the vignette to increase the sense of realism and personal involvement. These are similar to the 'Contextual variables' in Rossi's original study which are intended to increase the level of realism, but not used in the analysis itself. These included the name or pseudonym of the dependent person, a place the dependent person likes to go, the name of a close personal friend or family member who could be depended upon in an emergency and an everyday errand the participant is responsible for.

4.4.3 Dynamic

Following the initial form which determined values for the independent and contextual variables, participants were presented with a scenario in which they run an errand and the person they care for disappears. They were asked a series of questions about how worried they are, where they think the person might be and ultimately what they would do next, given a fixed series of choices, they were then presented with a new vignette based on that choice.

Participants were asked what they would do in a given scenario from a series of fixed choices, the scenario then unfolded dependent upon these choices in a branching structure and participants were then presented with an additional 'stage' within the vignette. At each stage of the vignette participants were also asked a series of questions about how they were feeling, questions relating to the hypothesis they had about the missing persons' whereabouts and how confident they were with the decision they had just made. The scenario comes to an end when participants finally choice "Call the Police", at this point they are asked further questions about their attitudes towards the police, before finally they are given closure and told that the person they care for has been found by the police. After this, they are asked a few final questions about their views on assistive technologies, and their appropriateness for use in this situation.

4.4.4 Qualitative and Quantitative

As well as gathering quantitative data in the form of decision selections and other probing questions designed to elicit feelings of worry and confidence in

one's own decisions, the study will also include several open questions that will allow participants to give reasons for their answers, thus providing a deeper insight into the narratives of caregivers during missing incidents. This will also allow additional considerations to be stated, thereby building upon and enhancing the findings from the previous study. This mixed approach allows both for a more rigorous and numerical analysis, facilitating the development of a predictive model, but should also provide additional insight into the motivations and constraints of care givers.

4.4.5 Extension of Critical Decision Method

The fixed decision options which were presented to participants were taken from the Critical Decisions identified from the carer interviews described in the previous chapter. Additionally, the individual scenarios which were presented to participants were heavily based on the first-hand reports of individuals who had experienced in searching for people who were missing.

However, the decision to search the position of last sighting was not included as an option but instead included in the original vignette presented to participants. Each stage of the vignette is thus comparable to the critical decisions identified previously, and the study design also asks a series of probing questions during each of the critical decisions, including self-reported levels of worry, hypotheses about the person's location and other possible courses of action that would be taken.

4.4.6 Changes from Pilot Study

A pilot study was conducted before the full study commenced so that usability and comprehensibility of the survey could be tested. The pilot study had five participants who were post-graduate researchers within Human Factors. Participants were asked to complete the questionnaire whilst the researcher was present, using the "talk through" method. Highlighting any difficulties they were experiencing, as well as the phrasing of and layout of the questions. A major and unfortunate change that had to be made to the study after the pilot, was the removal of questions around time estimates for each task. This question was prone to failure, both due to technological limitations and usability issues. Other minor changes were also made to the study design before its launch, these

included removing the requirement of participants to estimate the amount of time they thought each activity would require and small changes to the wording of the questions. After some initial data was gathered, recruitment was outsourced to Qualtrics (discussed below), a few additional minor changes were also made at this point, though the content of the vignette remained identical. To ensure high quality data, Qualtrics introduced several 'attention filters' which would appear intermittently throughout the scenario, to ensure the participants were attending to the task adequately, these were typically responses to simple maths questions "2+2 = ?". Finally, a questionnaire format was decided upon and developed in Qualtrics. The structure and content of the questionnaire can be found in Appendix C.

4.4.7 Ethics

Due to the nature of the study, in asking respondents how they might feel if a person they cared for disappeared, psychological distress was considered to be the main ethical concern. Despite the study's low fidelity, the study had the potential to cause undue distress to participants. Therefore, various procedures were devised to mitigate and reduce any potential distress. Respondents are fully briefed about the nature of the survey prior to its commencement and are told that the scenario might be distressing to some people before they are asked to sign a consent form, details of the informed consent form the initial questions in Appendix C. In addition, participants will had the opportunity to opt-out of the study at any stage. If they completed the study or chose to opt out early, participants will be directed to a debrief page. They are then provided with some advice from the direct.gov and metropolitan police website about what to do when a person at risk goes missing. The missing people charity hotline is also provided, as well as a helpline to help deal with anxiety and stress. The researcher's email address is also made available at this point. The scenario itself also ends on a positive note in order to reduce the potential distress of the participant. Respondents were told that the absent person has been found in good health by the police. Ethical approval for this study was granted by the University of Nottingham's Ethics committee within the faculty of engineering.

4.4.8 Recruitment

Initially, participants were targeted via a social media promotion, including the use of promotions on Facebook and Twitter. However, recruitment slowed after the first month, leaving only 50 completed responses. For this reason, the Questionnaire company Qualtrics were enlisted to recruit 100 carers (either paid of familial) and 100 parents of children. Qualtrics keep a record of people who have signed up to their questionnaire answering service, including age, gender and occupation. Qualtrics contacted people in their database who matched the criteria described above. In conjunction with the participant recruitment agency, several additional screening criteria were also agreed upon, these included a minimum completion time of five minutes, comprehensible and intelligible answers to open questions and passing certain 'attention filter' questions.

4.5 RESULTS

This summarises the results of 272 participants who completed an interactive vignette investigating decision making within missing person search. These vignettes consisted of an online questionnaire which used participants' personal information to form the basis of customised vignettes, asking specific questions about what the participants would do if they themselves were confronted with a missing person scenario.

4.5.1 Participant Demographics

Table 4.1 describes the demographics of participants and who completed the scenario study alongside responses to initial background questions. Partial responses have been removed from the dataset. Attrition rate for this study was very high (48.7%), however, this is likely to be an artefact of the recruitment method. The majority of participants who completed the first page of questions went on to complete the questionnaire, with the vast majority of dropouts failing to make the first vignette. In addition, a small number of participants were filtered out due to failing "attention filters" (10) and a further three were filtered out due to their responses to open questions being incomprehensible (3). Due to the nature of the study design, it was not possible or appropriate to screen for outliers in a way in which one might do when identifying outliers in a more traditional experiment.

Table 4.1 Participant Demographics

Carer Recipient Status	
Formal	25
Informal	247
Child	152
Adult	120
Gender of Care Recipient	
Male	131
Female	138
Other / Prefer not to say	1
Gender of Carer	
Male	89
Female	182
Other / Prefer not to say	1
Mobility of Care Recipient	
Mobility is not an issue	165
This person can walk around unaided	39
This person has difficulties	25
This person can only move around with a walking aid	28
This person cannot move without assistance	15
Dependence of Care Recipient	
Almost entirely Independent	14
Very independent	22
Independent	22
Somewhat dependent	70
Dependent	91
Very dependent	53
Carer Transportation	
Yes	241
No	31
Care Recipient Mobile Phone Use	
Has Phone	160
Does not have phone	112
Completion Rate	
Started	559
Finished	275
Removed	3
Attrition	48.7%

4.5.2 An Overview of Results

Various methods for analysing the data will be discussed, including approaches aimed at developing predictive models. Several of the initial independent variables will be also analysed in regards to their relationship to the number of choices participants made before contacting the police in order to discover

which factors are the main determinants of decision-making during these incidents. Finally, this section will aim to demonstrate, a "minimally sufficient action" hypothesis from the available data. Table 4.2 shows which decisions were made at what point during the incident for all participants. The prevalence of each decision is also given, along with the average position of each decision within the incidents.

Table 4.2 Decision Frequency at Vignette Stage

	1ST	2ND	3RD	4TH	5TH	6TH	TOTAL	% OF INCIDENTS	AVE POSITION
CALL MOBILE PHONE	110	10	9	4	0	0	133	48.9	1.30
SEARCH NEIGHBOURHOOD	71	55	31	22	7	0	186	68.4	2.13
GET IN THE CAR	5	33	26	26	19	0	109	40.0	3.20
CHECK KNOWN LOCATION	16	41	42	18	9	0	126	46.3	2.71
ENLIST HELP	41	55	34	23	13	0	166	61.0	2.47
CALL THE POLICE	29	49	52	49	45	48	272	100	3.65
TOTAL	272	243	194	142	93	48	992		

Table 4.2 shows that the most common decision (excluding the forced choice to call the police) was to search the neighbourhood and immediate vicinity (68.4%), followed by the decision to enlist the help of a friend or family member (61.0%). The least common decision was to get in the car (40.0%). The table also shows the average position in which each decision was likely to occur, however, this should not be considered an indication of rank or ordering preference as the decision sequences were of different lengths.

4.5.3 Predictive Models of Decision-Making in Missing Incidents

An explicit aim of this thesis is to create a predictive model of searcher behaviour during missing incidents. The data collected from Study 2 allows for the development of various models which will be explored here. Two such models will be presented and appraised before finally one of these will be selected. The etymological route of 'prediction' (L. *praedicere*) literally means, 'to say before'; stating beforehand what will happen at some future time. Prediction usually depends upon inductive statistical inferences about observed data, rather than deductive inferences made from first principles (Aitchison & Dunsmore, 1980).

One such predictive model is a Markov Model. Markov models are stochastic models which models ordered or sequential data and describe the dependencies of current information with respect to previous information. Markov models consist of discrete states and probabilities relating to transitions between those states, they make the assumption that the sole determinate of the next state transition depends upon current state membership. Markov models can be used to recognise patterns in existing data and use that information to predict or estimate transitions between future states, given any current state.

Treating the decision choices as a series of finite states, with the initial vignette scenario as the start state and the decision to "Call the Police" as the termination state, the following probability table was created from the vignette response dataset. This table shows the likelihood of moving from any given STATE A to STATE B, for all participants. For example; the likelihood of moving from the initial presentation of the vignette to "Enlist the help of a friend" was found to be 28.8% and the likelihood of a participant who had just searched the

neighbourhood to “Call the Police” as the next decision was found to be 48.7%. Each item of the table was calculated by summing the total instances of a STATE A-STATE B transitions and dividing this by the total instances of STATE A as described by the pseudo-code.

Using Markov modelling methods allows for predictions to be made about what event is likely to proceed the current event, however other methods have been used in the study of Emergency Behaviours (Canter, 1980; Lawson, 2011). Residuals are calculations which express the difference between the observed and expected values and allow an analyst to determine whether a transition deviates from that expected by chance. Standardised residuals are given by the residual divided by an estimate of the standard deviation and show the ratio of variance from the expected value and thus allow strengths of relationships to be measured. To highlight the differences in the Markov and Residual measures, consider a state transition AB which occurs for all cases of B, that is, if B occurs, it occurs before A. If the frequency of choice B in the data set is low, the AB value given by simple probability or Markov modelling will be a low value, even though the relationship is strong. Residuals account for this difference, and thus in such a case the residual value of AB would be high. A matrix table is set up as before, but the total frequency is used instead of the likelihood (i.e. values are not initially divided by the sum of rows). Instead standardised residual values are calculated for each value, by the following formula.

$$X = \frac{(O - E)}{\sqrt{E}}$$

$$E = \frac{Row\ Total * Column\ Total}{Grand\ Total}$$

Standardised residuals therefore tell us how much more likely an AB transition is, given A, than would otherwise be expected by chance. This allows inferences to be made about the casual relationships between actions.

Table 4.3 Description of State-Transitions is a summary of the 992 state-transitions that were observed across all incidents. The rows indicate the previous decision made by participants whilst the columns represent the next choice that is made. Included in the table is the raw count of each transition and

the percentage of each transition in the context of all transitions. Additionally, the table includes the standardised residual, calculated by the formula above and the percentage of each transition within the last choice, which will be used to create a Markov model.

Table 4.3 Description of State-Transitions

			LastChoice						Total
			check likely place	enlist help	get in car	mobile phone	search nearby	Start	
Current Choice	call police	Count	43	63	59	15	63	29	272
		Expected Count	34.0	45.5	30.4	36.5	51.0	74.6	272.0
		% within LastChoice	34.7%	38.0%	53.2%	11.3%	33.9%	10.7%	27.4%
		% of Total	4.3%	6.4%	5.9%	1.5%	6.4%	2.9%	27.4%
		Standardized Residual	1.5	2.6	5.2	-3.6	1.7	-5.3	
	check likely place	Count	0	23	19	36	30	16	124
		Expected Count	15.5	20.8	13.9	16.6	23.3	34.0	124.0
		% within LastChoice	0.0%	13.9%	17.1%	27.1%	16.1%	5.9%	12.5%
		% of Total	0.0%	2.3%	1.9%	3.6%	3.0%	1.6%	12.5%
		Standardized Residual	-3.9	.5	1.4	4.8	1.4	-3.1	
	enlist help	Count	32	0	20	35	38	41	166
		Expected Count	20.8	27.8	18.6	22.3	31.1	45.5	166.0
		% within LastChoice	25.8%	0.0%	18.0%	26.3%	20.4%	15.1%	16.7%

		% of Total	3.2%	0.0%	2.0%	3.5%	3.8%	4.1%	16.7%
		Standardized Residual	2.5	-5.3	.3	2.7	1.2	-.7	
	get in car	Count	16	25	0	16	49	5	111
		Expected Count	13.9	18.6	12.4	14.9	20.8	30.4	111.0
		% within LastChoice	12.9%	15.1%	0.0%	12.0%	26.3%	1.8%	11.2%
		% of Total	1.6%	2.5%	0.0%	1.6%	4.9%	0.5%	11.2%
		Standardized Residual	.6	1.5	-3.5	.3	6.2	-4.6	
	mobile phone	Count	7	6	4	0	6	110	133
		Expected Count	16.6	22.3	14.9	17.8	24.9	36.5	133.0
		% within LastChoice	5.6%	3.6%	3.6%	0.0%	3.2%	40.4%	13.4%
		% of Total	0.7%	0.6%	0.4%	0.0%	0.6%	11.1%	13.4%
		Standardized Residual	-2.4	-3.4	-2.8	-4.2	-3.8	12.2	
	search nearby	Count	26	49	9	31	0	71	186
		Expected Count	23.3	31.1	20.8	24.9	34.9	51.0	186.0
		% within LastChoice	21.0%	29.5%	8.1%	23.3%	0.0%	26.1%	18.8%
		% of Total	2.6%	4.9%	0.9%	3.1%	0.0%	7.2%	18.8%

		Standardized Residual	.6	3.2	-2.6	1.2	-5.9	2.8	
Total		Count	124	166	111	133	186	272	992
		Expected Count	124.0	166.0	111.0	133.0	186.0	272.0	992.0
		% within LastChoice	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
		% of Total	12.5%	16.7%	11.2%	13.4%	18.8%	27.4%	100.0%

This state-transitional diagram Figure 4.2 (below) is a visual representation of the "% within LastChoice" data given in Table 4.3. The arrows depicted indicate the likelihood of moving from any state to any other state, it shows the probabilities of state transitions which have a likelihood of more than 25%. This state-transitional diagram was constructed with the "% within LastChoice" data taken from Table 4.3.

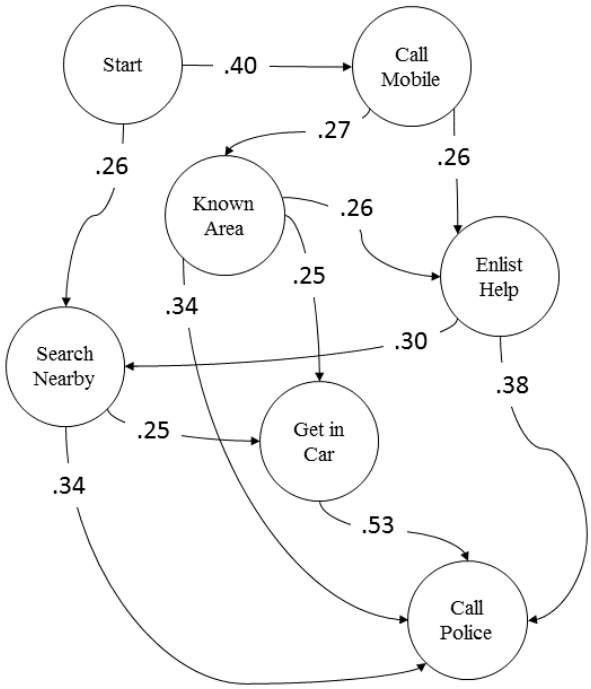


Figure 4.2 Markov Model of Searcher Behaviour

Transitions of less than 25% excluded for clarity.

Results show that the most likely state transition was the decision to call the police after searching the neighbourhood in the car (53%), followed secondly by the decision to call the care recipient's mobile phone immediately after noticing a care recipient was absent (marked as "start" in Figure 4.2).

Similarly, the standardised residuals given by Table 4.3 were used to produce the Standardised Residual Model of Searcher Behaviour presented in Figure 4.3 (below). Arrows in Figure 4.3, indicate the standardised residuals calculated for each state transition. Relationships of less than two were excluded from the diagram for clarity and statistical significance.

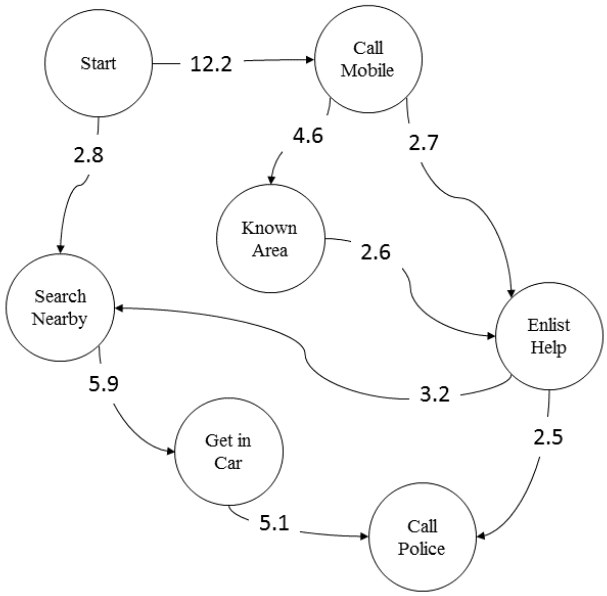


Figure 4.3 Standardised Residual Model of Searcher Behaviour

The highest value given by the standardised residuals was the transition from noticing an absence to the decision to call the police, this suggests that the causal relationship between these two events is the strongest.

The Markov model depicted in Figure 4.2, indicates the probability of moving from one state to another, whereas the standardised residual model shown in Figure 4.3, indicates state transitions in which the observed frequencies are significantly different from the expected frequencies. The Standardised Residual Model and the Markov Model will be discussed further, later in the chapter in regards to their usefulness and utility in accomplishing the thesis' aims.

4.5.4 Care Recipient Age as Determining Factor

The following sub-sections will investigate the relationship between stated independent variables and number of number of decisions made. As "Calling the police" is the termination state of the vignette it can be assumed that less total decisions made equates to a faster level of escalation. Most of the distributions related to number of decisions made are not normally distributed and therefore do not meet the criteria for parametric testing.

This section will investigate the differences between total decisions made between carers of adults and carers of children. Given the literature surrounding missing adults, it is hypothesised that the carers of adults typically wait longer before calling the police than the carers of children. Table 4.4 gives the frequencies of the total number of decisions for the carers of adults and the carers of children.

Table 4.4 Number of Decisions Made by Carer Type

	All	**Carers of Adults**	**Carers of Children**
1	29	14	15
2	49	11	38
3	52	18	34
4	49	20	29
5	45	27	18
6	48	30	18
Total	272	120	152
Ave.	3.65	4.04	3.335

Similarly, Figure 4.4 shows these values in a line-graph. As is evidenced by the graph, the distribution of adult total choices is not normally distributed, and the carers of adults typically wait longer before calling the police.

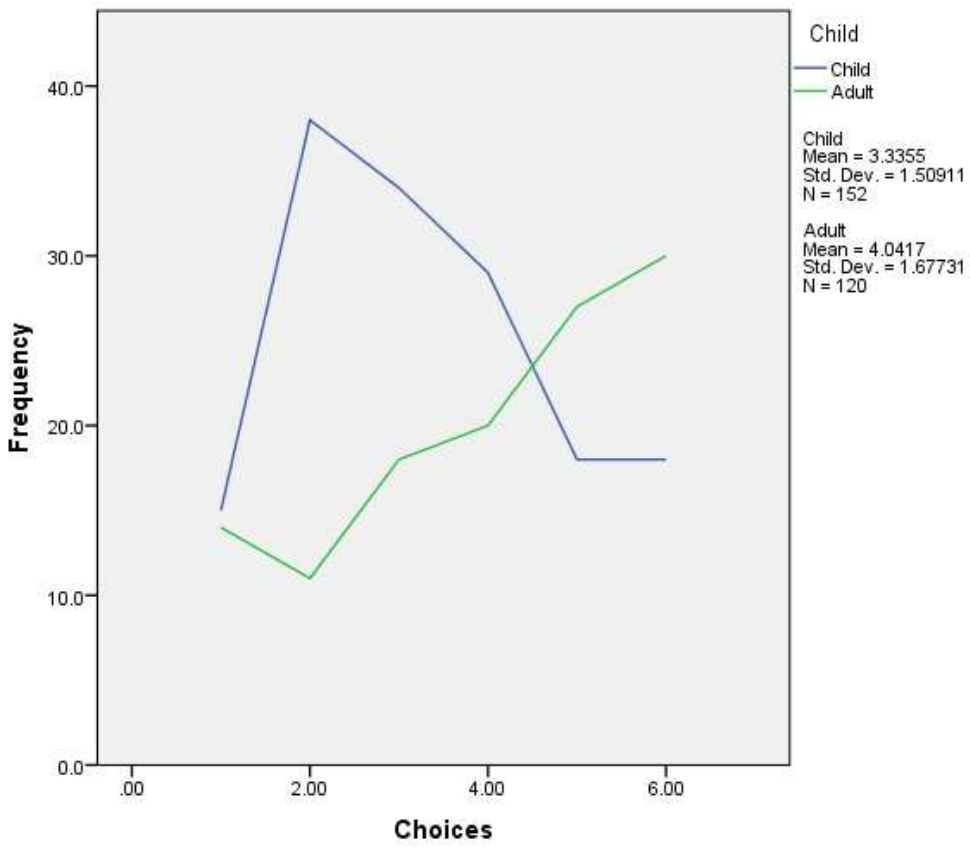


Figure 4.4 Number of Decisions by Carer Type

To test the hypothesis that the carers of adults typically wait longer before calling the police than the carers of children, two hypotheses are presented.

H_0 – The carers of adults do not make more decisions before calling the police than the carers of children.
H_1 - The carers of adults make more decisions before calling the police than the carers of children.

The appropriate statistical test for this hypothesis with this data is the Kruskal-Wallis, which stipulates a critical value of 11.07 ($p < 0.05$, $df = 5$). The observed value of 22.84 far exceeds the critical value, therefore H_0 can be rejected and H_1 can be accepted.

4.5.5 Gender of Care Recipient

The next independent variable of consideration is the gender of the care recipient. Table 2.1 gives the number of decisions made for the carers of males and the carers of females.

Table 4.5 Number of Decisions by Caree Gender

	Carers of Males and Carers of Females	**Carers of Males**	**Carers of Females**
1	29	12	17
2	48	19	29
3	51	25	26
4	49	29	20
5	44	21	23
6	48	25	23
Total	269	131	138
Ave.	3.65	3.79	3.52

These distributions are not normal and therefore the appropriate statistical test is the Kruskal-Wallis. Unlike the previous independent variable, there are no indications that there are any associated differences, and therefore a 2-tailed hypothesis ($p > 0.1$) is given.

H_0 – There is no difference in the number of decisions made by the carers of males and the carers of females.
H_1 - There is a difference in the number of decisions made by the carers of males and the carers of females

$X^2_{obs} = 4.70$, X^2_{crit} $(df = 5; p < 0.1) = 9.24$

X^2_{obs} is less than X^2_{crit} and no significant differences between the number of choices made before calling the police and the gender of care recipient have been observed. Therefore, H_1 is rejected and H_0 is retained.

4.5.6 Gender of Carer

The final difference that will be investigated is the gender of the carer. As before, the data is not normally distributed and therefore the appropriate statistical test is the Kruskal-Wallis. Also as before, there exists no previous research that suggests a difference between the amount of time male and female

carers would take before calling the police so a two-tailed hypothesis will be investigated (that there is a difference between the amount of decisions male and female carers make before calling the police).

H_0 – There is no difference in the number of decisions made by male carers and female carers.

H_1 - There is a difference in the number of decisions made by male carers and female carers.

Table 4.6 Number of Decisions by Carer Gender

	Male Carers and Female Carers	**Male Carers**	**Female Carers**
1	29	9	20
2	48	14	34
3	52	15	37
4	49	19	30
5	45	16	29
6	48	16	32
Total	271	89	182
Ave.	3.65	3.75	3.60

$X^2_{obs} = 1.66$, X^2_{crit} $(df = 5; p < 0.1) = 9.24$

X^2_{obs} is below the critical value and therefore there are no observed significant differences between number of choices made before calling the police for male and female carers, therefore, H_1 is rejected and H_0 is retained.

4.5.7 Mobility

Unlike the previous sections in which statistical analysis was used to check for differences between groups, the hypothesis being tested in this section is that there is a correlation between levels of mobility and amount of decisions before calling the police; where lower mobility amounts to less decisions. Table 4.7 gives the breakdown of number of decisions by mobility.

Table 4.7 Number of Decisions by Mobility

	Mobility not an issue	Can walk unaided	Has difficulties	Assisted Only	Cannot move
1	10	4	2	6	7
2	36	4	2	5	2
3	36	5	5	5	1
4	33	4	4	5	3
5	25	10	5	5	0
6	25	12	7	2	2
Total	165	39	25	28	15
Ave	3.04	4.23	4.16	3.14	2.53

Figure 4.5 shows the same data plotted on a graph with error bars showing a 95% confidence interval[1].

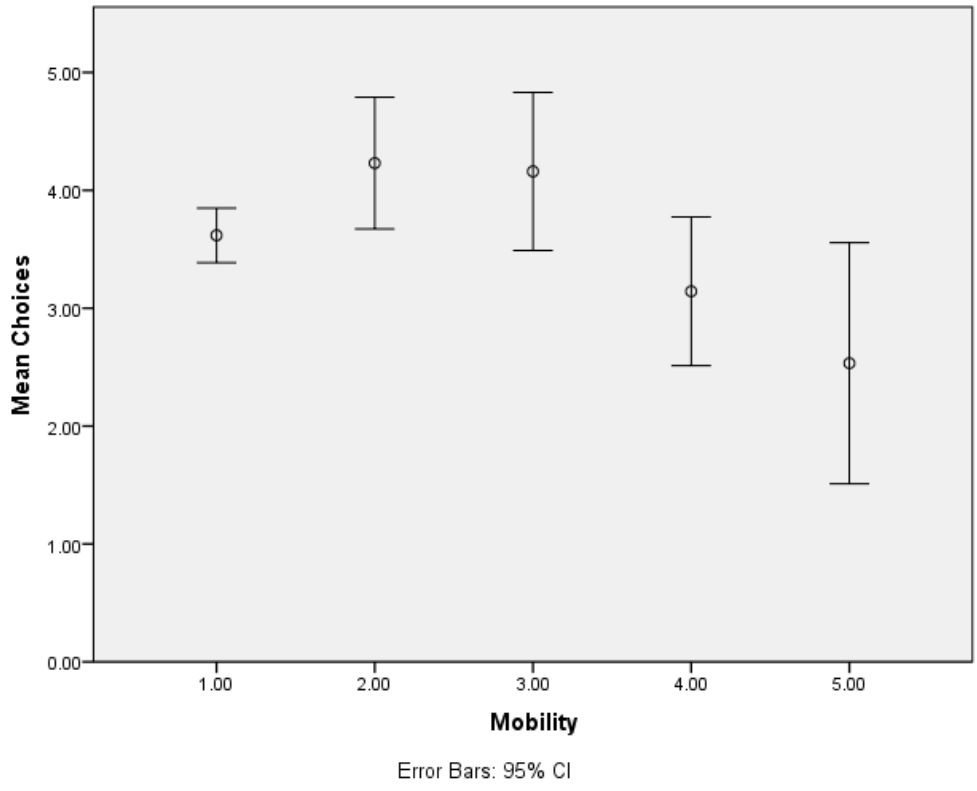


Figure 4.5 Number of Decisions by Mobility

[1] Mobility score of "1" is "Mobility not an issue", "2" is "Can walk unaided", etc.

Mobility was classified on a five point ordinal scale by participants and therefore a Pearson is inappropriate, instead a Spearman's Rho test was conducted to see whether mobility correlated with the amount of choices taken (Table 4.8). A one tailed hypothesis was conducted due to the assumption that the carers of those with lower mobility would contact police sooner in the event of a noticed absence, subsequently, hypothesis are as follows.

H_0 – Mobility is not negatively correlated with the total number of decisions made before police contact.

H_1 – Mobility is negatively correlated with the total number of decisions made before police contact.

Table 4.8 Choices by Mobility Spearman's Rho

			Mobility	Choices
Spearman's rho	Mobility	Correlation Coefficient	1.000	-.035
		Sig. (1-tailed)	.	.283
		N	272	272
	Choices	Correlation Coefficient	-.035	1.000
		Sig. (1-tailed)	.283	.
		N	272	272

The Spearman's rho calculation indicated a non-significant correlation of -0.35 between mobility and number of choices before contacting the police meaning that H_1 should be rejected and H_0 should be retained. However, it is likely that this data might be skewed due to children being reported as having higher levels of mobility than adults with care and support needs.

4.5.8 Mobility in the Adult Population Only

In order to see whether mobility was a predictor of choices for the adult population, children were excluded from the dataset and the Spearman's rho was rerun with new hypotheses (Table 4.9).

H_0 – Mobility is not negatively correlated with the total number of decisions made before police contact in the adult population.

H_1 – Mobility is negatively correlated with the total number of decisions made before police contact in the adult population.

Table 4.9 Choices by Mobility Spearman's Rho - Adults Only

			Choices	Mobility
Spearman's rho	Choices	Correlation Coefficient	1.000	-.206*
		Sig. (1-tailed)	.	.012
		N	120	120
	Mobility	Correlation Coefficient	-.206*	1.000
		Sig. (1-tailed)	.012	.
		N	120	120

*. Correlation is significant at the 0.05 level (1-tailed).

Table 4.9 demonstrates a statistically significant correlation, with a correlation coefficient of -0.206 for mobility and choices in the adult population only. This suggests that as mobility decreases the likelihood that the police will be called earlier increases. Therefore, the H_0 can be rejected and H_1 can be accepted.

4.5.9 Dependence

Similar to mobility, this section will investigate dependence (given as an ordinal score) as it relates to total number of decisions. Table 4.10 shows the number of decisions made by level of dependence.

Table 4.10 Number of Decisions Made by Dependence

	Very Dependent	**Dependent**	**Somewhat dependent**	**Independent**	**Very Independent**	**Almost Entirely Independent**
1	12	13	4	0	0	0
2	16	21	8	1	0	3
3	12	26	9	3	2	0
4	7	18	14	5	5	2
5	2	7	17	7	7	5
6	4	6	18	8	8	4
Total	53	91	70	22	22	14
Ave.	2.68	3.03	4.23	5.18	4.95	4.50

Figure 4.6 shows the same data in a line graph with confidence intervals of 95% provided by the error bars[2].

[2] "1" relates to "Very dependent", "2" to "Dependent", etc.

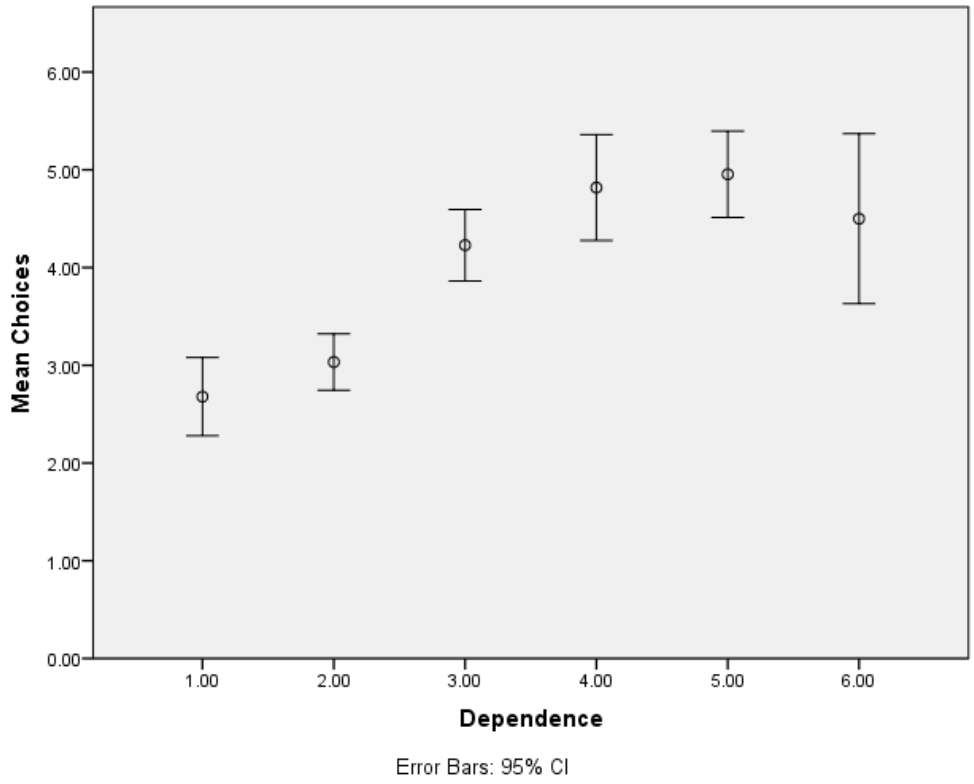


Figure 4.6 Number of Decisions by Mobility

Similar to the mobility classifications, dependence was answered on an ordinal scale by participants and therefore the appropriate statistical test is Spearman's Rho (Table 4.11), in the ordinal scale provided, a dependence score of 6 indicates highly independent, and a dependence score of 1 indicates highly dependent. Hypotheses are as follows:

H_0 – Dependence is not negatively correlated with the total number of decisions made before police contact.

H_1 – Dependence is negatively correlated with the total number of decisions made before police contact.

Table 4.11 Choices by Dependence Spearman's Rho

			Choices	Dependence
Spearman's rho	Choices	Correlation Coefficient	1.000	.494**
		Sig. (1-tailed)	.	.000
		N	272	272
	Dependence	Correlation Coefficient	.494**	1.000
		Sig. (1-tailed)	.000	.
		N	272	272

**. Correlation is significant at the 0.01 level (1-tailed).

Table 4.11 indicates that there is a strong correlation (correlation coefficient of 0.494) between levels of independence and number of choices made by carers. Therefore, H_0 can be rejected and H_1 can be accepted.

4.5.10 Initial Worry and Total Choices

This section will explore the relationship between self-reported worry during the incidents and choices made. A modified pairwise ranking will determine decision-order preference, and a correlation between these ranks and worry will be tested. In addition, the influence of antecedent factors previously identified as significant to choice amount upon worry will be investigated.

The first hypothesis to be tested first reported worry immediately following a noticed absence correlates with total decision choices, where higher reported initial worry entails less decisions before contacting the police.

H_0 – There is no negative correlation between first reported worry and total decision choices.

H_1 – There is a negative correlation between first reported worry and total decision choices.

Figure 4.7, shows the mean worry for the total number of decisions made in incidents. Confidence intervals of 95% are also given by the error bars.

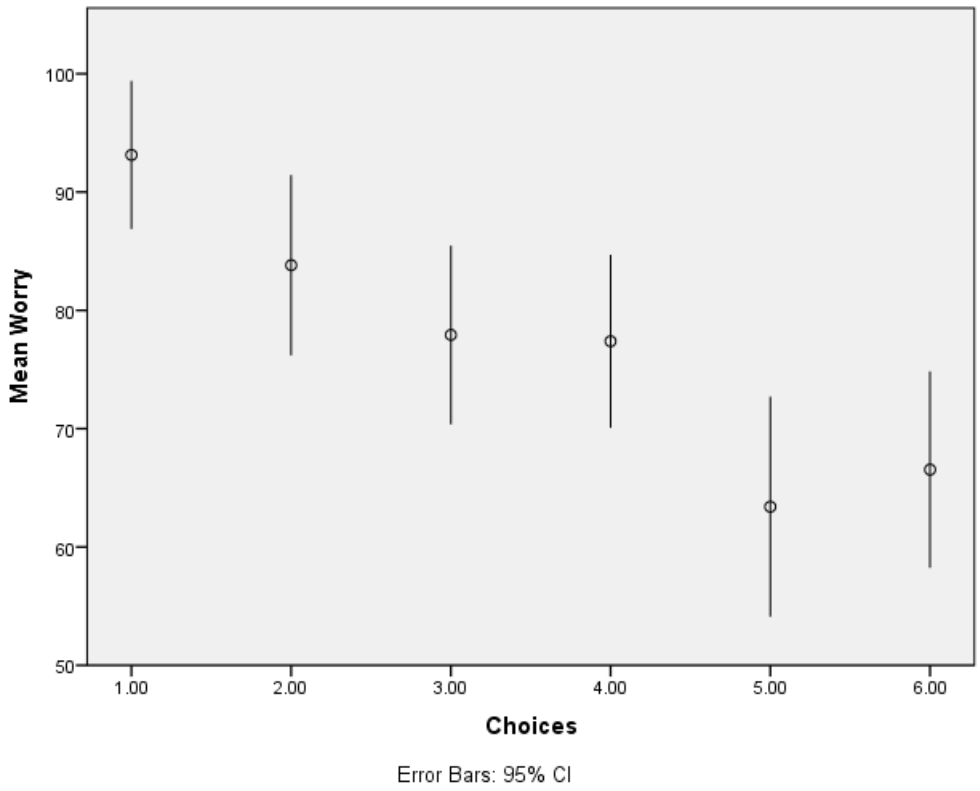


Figure 4.7 First Reported Worry by Total Choices

As choices and self-reported worry are both intervals, the appropriate statistical test is the Pearson correlation, the results are given in Table 4.12.

Table 4.12 Worry and Choice Amount Pearson

		Worry	Choices
Worry	Pearson Correlation	1	-.310**
	Sig. (1-tailed)		.000
	N	272	272
Choices	Pearson Correlation	-.310**	1
	Sig. (1-tailed)	.000	
	N	272	272

**. Correlation is significant at the 0.01 level (1-tailed).

Table 4.12 indicates that there is a highly significant correlation of -0.310 between worry and total choices made, indicating that higher reported initial worry results in less decisions being made before contacting the police. This means that H_0 can be rejected and H_1 can be accepted.

4.5.11 Worry and the Perceived Cost of Action

An additional hypothesis will be explored in this section; that higher perceived decision costs are correlated with higher levels of self-reported worry. An assumption here that will be investigated is that that decisions made later on in incidents typically involve a higher perceived cost to the carer; whether that is time, effort or social stigma.

In order to determine the relative ordering of where each decision occurred in the dataset (regardless of how prevalent each particular decision was overall), a pairwise ranking table was created to determine which decisions where likely to be chosen earlier on in the incident. The table consists of cells whose values were determined by a pairwise analysis. The sum of each time decision A occurred before decision B within the dataset subtracted by the sum of decision B occurring before decision A. Normally, pairwise rank evaluation does not include a subtractive element, but due to rank lists consisting of different lengths, commonly occurring decisions would be assigned higher values than less frequently occurring (but more prioritised) decisions using an additive pairwise rank method only. Thus, in order to properly represent the relative ordering of the decisions, whilst ignoring the likelihood of a particular decision being made for any given incident, the subtractive element of the pairwise ranking rectifies this overrepresentation of prevalent but less prioritised choices. The results of these rank order calculations were then normalised, this also allows for a comparison between different sub-sections of the results.

Table 4.13 Variation on Pairwise Ranking Method for Decision Order Preference

	mobile phone	Search the neighbouring	Get in the car	Check to see if	Enlist the help	Call the police
mobile phone	/	-422	-297	-348	-435	-405
Search the neighbouring	422	/	-56	-26	-12	-420
Get in the car	297	56	/	14	28	-89
Check to see if	348	26	-14	/	-6	-118
Enlist the help	435	12	-28	6	/	-273
Call the police	405	420	89	118	273	/
SUM TOTAL	1907	92	-306	-236	-152	-1305
Rank	1	2	5	4	3	6

Table 4.13 shows the relative priority of where each decision is likely to occur within the incident when it is chosen. The table shows that the decision to "call the person's mobile phone" is made first, followed very shortly before the decision to enlist help. "Get in the Car", was the last possible decision to be made (as "Call the Police" is a forced last choice). This ranking ignores how often each decision is chosen within the dataset.

Whilst the association between perceived costs and rank order (given in Table 4.13) cannot be fully established, the results indicate prima facie support for such an assumption. For example, it is likely that getting in the car and searching the surrounding areas involves a higher perceived cost than searching the neighbourhood on foot. Similarly, one would expect the decision to call the mobile phone of the missing person to involve relatively low perceived costs, which concurs with the rank ordering results demonstrating that calling the mobile phone typically occurs as the first choice of carers. Figure 4.8 shows the relationship between self-reported prior to each decision and consequent decision-choice by rank.

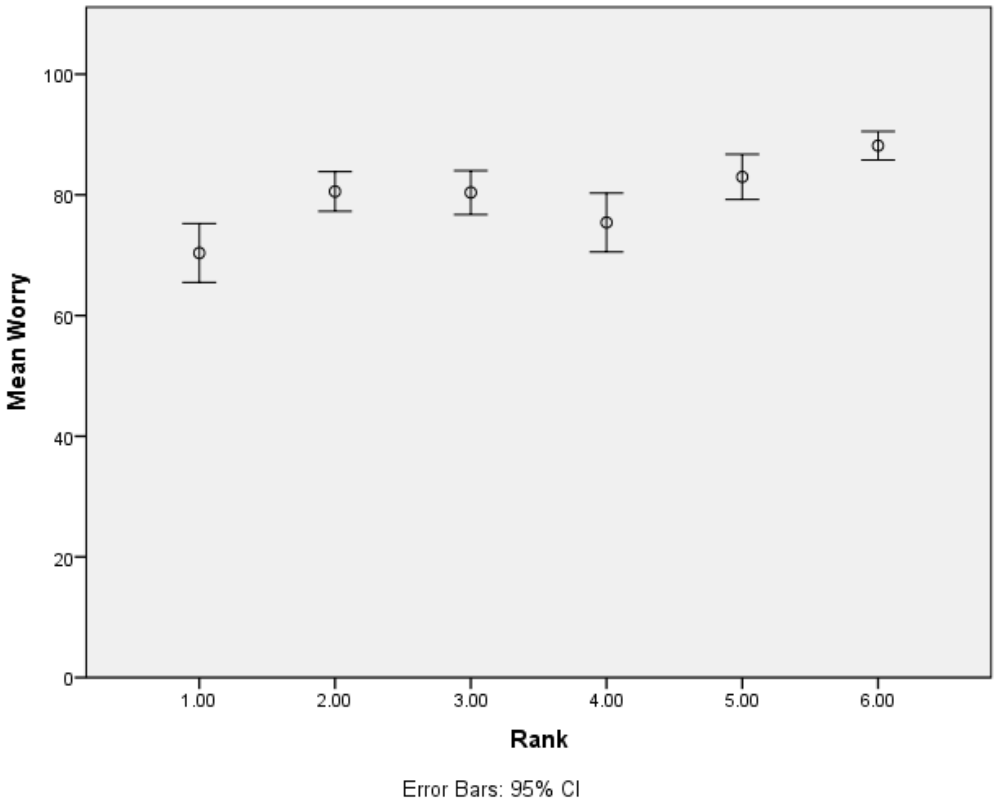


Figure 4.8 Self-Reported Worry and Decision Rank

As decision rank is ordinal data, the appropriate statistical test is a Spearman's Rho (Table 4.14).

H_0 – There is no positive correlation between average worry associated with a decision and the rank-order in which the decision occurs.

H_1 – There is a positive correlation between average worry associated with a decision and the rank-order in which the decision occurs.

Table 4.14 Correlation of Self-Reported Worry and Decision Rank

			Rank	Worry
Spearman's rho	Rank	Correlation Coefficient	1.000	.215**
		Sig. (1-tailed)	.	.000
		N	992	992
	Worry	Correlation Coefficient	.215**	1.000
		Sig. (1-tailed)	.000	.
		N	992	992

**. Correlation is significant at the 0.01 level (1-tailed).

Table 4.14 confirms the hypothesis that there is a correlation between self-reported worry and decision rank, and hence H_0 can be rejected and H_1 can be accepted. This lends support to the idea that higher levels of self-reported worry are associated with the propensity to make decisions with a higher perceived cost.

4.5.12 Worry and Mobility

Correlations between initial self-reported worry and antecedent factors, such as mobility and dependence will also be investigated. It is hypothesised that higher lower levels of mobility will result in a higher reported worry immediately after a noticed absence. As mobility was captured using an ordinal scale the appropriate statistical test for both of this hypothesis is the Spearman's Rho (Table 4.15).

H_0 – There is no negative correlation between the initial worry reported and the mobility of the care recipient.

H_1 – There is a negative correlation between the initial worry reported and the mobility of the care recipient.

Table 4.15 Spearman's Rho Test for Worry and Mobility

			Worry	Mobility
Spearman's rho	Worry	Correlation Coefficient	1.000	.197**
		Sig. (1-tailed)	.	.001
		N	272	272
	Mobility	Correlation Coefficient	.197**	1.000
		Sig. (1-tailed)	.001	.
		N	272	272

**. Correlation is significant at the 0.01 level (1-tailed).

Table 4.15 demonstrates that there is a significant but relatively weak correlation between first reported worry and mobility, where lower levels of mobility correlated with higher levels of initial worry (given that higher scores of mobility correspond to less mobility, see Table 4.7). This means that H_0 can be rejected and H_1 can be retained.

4.5.13 Worry and Dependence

Similarly, it is hypothesised those who care for people who are more dependent will tend to report higher worry following a noticed absence than those who are more independent.

H_0 – There is no negative correlation between the initial worry reported and the independence of the care recipient.

H_1 – There is a negative correlation between the initial worry reported and the independence of the care recipient.

Table 4.16 Spearman's Rho Test for Worry and Dependence

			Worry	Independence
Spearman's rho	Worry	Correlation Coefficient	1.000	-.373**
		Sig. (1-tailed)	.	.000
		N	272	272
	Independence	Correlation Coefficient	-.373**	1.000
		Sig. (1-tailed)	.000	.
		N	272	272

**. Correlation is significant at the 0.01 level (1-tailed).

Table 4.16 indicates a significant correlation between independence and first reported worry. H_0 can be rejected and H_1 can be accepted. Higher levels of dependence entail higher first reported worry.

4.6 DISCUSSION

4.6.1 General Discussion of Findings

Results demonstrate that only a relatively small amount of carers and parents will make the decision to "get in the car and search the surrounding areas", and when this does happen, it tends to be the penultimate decision before contacting the police. Conversely, the decision to call the mobile phone of the care recipient was usually made as the first decision following a noticed absence. Enlisting the help of a friend or colleague was a decision made in 61.0% of incidents and often occurred immediately after searching the surrounding area. This finding is in concurrence with the earlier interview studies, in which carers typically enlisted help early on in the incident. This suggests that enlisting help is often prioritised by carers and parents, highlighting the fact that missing person search prior to police involvement is often a collective, rather than an individual task.

Significant differences were observed between the carers of adults and the carers of children in the number of decisions made before contacting the police.

The carers of adults typically exhausted more options before contacting the police. This finding is in concurrence with other missing persons research, which suggests that the carers of those with dementia typically conduct extensive informal searches before calling the police (R. J. Koester & Stooksbury, 1995).

A significant correlation was also established between the amount of decisions taken before call the police and the levels of independence, where higher levels of independence meant more actions before an official report. Likewise, a correlation was observed between the reported levels of care recipient mobility and total decisions before police involvement. The direction was as predicted, with higher levels of mobility resulting in more exhaustive searches before police involvement. These findings, whilst unsurprising, further elucidate the antecedent factors which determine carer behaviour in missing incidents. This information could be useful to the designers of assistive technologies designed to help with missing incidents by highlighting likely differences in carer behaviour based upon care recipient characteristics. Additionally, this information could be used to build upon the Missing Person Conceptual Model as described in Figure 2.3.

4.6.2 Predictive Models of Searcher Behaviour

Two models of searcher behaviour were presented in section 4.5.3; the Markov Predictive Model (Figure 4.2) and the Standardised Residual Model of Searcher Behaviour (Figure 4.3). Models of human behaviour incorporating standardised residuals of state transitions have been used in other research investigating evacuation behaviour in the case of fire (Canter, 1980; Lawson, 2011). These models were used to compare various fire evacuation simulations with real-life incidents and with other fire evacuation simulations respectively. Standardised residuals of state transitions show the statistical deviation from expected frequencies and thus suggest how much more likely one event is, given that a particular event preceded it. The values determined by this analysis are called "strength of association" values by Canter (1980). Hence, they hint at underlying causal relations between events. This approach is particularly suitable for incidents which may involve the high presence of extrinsic events not directly caused by the decisions of an actor. For example, "encounter

smoke" and "hear fire alarm" are events which were not necessarily the result of a decision. This is useful for determining the effect that any particular event may have on subsequent behaviour. In the case of previously described fire evacuation studies, this may be useful in determining the causal influence of hearing a fire alarm on decision choice. However, if the goal is merely to determine what individuals are likely to do in a given situation, the overall likelihood of one decision occurring after a given decision is the most useful method. The standardised residual approach essentially controls for the prevalence of each decision choice, consequently, "strength of association" values may be high for certain transitions even though the overall frequency of that transition is low.

Conversely, the Markov Model merely gives the likelihood of subsequent decision given a particular state, but does not provide any information to how much this likelihood has increased. This value takes into account the overall frequency of the subsequent decision within the dataset and allows predictions about which action will be taken next. Whilst both the Markov and Residual Models shed light on important aspects about the relationship between decisions within missing incidents, the Markov model more strictly adheres to the description of "prediction" given throughout this thesis. However, the performance of predictive models need to be estimated in order to assess their accuracy. One such method of validation is known as k-fold cross validation. This method involves iterations of partitioning the data into training and testing subsets and testing each training set against a validation subset. K-fold validation methods are exhaustive; meaning that every piece of data is used both in the training and validation phase exactly once. Measures of goodness of fit are taken at each stage of the validation, and averaged to give an overall indication of performance. A simple, straight-forward and easy to understand measure of goodness of fit is Mean Absolute Error (MAE), which is calculated by determining the absolute difference between state transitions between the training and validation sets, and averaging for the entire model. By averaging the MAE across all iterations of the validation, a result is generated which indicates the average error for the entire model; thus providing an indication of the likely performance of the predictive model to unseen data. For this reason,

a K-fold cross validation was performed on the Markov model (Figure 4.2) using C# scripting in Visual Studio; the entire dataset was split into 16 partitions, of 17 entries each which were each iteratively evaluated, resulting in a mean absolute error of 8.57 (given in percentage). This indicates every transition on an unseen dataset will differ by an average of 8.57 percentage points from the model. Whilst there are is no consensus on what an acceptable MAE would be within this specific context, an MAE of 8.57 percentage points indicates that this model is likely to generalise reasonably well to unseen data and is likely to perform with a relative degree of accuracy. If more participants had have participated in the vignette survey, it is likely that the MAE would increase owing to the law of large numbers; which stipulates that the more results that are obtained, the more likely the averages of those results will tend towards the expected value, or true average of the population.

4.6.3 On the Perceived Cost of Action

Using a novel approach to rank order analysis, the relative priority of each decision was able to be identified, despite the heterogeneous lengths of individual 'decision-lists'. This allowed the analysis to show where a decision would be likely to occur even in incidents where it did not. A speculative hypothesis is that the rank order of decisions made represents a perceived associated cost of the decision, with those decisions with lower associated time, commitment and guilt costs appearing earlier on in the incident. The decision to "call the mobile phone" (of the care recipient), presumably has a very low associated time, commitment and guilt cost, whereas the decision to "call the police" is seen as a very big commitment which may also be associated with feelings of guilt on part of the care recipient (Stevenson et al., 2013). The rank ordering analysis broadly lends support to the idea that less costly actions will be prioritised in missing incidents.

Higher levels of self-reported worry correlate with participants taking decisions with a lower rank ordering (i.e. those with an assumed higher associated cost), thus bypassing some of the initial decisions less worried participants tend to take. A very high level of self-reported worry initially, is likely to result in the participant choosing to call the police immediately. Levels of self-reported worry also correlate with some of the initial background (independent)

variables, such as levels of independence and mobility. This demonstrates that the higher the individual risk to the care recipient, the more likely the carer is to engage in more 'costly' decisions.

4.6.4 Aims

This study set out to form the basis of a predictive model of care-giver behaviour during missing incidents for vulnerable people and explore factors which may affect decision-making immediately following a period of noticed absence. Two models were presented which showed the relationship between decisions during missing incidents. The Markov model, showed the likelihood of respondents choice given a previous choice, whereas the residual model showed statistically significant differences between expected values, estimating the causal relationships between choices. After a brief discussion, it was concluded that the Markov Model was more in keeping with the description of prediction used previously in this thesis and thus, satisfies objective 3.

Form a model of guardian and carer behaviour during Missing Incidents.

In addition, the relationships between various individual decisions and total decision frequencies showed significant differences between the carers of adults and the carers of children (Table 4.4), but no gender differences for both carer (Table 4.6) and care recipient (Table 4.5). The study also established the relationship between mobility and total choice amount, as well as between care recipient independence and choice amount and in so doing satisfied objective 4.

Measure the extent to which various carer or care recipient circumstances affect search strategies.

Taken together these models can be considered predictive models of human behaviour during missing incidents, thereby achieving the predictive aspect of this thesis; "To form the basis of a predictive model of human behaviour during missing person search, including the identification of factors which affect carer search strategies".

4.6.5 Concurrence with earlier findings

The general order of the decision making process is similar to earlier findings in the previous study; enlisting the help of a friend or colleague was one of the first decisions in the incident, followed by searching nearby on foot before getting in the car, and finally, calling the police. The exception to this is where the decision to "call mobile phone" was made. Perhaps, this is a consequence of presenting participant's with the suggestion to "call mobile phone", rather than thinking about this action themselves.

The results generally support the findings from the initial interview study, suggesting that an interactive vignette approach can build upon and further quantify work from critical decision method interviews. An online approach is also considerably less time consuming for the researcher, therefore substantially more participants can be recruited in a relatively small amount of time. Using a more quantitative method also allows the researcher to correlate variables in a way that is not available in more qualitative research. An examination of background factors (levels of mobility and independence age and gender of carer and care recipient) also becomes available to the researcher and the extent to which these influence the decisions can be thoroughly investigated.

4.6.6 Discussion of Method

This approach to experimental vignette design has a wide variety of applications within Human Factors research and would be particularly useful in situations where direct observation is difficult or impossible, such as in emergency or time critical situations. Vignettes are often used in order to gauge opinions about controversial topics, by allowing the participant to distance themselves from their own judgments, in this case however, the vignette is created to be more personal, rather than less, in an effort to elicit more realistic and specific responses from the respondent. This inverts the usual logic of the purpose of vignettes, yet maintains and builds upon its strengths. Opinions and attitudes are able to be expressed within the context of a hypothetical incident. This method allows participants to "fill in" the missing information and thus overcomes the criticism by Chapman and Milham (2006) who suggest that when fictional personas become more specific they become less generalizable. In this case, the scenario is fictional, but the no fictional personas are used and

the specificity of the actors is provided by the participant themselves. This approach also overcomes Finch's criticism of vignettes (Finch, 1987), that asking what someone else would do is categorically different to asking them what they think they themselves would do.

This particular approach to vignettes also combined qualitative and quantitative methods. The qualitative results have been analysed and discussed within this chapter, but other, richer data was also provided by participants and will be discussed further in chapter 7. This method allowed participants not only to discuss *what* actions they would take in a given scenario, but *why* those actions would be taken.

The scenarios used in the study and decisions available to participants were heavily informed by the CDM interviews discussed in Chapter 3 and decision points were taken directly from descriptions in previous incidents. The previous interview studies facilitated the creation of a taxonomy of actions that allowed the understanding of decision-making within missing person searches to be better constrained and understood. Analysis also revealed the relative ordering of decisions for the group as a whole, and examined differences between groups.

4.6.7 Limitations of the Approach

An obvious criticism of the approach is its low ecological validity. A text based simulation is unlikely to induce the same feelings of worry and anxiousness that people conducting missing person searches for vulnerable people experience. People experiencing a highly stressful situation may be prone to make poorer decisions (Wemm & Wulfert, 2017).

The immediate context surrounding the missing incident was not discussed, as doing so would considerably reduce the generalisability of the scenarios. Participants were told that they had just completed a certain household task and discovered the person they care for is absent. Other antecedent factors which were shown to be considerations in the critical decision method interviews (such as recent mood and past behaviours) were omitted as additional specificity may mean that the scenario would become less applicable.

Presenting people with a series of fixed choices may influence their responses in a way that asking open questions would not. The participant is presented with a series of selection tasks, rather than asked to report on what exactly they think they would do. The clear limitation is that it does not allow participants to deviate in any way from the choices available to them[3]. But there is an addition problem; it might be the case that people are not always able to produce an exhaustive list of sensible actions to take during a missing incident. They may, for example, forget that the care recipient has a mobile phone, they may not have considered 'getting in the car', until it was suggested to them. This distinction is broadly analogous to the recognition/recall distinction within memory (Du Plessis, 1994). Talk-through and other similar approaches (Lawson, 2011) do not suffer from these limitations.

4.7 CHAPTER SUMMARY

This chapter presented a vignette study into the decision-making of care givers during missing incidents. The data from the study was used to inform a predictive model of care giver behaviour, and to identify the influence of antecedent factors which influence search strategy. The decision to enlist the help of another person was made often, and usually prioritised in the incidents. This suggests that missing incidents typically involve multiple people, even prior to police involvement. The next chapter will build upon this understanding and explore currently available technologies which may assist with Missing Incidents and discuss user-group perceptions of these technologies.

[3] In the study described, participants could use an open response field to type in what they would do instead, but the scenario only unfolded based upon the fixed choices.

5 THE DESIGN OF ASSISTIVE TECHNOLOGIES

5.1 CHAPTER OVERVIEW

This chapter will survey currently available technologies designed to help with missing incidents and discuss public attitudes towards them. It will also incorporate unseen data from the previous studies in order to inform the development of a prototype technology that is intended to support carers during missing incidents. By taking a user-centred approach to the design of assistive technologies which considers the needs of the target user-group and currently available technological interventions, a design concept will be suggested and developed into a prototype.

5.2 INTRODUCTION

This chapter will use hitherto undiscussed results from the previous studies, in conjunction with a summary of currently available technologies in order to assess the requirements and user expectations of assistive technologies designed to help with missing incidents. Previous chapters have focused on behaviour, decision-making and emotional attitudes towards missing incidents; this chapter will discuss the findings within the context of technology development. Systematic evaluations of missing incident assistive technologies are rare, one such evaluation of note is the Cochrane report on Non-Pharmacological Measures to Prevent Wandering in Dementia, (Robinson et al., 2006). However, the Cochrane report focuses solely on dementia and may not be applicable to other at-risk groups. Additionally, in the time since the report was published, location-based technology services have become far more ubiquitous, and technological literacy has increased, particularly amongst the elderly (Anderson & Perrin, 2017). This chapter will describe the types of technology currently available, attitudes towards those technologies and specific concerns of those conducting missing person searches. In doing so, this chapter will meet two objectives of the thesis; Objective 5 **"Elicit the general attitudes held by carers about the use and appropriateness of assistive technologies to assist with missing person search"** and Objective 6, **"Survey currently available**

technologies designed to help with carers and guardians manage missing incidents".

5.3 BACKGROUND

The design of appropriate technologies for assisting with decision-making in complex, time-critical environments is a non-trivial task. Don Norman describes the task of designing for assistance with complex tasks such as these "Cognitive Engineering", "neither Cognitive Psychology, nor Cognitive Science, nor Human Factors" (Donald A Norman & Draper, 1986, p. 32). Despite this, there are many concepts and methodologies of Cognitive Psychology and Human factors which can be applied. For example, it has long been established that the amount of information that can reasonably be stored in short-term memory is around seven (Miller, 1956), this knowledge should be used to inform the development of complex systems so that a user is never expected to memorise a series of items that would exceed their capacity. Cognitive engineering, such as, the design of assistive technologies designed to assist with or prevent missing incidents should take into account the specific abilities, limitations and preferences of users.

Some suggestions proposed by Donald A Norman and Draper (1986) on the subject of cognitive design include; starting with the needs of the user, letting the requirements for interaction drive the design of the interface, and in turn the design of the interface drive the technology. This encourages the design of technology to be driven by genuine user-needs, to meet specified requirements, rather than expecting users' behaviour to change to meet the requirements of technology. This chapter will investigate the experiences of those conducting missing person searches and the currently available technologies, it will also investigate attitudes towards those technologies, before finally discussing their strengths and shortcomings. In so doing, a user-centred design process will inform the design and implementation of a technological device intended to help carers and guardians during these incidents, this design of this technology will be discussed in chapter 6.

5.4 SURVEY OF EXISTING TECHNOLOGIES

Whilst there exist technologies designed to help with, manage and mitigate missing incidents the majority of this technology is focused upon people living with dementia, who represent a group particularly at risk. In addition, technologies designed to help manage these behaviours are largely targeted at care homes, who may have multiple residents with difficult to manage behaviours, and the budget to install some of the more comprehensive systems.

It has been over ten years since a full-systematic review of non-pharmacological methods to prevent wandering behaviours was conducted by Cochrane (Robinson et al., 2006). In that time, portable location-based technology has become ubiquitous for much of the population. However, comprehensive comparisons for interventions designed to manage or mitigate these difficult to manage behaviours in a real-world context have not been forthcoming. In the absence of randomised controlled trials which seek to compare outcomes between various interventions, it is impossible to know with any certainty which interventions are likely to be effective.

Whilst such a trial is far beyond the scope of this thesis, it remains an open research question. In lieu of such evidence, the following tables summarise currently available technologies, their intended usage and any associated costs. The following tables were produced by a review of currently available commercial technologies for consumers, and was conducted by a simple web search. Alzheimer's.org provides a list of available technologies designed for mitigating missing incidents and this served as a starting point ("What assistive technology is available?,"). The following tables are by no means a comprehensive list of all available technologies, but do give an indication of which technologies are currently readily available to consumers.

Table 5.1 Categories of Assistive Technology

Type	Description	Examples
Home Modification Systems	Modifications made to the person's place of residence. These usually generate an alert which can be sent over the internet via wifi.	CCTV, Pressure Pads, Motion Sensors, Door Alarm, Window Alarm.
Purpose-built Wearable devices. (Local / Tagging)	Wearable devices, usually containing an RFID chip combined with RFID readers on doors that send notifications when a signal is received. These can generate an alert to be sent over the internet via wifi.	DoorWatcher Wristband Monitoring System, Harland Simon's Wandering Patient Safety System,
Purpose-built Wearable devices (Global / Tracking)	Wearable devices, with location technology and a mobile phone or internet connection, specifically designed for monitoring people who may be prone to becoming lost. Often these contain alert systems or fall detectors.	Philips GoSafe, Proximity Quick Wandering Alert,
Purpose-built mobile phone applications.	Mobile phone applications specifically designed to find family members who are missing. Often these may have additional features, such as a "help" button.	Tell My Geo, Comfort Zone Check-in Mobile, GPS Tracker, GPS Tracking.
Appropriated Mobile phone applications.	Common mobile phone applications designed for other purposes, such as locating phones. These require that the person keep a charged mobile phone on them at all times and have an active internet connection and GPS Signal.	FindMyIphone (apple), Find My Device (google), Manufacturer apps (e.g. Samsung, find my phone).

Table 5.2 Evaluation of Assistive Technologies

	Home Modification Systems.	**Purpose-built wearable devices (local / tagging)**	**Purpose-built wearable devices (global / tracking)**	**Purpose-built mobile phone applications.**	**Appropriated Mobile Phone applications.**
Remote Alarm.	May or may not connect to local wifi / phone line.	May or may not connect to local wifi / phone line.	Can notify over the internet.	Can notify over the internet.	Location can be accessed anywhere, does not generate alarm.
Global Positioning.	Can only notify that a person has left the building.	Can only notify is person is in specific location or not.	Can locate provided GPS signal is found and internet available.	Can locate provided GPS signal is found and internet available.	Can locate provided GPS signal is found and internet available.
Standalone solution.	Does not require additional equipment.	Does not require additional equipment.	May require additional equipment, or internet service.	Requires mobile phone with internet.	Requires mobile phone with internet.
Upfront Costs	Often high upfront costs for full system.	Often high upfront costs.	Moderate upfront costs.	No / Low upfront costs.	No upfront costs.
Ongoing subscription.	Do not usually require subscription.	Do not usually require subscription.	Often requires subscription.	Some services require subscription.	Does not usually require subscription.
Requires internet.	May or may not connect to local wifi / phone line.	May or may not connect to local wifi / phone line.	Requires internet connection.	Requires internet connection.	Requires internet connection.

Requires regular charging.	Usually powered via direct home supply.	Usually RFID, which does not require charging.	Requires regular charging.	Requires regular charging of mobile phone.	Requires regular charging of mobile phone.
Ease of use.	Once set up, easy to use.	Once set up, easy to use.	Purpose built and usually very easy to use.	Requires person is smartphone user.	Requires person is smartphone user.
Provides additional functions.	May contain additional sensors for movement and fall detection.	May contain alert buttons, fall detection.	May contain alert buttons, fall detection.	Can contain alert buttons and provide assistance if lost.	Provides location and phone details, but nothing specific.
Permits relative freedom of movement.	Does not permit person to leave designated place.	Does not permit person to leave designated place.	Permits "geo-fencing", meaning large areas can be defined.	Permits "geo-fencing", meaning large areas can be defined.	No restrictions on freedom.
Resilient to type 1 error.	May generate alarm if window or door opens, or visitors arrive.	Will only generate alarm if device leaves specified area.	Will only generate alarm if device leaves area.	Will only generate alarm if device leaves area.	Will locate device.
Resilient to type 2 error.	Will generate appropriate alarm if door or window opens.	Person may not be carrying device.	Person may not be carrying charged device.	Person may not be carrying charged device.	Person may not be carrying charged device.
Setting	Typically used in carehomes.	Typically used in carehomes.	Used by residents living at home.	Used by residents living at home.	Used by residents living at home.

Table 5.2 Evaluation of Assistive Technologies (page 147) compares the various categorisations of technological interventions a series of price, robustness and usability considerations.

Home modification systems are often reasonably robust, and resilient to type 2 errors (false positives) and do not require the person with care and support needs to modify their behaviour or learn to use a new piece of technology or service. However, installation costs are typically much higher than alternative methods and the device is solution requires that the person with care and support needs remain confined indoors. As such, these alterations are typically only appropriate for those with mid-late stage dementia, and far less applicable to other groups. Wearable RFID devices connected to alert systems have much of the same strengths and weaknesses of other home modification systems, but the addition of an RFID bracelet means that doors and windows can be opened by others without triggering an alarm system. This means that these systems are much more resilient to type 1 errors (false negatives), but due to their dependence on the person of interest wearing a particular bracelet or other device, less resilient to type two errors, as the person may be able to simply take the device off. RFID-based and other home modification systems are typically robust, though they are not suitable for those wishing to maintain independence.

Purpose-built wearable devices improve upon the aforementioned systems, as they are also able to help locate a person, rather than merely indicate if a person has left a designated area. Typically, wearable devices such as these take the form of pendants, badges and custom built insoles. Upfront costs are typically lower than home modification and RFID systems, but often these services require an ongoing subscription. In addition, positioning approaches such as these require not only in-built GNSS receivers, but also depend upon a working internet connection. These services necessitate the use of a battery, which will require regular charging. This may in turn reduce the appropriateness of such systems for people who may be less familiar or comfortable with wearable devices. Additionally, some of these systems also require that the person in question carry the device with them at all times, which again, may be particularly difficult for a person with memory deficiencies. However, purpose-built wearable devices do often include functions which are particularly

appropriate for people living with dementia such as an alert button, fall detection and tele-health services. These products are most appropriate for individuals with sufficient cognisance wishing to maintain their independence, but may not be appropriate for those in institutional care or in the later stages of dementia.

Purpose-built mobile phone applications often contain much of the functionality of the wearable devices but usually have a much lower (or no) subscription or upfront costs. Like the wearable devices, they require an internet connection and GNSS receivers to function as desired, but provided that the person of interest already has a smart phone, they require no additional equipment. Less equipment also means that compliance is likely to be higher as the person of interest does not have to remember additional procedures for leaving the house. Applications such as these do often have some additional functionality for particular groups, such as children or people living with dementia; but they do not typically contain fall detection or telehealth services. The technological skills required for smartphone use may be difficult to acquire as people get older and particularly difficult for those with dementia and young children (Malinowsky, Almkvist, Kottorp, & Nygård, 2010), due to this fact these technological solutions will only be appropriate for those who can already use smartphones.

Similarly, appropriated applications can only be used as tracking devices if the persons at risk are themselves smartphone users. Appropriated applications typically have no upfront costs (aside from any mobile phone carrier fees), but they do not provide any specific functionality designed to help people with dementia. In addition, these appropriated applications are likely to be open to intrusions of privacy of personal autonomy as family members and care-givers can easily access the person's location without their knowledge. Whilst these applications may be used by carers in certain situations, it is clear that they are not optimal and should certainly not be the first choice for concerned carers.

The vast majority of currently available technologies designed to mitigate the risks of missing incidents focus on either location surveillance methods, or potentially restrictive alarm systems, but to the author's knowledge no

technology is designed to assist in conducting, planning or decision-making processes of missing person incidents, such technologies may be used to support and facilitate more appropriate courses of action and could be used in cases where intrusive measures are deemed inappropriate.

5.5 Perceptions and Attitudes

5.5.1 Perceptions of Missing Incidents

In addition to being logistically difficult to organise a timely and effective response, missing incidents also invoke numerous emotional stressors on those involved. As discussed in Chapter 3; carers and guardians often feel anxious and uncertain about their own decision-making abilities as well as concerned about the health and well-being of the missing person. These stressors may affect decision-making during missing incidents, as well as influence people's expectations of and preferences for various assistive technologies. Adopting a user-centred approach means considering the experiences of people engaged in the task of interest. The following section examines qualitative data elicited from study 2 in order to illustrate relevant concerns and expectations for the purposes of developing guidelines for appropriate interventions.

In addition to the choices participants in study 2 were presented with, they were also asked what could have happened to the person they care for. This question was given open responses so that participants could mention specific details of what may have happened to the person they care for. Full details of the questions asked to participants can be found in the final section of Appendix C. A thematic analysis was performed on the responses to convert them into categories, and a count of each category response is given in Figure 5.1 Participant Hypotheses on Whereabouts.

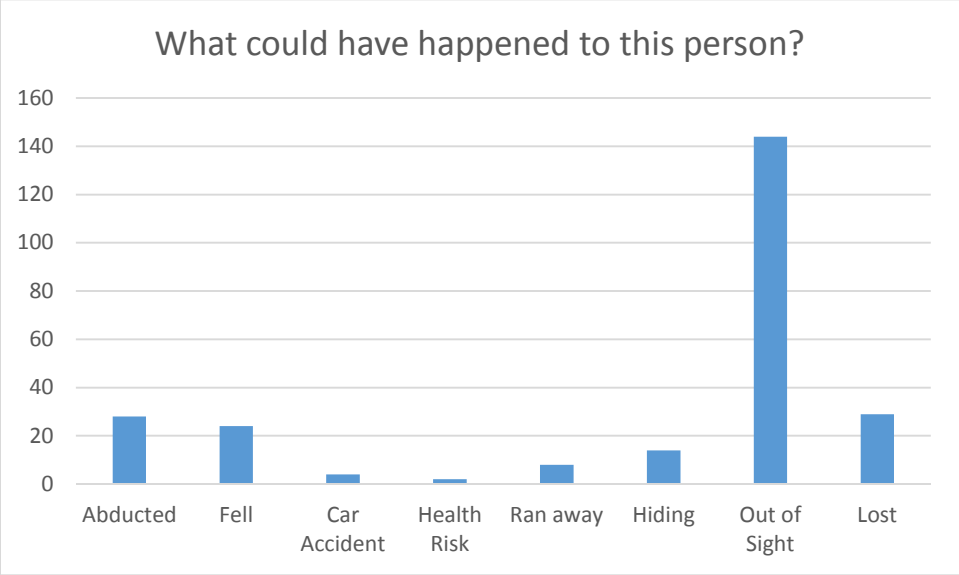


Figure 5.1 Participant Hypotheses on Whereabouts

Figure 5.1 illustrates where participants thought their care recipient was likely to be immediately following a noticed absence. These figures are the result of codified responses, the "out of sight" category, represents participants who indicated the person they care for knew where they were but had perhaps left without notifying their care givers. This category was by far the largest and indicates that most people do not immediately assume the worst in Missing situations. Often, responses in the "out of sight" category involved failing to notify the primary caregiver of plans to visit friends or other family members, or simply wandering outside.

During the vignette, participants were also asked which type of risk the missing person was most likely to encounter. An overwhelming majority of participants thought that physical injury (such as a fall or an accident) was the biggest risk to the person under consideration (Table 5.3).

Table 5.3 Perceived Risk

Risk	Total	Percentage
Physical	183	67.3
Health	53	19.5
Psychological	36	13.2

As discussed in Chapter 3, the decision to contact the police following a noticed absence is one which can cause considerable distress and anxiety to caregivers. The interview study conducted with carers highlighted various concerns and internal dilemmas which carers faced when making this decision, however, the small sample size in the interview may not have been entirely exhaustive. Subsequently, the vignette study discussed in chapter 4 also asked participants various questions about how they would feel about contacting the police in such circumstances as one of the scenarios. Figure 5.2 shows the responses of 272 participants when asked "Do you feel better or worse after contacting the police?"

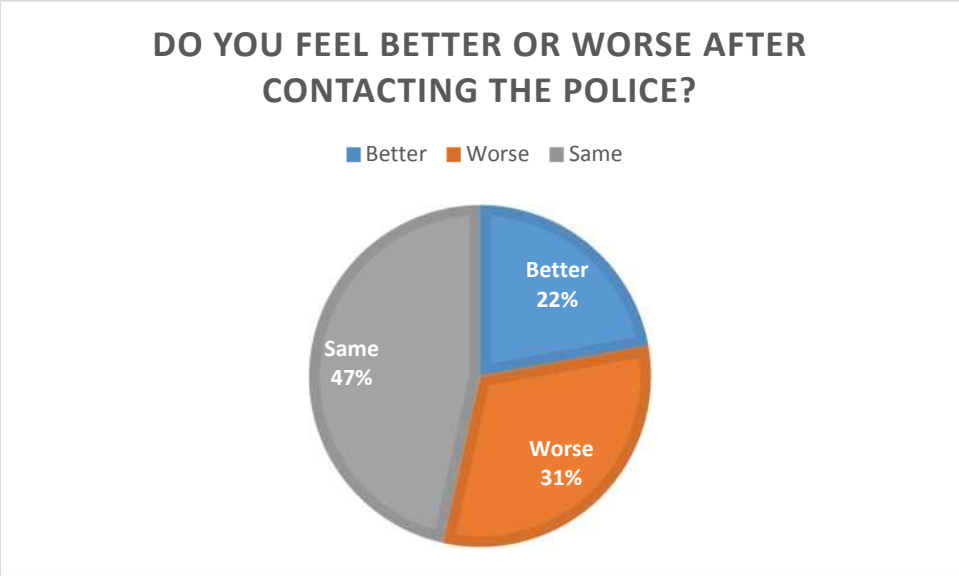


Figure 5.2 Attitudes towards Police Response

Data taken from study 2 (N=272)

As shown in Figure 5.2, nearly half of respondents stated that they would not feel any better or any worse after contacting the police and nearly a third of participants reported that they would feel worse. The respondents were then asked why they had this particular attitude and asked to complete an open-text response. As before, these responses were then codify using thematic analysis, three iterations of coding produced responses which were exhaustive (they covered the dataset) and exclusive (there was little overlap between thematic categories). Table 5.4 shows the results of such analysis, cross-referenced with the responses given about attitudes towards the police response.

Table 5.4 Reasons for Attitudes towards Police Response

	Better	The Same	Worse
Still at risk	1	68	13
More resources	27	3	0
Assurance	7	0	0
Not take concern seriously	0	5	3
Do everything in their power	7	2	0
Too much time	0	13	17
Might be ineffective	0	12	4
Becomes "real"	1	3	27
Best / Only course of action	6	0	5
My responsibility	1	3	6
Out of character	0	1	2
Might be overreacting	0	1	6
Don’t Trust Police	0	3	4

The most commonly stated reason for the attitudes towards the police response was that the missing person may still be at risk and that the situation has not changed significantly since police contact. This reason accounted for the vast majority of participants who reported feeling the same after police contact. The second most commonly stated reason for the attitudes to police involvement was that the situation “becomes real”, one participant stated “As [I’ve] phoned the police and they are showing concern this confirms my fears are not irrational.” [P32] and another claimed it “Reinforces the severity of the situation” [P34]. This is very much in concurrence with the remarks made by two of the carers in the interview studies, with one claiming that calling the police “Made it real” [P3]. The main reason that people reported feeling better after contacting the police was because the police have more resources available to them, and they are considered to be better trained, more experienced and better equipped to deal with the situation. Contrastingly, the main reason people

reported feeling worse after contacting the police was because they felt that they were wasting time whilst on the phone to the police instead of engaged in actively looking for the missing person. In addition, some of the care givers also resented the fact that they would probably be advised to remain at the missing person's place of residence. A consideration of these responses may help to shed light on why carers of vulnerable and at risk people often delay contacting the police in a timely manner.

In conclusion, the data indicates that carers do not immediately assume the worst following a noticed absence but instead assume more likely explanations for the disappearance. Concerns of physical injury (for example either via a fall or road accident) feature prominently as the biggest perceived risks and the decision to call the police is often met with ambivalence. Participants in the study were reluctant to call the police as they saw it as a confirmation of their fears.

5.5.2 Expert Attitudes towards Assistive Technologies

During the initial series of interviews in Study 1, search and rescue experts mentioned several technologies that are employed by Mountain and Lowland Rescue teams in the UK designed to help with search tasks. Specifically, two interviewees referred to "SARLOC", a mobile phone application developed by Russ Hore of Ogwen Valley Mountain Rescue Team. If a walker becomes lost and requires assistance, he or she is sent a text message from the responding mountain rescue team, which provides a link to a webpage. Upon opening the webpage, the missing person's location is obtained from the GNSS receivers in the phone and this information is sent over the internet to the respective Mountain Rescue Team's database. This application has the potential to find missing people who are seeking assistance, providing that they have a mobile phone with GNSS capabilities. However, search and rescue teams were quick to point out that whilst this software can be an excellent tool, the success of the app should in no way encourage overreliance of the smartphone to be used as the sole navigation tool.

A more comprehensive technological solution to search planning and management was also mentioned by one of the incident commanders during the

interviews. SARMAN^{TM} is an incident management system designed for search and rescue teams to enable them to better co-ordinate and plan searches . It allows for the live communication and tracking of multiple teams, topological maps and routing and tracking features. In addition, it provides automated drawing of concentric search areas based upon statistics from similar incidents. Whilst the package was viewed favourably by the interviewees who mentioned it, an incident commander stated that he did not feel confident in using the software on his own because he lacked the technological expertise. Whilst such technologies might not be entirely appropriate for use by non-professionals, several of the features provided by SARMAN^{TM} may be of use for those wishing to develop assistive technologies to help with missing persons for non-

5.5.3 Carer Attitudes towards Assistive Technologies

At the end of the scenario in Study 2, participants were asked to choose which of the following technologies may be have been helpful during a missing incident, Figure 5.3 shows the responses of participants.

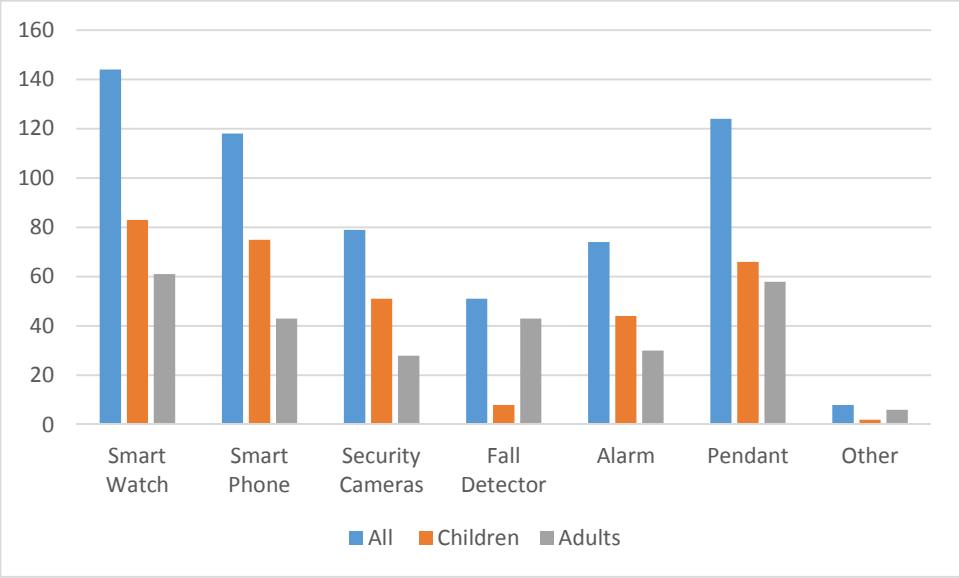


Figure 5.3 Assistive Technology Preferences

Figure 6.2 shows the preferences of assistive technologies given by participants in study two. Participants were allowed to give multiple answers to the question "Which of the following technologies do you think would be helpful in this situation? [Choose as many as you think would be appropriate]". The smart watch was the most preferred device for both the carers of adults and the carers of children. Whilst the pendant was the second most preferred device for adults, the smart phone was the second most preferred device for children. Participants were then asked to comment on their choices, in an open text box. The following categories of responses were given:

Would comply/enjoy wearing

This reason was often given for the smart watch and mobile phone, whereas specialist technologies (such as pendants, for example) would be less preferred by the person required to wear them.

Serves other functions

Smart watches and smart phones were often chosen because they serve additional functions aside from tracking and location services. That is, they are of some usefulness to the person who might wear them, aside from their assistive aspects.

Allows independence

Carers and guardians often mentioned that they would feel safer and permit their carer recipients more freedom if they were able to monitor that person's whereabouts remotely.

Allows for accurate tracking

The tracking feature was considered a very important feature by many respondents who answered the question. Whilst intensive monitoring and surveillance can sometimes be ethically and legally dubious; many participants in this survey did comment about their desire for accurate location tracking.

Couldn't take it off

Some respondents to the survey were concerned that mobile phones and smart watches may be removed if the person in question did not want to be found,

or they may be removed by a potential abductor. They were concerned that wearable tracking devices may be of little use in a kidnapping or abscondment scenario. However, overly restrictive monitoring measures are not ethically unproblematic, as will be discussed later.

Other options intrusive

Some participants felt that specialist technological tracking devices would be too intrusive, but that devices such as mobile phones, which are already commonly used are not considered as intrusive, despite also having tracking functionality.

Would allow me to contact missing person

Many participants chose the mobile phone as it also allows the missing person to be contacted by their carers and guardians should they become missing or in danger.

Provides alert

Some participants suggested that their choices were based upon the fact that the specific technology they preferred allowed for sending alerts, so that they could be notified quickly if an incident requiring their attention occurred.

These responses indicate that carers and guardians often consider many separate, often contradictory reasons for technology preference, though care recipient compliance was often a major consideration in their choices. Rates of compliance are likely to be affected by the perceived functionality of the technological device by those who are intended to wear it. Increasing the usefulness of the device to the intended wearer is likely to increase their use.

5.6 Limitations of Existing Technologies

Currently, there exist various technological interventions designed to prevent, mitigate or manage missing incidents in those with care and support needs, though in the absence of systematic comparisons of real-world outcomes, drawing firm conclusions about the usefulness of any given technology over another is impossible. Further, direct comparisons of these technologies may not ultimately be desirable, as these interventions are designed to be used by very different end-user groups (see table 5.2), in a multitude of different environments and care contexts. Additionally, varying levels of capacity,

independence and risk suggest that any single technological intervention is unlikely to be a panacea; applicable and appropriate for all persons at risk. But instead, carers must consider the appropriateness of each technology based upon their own circumstances, the level of risk, the likelihood of compliance and any up front or on-going costs associated with that technology. No one particular technological artefact or system is capable of providing a complete solution to the problem of missing incidents, but rather, individuals should develop a strategy based on their own circumstances which make use of currently available technologies and take in to account both the risks and benefits associated with the use of those technologies.

In the studies presented so far, several key points have emerged which may be of benefit to those wishing to develop technological interventions designed to help with missing incidents.

1. Privacy, autonomy and usability are legitimate concerns of carers and family members and these concerns often outweigh any possible benefit of current assistive technologies.
2. Technological solutions which require a person at risk to wear a device need to provide the wearer with a function, and also need to overcome various usability and compliance issues.
3. Missing Incidents typically involve more than one person conducting a search task.
4. There exists a variety of technologies to help with missing incidents, but these typically involve location tracking, monitoring or surveillance.

Technology developers must take into account the reasons for technology preferences and develop a user-driven approach to design. Data elicited from study 2 suggests that safety, independence and additional functionality are all considerations of carers when deciding which (if any) assistive technology would be appropriate for their needs and the needs of those they care for. Whilst tracking and alert features are considered beneficial, privacy and independence are also factors considered by carers and developers must take steps to ensure that technology does not further reduce the independence of people with care and support needs. Additionally, devices such as mobile phones and smart

watches, which provide other non-stigmatising functionality were the most preferred devices. This suggests that providing some additional functionality for the wearer may reduce the stigma associated with these assistive technologies and increase compliance.

All of the technological interventions discussed in this chapter involve monitoring and surveillance technologies, which are in many cases, overly intrusive and have the potential to restrict the freedom and autonomy of the people they are designed to help. Furthermore, such measures may be in breach of the Mental Capacity Act of 2005 which stipulates that overly restrictive or intrusive measures (including tracking devices and other surveillance technologies) may be used but only if it can be shown that they are in a person's best interests. In addition, all of the currently available technology is aimed at monitoring the caree in some form or another, yet no technology is intended to facilitate search planning or to provide decision-making support. Planning and support technologies could be used in conjunction with location and monitoring services to better coordinate and manage missing incidents. Alternatively, planning and decision-making support technologies may be used in cases where high surveillance and restrictions are deemed disproportionate to the risks.

It therefore seems reasonable to suggest a different type of technological intervention than what is currently available, which does not depend upon surveillance or the restriction of movement, but instead facilitates the communication and coordination of small teams of responders. Such a technology might be applicable to use for individuals where location tracking or other monitoring techniques are deemed too intrusive, or where location technology is unable to provide an accurate position (through non-compliance, forgetfulness or technological error).

5.7 Requirements of a New Technology

As discussed above, many of the existing technologies depend upon tracking and monitoring technologies which may not necessarily be acceptable to or appropriate for all people. Additionally; compliance, battery life and forgetfulness might be limiting factors in the usefulness of these solutions. According to data collected in the previous studies, communication is a crucial

element of all search and rescue activity. This was evidenced by Figure 3.3 Decision Sequence Timeline of Carers and Figure 4.2 Markov Model of Searcher Behaviour, which both indicate that a significant amount of those engaged in missing person searches enlist help, and most of those who do so enlist help very early on in the incident. Additionally, search and rescue experts expressed concern that information about the missing person may be inaccurate due to potential sources of communication failure. The initial critical decision, of Search and Rescue experts, "Decided if Callout is valid" (see Appendix B.2) is made based on a consideration of the quality of information being received from the police, likewise the excerpts discussed in the Global Theme "Communications with the Police" (see Appendix B.1), also indicate the value of accurate information to all search and rescue activities. For this reason, a digital technology which facilitates better communication at the early stages of missing person incidents may improve outcomes for missing people and reduce the stress and emotional burden placed on carers and guardians.

Location and Geo-spatial information are of paramount importance in Search and Rescue operations, and professional search and rescue teams rely highly on map use in order to maintain high situation awareness of the overall search plan. Furthermore, during missing person searches conducted by professional search and rescue organisations, each individual team has access to a radio in order to communicate with the Incident Commander and other members conducting the search.

Additionally, it must be shown that such a technology does indeed lead to better communication, more overall knowledge of the incident, and ultimately, better search outcomes. For this reason, the technology must be designed to allow experimental field trials, without endangering the lives of people who are already at risk. One such method which would allow for experimental testing is the use of surrogate search targets in a naturally occurring environment. The application must be able to detect when participant's find these targets in order to determine the performance of teams. Finally, under experimental conditions, participants must be given a standardised period of time in which to conduct the search activities so as to make search activities comparable across all trials, for this reason, a timer function should be implemented and controllable by the

experimenter. The experimenter must also have the ability to change the available features for the purposes of experimentation and comparison. Finally, the experimenter must be able to have an overall view of the search activity during the experiment for the purposes of safety.

5.7.1 Functional Requirements of a New Technology

In light of these requirements and considerations, a series of functional requirements are explicitly stated below. The requirements A-E represent features a future technology may adopt, whereas the requirements F-K are necessary components for testing and evaluating the effectiveness of the software.

Requirements for Application

A. Display Map of current location.
B. Display geo-spatial information of individuals and teams current locations.
C. Display geo-spatial information of individual's and teams' location history.
D. Give users the ability to refer to geo-spatial locations.
E. Facilitate audio communication.

Requirements for Testing

F. Facilitate the recording of surrogate search targets.
G. Store data of surrogate search targets for later analysis.
H. Record participants location histories for later analysis.
I. Produce an "admin" mode in which displays information and facilitates actions not available to users (such as the location of search targets and starting a timer).
J. Produce a "timer" for the purposes of testing and experimentation, controllable by the admin.
K. Enable the admin to control various features of the application for different experimental conditions.

5.8 THE DESIGN OF A NEW TECHNOLOGY

Based upon this understanding, a design concept was proposed which would allow small teams of first responders to coordinate a search task, through shared visual and audio communication channels (Figure 5.4).

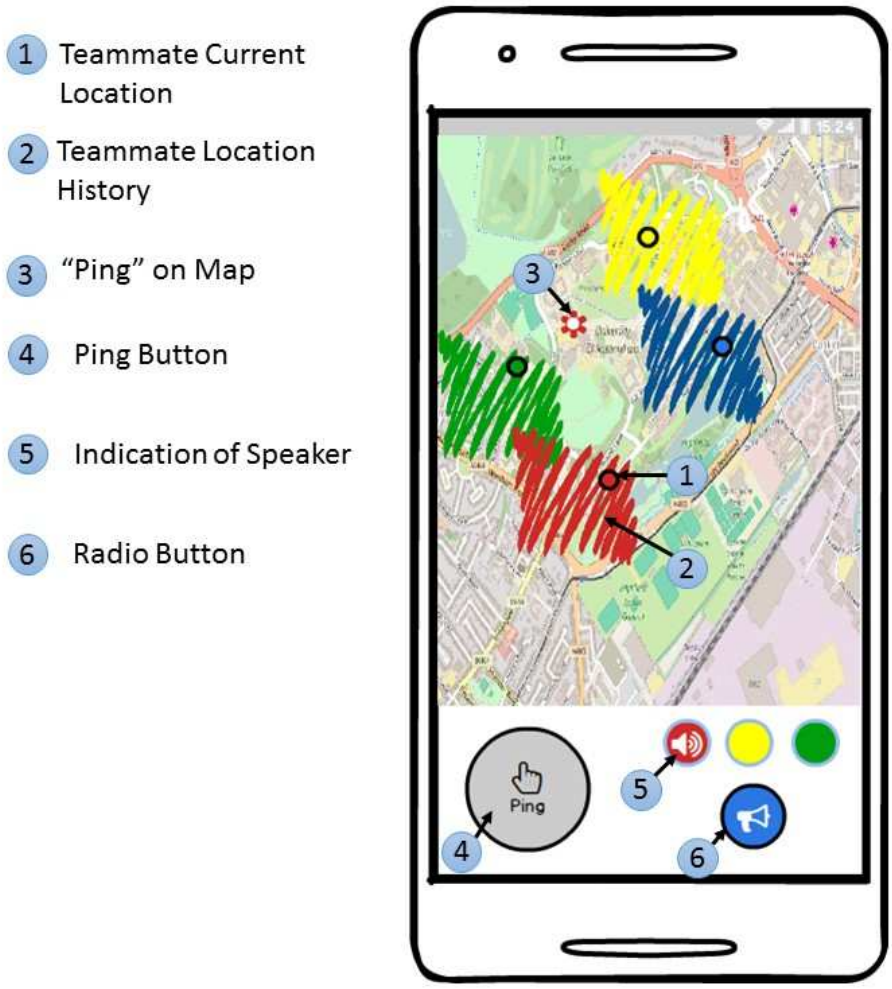


Figure 5.4 Design of Technological Intervention

The system, as proposed involved various visual information displays, including a map of the current area, the location of each teammate, and a 'trail' of where each participant's location history. In addition a "ping" feature, allowed participants to draw their teammates' attention to specific locations.

1) A small colour-coded marker indicates the real-time locations of teammates (requirement A and requirement B).

2) A colour-coded “trial” indicates the location histories of teammates (requirement C).
3) A “ping” feature, is used by teammates to highlight specific areas on the map of interest (requirement D).
4) The “ping” button acts as a toggle which allows participants to point to an area of interest on the map (requirement D).
5) The speaker indicates which teammate is currently talking (requirement E).
6) The button allows for open audio communication talking (requirement E).

5.9 APPLICATION DEVELOPMENT

An Android application was developed for based on this design, which was developed in such a way to test the effect of various system features and allowed for an experiment using this technology to be monitored with reasonable accuracy. The application recorded participants’ movements on the search task and also recorded when a “search target” with an NFC tag had been scanned. NFC tags were used for the purposes of an experimental trial in order to record when participants had found a designated “search target”. The design of the application went through numerous iterations, before being developed in conjunction with Philips Research, in March 2017.

5.9.1 Information flow

It should be noted however, that due to time constraints, technical limitations and cost, inbuilt audio communications features were not able to be developed (requirement E). One design concept described in Figure 5.5, illustrates an alternative to inbuilt audio features which instead utilised a conference calling system. However, this concept also proved impractical, and the audio communication was provided (separately) by a Skype conference call. All other information flow for the final Application remained the same as described in Figure 5.5.

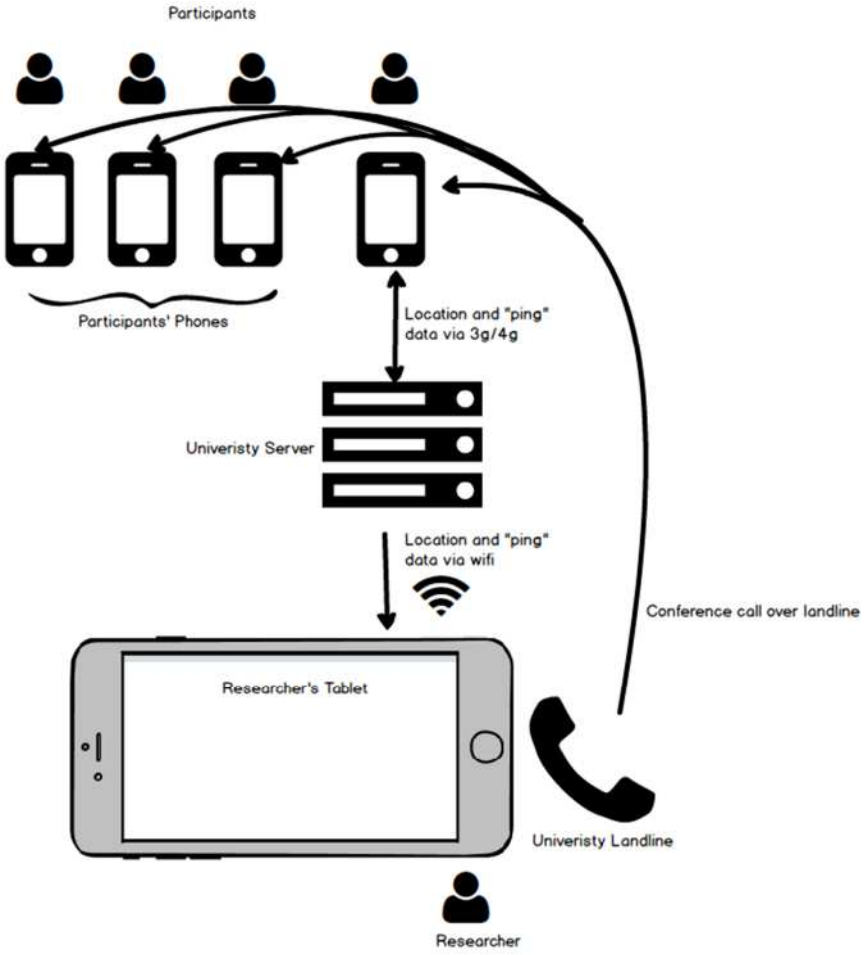


Figure 5.5 Information flow of Software System

Figure 5.5 also shows communication with a server. This was done via JSON requests by each instance of the application running. Data was transferred between phones and the server in order to show the location of current team mates (requirement B and to keep a history of locations requirement C). It also allowed data about each of the trials to be stored on the server, and thus satisfied requirement G and requirement H.

5.9.2 User Position

Using GoogleMap's API, an interface was created which allowed participants to see their own location and the location of their teammates using "markers". These markers were designed in GIMP and show the current location of all team members. Users are assigned both a number and a colour in order to differentiate themselves from other users. In addition the colour of the number is black to indicate another user, and white to indicate the user's marker (Figure 5.6). The

provision of a Map using GoogleMap's API satisfies requirement A, whilst the presentation of current teammates locations satisfies requirement B.

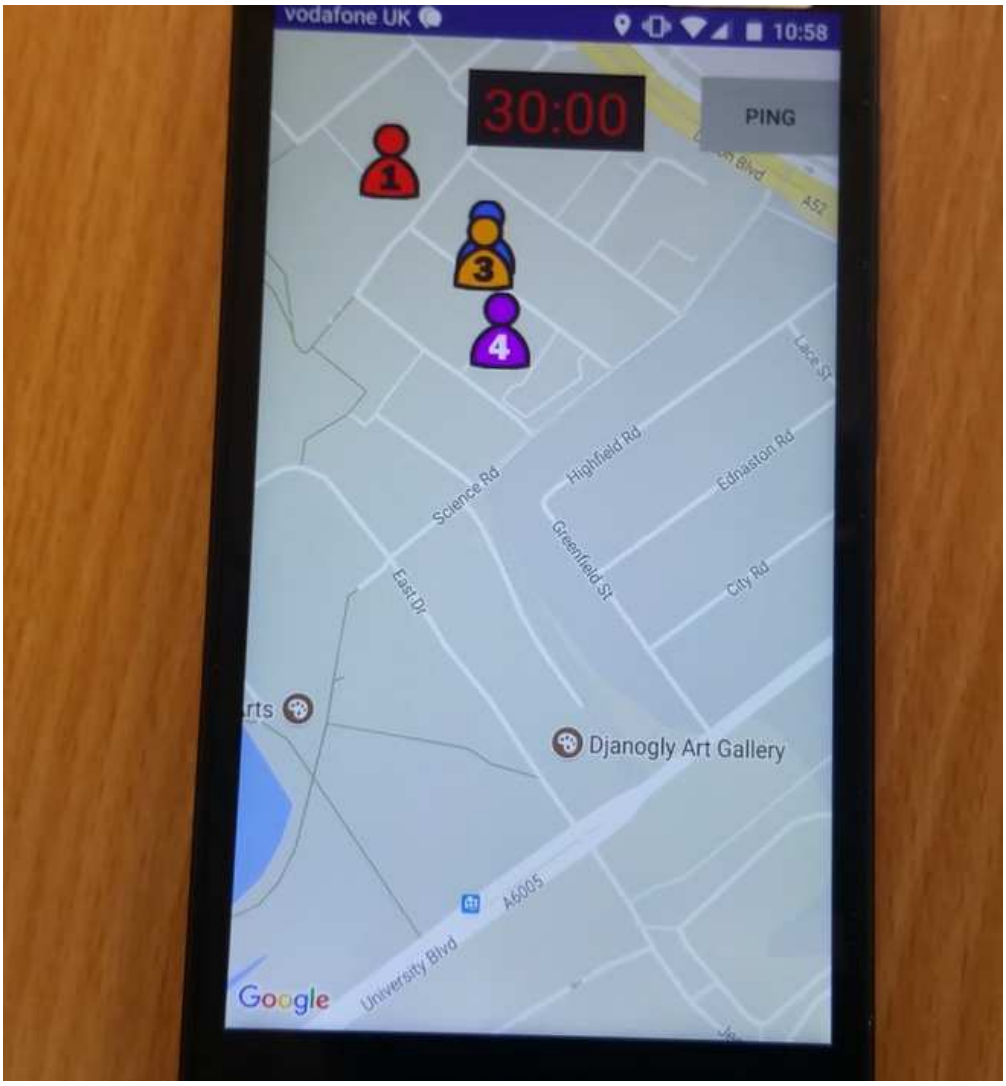


Figure 5.6 Interface Showing Multiple Teammates

5.9.3 Location Histories

In addition to users' current location, it was decided that a "trail" would be appropriate for visually representing a person's location history. Location histories were stored remotely on a password protected server and using JSON requests, this was visualised on each phone using the google "line" class within the google API. However, the google "line" class, specified width in pixels, not in real distance with respect to the geographical positions on the map. An intention of the "trails" was not just to show a location history of all users', but

also to give an indication of where the spaces which users' were likely to have seen (analogous to "sweep width" as described in Chapter 2). When users' zoomed in and out, the thickness of these trails therefore should scale up and down to indicate real physical spaces. For this reason, the thickness of the lines were given by an appropriate value divided by the total physical space the map represents, so that the lines were approximately 10 meters wide in real distance. This method allowed data about the location histories of users to be presented visually to participants, thus satisfying requirement C. Figure 5.7 shows a trail from the current user; participant 4.

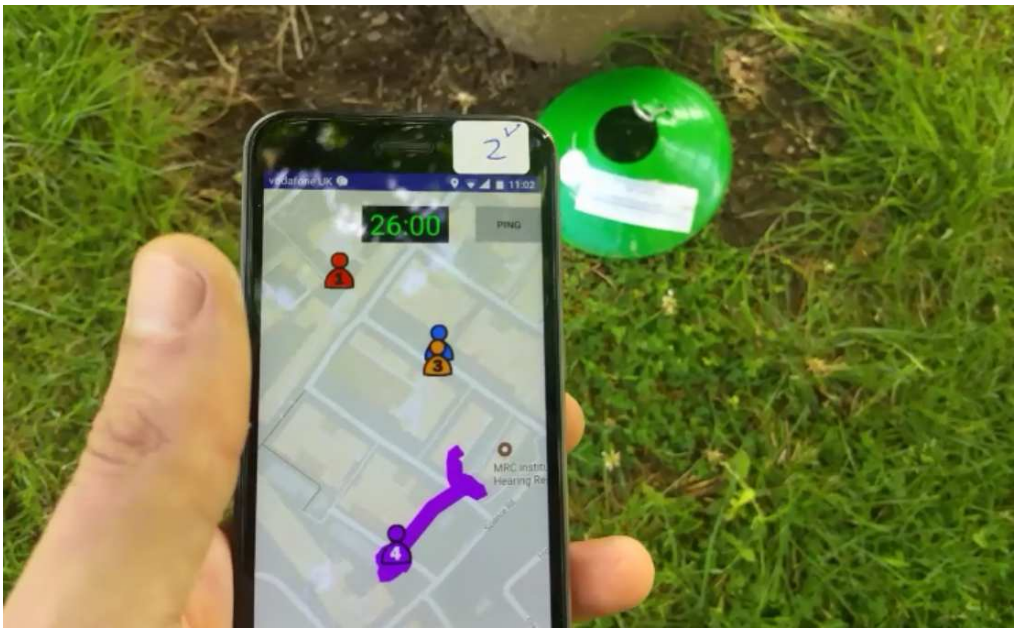


Figure 5.7 Picture of Application demonstrating Trail Functionality

5.9.4 Pinging as Pointing

The "Ping" feature was designed to act as a method for participants to highlight specific locations, in lieu of being able to physically point on a map (requirement D). This was implemented using the google "circle" feature and an animator class, so that a circle "pulsed" in size from small to large. "Pings" were also accompanied by an audio chime to draw users' attention. Figure 5.8 shows two devices running the application showing semi-transparent blue circles in the same location on each device. Ping circles are colour-coded to indicate which user initiated them.

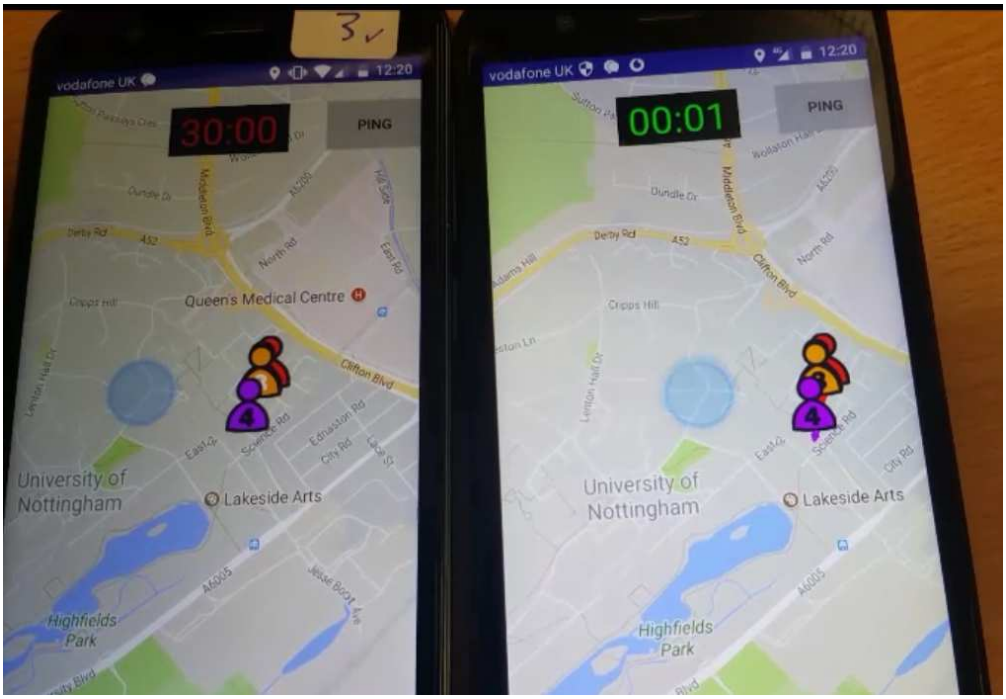


Figure 5.8 Demonstration of Synchronicity of Pings

5.9.5 NFC Tags and Scanning

Finally, additional features were required which would enable "search objects" to be registered during an experiment (requirement F and requirement G). It was decided that each search object should contain an Near-field communication (NFC) tag, owing to the low cost of tags and their weather resistance compared to visual markers (such as QR codes). NFC tags can also be easily updated and modified. Subsequently, the application was developed to read NFC tags and transmit this information to the server in order to register that a specific target had been found during the experiment. The application was also designed to inform participants whether a scan had been successful and had not been scanned by another user (Figure 5.9), or if the search target had previously been scanned by another user (Figure 5.10). Prior to the trials, the experimenter used an off-the-shelf-application to write NFC tags with appropriate identifying numbers (from 1-99). The application registered when an NFC tag had been scanned and then checked with the server to see if the same cone had already been scanned within that session. If the scan was unique, users would be told their scan was successful (Figure 5.9 Screenshot of Successful Scan), however,

if the cone had already been scanned during the session, users were shown that their scan was not valid (Figure 5.10 Screenshot of Repeat Scan).



Figure 5.9 Screenshot of Successful Scan



Figure 5.10 Screenshot of Repeat Scan

5.9.6 Features for Testing

In order to evaluate the features of such a system, it is a requirement that the various application features can be enabled and disabled (requirement K). For this reason, another version of the interface was developed which showed the same map and contained the same NFC capabilities, but did not show users the

locations of their teammates or any location histories. This version sent all the same location and scanning data to the server, but from a user perspective behaved very similar to any other smart map (such as google maps). A separate login for the application allowed the researcher to view the location histories and current positions of users, but these were not visible to the users themselves, this feature satisfied requirement I. Finally, a timer feature was added to the application and controllable by the experimenter in admin mode, in order to allow for future testing (requirement J).

5.10 Limitations of Proposed Technology

Whilst the proposed technology aims to facilitate communication between teams of individuals conducting missing person searches, it should not be considered a complete solution for all missing person activity. The application as designed does facilitate communication within teams, but currently, the larger technological infrastructure about how such a technology should be deployed have not been investigated. For example, the design discussed in this chapter provides no solution of how missing person alerts will be generated, who will be enlisted in the missing person search and does not currently consider data safeguarding (for example, GDPR compliance). Presumably, a more comprehensive solution would also have the capability of notifying police in a timely manner and facilitating data transfer between initial search activity and the police missing person department, which would reduce the necessity of conveying information to the police (which may invite inconsistencies, omissions and inaccuracies).

Neither does the application currently provide any advice for conducting search operations, which may be of great benefit to those conducting missing person searches. For example, generic advice such as how to conduct grid-searches, or sweep-width estimation may be of benefit to non-experts wishing to make their search activity more effective. The application may help to facilitate better communication, but as yet, it provides little in the way of decision-making support. A more comprehensive solution may also integrate this type of assistance in the form of reminders, tips and better integration with existing systems.

Whilst this technology was proposed based upon both an understanding of how missing incidents unfold, and in light of the potential drawbacks of existing technologies according to carers and parents (described in 5.5.3 and 5.4). Further work also needs to elicit the attitudes of users who have experience in using this technology if such a product were to be taken to market. This will be explored in a limited way in the following chapter, in the form of post-trial interviews. However, in order for a technology to be considered safe market-ready, more comprehensive user testing would have to be conducted to ensure that the technology is robust, effective and easy to use.

It would also be an advantage of the technology if it allowed for further customisation. For example, users may wish to change the icons so they can more easily tell who else is conducting the search activity. A potential future application to assist with communication in missing person searches may also integrate information from other sources (such as wearable tracking devices). It may be possible, for example, to identify areas of high probability based on the missing person's previous location histories and illustrate this information on the map. Further elements of personalisation may also include specific instructions generated by the carer or guardian about the missing person's location preferences and the ability to customise the layout of the application based upon various usability requirements. As yet, the application which has been developed does not include these features, but it is important that such an application should have the ability to personalise.

The use of NFC tags for the experiment itself, also meant a significant time commitment for the researcher, as each NFC tag had to be written to, placed on a sports cone and then scanned again (to record the location) when the objects were placed around the university. This was a time consuming process, and indicates that the technique could not be easily scaled up for larger studies without a commensurate time commitment, this may be a limiting factor for others who wish to repeat the trial design. Alternatives could involve QR codes, or simply requiring participants to take pictures of search targets.

Finally, another shortcoming of the application is that requirement E (facilitate audio communication) was unable to be implemented in the application due to

the cost and time limitations of storing additional audio-data on the server. For this reason, a “Wizard of Oz” style approach will have to be implemented, where Skype calls running in the background will facilitate audio communication between teammates.

5.11 CHAPTER SUMMARY

This chapter investigated the development and appropriateness of existing technologies designed to prevent, mitigate and assist in missing person incidents. It began with a survey of existing technologies and a discussion people’s perceptions and preferences of such technologies and identified various reasons which were given for technology preference. A discussion highlighted the strengths and weaknesses of various technological interventions in addressing the needs of users and the need for decision-making support was demonstrated. A new design concept based upon these requirements was proposed and developed. The next chapter will build upon this work and describe a study involving this technology designed to help co-ordinate small teams of local responders in missing incidents.

6 FIELD TRIAL OF ASSISTIVE TECHNOLOGY

6.1 CHAPTER OVERVIEW

Based upon the previous work, this chapter will further outline the motivation for developing a mobile phone application which assists care givers during missing incidents, and discuss how this application was developed. Using this application, a field experiment was devised in which participants worked in teams in order to find a series of "search targets" in a naturally occurring outdoor environment. The chapter will report on the key findings of the study and focus on effectiveness, situation awareness and user expectations of such a technology. Finally, general lessons of the trial will be discussed in order to further elucidate the potential benefits of decision-making support and to provide guidance on how such systems could be further improved.

6.2 INTRODUCTION

The previous studies indicate that even prior to an official police report Missing Incidents typically involve multiple individuals, possibly separated geographically, working together to achieve a common goal. Effective communication not only has the potential to reduce the psychological stress and anxiety felt by care givers during missing incidents, but can also materially assist in the logistics of search planning and management. Carer interviewees in Study 1 explained how they felt the need to inform a peer or family member both for material assistance and emotional reassurance. Similarly, 61% of respondents in Study 2 made the decision to enlist the help of a friend, colleague or family member during the fictional incident and those who did so, tended to enlist help very soon after noticing an absence. Clearly, communication is an important aspect of missing incidents. In light of this, an android prototype application was developed with the aim of enhancing communication between small teams of individuals conducting a search task and to investigate whether such a technology has the potential to increase search efficiency.

The first study described in this thesis consisted of retrospective accounts of missing incidents, whilst the second comprised of hypothetical "what if" scenarios; both of these approaches are problematic in terms of ecological

validity (Cicourel, 1982). Moreover, whilst interviews typically elicit rich and comprehensive data, there is the potential for interviewees to reconstruct aspects of incidents which they may fail to remember or be influenced by leading questions (Loftus & Palmer, 1996). Study 2 does not suffer from these shortcomings, however, asking people what they think they would do in a given hypothetical scenario is not necessarily the same as observing those incidents directly. People may have a more favourable view of their decision-making abilities in stressful situations than is warranted. Further, a text-based hypothetical scenario is markedly different from a real incident. Most notably, the physical aspects of wayfinding and orientation are absent from such a study and the high levels of emotional stress and anxiety are likely to be absent from a hypothetical scenario.

The purposes of study 3 were to both trial a potential technological intervention aimed at assisting care givers during the initial stages of a missing incident, to investigate various how various modes of communication affect situational awareness, and to analyse the relationship between situational awareness and task performance within a "real-world" environment. Unlike the previous two studies, Study 3 implements a field experiment design in which the experiment is conducted in a naturally occurring environment. This method is generally higher in ecological validity, owing to its higher realism and closer resemblance to the incident of interest. In doing so, this chapter aims to address objective 7, **"Develop and test a technological intervention which could be used during Missing Incidents".**

6.3 BACKGROUND

Research 'in the wild', broadly characterises a paradigm shift within Human-Computer Interaction research in which design, development and evaluation of technological interventions take place in-situ, rather than in an artificial laboratory environment (Chamberlain, Crabtree, Rodden, Jones, & Rogers, 2012). This marked shift allows for technologies to be evaluated and appraised by potential end-users in a way that much more closely resembles how these technologies would be used in a real-world setting and allows researchers to better understand how technologies are likely to be adopted and perhaps even

appropriated. Whilst ‘research in the wild’ is a comparably new research methodology broadly within the discipline of HCI, Hoffman and Woods (2000) point to the numerous historical threads with have contributed to the understanding of cognitive and collaborative activity across both human and machine agents. They cite research areas as diverse as knowledge elicitation techniques for expert systems, (Boose & Gaines, 1989), Naturalistic Decision Making (Zsambok & Klein, 1997) and Situated Cognition (Hutchins, 1995) as various attempts to understand interactions between cognition, culture and complex artefacts in context. Whilst the methodology that will be employed here differs slightly from the definition of “in the wild”, as given by Rogers and Marshall (2017), in that it does not “create and evaluate new technologies and experiences in situ” (p.6); it does use a new technology in a naturally occurring physical environment for the purposes of evaluating the likely real-world outcomes and associated behavioural change. This methodological approach, also bares resemblance to the foraging research described in chapter 2, (Goldstone & Ashpole, 2004; Hills, 2011; Kalff et al., 2010), though to the author’s knowledge, no such experiments have been conducted investigating human foraging behaviour in physical environments.

As discussed in chapter 2, situation awareness (SA) describes the knowledge an individual has about their environment, often with respect to a specific task or series of tasks. SA is said to be intrinsically linked to decision-making (Mica R. Endsley, 1995) and may in some cases be linked to performance (Ma & Kaber, 2007). P. M. Salmon et al. (2009) state that “Assessing operator situation awareness is a key component of sociotechnical system design and evaluation” (p. 490). However, operationalising SA, for the purposes of measurement, is not always straight forward and two distinct approach are available; objective measures and subjective measures. One example of a subjective measure of situation awareness is the Situation Awareness Rating Technique (SART) (Selcon & Taylor, 1990). This rating scale was developed for use in Aerospace operations, but is general enough to be used for other domains (P. M. Salmon et al., 2009). SART was developed for a post-trial questionnaire that is relatively quick to administer. The SART questionnaire asks participants to rate the variability of the situation as well as their overall impressions of the quality and

quantity of information they are receiving on a Likert scale. Conversely, an "objective" approach to assessing situation awareness was developed by M. R. Endsley (1988), the Situation Awareness Global Assessment Technique (SAGAT). Like the SART, the SAGAT was developed within the domain of Aerospace, as a means of assessing the SA of pilots during a simulation. Endsley suggests that an effective measure of SA involves determining an operator's knowledge of goal-specific and system critical information. However, whilst there is clearly some value in assessing the SA during the task, the SAGAT is a disruptive technique which involves stopping the simulation or activity in order to determine if an operator is aware of the state of various system elements. Additionally, such an approach would be difficult to implement during an experiment involving physical search activity, and would be likely to unduly influence behaviour and communication. Objective and subjective measures of SA test important aspects of operator knowledge and self-appraisal of that knowledge. For these reasons, this experiment will take one measure subjective measure of SA (the SART), one objective measure of SA (a post-trial questionnaire) and one measure of performance (number of cones found per participant).

6.4 METHOD

6.4.1 Protocol

Participants arrived at a pre-specified location centrally located on the University of Nottingham University Park Campus. They were given an information sheet detailing the study and asked to sign a consent form. Instructional videos were created for the purposes of demonstrating the various system features to participants for each of the conditions. Participants watched these videos after signing the consent form. Following this, they were given a mobile phone and a demonstration of the application described in Chapter 5, which was installed. The study implements a 2x2 experimental design. Participants were given one of two versions of the application, one of these displayed a "shared map", and the other simply displayed the map and participants current location. Half of all participants were connected to a Skype audio conference call and the other half were given the means to make one-to-

one phone calls to each other using stored contacts. Each participant was then asked to begin walking in opposite directions until they were no longer visible to their teammates. At this point the researcher began the experiment timer and the participants began the experiment.

All participant groups were engaged in searching for a variety of search targets on foot on the grounds of University Park at the University of Nottingham whilst using an android phone with the application described in the previous chapter. Search targets were be placed outdoors within the grounds of the University of Nottingham campus. These targets were sports cones fitted with NFC tags which participants were asked to touch with their mobile phone to confirm they had found the targets. Trials were 30 minutes long each excluding start times and post-trial interviews, though total participant time was approximately to be an hour and fifteen minutes. Participant's locations were also monitored at this point to ensure they are not running, and to ensure their safety.

Once 30 minutes had passed, participants were informed that the trial was over and asked to make their way back to the study HQ. Participants were asked at this point not to communicate with each other.

Participants then answered post-trial questionnaires described below and a brief semi-structured group interview was conducted.

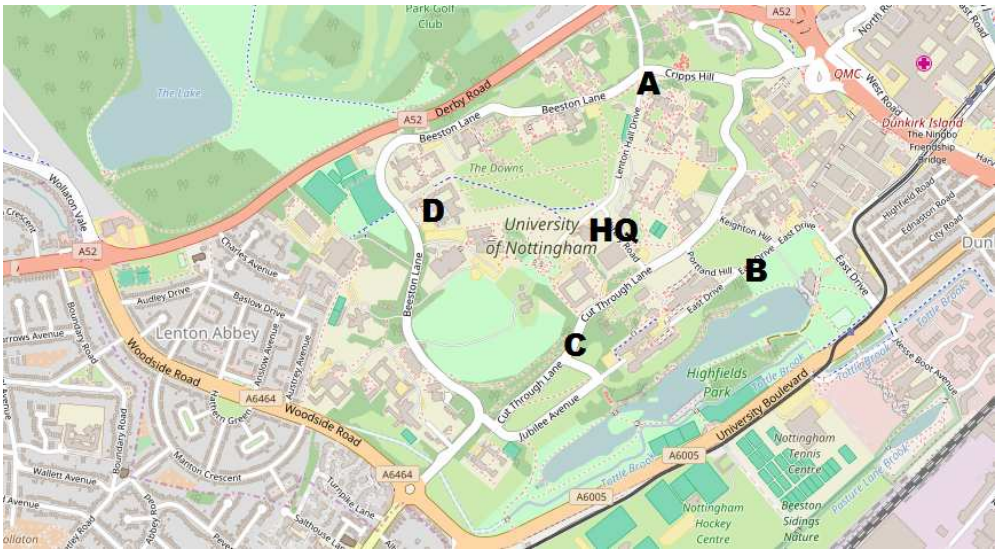


Figure 6.1 University Park Map

Figure 6.1shows the University Park Grounds, which are clearly delineated by roads and gates. Searchers were informed not leave the grounds of the University during the task. HQ denotes the library, which served as the headquarters of the study, and the letters A,B,C & D are the general direction that people were told to go at the start of the trial. Once the timer began, partcipants were free to choose their direction and strategy.

6.4.2 Conditions

Participants were in one of four conditions, each reflecting different modalities of communication:

Basic Condition (BC): Participants were able to contact each other via standard one-to-one calling features and able to see their current location, but will had no record of where they or their team members had searched.

Shared Audio Only (AO): Participants were able to communicate to each other via an open radio channel, and able to see their current location, but had no record of where they or their team members had searched.

Shared Visual Only (VO): Participants were able to contact each other via standard one-to-one calling features. In addition, participants were be able to see a record of where they and everybody in their team had searched and their current location.

Full Features (FF): Participants were able to communicate to each other via an open radio channel. In addition, participants were able to see a record of where they and everybody in their team had searched, as well as their current location.

Table 6.1 Experimental Conditions for Study 3

	Shared Visual	No Shared Visual
Shared Audio	Interactive Map, Skype (FF)	'Standard' Map, Skype (AO)
No Shared Audio	Interactive Map, Phone Calls (VO)	'Standard' Map, Phone Calls (BC)

6.4.3 Measurements and Recordings:

Participants locations were monitored during the entirety of the experiment, “ping” data, “trails” and cone “scan” activities were all sent automatically by the application to a password protected server, both for use in the trail and later analysis.

Participants were issued with a series of questions relating to their performance after the trial (Appendix E). Using data generated from the trials a “map drawing” was produced immediately after the timer had stopped (shown in Figure 6.2), which was used as a reference to mark participants responses.

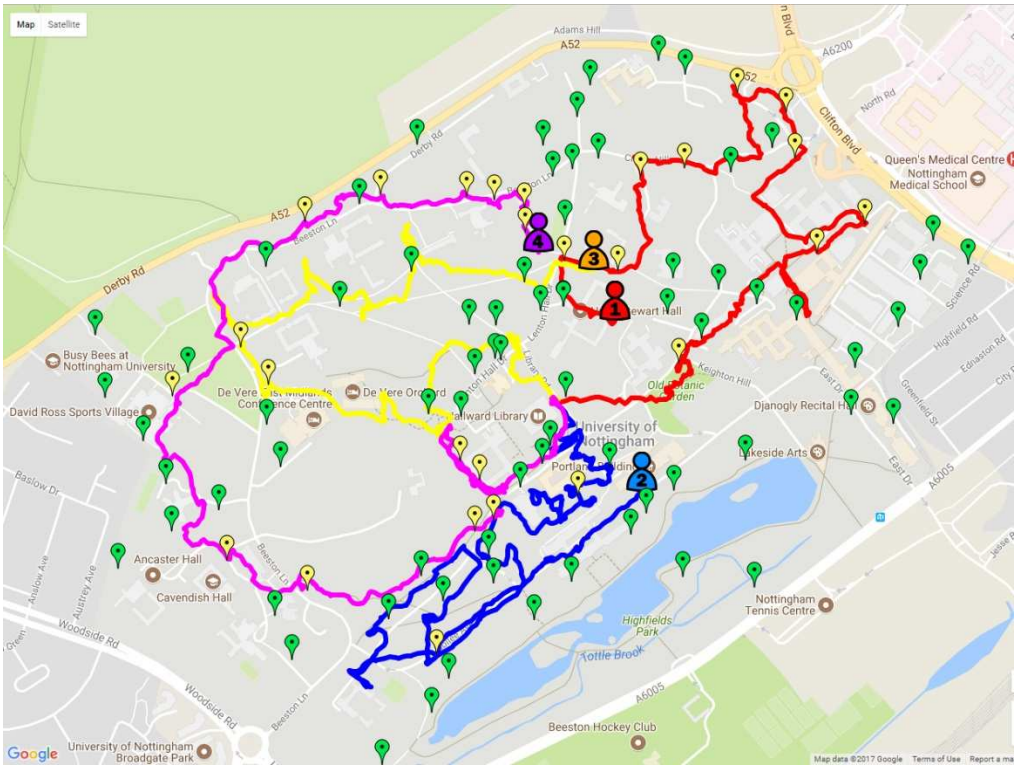
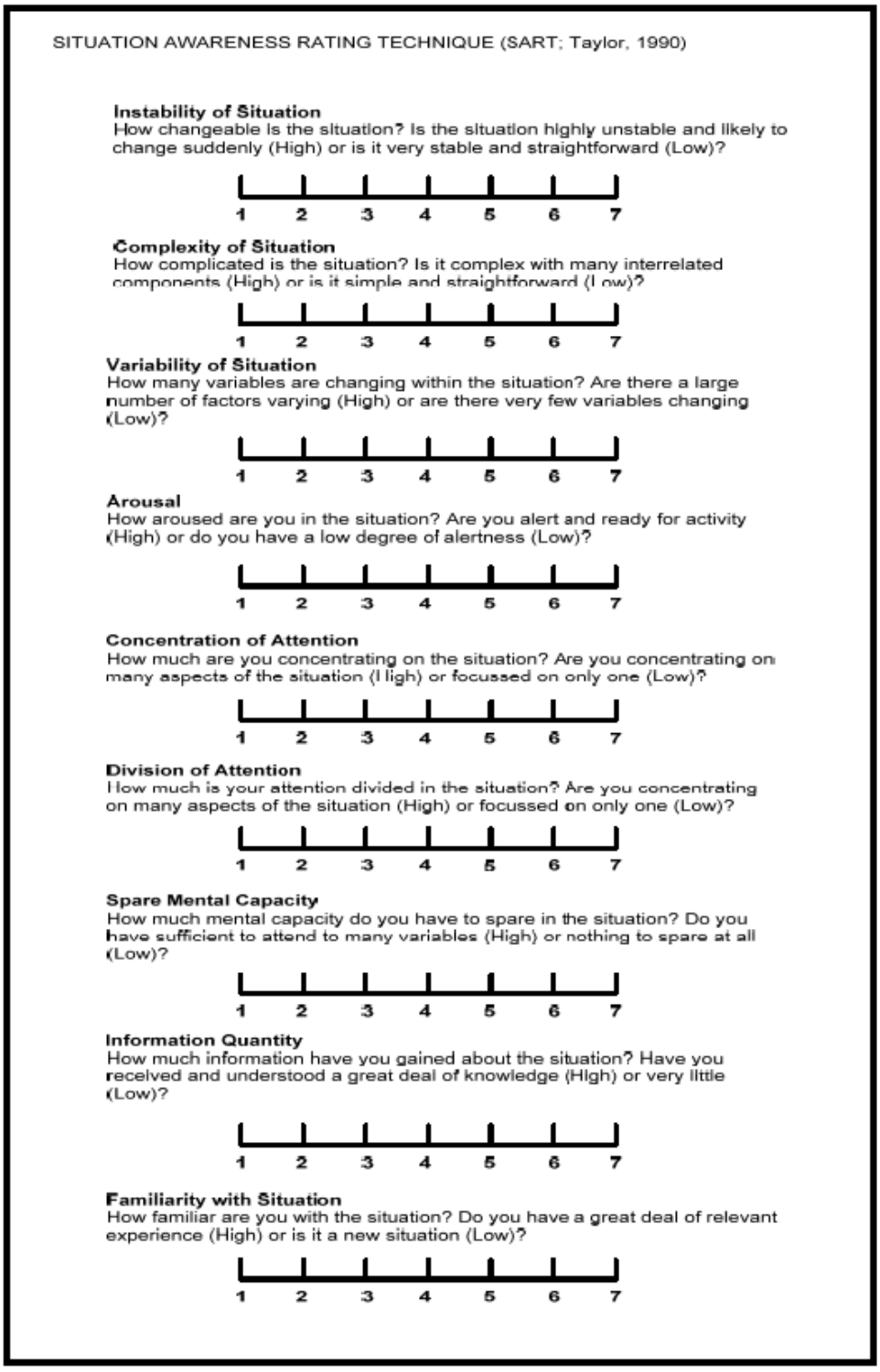


Figure 6.2 Researcher's View during the Experiment

Figure 6.2, shows the information which was available to the researcher during the trials. Indicated by the numbered markers are the participants’ current positions, participants’ location history (indicated by the coloured lines) and information regarding the location of search targets; where green represent unscanned targets and yellow represent scanned targets.

Participants also completed a SART questionnaire in order to measure SA subjectively; this is shown in Figure 6.3.


SITUATION AWARENESS RATING TECHNIQUE (SART; Taylor, 1990)

Instability of Situation
How changeable is the situation? Is the situation highly unstable and likely to change suddenly (High) or is it very stable and straightforward (Low)?

1 2 3 4 5 6 7

Complexity of Situation
How complicated is the situation? Is it complex with many interrelated components (High) or is it simple and straightforward (Low)?

1 2 3 4 5 6 7

Variability of Situation
How many variables are changing within the situation? Are there a large number of factors varying (High) or are there very few variables changing (Low)?

1 2 3 4 5 6 7

Arousal
How aroused are you in the situation? Are you alert and ready for activity (High) or do you have a low degree of alertness (Low)?

1 2 3 4 5 6 7

Concentration of Attention
How much are you concentrating on the situation? Are you concentrating on many aspects of the situation (High) or focussed on only one (Low)?

1 2 3 4 5 6 7

Division of Attention
How much is your attention divided in the situation? Are you concentrating on many aspects of the situation (High) or focussed on only one (Low)?

1 2 3 4 5 6 7

Spare Mental Capacity
How much mental capacity do you have to spare in the situation? Do you have sufficient to attend to many variables (High) or nothing to spare at all (Low)?

1 2 3 4 5 6 7

Information Quantity
How much information have you gained about the situation? Have you received and understood a great deal of knowledge (High) or very little (Low)?

1 2 3 4 5 6 7

Familiarity with Situation
How familiar are you with the situation? Do you have a great deal of relevant experience (High) or is it a new situation (Low)?

1 2 3 4 5 6 7

Figure 6.3 SART (from Taylor 1990)

After the trial was completed and participants had answered the two questionnaires, a semi-structured group interview was conducted and

participants were asked how well they thought they communicated, how they thought the technology helped or hindered their task and what improvements could be made if the technology were to be developed further.

6.4.4 Participants and Trial

A total of 52 participants were recruited for this study. Participants could either enlist as complete teams, partial teams or individuals. Participants who did not enlist as part of a full team were assigned teammates from the participant pool. Of the 50 participants who were recruited, 48 took part in the trial. The 4 participants who were recruited but did not participate in the trial did not attend the trial with a full team and so were unable to participate. Recruitment was conducted largely through an online campaign via Facebook and word of mouth. A Facebook page was created for the purposes of recruitment, and in order to provide a public "scoreboard" for participants' performance during the trial. The advertising campaign took the form of a "Treasure Hunt", and winning teams would win £100 in vouchers as a team prize for all four participants. It was hoped that the prize would act as an incentive for high performance and increase the importance placed on the task by participants. However, for the purposes of fairness a winning team was picked from each of the four conditions in order to ensure that each participant had an equal chance of winning.

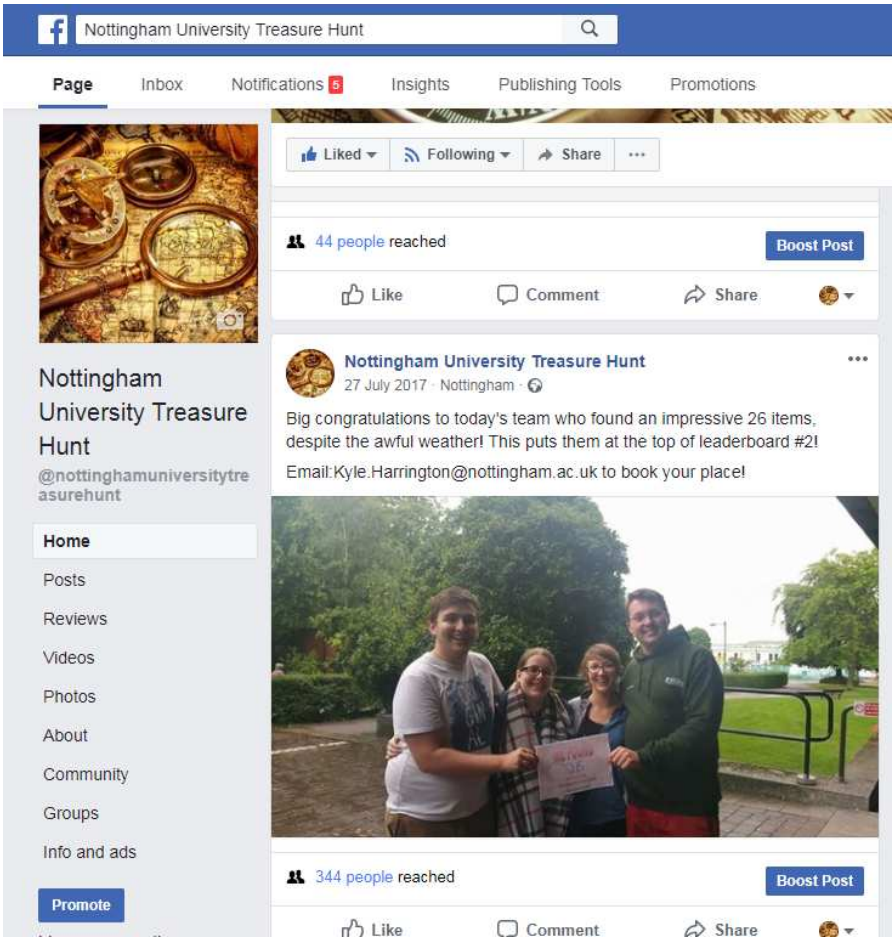


Figure 6.4 Nottingham University Treasure Hunt

Participants were assigned to groups based on an ordering system, so that if the desired number of participant groups were not able to be recruited, there would be a more equal distribution of participants across conditions.

The trial ran from September to November 2017, with three separate blocks of trials, in September, October and November. Between each trial block the researcher performed a visual inspection on the quality, quantity and location of the search targets and ensured the NFC tags were still in good condition.

6.4.5 Ethics

Participants were informed prior to the experiment to wear "appropriate" clothing, for the task (e.g. no high heels, weather appropriate clothing). Participants were informed to the purposes and methods employed in the experiment via an information sheet (Appendix D.1) and gave informed consent (Appendix D.2). Additionally, a tutorial video for each of the conditions was produced and played to participants informing them of specific features and

advising caution whilst crossing roads. Approval for the distributions of cones was obtained by University of Nottingham estates, this study also obtained relevant ethical approval from the University's ethical review board in engineering, and was given approval by the department's Health and Safety officer. Participants' data was stored on a password protected server and their data was separated from any potentially identifying information. However, participants were allowed to enter a competition in compensation for their participation, and some participants agreed to sharing pictures of themselves on the study's Facebook page.

6.5 RESULTS

There was a great deal of variability in the results for all of the dependent variables measured. Despite differences observed between different conditions, few of the results were statistically significant. The results which were significant indicate that knowledge of teammate's locations improved with many-to-many audio communication, and that their own subjective assessment of situation awareness improved with additional visual information about their teammates positions (though, their actual situational awareness or performance did not seem to increase). None of the dependent variables in the results were normally distributed (as indicated by the Sharpo-Wilks), and therefore, non-parametric statistical tests are the most appropriate means of analysing the data. However, there are no universally agreed upon non-parametric equivalents of the two-way ANOVA, which would be the most appropriate method for analysis. For this reason, the results section will be presented in three parts; a non-parametric analysis of each individual factor, a presentation of the estimated marginal means, and finally, a test for correlation between measures that are assumed to be correlated.

6.5.1 Descriptive Statistics

Table 6.2 Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
ConesFound	48	0	20	8.00	4.925
Distance	48	1193	3737	2785.27	433.616
MapScore	48	2	10	6.06	2.282

SARTScore	48	5	33	18.85	5.036
Repeats	48	0	5	1.15	1.598
Valid N (listwise)	48				

Table 6.2 gives descriptive statistics for dependent variables under consideration, a full breakdown of these results can be found in Appendix F. The descriptive statistics demonstrate a considerable range and high standard deviation in many of the results obtained from the experiment. For example, the number of cones found per participant had an average value of 8, but a range of 20 and a standard deviation of 4.93. This suggests that many other factors may have affected the performance of participants during the trials.

6.5.2 Non-Parametric Analysis of the Effect of Individual Factors

The appropriate non-parametric statistical test for determining if there are differences in the distributions of ratio data between various experimental populations in a between-subjects experimental is the Mann-Whitney U. If each factor (visual information and audio communication method) is analysed individually using this method, two significant results emerge.

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The distribution of ConesFound is the same across categories of VisualMap.	Independent-Samples Mann-Whitney U Test	.100	Retain the null hypothesis.
2	The distribution of Repeats is the same across categories of VisualMap.	Independent-Samples Mann-Whitney U Test	.084	Retain the null hypothesis.
3	The distribution of MapScore is the same across categories of VisualMap.	Independent-Samples Mann-Whitney U Test	.803	Retain the null hypothesis.
4	The distribution of SARTScore is the same across categories of VisualMap.	Independent-Samples Mann-Whitney U Test	.040	Reject the null hypothesis.
5	The distribution of Percentage is the same across categories of VisualMap.	Independent-Samples Mann-Whitney U Test	.196	Retain the null hypothesis.

Asymptotic significances are displayed. The significance level is .05.

Figure 6.5 Non-Parametric Testing of the Effects of Visual Information

Figure 6.5, shows the readout from SPSS, and indicates that the presence of a shared visual map (as per VO & 4) significantly increases the scores of participants in the SART questionnaire, from 17.63, to 20.08. However, despite this increase, objective measures of participant's situational awareness actually decreased under these conditions from 6.17 to 9.16, though this difference was not significant.

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The distribution of ConesFound is the same across categories of Skype.	Independent-Samples Mann-Whitney U Test	.909	Retain the null hypothesis.
2	The distribution of Repeats is the same across categories of Skype.	Independent-Samples Mann-Whitney U Test	.355	Retain the null hypothesis.
3	The distribution of MapScore is the same across categories of Skype.	Independent-Samples Mann-Whitney U Test	.004	Reject the null hypothesis.
4	The distribution of SARTScore is the same across categories of Skype.	Independent-Samples Mann-Whitney U Test	.420	Retain the null hypothesis.
5	The distribution of Percentage is the same across categories of Skype.	Independent-Samples Mann-Whitney U Test	.387	Retain the null hypothesis.

Asymptotic significances are displayed. The significance level is .05.

Figure 6.6 Non-Parametric Testing of the Effects of Audio Communication Method

Figure 6.6, indicates that the objective knowledge each participant had of their teammate's location significantly improved in conditions where participants had a shared audio channel (6.96/10) as opposed to standard calling features only (5.17/10).

6.5.3 Presentation of Means

Whilst no statistically significant results were obtained in the numerous two way analysis of variance tests which were conducted, there are considerable differences in the mean scores of many of the dependent variables between conditions.

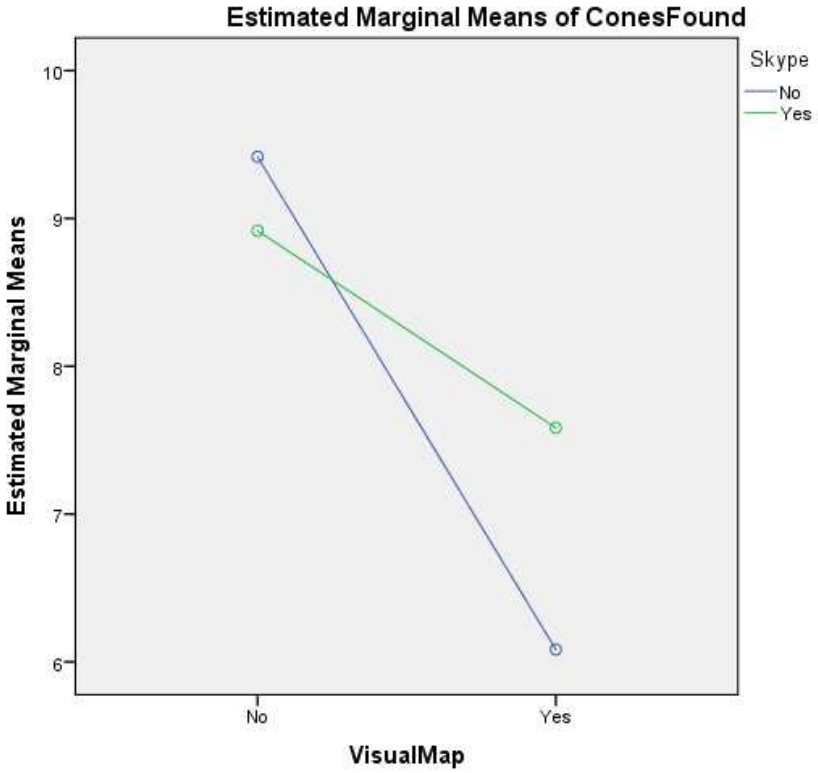


Figure 6.7 Mean Scores of Total Cones Found by Participants across Conditions

Figure 6.7, shows the mean scores for the number of cones participants found under each condition. The highest average was obtained by participants who were in the basic condition (BC) with no shared visual information and standard calling features (9.42). The second highest score was achieved by participants who had many-to-many audio communication methods (8.92), followed by those participants who had many-to-many audio and shared visual information (6.08), whilst the worst average performance was by participants in VO, who had access to shared visual information, but only had access to standard calling features. As mentioned earlier, participants who had a many-to-many calling feature typically performed better than those who did not (although the best performers overall did not have this feature), and those participants who were presented with shared visual information performed worse on average than those who did not (regardless of audio communication mode).

Figure 6.8, shows the average SART scores obtained by participants after each trial. It demonstrates that subjective ratings of situational awareness increased

if either more visual information was present, or if participants had a shared audio channel. The highest average SART scores were obtained by teams who had both additional visual and auditory information (21.58), scores with either (but not both) of these additional sources of information were comparable (Visual only; 18.58. Auditory only; 18.33) and the lowest SART scores came from participants who had neither enhancements (16.92).

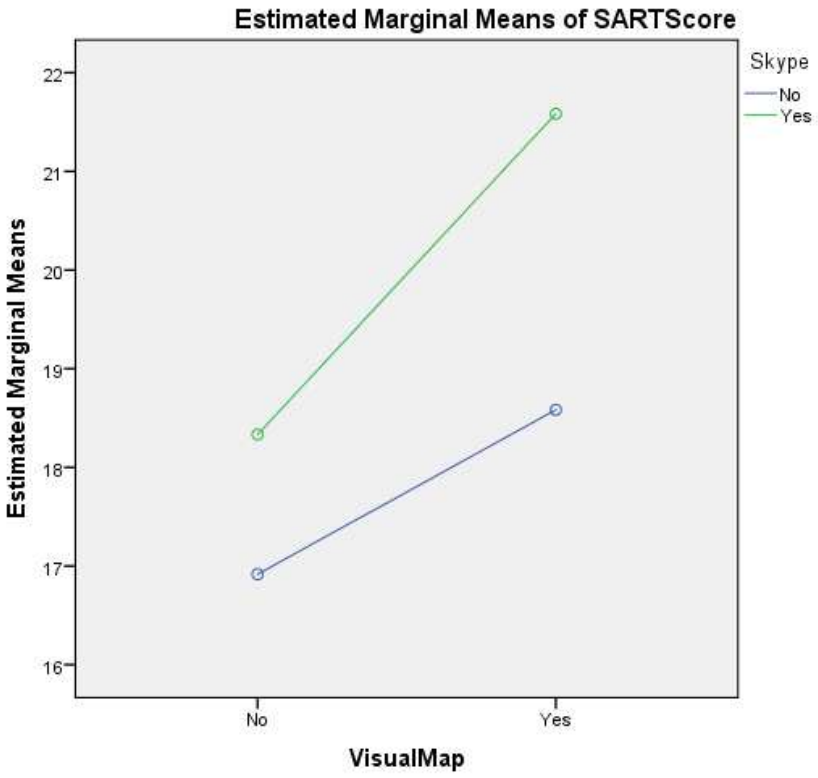


Figure 6.8 Mean SART Scores across Conditions

However, when asked to recall the proximity of participants to a series of set markers following the trial, the effect of each informational improvement was not as straight forward. Those participants who had access to a many-to-many audio communication tended to perform better than those who did not, but additional visual information about team mates locations appeared to benefit only those who had many-to-many audio communication, whilst decreasing the scores of those who did not (Figure 6.9).

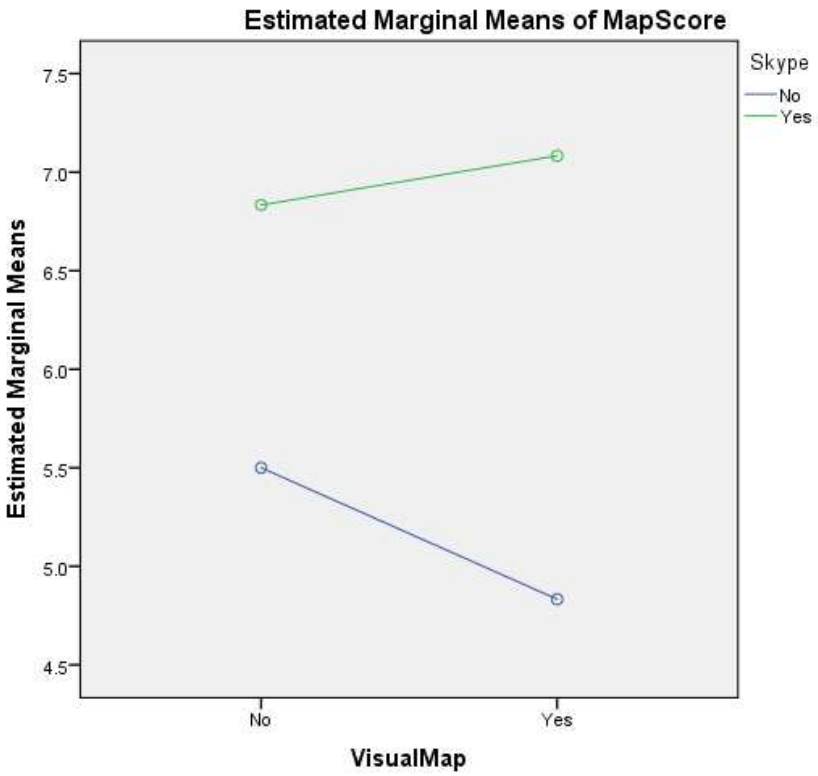


Figure 6.9 Means of Map Questions under each Condition

Figure 6.10, (below) shows how many cones were found by multiple participants as a percentage of the total cones found by each participant. It can be taken as an approximate measure of efficiency, as multiple players finding the same cone did not count towards the teams' overall score. An interesting relationship can be observed, which resembles an XNOR logical function. Participants were the most efficient in conditions which either had full visual and auditory information, or neither full visual nor full auditory information. Participants who received only one of these pieces of information were far less efficient, with the many-to-many audio condition rescanning approximately 23% of all search targets.

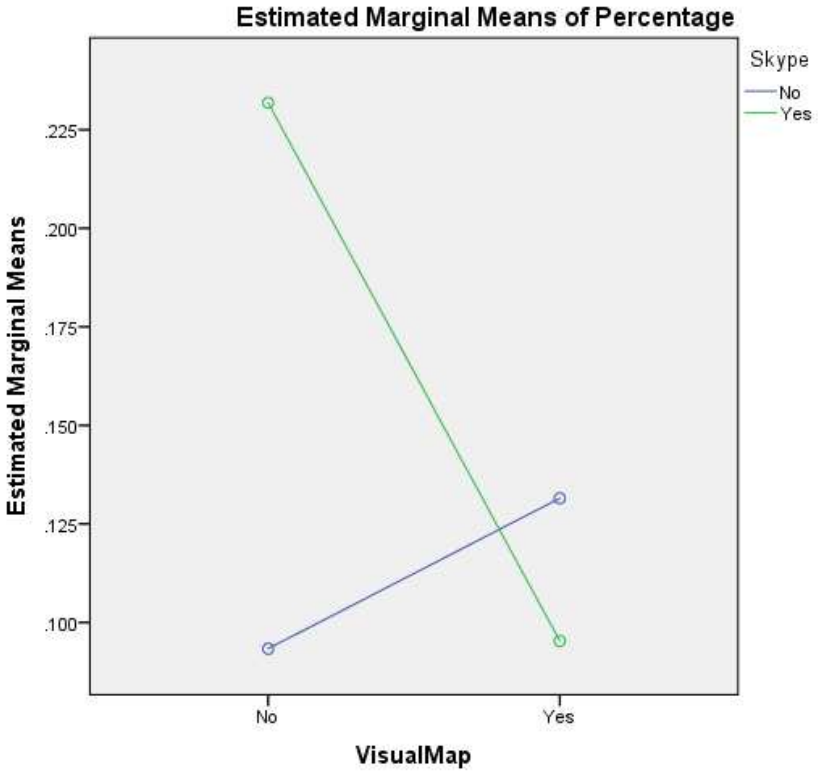


Figure 6.10 Percentage of Cones found by Multiple Participants

6.5.4 Correlations between Measures

Pearson correlations were conducted on various measures, which could be reasonably assumed to be correlated. However, no such correlations were observed in the data. Firstly, the correlation between SART score (which is a subjective measure of situation awareness) and post-trial Map Score (which is taken to be an objective measure of situation awareness) was tested (see Figure 6.11), and no correlation was observed. Similarly, there was no correlation between the number of search targets found and the MapScore. There was a slightly higher correlation between SART and performance, though this was still weak and not statistically significant (0.148).

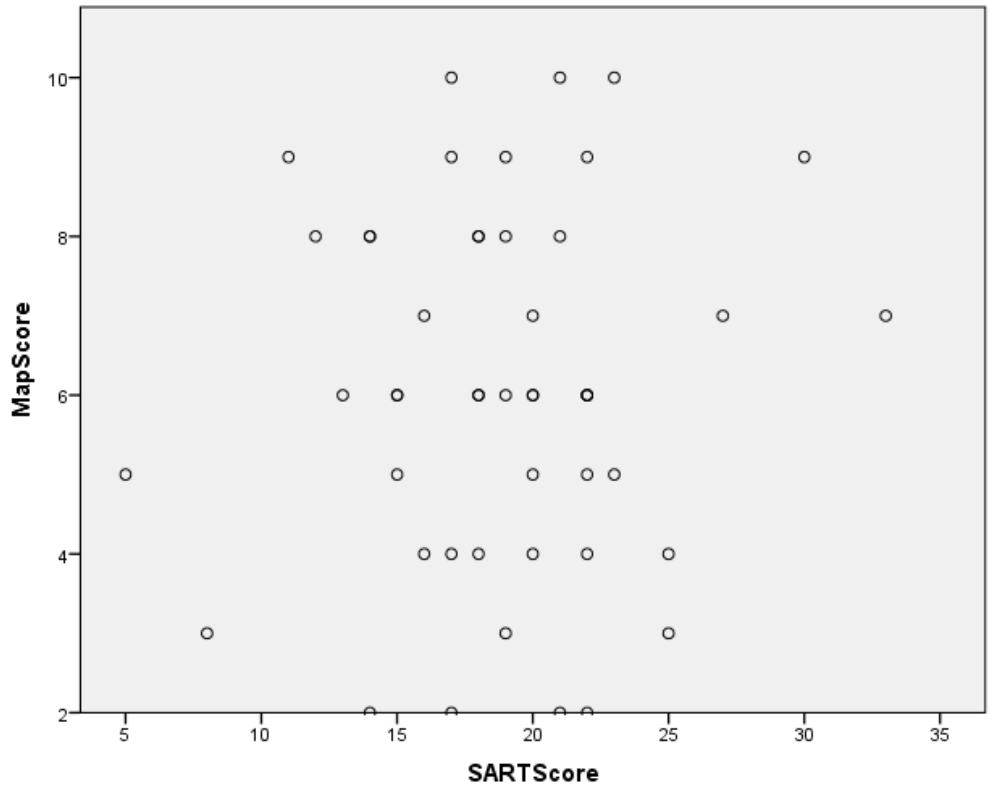


Figure 6.11 Correlation between SART score and MapScore

6.5.5 Interview Findings

Participants generally indicated that the study design was "well-constructed" (BC, trial 1), and "simple but not easy" (AO, trial 1) and many participants also said that the technology "has potential helping people with the search" (FF, trial 2). Participants generally thought the various system features helped their ability to search effectively.

"Definitely helped being able to hear other people, getting an idea of which area they were in", AO, trial 1.
"Being in constant contact with each other and being able to see where each other were made us a lot better at what we were doing than if we just had maps and were walking around", FF, trial 2.
"We wouldn't be able to find as many cones if we couldn't talk to each other", AO, trial 1.

"I think the map was particularly important because not only could you see where a person was at that moment, but you could see where that person has been in the past", FF, trial 1.

"I struggle with direction so it was good to see where everyone else was, not just where everyone else was but where they'd been, the ping feature was good as well", VO, trial 2.

It is also interesting to note that many of those who only received visual information of their own position but no indication of their team mates positions (as in BC and AO) expressed that additional visual information would be of benefit to them:

"It was good to have that feedback as to where people where, but that feedback would be better on the map. It was silly that we could see ourselves but not other people…It would good to be able to see where everyone else has looked on the map and where they are now", AO, trial 2.

"A trail of where you went and maybe it changes colour of how long you went, maybe a lighter colour, seeing each other on the map. Maybe landmarks could be highlighted, or you ping it, like you say go to George Green and the *poop* like you do in star craft or something, like check over there", BC, trial 2.

"Given that we were able to see where we were on the map, I'm wondering whether it would be able to see where everyone else was on the map, so that way you could kind of co-ordinate a bit better", AO, trial 3.

"Someone said it was a shame we couldn't see each other's dots on the map, that would have been very helpful and maybe also when the person already went", BC, trial 2.

Participants who only had access to one-to-one audio communication methods also indicated that they would benefit from a shared audio channel, such as Skype:

> "It would be a lot easier to have a group call, it didn't happen but you might try to call someone up already on the phone. Group call would have made life easier, and it would be good to see where other had gone", BC, trial 1.
>
> "Skype calls would be better if you could have group calls as well", VO, trial 2.

Whilst participants generally indicated that they believed the various communication features enabled them to conduct more efficient searches, one participant in FF noted that they found the shared map to be more useful in planning the search than shared audio:

> "I think being able to talk to the team was good for team morale and in a real situation that would really help because I think some people would be more prone to panic and be not as effective", FF, trial 2.
>
> "I think talking was more for the team morale than communication", AO, trial 1.

Others who also had access to the shared map, (VO and FF) stated that a potential drawback of the highly visual interface was that it may be too distracting:

> "I think it's maybe not the best idea looking at the screen when you are running around, but the map is really useful. So perhaps I wouldn't look at the screen all the time, but I found myself looking at the screen a lot", FF, trial 3.
> "At one point I was looking at the screen and I walked into a building, without looking", FF, trial 2.

Overall, participants were generally in favour of additional means of communication to aid the search task, and those who were in conditions without all system features often suggested that such features would be of benefit to them. However, additional suggestions as to how the system could be further improved were made by a few participants and these suggestions typically involved the ability to better plan and coordinate search areas:

> "I think a bit of planning, the technology seems helpful, but it would be better if it allowed us to plan", FF, trial 3.
>
> "I think the software could help inform some basic strategies, because not everybody will get the idea that you need to spread out. Perhaps some strategies, or whether it's useful to repeat other people's traces and with a missing person they are mobile as well." FF, trial 2.
>
> "You could give a set search area for each person", VO, trial 3.

Participants generally indicated that they thought the task resembled a missing person incident, but did highlight a few areas where it differed from real incidents:

> "I imagine there's probably more variables in a real life missing person search", AO, trial 1.
>
> "They'd usually go somewhere that they know, when I've searched for missing people with dementia, you go somewhere you know they know", AO, trial 2.
>
> "All the time I was thinking whether I could ask somebody if they had seen the missing cones, because I would do that for a missing person", BC, trial 2.

6.6 DISCUSSION

6.6.1 Performance

There were no statistically significant differences in performance between conditions (where performance is cones found per person); neither audio nor visual communication channels appeared to significantly affect total cones found. Neither were there any observed statistically significant differences between groups in the efficiency of search (where efficiency is taken to be an inverse of repeated cones found). However, there was a great deal of variability between individual participants. The standard deviation of cones found was 4.925, whilst the mean score was 8.00. Such variation is likely to make any significant differences considerably more difficult to observe. Whilst it is maintained that this experiment represents an important methodological step in evaluating the effectiveness of assistive technologies in a naturally occurring environment, search performance has proved particularly difficult to measure in a way in which controls for a variety of other factors and isolates the effects of various technological interventions. Nevertheless, it is clear that technologies such as these should be properly evaluated in a way which resembles their intended usage. It may be the case that a larger scale study would yield statistically significant differences in search performance between conditions, but it may be the case that additional factors would have to be controlled for. Good performance on the task is likely down to numerous factors, such as sense of direction, eye-sight and “luck”. A repeated measures experiment would be able to control for individual differences, however this would be logistically difficult to implement without replacing the search targets between conditions.

6.6.2 Situation Awareness

Situation awareness was measured in two ways in this experiment; objectively and subjectively. The objective measures of situation awareness involved asking participants to answer questions about the locations of their teammates once the trial was completed (Appendix E), and the subjective measures involved asking participants to complete a SART, a well-established measure of situation awareness. Interestingly, visual and audio communication channels affected each of these outcome differently. Shared audio channels were shown

to be a significant improvement on the objective measure of situation awareness, whereas, increased visual information only affected the subjective rating of situation awareness. The SART measures amongst other things, the perceived complexity and variability of the situation, but also the quality and quantity of information received. Despite there being no observed differences in the objective measures of SA or performance due to the presence of a shared map, there were significant differences in the SART. Increasing the trust that users' have in the quality of information may be a significant benefit to people in highly stressful missing incident scenarios. Previous studies indicate that communication is a recurring theme, and so increasing confidence in the quality and quantity of information may have significant real-world benefits, such as reducing the high levels of stress, anxiety and helplessness felt by some carers.

There was no statistically significant correlation between SART and the objective measure of SA. This may indicate that people often incorrectly assess their level of knowledge, or that there is little correlation between "objective" and "subjective" measures of situation awareness. However, perhaps a post-trial questionnaire about various system elements is a measure of recall; not SA. The findings indicate significantly higher recall of teammates locations when many-to-many communication was available, this may be because geo-spatial information presented audibly requires deeper semantic processing than the same information presented visually and this effort assists recall (Eysenck & Eysenck, 1979). Another theory is that participants are more likely to describe landmarks via audio communication and this facilitates survey knowledge (Waller & Lippa, 2007).

6.6.3 Extraneous Variables

No trials were run before sunrise or after sunset, but that is not to say that visibility was constant for all trials. Cloud coverage, precipitation levels and time of day may have adversely affected performance in several trials. The weather was not controlled for during the study, but trials were run under numerous environmental conditions, excluding very heavy rain or wind. This is likely not only to affect the visibility of the study, but precipitation may also affect walking speed and crucially, the usability of the touch screen devices participants were issued with. Waldron (2017) identified several environmental

factors such as temperature and wind speed which affect human behaviours such as travel speed and travel direction.

The application was developed on an Android phone, whilst all users in the study confirmed that they were smart phone users, not all were familiar with the Android operating system. An instructional video was presented to all participants explaining various system features and controls. In addition, a brief description of the phones physical buttons and basic Android operations was given to participants in order mitigate the potentially adverse effects of unfamiliarity with technology. Unfortunately, in a few cases, participants' muted their microphones during the trial, whilst this was usually quickly remedied, it did temporary hinder communications between participants.

There were also likely to be other individual differences between participants which could have affected the results, for example navigational abilities (Bryant, 1982), familiarity with the campus and inter-team differences.

6.6.4 The Ecological Validity / Reliability Trade-off

The study took the form of a field experiment and therefore was more ecologically valid than a similar study would have been under laboratory conditions. The price for this higher realism was ultimately less reliability and less control over the environmental factors which may have influenced search task performance. As suggested by Piliavin, Rodin & Piliavin, "the ideal research strategy over the long haul is to move back and forth between the laboratory, with its advantage of greater control, and the field, with its advantage of greater reality" (Piliavin, Rodin, & Piliavin, 1969, pp. 289-290). Whilst it is debatable whether this environment was truly *in situ*, the use of a naturally occurring environment was crucial in establishing realistic behaviours and limitations of the technology. By conducting the search tasks in the physical world (Kalff et al., 2010cf), participants were able to comment specifically on how the application was able to meet their requirements and how it affected their physical movement. Participants also mentioned they wanted to ask passers-by if they had seen any search targets; something they would do in a real-missing incident. Study 3 is far more "in the wild" than controlled laboratory experiments, but is not an evaluation of the technology based upon

its true intended purpose. Further testing and development would be required before this technology could be tested for use in real missing incidents. Nevertheless, evaluating technologies in environments with high-ecological validity is likely to yield realistic user-behaviours.

6.6.5 Other Limitations and Areas for Future Work

Whilst the location data for each participant was stored digitally on a remote server for each of the trials, numerous errors with the data storage meant that much of this data was unusable for a more in depth analysis of pathfinding and search behaviours, and thus made systematic comparisons between conditions impossible. Figure 6.12 shows an image which has been generated from server data stored on trial VO1.

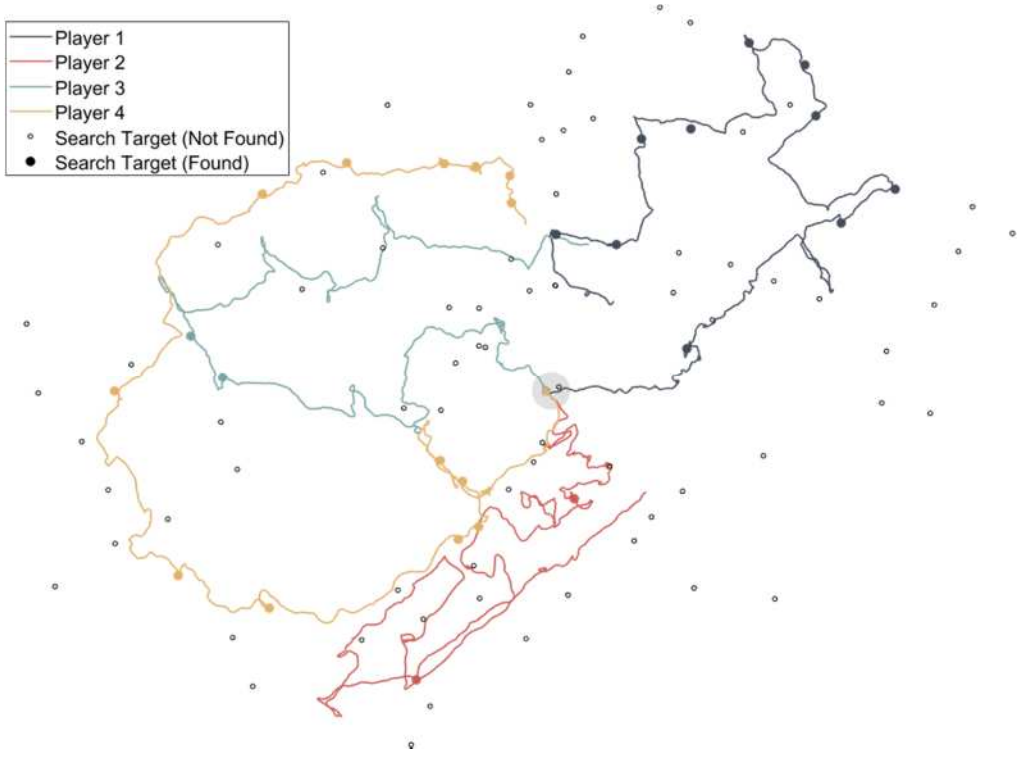


Figure 6.12 Data Visualisation of Server Data for Trial VO1

Figure 6.12 shows all four participants splitting up and covering different areas on campus. Participants in this trial tended to stick loosely to paths within the university campus. Unfortunately, however, not all the trials saved correctly on the server, which resulted in a loss of trial data. Figure 6.13 shows trial AO2, in which the participant highlighted in blue and the participant highlighted in red,

followed much of the same paths. This figure also demonstrates some of the technical problems with the storage of and handling of location data, as search targets which are indicated as “found” appear not to be on any path.

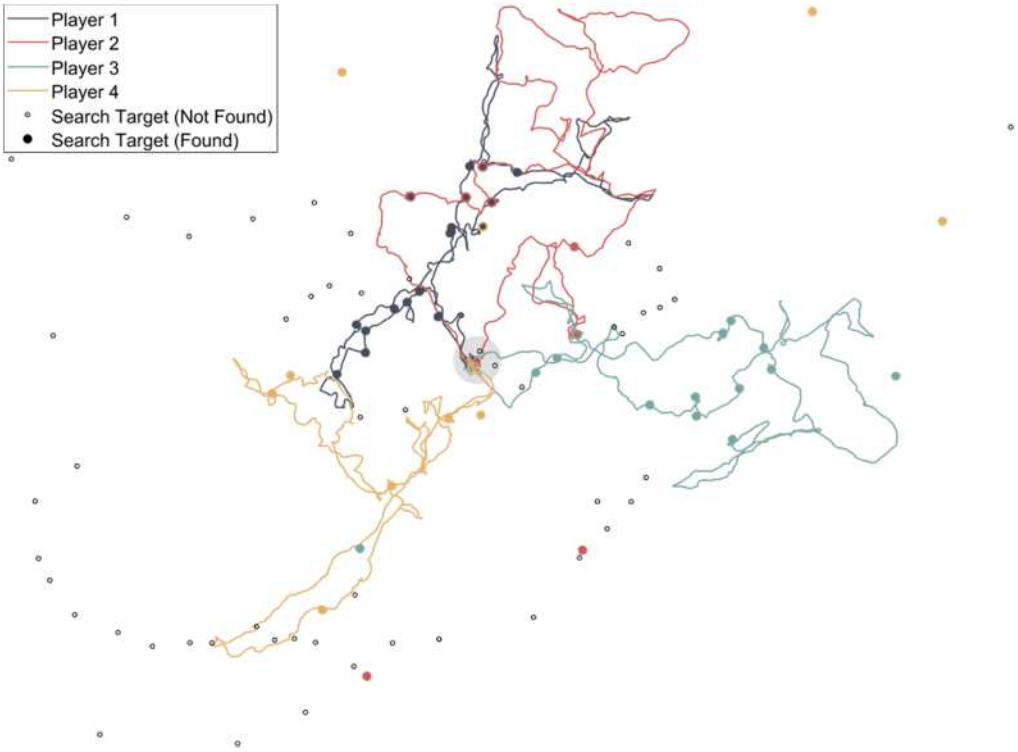


Figure 6.13 Data Visualisation of Server Data for Trial AO2

One could conclude from a comparison between Figure 6.12 and Figure 6.13 that those in the visual only condition covered a larger unique area than those in the audio only conditions, but this trend was not consistent across all trials. Illustrated in Figure 6.14 (below) is another “Audio Only” trial condition (trial AO1), however in this condition, participants covered far more unique ground.

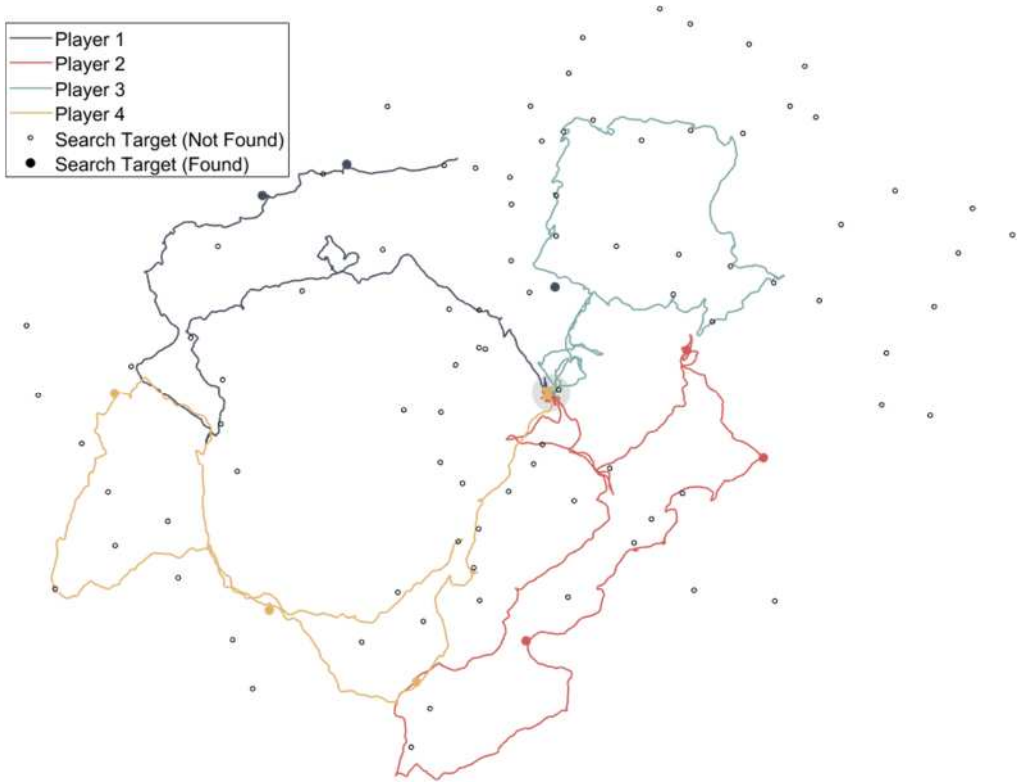


Figure 6.14 Data Visualisation of Server Data for Trial AO1

A further analysis was conducted on the available data in order to determine whether participants during each of the trials were able to detect cones which they passed within 15 meters of. The rationale for this analysis was to determine whether participants were less likely to notice search targets which were (theoretically) within their immediate line of sight. Averages for each of the trials which were successfully saved are given in Table 6.3.

Table 6.3 Percentage of Targets found within 15 Meters

Trial	% found	Condition Average
AO1	20	37.28
AO2	59.7	
AO3	32.14	
FF3	37.5	37.5
BC2	68.12	50.725
BC3	33.33	
VO1	61.36	61.36

Table 6.3 does not show any clear trends in regards to the successfulness of locating targets within a 15 meter radius of participants between trials. In

addition there is too little data and too much variability to draw any strong conclusions about

6.7 CHAPTER SUMMARY

This chapter presented a field experiment in which participants, working in teams, were asked to find artificial search targets under strict time conditions in an outdoor area with the use of a communication aid. The results show that many-to-many audio communication channels have the ability to increase situation awareness during a search task, whilst additional visual information increases participant's subjective rating of their own situation awareness, despite there being no significant differences in task performance. Whilst there is a clear and pressing need to facilitate effective communication between all concerned parties during missing incidents, more work needs to be undertaken in order to ensure that any potential technological intervention does not unduly distract users from the task. The next chapter will draw upon the findings of the previous chapters in order to develop a series of design recommendations which may be of use to technology developers, policy makers and other stakeholders.

7 DISCUSSION AND RECOMMENDATIONS

7.1 CHAPTER OVERVIEW

This chapter will bring together the central findings of the work described in this thesis in order to discuss their significance and to bring novel insight into the process of missing person search. It will both attempt to place the current work in its theoretical context, as well as present actionable information in the form of evidence-based design recommendations that may be of use to those wishing to develop assistive technologies aimed at preventing, or mitigating the risks associated with missing incidents. In so doing, this chapter will address the final objective of the research, **"Explore how the findings may have practical benefit to care recipients and carers, as well as technology developers, policy-makers and other stakeholders"**. Attention will also be given to the numerous legal and ethical concerns which must be taken in to account when designing technology for at risk groups.

7.2 DISCUSSION OF FINDINGS

7.2.1 Stress, Responsibility and the need for Support

Carers and guardians seek out others both for material assistance in the search, but also for reassurance and emotional support. This was demonstrated in Study 1 when carers were asked why they had enlisted the support of a friend or college, many responded that there was a need for support reassurance, which is evidenced by the global thematic sub-category (Appendix B.4). Interviewees also described an abundance of meta-cognitive thoughts (e.g. "Am I doing the right thing?") which were particularly prevalent when they were describing the decision to enlist help (Table 3.3 Intersection of Global Themes and Critical Decisions Carers), this suggests that enlisting help may invoke feelings of conflict and guilt.

"...I suppose that's the point at which, y'know you kind of want somebody to help and hold your hand a bit and say, it's ok, y'know it'll be ok. and I suppose [R&C] were the nearest things to friends that I had in the village...I'd moved away from my y'know, completely away from my home environment and...it's very difficult to be friendly with anybody when you've got an 87 year old, 5 foot ten of dementia walking around, on your left shoulder" – Study 1, Carer 1

This finding is also supported in study 2, which indicates that around 61% of people will enlist the help of a friend of colleague before contacting the police. The need for emotional support and reassurance should not be underestimated in highly stressful situations involving missing people, even in situations where the carer is a paid professional. As mentioned towards the end of chapter 2, additional stressors can cause significant errors in judgment and the evaluation of decision outcomes (Wemm & Wulfert, 2017), which has the potential to result in poorer choices being made, and consequently, worse outcomes for those at risk. The model illustrated by Figure 3.5 Reactive Search Strategies of Carers, which was a description of the decision-making strategies employed by carers and guardians indicates that carers typically evaluate one option at a time, and the findings discussed from study 2 (Figure 4.8 Self-Reported Worry and Decision Rank) indicate that this decision will tend to be the least "costly". It follows therefore that people engaged in the missing person task are more likely to ask for support if they perceive this action as a lower perceived cost than alternative options. For this reason, decreasing the perceived cost of enlisting help may encourage carers to seek assistance earlier in the incident.

7.2.2 The Independence / Safety Trade-Off

Carers and guardians have a legal and/or implied duty of care to their care recipients and a desire to ensure their safety and wellbeing. However, often this may be at odds with the care recipient's right to autonomy, as overly restrictive or intrusive measures (such as locked doors or tracking devices) could be considered a deprivation of liberty and a safeguarding issue, which falls under the Mental Capacity Act of 2005. Carers and guardians have expressed concerns about the conflict between safety and autonomy, as was evidenced both during

the in the interviews and responses to the survey about assistive technology given in 5.5.3. All of the technologies discussed in section 5.4, Survey of Existing Technologies promise higher safety, but at a cost of higher surveillance or a restriction of liberties. The safety-independence trade-off might make location tracking devices inappropriate for some cases where the perceived risk is low, or concerns about autonomy and freedoms are particularly important.

This trade-off has been noted elsewhere (Lawrence & Murray, 2010) and is a pervasive concern across the entire health and care sector. Insufficient resources and expertise can often lead to an overly cautious approach, which focuses on reducing risk, rather than promoting independence. If preventive measures are decided upon the basis of safety, these should always be made in the person's best interests and the least restrictive option must be preferred. Technology developers must take into account this inherent conflict when attempting to suggest interventions, as overly restrictive or intrusive measures are not only an infringement of personal liberties, but may not be viewed favourably by the care community as a whole.

7.2.3 Reluctance to "Escalate"

Study 1 and Study 2 described in this thesis both highlight the anxiety that carers feel when enlisting help. Carers will typically enlist the help of friends or colleagues before contacting management and eventually informing the police. Each of these communications can be seen to represent an escalation in the incident, as carers and guardians will usually contact the person with lowest perceived authority first. It could be suggested that carers weigh up the associated costs of an action with the likelihood of that action resulting in finding a positive outcome, compared to that of other potential actions.

These perceived costs of action may involve associated time costs that could be diverted into other activities, but importantly these costs also include a wide range of less tangible factors; such as concern of failure in one's duties as a carer and the embarrassment of overreacting. Figure 4.8 Self-Reported Worry and Decision Rank, also suggests that there is a perceived cost of action and people conducting absenteeism search are willing to make choices with a higher perceived cost if they are more worried. This suggests that as people become

more worried, the also become less loss averse and are more likely to engage in activities with higher associated costs (like getting in a car and driving around the area, or calling the police). One way of interpreting this finding is that those conducting informal missing person searches intuitively estimate the likely "return on investment", in order to decide on an appropriate course of action. In circumstances which are considered to be of particularly high risk individuals are willing to pay a higher 'price', and are therefore less loss adverse than in situations where the risk is perceived as lower. This it at odds with other work within the decision-making field, which suggests that people are more likely to be prone to certain biases (such as loss-aversion) in more emotionally stressful situations (Smith & Kida, 1991). However, it could be argued that people involved in these incidents are still prone to undue loss aversion, but that the level of perceived risk greatly outweighs the increased influence of emotions upon decision-making. It could also be the case that people involved in incidents of far greater risk are prone to a variety of other decision-making biases, which and unduly affect search outcomes but are nevertheless hard to observe.

It is difficult to state with certainty whether those involved in incidents with higher perceived risk are more or less prone to 'irrational' decision-making, as the data here suggests that those who are more worried about the missing person are also those more likely to engage in actions with higher perceived costs, which seems an entirely appropriate response, prima facie. Moreover, it is difficult to identify "decision-making biases" in a manner so often described by the behavioural economists' laboratory studies (e.g. D. Kahneman & A. Tversky, 1979; Thaler et al., 1997; van den Bos et al., 2009), in complex real world environments. Real incidents; unlike artificial gambling tasks, often have no obvious solutions and individuals are rarely presented with discretised choices, but rather, individuals must generate their own solutions based upon impartial (and often imperfect) knowledge. Even with a full accounting of the salient facts after an incident, it is still difficult to determine whether a particular decision was the most appropriate course of action; even if that course of action led to a favourable outcome. For example, the expected return on a lottery ticket is often orders of magnitude less than the cost; meaning that lottery tickets are not "fair bets", even if an individual wins the lottery, they took a wager with a

lower expected return than the cost of the ticket, meaning that their actions were (strictly speaking) irrational. Likewise, positive outcomes in missing incidents do not necessarily entail appropriate decision-making, nor negative outcomes poor decision-making.

Consequently, it is difficult to evaluate the appropriateness of various causes of action based upon the data elicited from the three studies described in this thesis, even when the incident outcomes are known. This is because it cannot be determined whether any particular decision was itself erroneous or the result of maladaptive biases in the absence of any counterfactual yardstick by which to evaluate the outcomes of alternative choices. All that we can say with certainty is that higher perceived risk is related to fewer choices being made before the police are contacted and that the perceived cost of escalation may cause people to delay seeking assistance in a timely manner. As we have already seen, some familial and informal carers of those living with dementia wait many days before contacting the police, which will substantially increase the risk of death or injury (R. J. Koester & Stooksbury, 1995).

Those wishing to develop interventions and assistance for Missing Incidents should consider that lowering this perceived cost of action would encourage escalation and in some cases, which would encourage people to contact the authorities in a timely manner.

7.2.4 The Effects of Antecedent Factors on Search Strategy

Study 2 used a natural experimental design in order to determine the effects of carer-caree relationships on search choices. The results indicate that the carers of adults will typically exhaust more potential options before calling the police than the carers of children, this is an intuitive finding which is in concurrence with other work on the subject. Mobility and care recipient dependence were also key factors in predicting the search strategy conducted by care givers, though gender did not have a significant influence. Unsurprisingly those participants who reported their care recipient as having a higher level of dependence typically made many more choices before contacting the police. Similarly, those participants who reported their care recipients as having higher levels of mobility also took longer than those participants who cared for people

with lower mobility. However, this was only the case when parents and carers were analysed separately, as the carers of children typically contact the police sooner, but children are likely to have higher mobility. Whilst these results are unremarkable, the work here represents an important an important step in developing an evidence-based approach to understanding these incidents. Using similar methods, it would be possible to identify the influence of other, as yet unquantified antecedent factors which impact upon the decisions made by carers in responses to Missing Incidents. Further, whilst a similar model was discussed in chapter 2 (see Figure 2.3 Missing Person Conceptual Model), this model lacked the data which would allow to quantifiable differences to be understood owing to various antecedent factors. The work described here is based upon the aggregate findings of 272 participants and allows these factors to be understood quantitatively, thus allowing for a greater understanding of the specific effects of each factor. A more comprehensive understanding could be developed by both; increasing the sample size of similar studies, or identifying other factors which may impact search strategy (such as the specific relationship between the carer and the person at risk, the history of similar behaviour, and so on). These findings could be used by technology developers, policy makers and local authorities to gain a more comprehensive understanding of activities before police contact.

7.2.5 Communication and Presentation of Information

The importance of communication within missing incidents cannot be understated. Communication happens at many levels during all stages of Missing Incidents, from the initial communication between family members, contacting the police, and communications from the police to search and rescue teams. Therefore, any possible technological intervention needs to account for the fact that communication as an integral part of Missing Incidents, and build this in to the design. In chapter 3, Search and Rescue Experts, as well as familial and professional carers all mention the importance of communication for co-ordinating activities, and in the case of carers, for providing emotional support and reassurance. Communication was also shown to be important in study 2, as the majority of people enlisted the help of a friend or colleague early on the missing incident. However, as we have seen from study 3, additional channels

of communication did not always lead to better search performance, or indeed a greater knowledge of the incident itself. Study 3 demonstrated that whilst the presentation of additional visual information did lead to an increase in participants' perception of their own situation awareness, it did not lead to objectively better situation awareness of their teammates locations, nor was it shown to increase performance. As was indicated by participants during interviews, it may be the case that additional visual information is overly distracting and detracts attention away from the very visual act of searching. Such a finding is in concurrence with Wickens' Multiple Resource Model (Wickens, 2008), which suggests performance may decrease if two tasks are sharing the same types of cognitive resources. Whilst many participants were in favour of additional visual information, and those who did not receive the "shared visual map", suggested solutions which were remarkably similar, this does not mean that additional visual information will always be a benefit. Conversely, those participants who received a shared audio channel performed significantly better on an objective assessment of their situation awareness, though there was no difference in their subjective assessment of their knowledge. It might be the case that when presented with a shared audio channel, participants had to mentally transform the words they heard in to geo-spatial co-ordinates and this deeper level of semantic processing led to far better retention (Eysenck & Eysenck, 1979). On the other hand, when participants could see where their team mates were on the shared visual map, there is less need for deep semantic processing or the need to retain that information. However; it remains unclear from the experiment whether participants with a shared audio channel had better knowledge ***during*** the search task, or whether they simply had better knowledge retention due to a deeper level of semantic processing.

Norman distinguishes between 'Knowledge in the Head' and 'Knowledge in the World'; where the former refers to learned rules, known declarative facts and accepted norms, whereas the latter refers to knowledge which can be derived from information in the world, such as labels, physical design constraints, etc. (Donald A. Norman, 2002). In conditions where participants were visually

presented with the locations of their teammates, much of the knowledge of the task was stored "in the world", and as Norman points out:

"Whenever knowledge needed to do a task is readily available in the world, the need for us to learn it diminishes" (Donald A. Norman, 2002, p. 77).

The fact that those who were presented with visual information did not perform significantly better in a test of task recall does not necessarily entail that those participants were at a disadvantage. The converse might in fact be true. Short term memory is said to have a limited capacity (Miller, 1956) and attentional resources are also considered to be finite (Kahneman, 1973). Participants who were not presented with a visual display of teammates' past and present locations may have needed to devote more cognitive resources to the task of understanding teammates' positions than those who were. Subsequently, if the cognitive resources required for this task, were similar to the cognitive resources required for other aspects of the search activity, this may have had a negative impact on their performance (Wickens, 1979). By allowing aspects of task knowledge to be 'outsourced' to an external device, it may be the case that participants can focus more of their attention to other task aspects, such as planning or the physical act of searching. Indeed, the famous 20th Century Philosopher A. Whitehead once argued;

"Civilization advances by extending the number of important operations which we can perform without thinking of them" (Whitehead, 2017, p. 66).

Whilst participants in study 3 generally found additional means of communication beneficial, some discussed the possibility of additional planning tools to further increase the effectiveness of search. Whilst it is clear that solutions intended to help coordinate small teams of searchers should focus on communication methods, that does not necessarily mean that additional channels of communication always result in more efficient search activities, or indeed better knowledge of the situation, but instead, more research is needed to determine how additional audio and visual information can be presented to individuals in a way that does not distract from the task at hand, increases situation awareness and leads to better performance.

The technology designed and tested in chapter 6 helps to facilitate communication during missing incidents; however, much more research and development would be needed in order to make such an application viable and robust enough to be utilised in real incidents. For instance, the technology which was trialled only supports a relatively narrow aspect of the overall task, but other features which could be integrated may include networking tools in order to enlist help from relevant people, general advice about suggested actions during missing incidents, and a record of medical and location history of the care recipient. Each of these aspects would need to be independently evaluated and compliant with various aspects of legislation, including GDPR requirements for data handling.

7.3 Legal and Ethical Considerations of Assistive Technologies

7.3.1 Capacity

Capacity is the ability to evaluate the pros and cons of a decision and to be able to communicate that choice. Mental capacity is a legally understood term, referred to in the Mental Capacity act of 2015 as the ability to make one's own decisions. In order to have capacity, an individual must be able to understand, communicate, use and weight the relevant information of a particular decision and have a grasp of the likely consequences of those decisions. The Mental Capacity act does allow restraint and restrictions to be used but only if it can be shown that they are in a person's best interests. Extra Safeguards may be required if the restrictions could be seen as depriving a person of their liberty. Judgements of this kind should made by multi-disciplinary teams or an independent mental capacity advocate (IMCA).

The legislation specifically mentions constant supervision whilst out and locking people in their homes. As mentioned in chapter 5, using technological tracking interventions without consent may be in breach of the Mental Capacity Act, as well as Article 5 of the Human Rights Act and should not be carried out by individuals without the proper applications and procedures. Devices that monitor and record the location of individuals without consent are legally problematic and sometimes ethically dubious.

Certain cognitive and neuro-degenerative disorders (such as dementia) may effect individuals more at certain times than others and the ability to make informed choices is often context dependent. A person may for example be deemed to have capacity at some times, or regarding some choices, but not others. Additionally, medication may also affect a person's cognitive abilities, and in turn their capacity. The concept that a person can be capable of making informed decisions at some times, but not as others, is known as 'fluctuating capacity'.

It is debated whether children have their own capacity, because as we have already seen, "Capacity" is neither fixed nor immutable, but depends upon the ability to comprehend and communicate a particular choice dependent upon a reasoned consideration of possible outcomes. In practice, parents or guardians will usually make or inform the decisions for those under the age of eighteen, but this is not legally uncontentious. The Children's' act of 1989 acknowledges that certain decisions affect life and wellbeing more than others; and that in some cases parents have the right to overrule the decisions of their children, but not in others. At 16 a young person can be presumed to have the capacity to consent and a young person under 16 may have the capacity to consent depending on their maturity and ability to understand what is involved.

Capacity is often confused with the legally understood term "power of attorney", but the two are distinct. Power of Attorney is a legal document which allows somebody to make decisions on another person's behalf. Ordinary power of Attorney allows somebody to make decisions on a person's behalf, provided that person is still deemed to have capacity, conversely, lasting power of attorney comes into effect if a person loses their mental capacity.

It should also be understood that capacity (under the law) is not synonymous with the philosophical concept of autonomy, though it has been suggested that the Mental Capacity Act makes this assumption (Herring & Wall, 2015). In order for a person to be considered to act autonomously, they must have both the cognitive capacity to evaluate likely outcomes, but also the affective ability to attribute value to that outcome. It has been argued by Herring and Wall (2015) that the current legislation permits those who might not have autonomy

to be deemed to have capacity and conversely, those who have autonomy might not be deemed to have capacity. Therefore, wider considerations of autonomy need to be taken into account to ensure as rigid adherence to the current legislation might be too narrow in scope to ensure a person's right to autonomy is preserved.

Acknowledging these legal definitions and frameworks is crucial to developing appropriate assistive technologies for persons considered at risk of becoming missing, as overly intrusive surveillance technology may be an infringement of a person's legal rights to autonomy and liberty. Surveillance and tracking technologies therefore, may be appropriate in some cases where the measures introduced are deemed to be proportionate to the risk, but certainly should not be implemented unthinkingly or where the intrusions are not considered to be proportionate. The technology which was trialled in study 3, is less subject to the concerns of the restriction of autonomy as it does not depend upon potentially intrusive surveillance methods, but instead seeks to equip carers and guardians with the communication tools they need to co-ordinate an effective response once sufficient risk has been established. Whilst it is beyond doubt that location technologies may be appropriate for some people with care and support needs, the technology developed as part of this research can be used in conjunction with other interventions or in its own right, with fewer concerns about restricting autonomy by overly intrusive surveillance methods.

7.3.2 Data and Integrated Communication Systems

An additional legal and ethical concern about the use of assistive technologies for at risk groups is the handling of personal and potentially sensitive data. This legal requirement should be of central concern to those wishing to develop technological solutions which store personal data (including, but not limited to, location data, age, name, etc.). Various regulations in the UK determine how data can and cannot be used, as well as who has the right to access it and where permission must be obtained. The Data Protection Act (2018) is a recent extension of the Data Protection Act of 1998 and an implementation of the EU directive known as GDPR. It stipulates various safeguards when storing or handling personal data, including a strengthening of the need for explicit consent in an easily accessible form, and as we have seen, issues surrounding

the consent of children and those with cognitive impairment are not always straight forward. Data subjects must also be granted rights to access any data which is stored about them, and have a right to remove their data under certain circumstances. Another important consideration in the development of such technologies is the principle of "Privacy by Design", this article stipulates that those wishing to build data storage systems are required to include data protection from the onset of system design, rather than as an addition to existing systems. Additionally, data controllers must only hold and process data deemed absolutely necessary for the competition of its duties and limit access to personal data to only those who require it for processing. Technology developers, carers and family members must take into account the necessary ethical and legal safeguards when designing, implementing and using systems which store and process personal data; particularly if data is being stored about individuals who are deemed to lack capacity, or who do not have their own power of attorney. Great care must be taken when attempting to develop technological solutions, even if their use is intended to be in the best interests of the user. Technology developers, or those wishing to use technology to monitor a family member should always take into account the right to autonomy and ensure that data storage and processing are kept to a minimum.

7.4 RECOMMENDATIONS

In light of the findings presented in this thesis, several evidence-based recommendations have been devised which may be of use to technology developers, policy-makers and other stakeholders to improve the outcomes of Missing Incidents and to reduce carer burden. These recommendations are made on the basis of how people are likely to behave during missing incidents including a consideration of the specific decision-making sequences and attitudes elicited from target populations. Whilst there may be other information provided in this thesis that may be of use to policy-makers and technology developers, it is believed that the following recommendations are the most strongly supported by the data.

1. **Facilitate an effective early response to Missing incidents, by co-ordinating small teams of local responders.**

Carers and guardians will often enlist the help of friends or colleagues almost immediately after discovering an absence. Assistance in this way serves two distinct functions; firstly, friends and colleagues can help with the search itself, by covering a larger area. Secondly, friends and colleagues provide emotional support and reassurance to carers and guardians during missing incidents. The carers of at risk people experience a high level of anxiety during missing incidents and are often consumed by self-doubt. Emotional reassurance and material assistance during the early stages of missing person search may reduce the stress faced by carers. Many of those who care for at risk people are often reluctant to 'escalate' the situation by enlisting the help of friends, family, colleagues or appropriate authorities for fear of being seen as failing in their duty of care. It is imperative therefore, that any alert system or initial method of communication between local responders should be seamless, so as to reduce the perceived cost of escalation.

2. **Promote the rapid exchange of reliable information about the missing person and current incident between all involved parties.**
   During Missing Incidents, there is a need for reliable information to be exchanged between carers, and their support networks, as well as local police, neighbourhood watch organisations and search and rescue agencies. However, much of this information exchange occurs in a largely ad hoc fashion, which may introduce inconsistencies or omissions. Carers may become increasingly agitated when having to repeat information to multiple relevant third parties, further contributing to anxiety, stress and the reluctance to contact relevant authorities in a timely manner. Streamlining this information exchange has the potential to reduce carer stress and increase the reliability of crucial information. One method of facilitating the rapid exchange of reliable information may be to create digital profiles for people at risk, detailing their likely behaviours, medication and address. If these profiles are created ahead of time, information exchange during the incident itself may be more accurate and less time-consuming than it is currently.

3. **Minimise the visual demand of any advice or instructions delivered via technology during any search task.**

   In the artificial search task described in chapter 6, participants were given mobile phones with bespoke applications in order to assess the influence of additional information on the search task. Whilst additional visual information increased participants' subjective rating of their situation awareness, it did not lead to better search performance, nor significantly better awareness of the situation. A few participants in the "high visual" conditions said that they felt distracted from the search task by the visual information being displayed on the phone. Whilst it seems intuitive to present participants with spatial information in a visual format, there is a concern that the visual demands of this information exchange may hinder the search task; which is also predominantly visual.

4. **Any device intended to be worn by a person at risk, should provide additional functions useful to the wearer which are separate from the "assistive" aspects of the technology.**

   Many currently available devices intended to help manage and/or mitigate missing incidents are purpose-built and as such provide no additional functionality for the user, this has the potential to be seen as stigmatising by people at risk and their carers and thus may reduce both compliance and enjoyment. Conversely, even the simple functionality of a watch gives people at risk a reason to wear an assistive device. Despite the fact that over 65s are one of the demographics least likely to be familiar with technology, technology literacy amongst this demographic is growing and likely to further increase as those currently reaching retirement will be more likely to have used "smart" technology than those currently already in retirement. Other "at risk" groups, such as teenagers are among the highest demographic of mobile phone users and therefore already carry devices fitted with tracking technology and communication tools. Devices which provide useful features for the user are likely to lead to higher rates of compliance and less perceived stigma.

7.4.1 Evidence for Design Recommendations

Table 7.1 Evidence for Design Recommendations demonstrates the evidence presented in this thesis which formed the basis of each recommendation. Each recommendation is numbered, along with the particular findings from this research which supports the suggestion.

Table 7.1 Evidence for Design Recommendations

	Chapter	Evidence
1	2	Statistical evidence suggests that the mortality rate of people living with dementia who become lost significantly increases in the absence of an effective early response. Expert testimony suggests that the likelihood of finding missing people diminishes over time as the area in which a missing person could travel increases exponentially.
	3	Carers and guardians often enlist the help of friends or colleagues almost immediately after discovering an absence, but do so in a non-systematic way.
	3	Most carers and parents often contact friends, family or colleagues very shortly after discovering a person is absent.
2	3	Search and Rescue volunteers spend a great deal of time ascertaining the accuracy and reliability of information about missing people.
	3	Carers and guardians are often frustrated that they have to repeat information to multiple people, and their high levels of stress may result in inaccuracies or omissions of important information.
	4	Many carers and parents will seek help early in the incident, facilitating communication may help to increase the accuracy of information exchange and reduce stress.
	6	Participants in conditions without many-to-many audio communication and those lacking comprehensive mapping information about the current incident commented that additional channels of communication would have assisted them in their task.
3	6	Whilst additional spatial information about the search task presented visually led to an increase in participant's subjective rating of their own situation awareness, it did not lead to a significant increase in their knowledge of their teammates positions (though a many-to-many audio channel did). In addition, performance for those in the high visual

		condition tended to be worse than those in the low visual condition (although this difference was not significant). Participants in the "high visual" condition, also reported being distracted by the information on their phones rather than attending to the search task. Wickens' "Multiple Resources" model of workload would also suggest that performance of a task would decrease rapidly if a secondary task also requires the similar cognitive resources.
4	5	The smart watch and mobile phone were the preferred devices of carers and guardians for use by a person with care and support needs. Reasons given for this preference, included familiarity with these devices and functionality. In other words; 'A reason to wear it'.

7.5 DISCUSSION OF THE APPROACH

7.5.1 Description, Prediction, Intervention

The structure of this thesis was based on the research paradigm of "Description, Prediction, Intervention", where each stage built upon the findings of the last. A description of typical missing incidents from the perspectives of 'searchers' was constructed via a review of relevant statistical and academic research into Missing Incidents, and an analysis of first hand incident reports. Eliciting a list of events and decisions which occurred during these incidents allowed for the development of the protocol employed in the second study. This presented participants with scenarios which resembled "typical" missing incidents and allowed them to choose various actions normally made during these incidents. In order to create a predictive model of decision-making an behaviour a large dataset was required; to this end, the protocol for the second study took the form of an interactive internet survey (to the author's knowledge, the first of its kind). Using Markov modelling, probabilities of likely actions were able to be determined. In addition, other factors were identified which were likely to affect incident strategies, which served as the independent variables in the natural experiment. In chapter 4, a Markov model was presented (Figure 4.2 Markov Model of Searcher Behaviour) which showed the likelihood of each decision preceding another, and the effect of independent variables on the total decisions made before contacting the police was also examined. However, the data elicited from this study also allows for multiple predictive models to be

generated with relative ease. Multiple models can be generated from the data which consider independent variables respectively; for example, separate predictive models can be generated for the carers of adults and children, or for those who look after people with relatively high mobility and relatively low mobility. Due to considerations of brevity, these models were not included in the thesis, but may be of use to those wishing to understand the differences between these groups. One of the findings from this predictive model of searcher behaviour is that most people will enlist help very early on in the incident, which led to the development of a technological intervention designed to help small teams of people communicate effectively during a search task. Various aspects of this intervention were separated out and tested in an experiment in a naturally occurring environment and the results from the experiment in conjunction with participant's comments about the technological intervention, allowed for the development of design recommendations, which constitute the "intervention" aspect of this thesis. Whilst the general understanding of "Description, Prediction, Control" given in Hale (2011) differs slightly from what has been presented here[4], it nevertheless remains a useful framework for developing solutions to little understood problems. This approach is likely to be applicable to other under-researched areas in which practical real-world interventions are desperately needed.

7.5.2 Incident Analysis Techniques

This thesis drew upon Incident Analysis techniques first developed by (Flanagan, 1954) and latter extended by Gary A Klein et al. (1989). Klein is particularly interested in eliciting the so-called "tacit-knowledge" of experts and the Critical Decision Method is an approach which seeks to understand how

[4] "Control" in Hale's understanding may be taken to mean that the casual relationship between two factors is known and controllable, whereas here it is taken to mean that once predictive models are known, intervention becomes possible, whether or not the exact causal relationship between factors has been established.

experts make rapid and effective decisions by asking them to give retrospective accounts of incidents which were on the edge of their abilities. Study 1 in this thesis utilised methods developed by Klein; in one case to understand expert decision-making, but in another, to shed insight on commonalities between similar incidents of non-experts. Whilst the goals of Klein's research are often about the development of training manuals and expert systems based upon a practical understanding of solutions to real-world domain specific problems, the same methods have been used in this thesis in order to understand typical responses to a particular type of incident. This approach seeks to derive a comprehensive description of typical incidents, rather than normative rules for best practice. In some respects, the structure of the Critical Decision Method interviews lends itself more to the approach taken in this thesis, because as we have seen, experts can be affected by the same decision-making biases and heuristics as the rest of the population, and whilst it is almost a tautology that experts make better decisions in their respective fields, that does not mean they are immune to error. Using the Critical Decision Method to describe current behaviour rests upon far fewer assumptions than using the same approach to derive prescriptive rules, such as those found in training documents or expert systems and for this reason, there is a good case for using this method in non-expert populations.

This thesis also built upon the Critical Decision Method in other ways. Wong and Blandford (2004) demonstrated how Emergent Thematic Analysis could be used to transcripts elicited from the Critical Decision Method in order to gain greater insight whilst preserving the exploratory nature of the approach. The work described here also uses thematic analysis, but analysis conducted across two thematic dimensions; the critical decisions themselves, and "global themes" which pervade across incidents. Braun and Clarke (2006), suggest that thematic categories should be exclusive (thematic categories should not overlap) and exhaustive (thematic categories should describe the entire dataset), but deciding upon which thematic categories best describe the data is open to interpretation on the part of the researcher. In the approach taken here, each dimension was (respectively) exhaustive and contained exclusive thematic categories. A two-staged approach allowed for separate aspects of the incident to be analysed

independently, but further, using the cross referencing tools within N-Vivo, it was also possible to see how aspects from these two dimensions related to each other. Chapter 3 described how this could be done with the "Critical Decisions" of the incidents with the "Global Themes", this made it possible to better understand the types of concerns and cognitive processes at each stage of the incident.

Study 1 involved the development of individual timelines based on incident reports of involved parties. Commonalities were identified across incidents for both groups interviewed and two 'generalised' timelines were developed. These generalised timelines were based upon action choices which participants identified during the interviews as "Critical Decisions", and serve as a preliminary descriptive sketch of likely stages of missing incidents from the perspectives of those conducting missing person searches. Finally, in Study 2, the structure of the study design was influenced heavily by the Critical Decision Method, but conducted prospectively instead of respectively. "Critical Decisions" were identified from Study 1, and then used as the fixed choices of a vignette style survey for Study 2, and similarly to the Critical Decision Method, participants were asked probing questions at each of these junctures. This method represents a new approach to conducting incident analysis and allows for large datasets to be generated without the associated time-costs usually associated with the Critical Decision Method.

7.5.3 Modelling Hard to Observe Behaviours

A large part of this thesis was dedicated to modelling difficult to observe behaviours in emergency situations; consequently, many of the methods employed and developed in this thesis may be applicable to other important domains (for example, emergency situations such as fires, earthquakes and extreme weather events). In particular, Study 2 demonstrates how predictive models can be generated from large amounts of data about difficult to observe incidents. The basic method for conducting such a procedure is outlined in Figure 4.1 The Structure of Interactive Vignettes; which is intentionally domain neutral and applicable to other hard to observe behaviours or situations. Once the data is collected, two ways of analysing and modelling decision-making have been suggested. One of these models (Figure 4.2) relied on simple-state

transitional probabilities (Markov Models) to determine likely decision sequences, whereas the other (Figure 4.3) was constructed from standardised residuals. It was suggested in Chapter 4 that the Markov Model was the most appropriate model to understand the data from study 2 as the desired outcome was in determining likely decision sequences (rather than understanding the probability increases of on event given another). However, if this approach was adopted by other studies, they may have different aims. If one wanted to determine causal relationships between two events, the standardised residual model would be far more appropriate. Additionally, one may wish to model the effects of external events (that is, events not caused directly by the participant) on decision choice. Using emergency fire evacuations, as an illustrative example, it would be possible to set up a similar experimental protocol in order to determine the effects of hearing a fire alarm sound on decision choice. When participants choose between a fixed series of choices, rather than deterministically assigning them to the next stage of the vignette based entirely on the previous choice, participants could be assigned to one of multiple conditions entirely at random. An analysis using standardised residuals would then be able to determine the causal relationship (that is, the difference between observed and expected outcomes) between hearing the fire alarm and subsequent choice and by doing so, model the effect that hearing a fire alarm had on that choice. The choice of which model to use for the analysis of the type of data collected during Study 2 would depend upon the design of the study protocol and the aims of the research. This type of analysis implements a similar approach to that taken by Lawson (2011), but rather than data collection from interviews or virtual environments, data was collected via an online survey. An obvious advantage of such an approach is that it is far easier to collate data from a larger population with relatively little scaling-up costs and far less associated time-costs than conducting interviews. This in turn allows for an investigation of differences between populations and greater statistical power and could be applicable to a wide variety of domains.

The approach taken here uses retrospective accounts to identify likely scenarios and “critical decisions”, which are then used to form the basis of a scenario and possible choices. This approach can yield rich qualitative data, as well as

considerable quantitative data which can be used as the basis of predictive models. Using digital online distribution methods, scenarios can be both representative of real incidents, yet also personalised to evoke specific issues that may influence participants decisions.

As Markov models become more accurate, they not only shed light on the behaviours of decision-making within missing person search, but can also be used as outputs in their own right. Using validated predictive models of behaviour help policy-makers refine their procedures for dealing with these incidents, and help missing persons institutions and technology developers to identify commonalities and typical sequences of activity.

7.5.4 Real-World Search Tasks

The final study presented in this thesis involved teams of individuals conducting "foraging-like" tasks in a naturally occurring outdoor environment. Whilst there have been various studies which investigate visual search behaviours in controlled laboratory settings (Duncan & Humphreys, 1989; Kiss et al., 2007; Wolfe, 1994) and other studies which seek to model foraging behaviour in virtual environments (Goldstone & Ashpole, 2004; Hills et al., 2008), quantitative investigations of human spatial movements in time remain elusive (Brockmann, Hufnagel, & Geisel, 2006). Various studies have sought to understand human movement patterns over a far longer time scale than the period immediately following a missing incident, (Brockmann et al., 2006; González, Hidalgo, & Barabási, 2008) though, these are not investigations into goal directed search tasks and shed little light on the expected behaviours of individuals conducting missing person searches. Study 3, presented in this thesis aims at better understanding how various communicational factors affect the foraging success of small teams with a common goal. Whilst certainly not an exhaustive investigation of human foraging strategy, this "treasure hunt" experimental approach arguably has far higher validity than either the traditional "visual search" paradigm, or conventional foraging research, as it investigated how humans actually make spatial-navigation decisions in an environment similar to one in which they may find themselves. Investigations into foraging and search behaviours which take place in simulated (as opposed to spatial) environments not only lack a certain element of face-validity, but

"virtual" searches which do not require movement generate different neurological firing patterns in the hippocampal place cells in test animals than navigation tasks which also involve movement (Chen, King, Burgess, & O'Keefe, 2013) and subsequently, experiments which study movements within virtual environments only may have limited relevance in describing spatial search behaviours. Whilst testing theories related to Area-Restricted Search (such as Lévy flight and) were beyond the scope of this thesis, it would certainly be possible to develop spatial foraging tasks combined with active tracking to evaluate the movement patterns of humans conducting foraging tasks in naturally occurring environments in order to test various theories relating to spatial search.

7.6 THEORETICAL ISSUES

7.6.1 A New Paradigm for Understanding Missing Incidents

Despite there being numerous pieces of research investigating missing incidents from many separate academic disciplines, the behaviour of carers, guardians and parents during the early stages of missing incidents is noticeably under-researched. This thesis began by bringing together statistical reports of missing incidents, qualitative studies into the context in which missing incidents occur and a variety of research paradigms to better understand behaviour, cognition and decision-making during these incidents. Also discussed were two models relevant to understanding missing incidents involving people who could be considered vulnerable. Figure 2.3 Missing Person Conceptual Model highlights the importance of understanding how various antecedent factors contribute to missing incidents and Figure 2.4 Pearlin's stress-process model of stress in carers indicates how various factors influence outcomes associated with the provision of care. The work described in this thesis, aimed to build upon these understandings within the context of missing incidents, and not only describe the antecedent factors (such as in Figure 2.2), but further identify the extent that specific isolated factors influenced search strategy. The third chapter of this thesis identified seven types of decisions typically made by carers during missing incidents, and the following chapter sought to determine the likelihood and probably sequence of each decision. Additionally, the influence of several

antecedent factors (such as, level of care recipient mobility and independence) on search strategy were investigated and a hypothesis regarding the "least-costly" necessary action was proposed based on the data (see Figure 4.8 Self-Reported Worry and Decision Rank). This work goes some way to quantify the influence of various background factors on search strategy, but should not be considered an exhaustive list of those factors. The Carer/ Care recipient relationship, for example, may be another factor which influences search strategy during missing incidents. It may also be the case that certain unexplored antecedent factors influence search strategy in a way which were not uncovered by either the interviews or the vignette study, this remains a question for future work. Nevertheless, it is hoped that the approach described in this thesis and the identification of the seven decisions made by carers; and the factors which influence those decisions, represents an important step in understanding these incidents and may be of use to policy-makers, technology developers and other stake-holders, as well as researchers working in the area of Missing Incidents.

7.6.2 Decision-Making in Complex, Real-World Situations

Whilst many studies investigating decision-making biases are conducted under controlled laboratory conditions, using contrived "gambling" problems (Preston, Buchanan, Stansfield, & Bechara, 2007; Smith & Kida, 1991; Wemm & Wulfert, 2017). Relatively little work attempts to investigate how these observed biases and heuristics might manifest themselves in complex real-world environments, such as emergency situations. Typically, research which investigates decision-making in real-world environments, does not attempt to determine whether decisions are "rational" courses of action, but instead seeks to determine how sufficing courses of action were made quickly, with only partial information (G.A. Klein et al., 1988).

An implicit goal of the work in this thesis was to discover whether such biases and heuristics would manifest themselves during missing incidents, with the intention that these biases could be overcome, and in turn result in better outcomes for missing people and reduced emotional anxiety for those conducing searches. However, Missing Incidents are vastly complex and situation dependent and therefore it often it is difficult to determine the "rational" course of action in order to ascertain whether any particular decision

differed from this expected ideal. Unlike the artificial wagers often used to describe cognitive biases within the field now known as “Behavioural Economics”, (Daniel Kahneman & Amos Tversky, 1979; Thaler et al., 1997; Tversky & Kahneman, 1973), decision-making in the real-world does not have easily calculated expected utility values, returns on investment, or indeed, even strict delineations of possible choices. Furthermore, even if it were possible to fully calculate these values, the specific situations in which Missing Incidents occur vary substantially, and what may be considered a “rational” choice in one situation, may not be so rational in another. It may indeed be possible to highlight specific examples of cognitive biases which manifest themselves within Missing Incidents (such as the sunk-cost fallacy, the endowment principle, and the availability heuristic), but it is unlikely that such findings will ever be able to determine the “rational” course of action that carers and guardians should follow in a given situation due to the high level of individual differences, personal preferences and behavioural histories of the missing people themselves. If anything, the work described in this thesis demonstrates that those conducting missing person searches largely make sensible decisions, despite the high levels of stress and emotional arousal during these incidents. Figure 4.7 First Reported Worry by Total Choices indicates that people are more likely to call the police the more worried they are about the missing person; and the level of worry, correlates to the level of mobility and independence of the missing person (Figure 4.5, Figure 4.6). Figure 4.8 Self-Reported Worry and Decision Rank also demonstrates that people who are more worried about the missing person, will engage in activities which are likely to have a higher perceived cost, which may indicate that actions are broadly proportionate to the perceived risk.

The approach taken in this thesis demonstrates how successive levels of explanation (description, prediction, control) can build upon each other and provides a framework for other decision-making research and technology development in hard to observe, real world environments.

7.7 CHAPTER SUMMARY

This chapter provided a discussion of the central findings of the research; highlighting numerous issues which face those carers and parents conducting missing person searches as well as providing a series of key design recommendations for those wishing to develop solutions. The general approach of the thesis was discussed as well as a discussion of the novel methodological contributions of the studies. Finally, the theoretical contributions of the research were discussed. The following chapter will demonstrate how this work addresses the research question and aims, as well as the limitations of the thesis and areas for further work, before concluding with a summary of the work conducted.

8 CONCLUSION

8.1 REVIEW OF AIMS

The aims of the research as identified in Chapter 1 will be highlighted, in order to demonstrate how the work in this thesis addresses them.

1. **To establish a descriptive framework for understanding Missing Incidents, based upon a synthesis of relevant existing research and an investigation into "real-life" missing person searches. (Description)**

In Chapter 2 of this thesis, the public, social and personal costs of Missing Incidents were discussed, with special consideration given to at risk groups; including people living with Dementia. A Human Factors approach to understanding the problem was put forward with reference to the "Onion" model; which focuses primarily on people, technology and artefacts, attempting to achieve goals and situated with a wider physical and social context. Various frameworks were discussed which describe how humans navigate, search and make decisions in time-critical environments under stress. A methodology designed for investigating decision-making in naturally occurring environments based upon difficult incidents, known as the "Critical Decision Method", was used to discover the how missing incidents unfold, and to examine the factors which effect decision making under these conditions. Numerous models have been discussed and developed (e.g. Figure 3.3 Decision Sequence Timeline of Carers, Figure 3.5 Reactive Search Strategies of Carers, Figure 4.3 Standardised Residual Model of Searcher Behaviour). This thesis, draws together numerous disparate areas of research and together with original empirical findings, provides a framework for understanding missing incidents.

2. **To form the basis of a predictive model of human behaviour during missing person search, including the identification of factors which affect carer search strategies. (Prediction)**

Chapter 4 of this thesis built upon previous, more qualitative, descriptive findings in order to ideate a fictional, yet (seemingly typical) scenario to

discover what parents and carers would do if a person they cared for became missing. A study was conducted which included 272 participants, whose responses to the scenario were recorded. Numerous factors which were thought to affect decision-making within missing person searches were identified and recorded for each participant and statistical tests investigated whether there were significant differences between decision-making and these factors. It was discovered that independence and mobility are correlated with postponing contact with the police. Using another analytical approach, each possible stage in the scenario was modelled as a "state", and a Markov model was created. The Markov model (Figure 4.2) illustrates the likelihood of any given participant making a particular decision given their previous decision. The Markov model demonstrates likely decision sequences, and numerous such possible predictive models can be created from the dataset which indicate how different populations are likely to react to these incidents. It is possible for example, to create predictive models which use only a particular subset of the population in order to make those predictions more specific to that particular group. One might be interested in identifying if there are different strategies employed between male and female carers, or if the carers of people who are independent differ in their approach from those who look after people who are more dependent. With a large enough dataset, it would be possible to produce numerous, models which would be more specific to multiple target populations. Each of these models would have to be independently validated in order to assess their predictive performance, but subsequently, would be more likely to be accurate as they reduce the heterogeneity of the dataset from which the models are produced.

3. **To develop evidence-based recommendations and guidance for the creation of future assistive technologies designed to help with missing person search. (Intervention).**

The studies in this thesis shed insight on how people are likely to behave during missing incidents; a critical stage in identifying the user-requirements of a possible future system. Study 1 and study 2 indicate that participants will seek the assistance of a peer, early on in the incident. Surveys distributed to participants during study 2, indicate user-preferences for assistive technologies that could be used during missing incidents (Figure 5.3) and participants

indicated strong preferences for smart phone and smart watch devices. However, interviewees during study 1 and respondents in study 2 stated a concern over specialist tracking technologies and overly restrictive measures. For this reason, a prototype technological intervention was designed, developed and tested which would allow small teams to communicate effectively during the initial stages of a missing incident. This design concept does not depend upon any wearable device being worn by a person at risk and thus avoids concerns associated with intrusive surveillance. Lessons learnt during this trial, along with general findings from the thesis were used to inform a series of design guidelines for the development of assistive technologies described in chapter 7.

8.2 LIMITATIONS AND FUTURE WORK

Whilst the work described here addresses the aims of the thesis, there are a number of areas in which it could be expanded upon. For example, other stakeholders who are involved with Missing Persons could be interviewed using the methodology outlined in Study 1; these include, charity and NGO workers, local police forces and at risk people themselves. These additional perspectives would further help to elucidate how incidents unfold and could be integrated with the findings from the Study 1 in order to develop a much more holistic understanding of the different requirements and constraints of other decision-makers involved in Missing Incidents.

The interactive scenario study as described in Chapter 4, could also be extended upon in a multitude of different ways. For example, it may be possible to identify other antecedent factors which influence decision-making within Missing Person search and measure these as independent variables within the study. These might include; specific care needs, history of hard to manage behaviours and closeness of care-caree relationship. Additionally, a larger dataset may be able to identify hitherto undiscovered relationships between variables that are not significant within the current data (e.g. gender). Another way in which the study could be expanded upon is with the addition of randomised choice outcomes. For example, a particular decision (like search around the neighbourhood) could lead to one of two or more possible vignettes.

This approach would facilitate an investigation of the causal relationships between choice outcome and the next course of action. Using the standardised residual approach to analysis as demonstrated by Figure 4.3, one would be able to determine the causal effect of different decision outcomes on future decisions.

The Application tested in Study 3, was generally well received by participants, and there was evidence that additional modes of communication enhanced both participants' knowledge of the situation and their own assessment of that knowledge. However, there are some suggestions made by participants who took part in the experiment which may warrant further investigation. One such example was planning features, whereby users would be able to highlight specific areas on the map to assign to specific people. More crucially however, is the problem of low realism. Despite the fact that participants conducted the experiment in a naturally occurring environment, it is a mistake to assume that the experiment is a perfect replication of real missing incidents. The level of emotional anxiety and stress are likely to be far higher in real incidents than in an artificial experiment and this may have a substantial impact on not only the strategies employed by searchers, but may also affect their use of the application. In order to discover how this application would be used in missing incidents; it would need to be developed further to include built-in open channel audio communications, friendlists and other security features necessary for handling sensitive data. If these features were included, it could to be evaluated in a longitudinal study investigating its use in real incidents. Such a study might seek to recruit the carers of high-risk groups, over a longer period of time in order to assess how the application performs "in the wild". The feedback from these users could be used as part of an iterative or participatory design process, where users' comments and feedback are used to inform improvements on a new iteration. However; the study design and technology itself would have to overcome a multitude of ethical issues if it were to be used during missing incidents. The storage, processing and exchange of data would have to conform to current regulations; particularly as the data stored may contain sensitive data about people with care and support needs. The application would need to be robust; free from software bugs and resilient to user-error. Moreover, the

usefulness of the application would need to be made evident to all those involved and concerns over the high visual demand would need to be addressed. When developing technological interventions designed to assist in high-stakes time critical incidents, every conceivable ethical precaution should be considered. Discussions with care providers and other stakeholders may highlight additional, as yet unforeseen issues as well as indicate how such a system could be integrated with existing systems. It is crucially important that the development of such systems do not cause undue risk to those involved and that the benefits of any trial are weighed against any risks or associated costs.

8.3 CONCLUSIONS

The work in this thesis aimed to answer the research question:

> "How can technology be used to support guardians and carers during missing incidents?"

The thesis began by demonstrating why this is a question worthy of serious consideration; highlighting the personal, economic and societal costs of missing incidents. Missing incidents cause undue stress to carers and family members and present considerable risk to vulnerable people. In addition, hard to manage behaviours (such as missing incidents) are a significant contributor to the breakdown of familial care and subsequent institutionalisation; often resulting in lower quality of life and increased public cost. For these reasons, there is a pressing need for effective interventions based upon an informed understanding of human behaviour, emotion and cognition, during emergency, time-critical situations. The development and adoption of personal and mobile computing presents unique opportunities within this domain, as well as within the area of health and wellbeing more generally. However, solutions which are not informed by the actualities of human behaviour risk unexpected user-behaviour and catastrophic system failure. To this end, a series of design recommendations were developed which are based upon findings from the three studies described in this thesis. The thesis adopted a three-stage approach to addressing the central research question; with each stage building upon the knowledge and explanatory power of the last.

Various research approaches relevant to Missing Incidents were identified and discussed, with particular focus dedicated to decision-making paradigms. “Naturalistic Decision Making”, is one such framework, which can be broadly characterised as the study of decision-making in complex real-world, naturally occurring environments. The “Critical Decision Method”, is a research methodology within the Naturalistic Decision Making framework which uses retrospective accounts of incidents to discover the tacit knowledge of practitioners. Using this method, six critical decisions were identified for carers conducting missing person searches, and seven for search and rescue volunteers. In addition, several key concerns and major considerations affecting carers conducting missing incidents were observed; it was discovered that most carers will enlist the help of a family member, friend or colleague early on in the incident; both to assist with the physical act of searching, but also to provide emotional support and reassurance. Carers also discussed the competing concerns of safety with the desire to request the liberty and autonomy of the missing person.

Using this understanding, a large scale interactive scenario study was designed. Participants were presented with a fictitious scenario in which a real person that they knew became missing. Critical Decisions which were identified in the previous study served as the basis of a fixed series of choices in the scenario. The scenario study used quantitative measures (decision-choices, self-reported worry, carer mobility and independence) as well as allowing for qualitative open responses to questions. This approach allowed for a more thorough investigation and verification of the findings in Study 1, as well enabling a predictive model to be put forward and an examination of various factors which affect overall strategy. Using an online distribution method for the vignette study also allowed for a small optional survey about assistive technologies to be added included in order to assess general opinions and attitudes held by carers and other potential end-users.

In the following chapter, some of the main findings from the previous studies were discussed, in relation to the development of new technologies and a summary of currently available technologies showed the shortfalls of these solutions. A design concept was suggested which allowed for small teams of

individuals conducting missing person searches to communicate with each other via a shared visual and audio channel. This design concept was developed into an Android application, for experimental purposes. Which not only implemented the additional modes of communications, but also allowed for participants' movements to be tracked in real time whilst conducting a search task.

A third study investigated the use of this application to test the effects of various modes of communication on search performance and shared situation awareness in a naturally occurring environment. No significant differences in performance were observed in the experiment; however, teams with a shared visual channel reported a higher perceived situation awareness than those without. Conversely, those with a shared audio channel performed significantly better on a questionnaire designed to test knowledge of the incident.

The main findings of the thesis were discussed in Chapter 7 and a series of evidence-based design recommendations were put forward based upon the work in this thesis. These include; facilitating the co-ordination of teams of first responders, facilitating a rapid exchange of reliable information between relevant parties, minimising the visual demand of any device intended to help those conducting searches, making the device have a "purpose". It is hoped that these recommendations will be of benefit to those wishing to design technology for mitigating and managing missing incidents. This work represents an attempt at a systematic understanding of how missing incidents unfold, how decision-making within missing incidents can be predicted, and ultimately how technology can be used address the problem.

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APPENDIX A.1

Consent Form

A Study into Searching For Vulnerable People

This study is part of a larger project into human search behaviour for vulnerable people in order to facilitate the development of safer walking technologies. The project is funded by an EPSRC iCase PhD studentship at the University of Nottingham sponsored in part by Philips research. The aims of the study are to discover emotional states, cues and decisions made by people searching for vulnerable people. You will be asked to describe an incident in which you were searching for a vulnerable person followed by a series of probe questions about the incident in question. Finally, you will be asked a few questions about your familiarity and opinions of assistive technology. If you are unsure of anything at this stage, you have the opportunity to ask the interviewer. The interview is expected to take between half an hour and an hour, although this may vary slightly due to the differences in incident and recollection of this incident. You do not have to answer any questions if you do not want to. Please indicate if you are feeling uncomfortable with the interview and it will be stopped immediately. You have the right to have your information withdrawn from the study even after the interview has finished.

Please tick the boxes if you agree with the statements and sign at the bottom of the document to give your consent.

- ☐ I have been informed and understand the purposes of the study and acknowledge any possible associated risks.
- ☐ I have been given the opportunity to ask questions.
- ☐ I understand I can withdraw at any time without prejudice without giving a reason.
- ☐ I am aware that any information which might potentially identify me or anyone I mention will be removed from published material.
- ☐ I am aware that data collected from the study will be stored securely for seven years after any publication.
- ☐ I agree to participate in the study as outlined to me.

Print Name: _____

Signature: _____

Date: _____

APPENDIX A.2

Interview Script

Introduction/Brief

Carers:

Hello, and thank you for agreeing to participate in this study, my name is Kyle Harrington and I will be conducting the interview today. This purpose of this interview is to help identify the thought processes occur when people search for a vulnerable person and try to determine the role that emotion plays in shaping the decisions people make when engaged in search and rescue scenarios. This is part of a larger research project that is attempting to facilitate the development of safer walking technologies for vulnerable adults as part of a PhD studentship at the University of Nottingham sponsored by Philips research. The interview consists of three parts; firstly, I want you to talk me through a particular situation where the person you care for left home against advice. If this has happened a few times before, I want you to think of a situation that was partially salient, unusual, or one of the first times this happened. Next, we will plot a timeline of this event and look at the decisions you made and try to assess what led you to make these decisions and how you were feeling when you made them. Finally, the interviewer will ask you some questions about your general level of familiarity with technology. The interview is expected to take between half an hour and an hour, although this may vary from interview to interview.

Please answer as honestly as you can, do not feel you have to answer any questions that make you feel uncomfortable. You have the right to stop the interview if you wish and the right to withdraw your data from the study. The interview data will be used for research purposes only. Your identity and that of anyone else you mention will be removed from the transcript.

If you agree to the terms, and want to participate in this study then please complete this consent form.

Subject Matter Experts

Hello, and thank you for agreeing to participate in this study, my name is Kyle Harrington and I will be conducting the interview today. This purpose of this interview is to help identify the thought processes that occur when people search for a vulnerable and also try to determine the role that emotion plays in shaping these decisions people make when engaged in search and rescue scenarios. This is part of a larger research project that is attempting to facilitate the development of safer walking technologies for vulnerable adults as part of a PhD project at the University of Nottingham sponsored by Philips research. The interview consists of three main parts and afterwards, I will just ask you a few questions about how you feel about technology that might help with searching for vulnerable people; firstly, I want you to talk me through a particular situation (preferably that of searching for a vulnerable adult) that was partially salient, unusual, or where your experience and expertise was of particular benefit. With your help I will plot a timeline of this event and look at the decisions you made. The next step is that we go over the timeline again and try to identify what led you to make these decisions and how you were feeling when you made them. Finally, the interviewer will ask you some demographic questions and questions about your general level of familiarity with technology. The interview is expected to take between half an hour and an hour, although this may vary from interview to interview.

Please answer as honestly as you can, do not feel you have to answer any questions that make you feel uncomfortable. You have the right to stop the interview if you wish and the right to withdraw your data from the study. The interview data will be used for research purposes only. Your identity and that of anyone else you mention will be kept anonymous removed from the transcript. All the data from the study will be on a password protected computer and encrypted for additional security.

If you agree to the terms, and want to participate in this study then please complete this consent form.

*** Wait for consent form***

For Subject Matter Experts

So now, I want you to think of an incident that may be suitable. Ideally, this is a situation when you were searching for a vulnerable adult and one in which your expertise was of particular importance. If you have any in mind could you give me a very brief description to see if it is suitable?

(If not suitable) Is there any other incident you can think of that might be appropriate, perhaps an unusual situation or something you had not previously anticipated or encountered?

(If it is suitable) Great! Ok, so now I want you to recall the event in as much detail as you can, start at the very beginning, even a little before if you are entirely unsure when the actual event began. Although this stage is a starting point, don't feel that you need to know EVERYTHING about the event if you can't remember. Also, although I do want to know about your expertise in this area, try to stay on topic in giving a detailed account of the incident in question and not your expertise in general. I will try to remain quiet at this stage, but may ask you at some points to clarify or prompt you if I think you are straying away from the topic. In your own time, please give a detailed account of this incident.

For Informal Carers

So now, I want you to think of an incident that may be suitable. Ideally, this is a situation which you remembered the most about. If this has been a frequent occurrence, perhaps, a particularity challenging incident. Are there any incidents like this that come to mind?

Ok, so what I would like you to do is explain for me in as much detail of you can exactly what happened from your perspective. Don't worry if you can't remember all of the details but try to give an account of everything you can remember from just before you discovered the problem to this person being found. I will try not to interrupt you at this point, but I may ask a few clarifying questions or prompt you if I think you straying off topic. In your own time, please give a detailed account of this incident.

* Take notes of salient incidents, sequences of events, times and facts

* Draw a time line based on these notes and in conjunction with participant

* Identify critical decision points

* For each critical decision point, elicit information for each category (Affective State, Cues, Decision, Effect)

Useful Probes:

For discovering decision cues:

Did you identify anything from previous experience or knowledge that led you to make this, as opposed to another decision?

What led you to make this decision as opposed to another possible option?

What led you to believe that this decision was the right one to make in this situation?

For identifying emotional states:

How did you feel at this point?

Would you say that this decision was influenced even in part by emotion?

Do you feel that your emotional state helped or hindered you in coming to this decision?

For discovering the effect:

What was the overall outcome of this decision?

In hindsight, would you have made this decision again or done something different?

Would a different decision at this point have resulted in a different outcome?

Is there any chance that the effect of this decision could have been different?

For further clarifying the decision:

Could you explain for me in a little more detail, exactly what this decision was and the procedures involved in executing it?

How exactly was this done, what were the actual things you needed to do to make this happen?

(for experts) Would you say that this would be a typical response to this situation; would I for example find support for this decision in an operating manual?

Fantastic, this has been very useful and I have alot of information for my study. I thank you for sharing that with me. If you have an extra five minutes I would just like to ask you some questions about your familiarity with technology and how you feel about assistive technology that may help find vulnerable people.

Questions Relating to Technology (Allow for open and informal responses)

1. Do you own a smartphone?
2. Have you ever used a smartphone?
3. Have you ever used an application on your phone aside from phoning or texting?
4. Have you ever used assistive technology either for yourself or somebody else?
5. Do you think that you would be interested in using technology that might help with finding vulnerable people when they go missing?
6. What are your opinions about using location based tracking technology to help find vulnerable people?
7. Do you think vulnerable people (the person that you care for), would comply with wearing a tracking device such as this?

APPENDIX B.1

Decision	Inclusion Criteria and Sub-Themes	Findings	Supporting Quotes
Decide if Callout is Valid Reference Frequency 5 Sources, 40 References Principle Decision Maker(s) Incident Commander, Mountain Rescue Control Sequence Order The first decision made by Search and Rescue teams upon hearing of an incident. Most Prevalent Global Theme:	This set describes the first decision taken by a Search and Rescue association after hearing about an incident. Is the callout valid and can we make a difference, were major considerations of the on-duty supervisor or incident commander. Sub-Themes • Process of Contact (9) • Information about Missing Person Risk (20)	Interview participants often described this decision as being one of the most important. Participants described the importance of trust in the local police services and expectations of prior Police investigations. Issues relating to the of availability of teams, knowledge of missing person and the operational considerations of informing on-duty commander of the incident are also explored in the sub-themes.	"Being a voluntary service we are always very keen to help, but we do realise that if we're calling people out from work or family things there's a level of responsibility for leadership; that it's a valid search." [P1] "We decide it's a valid - we have a couple of levels of call. Urgent is literally you drop everything and go it's actually life defiantly at risk." [P1] "I had several other conversations with a chap from south Yorkshire and had another conversation with one of my deputies and it was like, 'yeah, this is probably gonna happen', if she's up there, the weather's cack, we're gonna go and look for her." [P2]

Communications with Police (13) Least Prevalent Global Theme: Clues (0)	• Expectations of Police (20) • Willingness and Availability (10)		"I personally would not select upon the nature of the call. I think if somebody said, 'it's a missing male, or a missing woman or a child', it wouldn't make a difference. If it was a child I would probably make a point of going. But I don't think that in itself would influence the decision" [P4]
Teams and Additional Resources Reference Frequency 5 Sources, 91 References Principle Decision Maker(s) Incident Commander, Police Sequence Order Typically, immediately follows "Is call out valid?"	This set describes decisions and actions taken by the incident commanders and the Police in enlisting additional teams and resources to assist in the search. Sub-Themes • SARDA & Air Support(47) • Availability (31)	The incident commander or on duty commander will usually enlist as many search and rescue teams as is possible, taking into account other resources at their disposal. These include SARDA (search and rescue dog association) and Air Support (Police and RAF helicopters). The decision of which teams and additional resources to enlist is based upon considerations of locality, geography and availability. These	"When we call out the team, the message goes to the whole team. We might call SARDA as well, in fact it's probably quite likely we would call SARDA at the same time. The search and rescue dog association. Our team hasn't got a search dog present, so the nearest one if they're available is in Buxton sort of thing, so there is a bit of travel time." [P1] "I'd rather turn a lot of people out, find 'em in two hours and bugger off back to bed, rather than have half as many out. They will be up there for 5 or 6 hours later. So, it's better for us and it's better for the missing person; doing it that way" [P2]

Most Prevalent Global Theme: Communications with Police (12) Least Prevalent Global Theme: Clues (1)	• Communications, Operations and Training (58) • Locality (28)	considerations are explored in further detail in the sub-themes pertaining to this decision.	"Because they're one of the teams that we butt upto because we butt up to Buxton team who are on that side, we butt up to them , they are on the west of us, the Derby team are to the south of us and the Woodhead team are to the north east. So we call them in first and they call in, there's the logistics of how to get there as well…" [P3]
Plan Search Area Reference Frequency 5 Sources, 89 References Principle Decision Maker(s) Incident Commander, Police Sequence Order	This set describes considerations made for the total area to be searched by teams and additional resources. It is distinct but related from the 'Sections and Sectors' decisions which relates to which team searches with sector within the overall search area.	This decision relates to the total size of the area to be searched by the team. Whilst there is guidelines in Search and Rescue Operational Procedures. Decision-Makers have to take into account a considerable number of variables when deciding the size and parameters of the search area. Often, the	"One of the things you always have is you've got to decide which area to search first. With some people because of what you can say about their background, you can say we'll take out the woods." [P1] "Once the first the initial areas had been done, how big would we make the area?" [P1] "If you took the mountain or the hill environment out of it we obviously have set searches for missing

Usually informally considered prior to arrival at Rendezvous and formalised upon arrival Most Prevalent Global Theme: Communications with Police (14) Least Prevalent Global Theme: Equipment (1)	Sub-Themes • POS and Clues (41) • Knowledge of Missing Person (32) • Geography and Features (52) • Time, Resources and Expertise (62)	position of last sighting or other clues including the history of the missing person will inform the epicentre of the search area. Other considerations which play a part in deciding the parameters include natural boundaries and available resources. These are explored in further detail within the sub-themes.	'vulnerables', do a radius around the last known location and all the rest of it. We were sort of trying to apply that logic together with local knowledge of where she had been before." [P2] "…you know, how far do you start searching? You've got to stop at some time, else you'll go on and on and on. And he was a good mile outside of the boundaries. The wider and wider you get, your areas are expanding all the time, you know, you've only got….pi-R squared haven't you?" [P3]
Sectors and Sections Reference Frequency 5 Sources, 94 References Principle Decision Maker(s)	This set describes dividing the search area into manageable sectors and allocating small teams to those sectors. It also details general advice given to party	Controllers often decide along with the rest of the team, the exact parameters of each section. Interview participants reported that section boundaries are often likely to consist of geographical and topological	"What we try to give is teams the areas which are reasonable, so probably we wouldn't have an area that is bigger than, well probably half a square kilometre." [P1] "Basically, you are cutting the map up into chunks, if you see what I mean, so basically saying you need a team to do this bit, a team to do this bit and then

Incident Commander/Controller Sequence Order This decision is usually taken once the search area has been decided and following standard "hasty" searches of the area. Most Prevalent Global Theme: Communications with Police (13) Least Prevalent Global Theme: Equipment (4)	leaders conducting searches within designated sections. Sub-Themes • Team Members and Equipment (50) • Sector Search Advice (33) • Priorities and Time Management (39) • Boundaries and Sector Size (40)	features of the landscape; this ensures that each party has a Physical indication as to the limits of their border. Parties designated to each sector were also given a size deemed reasonable based on prior geographical and topological knowledge. Team members were allocated to teams dependent upon experience and expertise, with decision makers ensuring that expertise were split between each of the teams.	something else. And then the next stage would be our controller would then say right, you're gonna be the team leader for this team, and your members.." [P4] "It means you can start thinking abit clearer, because you're actually bringing things into little pockets rather than a great big vast area; where you think, 'what the bloody hell is going on here?' sort of thing" [P3] "We try to select a mixture of teams. Within teams, so you you've got some experienced people with less experienced, make sure there is a couple of guys in their for sure so you can shift anything that's heavy etc." [P5]
On-Ground Decisions	Whilst no participants explicitly identified any	This set pertains to decisions made by deployed team	"we would probably have two people go round the boundaries of the fields - the fences, and one person

Reference Frequency 5 Sources, 60 References Principle Decision Maker(s) Party/Team Leader, Search Members Sequence Order During the normal course of a search when team members are deployed Most Prevalent Global Theme: Communications with Police (8), Team Safety and Wellbeing (8) Least Prevalent Global Theme: Clues (0)	particular "On-Ground" Decisions. The actions and decisions made by deployed team members and party leaders represents an important part of the decision making process during the search and rescue task. These decisions relate to actions which are considered to be of great importance but are often more reactive than proactive. Sub-Themes • Search Pattern and Navigation (45) • Health and Safety (12) • Communications and Equipment (33)	members when responding to events within the environment or to changes in the well-being of their team. Many of the considerations discussed involved considerations of health and safety as well as identifying potential clues and communicating these back to central control. Other decisions which belong to this category involve the specific navigational decisions to arrive at a designated sector, as well as the specific type of search pattern to be employed within that sector.	cross the middle of the fields, mainly corner to corner" [P1] "we will do hasty searches of paths tracks, easily accessible things, you know get them specific points of interest that's maybe not in their direct line of travel" [P2] "Do aloud of shouting, maybe he'll answer you, maybe he won't, maybe you'll find him this way" [P3] "Came across a very large deep pond that wasn't on the map – called that one …If you'd've gone over the edge of that, you'd've gone straight in the water" [P4] "one of the things, that is in there is as team leader, you have to swap searching time for thinking time, because the team leaders don't search, they walk behind a team but don't search and they're thinking ahead, always know what happens next. Never take your team anywhere that your brain hasn't been to." [P5]

	• Clues and things of interest (22)		
Care of Casualty Reference Frequency 4 Sources, 23 References Principle Decision Maker(s) Section leader, Incident controller Sequence Order Where applicable this was the last decision made by the Search and Rescue Team Most Prevalent Global Theme: Equipment (9)	This set of decisions relates to treating a casualty with appropriate first aid, as well as ensuring transportation of casualty to further treatment or removing them from immediate danger. Sub-Themes • Team Communications and Operations (20) • Assessment (21) • First Aid and Treatment (10) • Transportation of Casualty (19)	Members of the search and rescue agencies are typically well training in the treatment of casualties. Often, there is also a designated first aider within each Section/Party. Interview participants described the importance of operational decisions as well as the immediate treatment of the casualty. The final part of the decision involved the disposal of the casualty. Very often, search and rescue teams erred on the side of caution and suggested taking casualties to hospital even if there was no obvious and	"There will be at least one other section, because one section will have to take a stretcher that will have all the kit in; normally, a couple of sections. In this particular case we could get the Landover to within 3 or 4 meters of him, so that was straight forward. If it's a long carry, we might just deploy the other sections without any kit at all to help with the carry, because it's quite a tiring…" [P1] "The RAF coming back for her was the quickest way of getting her off the hill and as a consequence getting my people off the hill so we could bugger off home. In terms of taking her to hospital…it was a case of, what do we do with her?" [P2] "…there is more to doing a job than just looking after a patient, very often the most important person is not the person looking after the patient but the person who's the

Least Prevalent Global Theme: Clues (0)		immediate danger to their health.	site commander, the person that's sitting there 50 foot away from the job actually looking, and everyone feeds into that and then he gives them a job to do." [P3]

APPENDIX B.2

Global Theme	Description	Examples
Team Safety, Wellbeing and Expectation Management Reference Frequency 5 Sources, 66 References Most Frequently Cited in: Plan Search Area (12)	This theme relates to ensuring team safety first and foremost during the search operation. It also includes consideration for the levels of exhaustion amongst personnel in light of the safety and efficacy of searching. Managing the team's expectations of what the most likely search outcome was also considered important for team leaders and controllers.	"Everybody was very tired, it had been a long day, we'd done a lot. We didn't find anything" [P3] "It's a health and safety thing firstly, we are trained; do not go into any sort of water of any sort" [P4]
Equipment and Resources Reference Frequency	Equipment and resources are an important consideration for professional search and rescue teams. They are employed to facilitate operational communications	"for a search we normally get the team vehicles and the team leadership there about half an hour before we call out the whole team because we

5 Sources, 52 References Most Frequently Cited in: Care of Casualty (9)	within teams, planning and navigation decisions of team members and the treatment of those requiring first aid as well as the disposal of any potential casualty.	wanna have maps ready, search plans, we want to talk to the police carehome people." [P1] "He's got a pack of emergency stuff and a bag" [P3]
Communications with Police Reference Frequency 5 Sources, 82 References Most Frequently Cited in: Plan Search Area (14)	Local Police play a very large role in the decisions made by search and rescue teams. The Police usually initiate the request of the Local SAR Team and provide background information to assist with the search. The responsibility for the search is shared between SAR and Police, though the extent of Police involvement changes between regions.	"So the police had done some homework basically, some background stuff." [P2] "The police, you know we spoke to them, said we've done that and they said right thank you, you can't do anymore thank you very much." [P4]
Clues Reference Frequency 5 Sources 33 References Most Frequently Cited in: Plan Search Area (13)	The main clue used by SAR teams is the position of last sighting. This will usually form the epicentre of the search area. Often, background information provided by the Police may also inform the search area. Very occasionally, other clues (e.g. cigarette ends, freshly cut saplings) will also be uncovered during the course of a search.	"There was no real guidance as to where he might have gone, so this was literally just a radius around the care home." [P1] "he'd got a length of rope in his hand he was walking towards where his brother once went, so you do have to make some assumptions" [P3]

APPENDIX B.3

Decision	Inclusion Criteria and Sub-Themes	Findings	Supporting Quotes
Search Position of Last Sighting Reference Frequency 5 Sources, 24 References Sequence Order The first decision made following a noticed absence. Most Prevalent Global Theme: "Astral Travelling and Hypothesis Generation" Least Prevalent Global Theme: "Responsibility and the Role of a carer"	This set describes the decision to search around the position of last sighting immediately following a noticed absence. It covers such decisions as searching in the person's room, around the house or care facility and would usually be conducted before raising any alarm. Sub-Themes • Rule out obvious places (18) • Making inferences to the whereabouts (11) • Levels of Anxiety (6)	At this stage in the incident, participants do not report being overly concerned about the safety and wellbeing of their care recipients. Carers reported hypotheses about the care recipients' whereabouts are relatively easy to generate and incidents such as these were reported to be common, as such the level of worry reported by participants at this stage was reasonably low.	"perhaps he'd gone to the loo which was another possibility" [P1] "He's usually in his bed at 8oclock, or down you know to get medication" [P2] "It was quite a bit residential home and it was quite rabbit-warreny and all the rooms linked together so you could never be completely sure that she didn't walk out of another room, so we went round a few times before we were quite certain that she defiantly wasn't there." [P3] "He wasn't around, so I went to the room, knocked on the door, nobody there. Knocked again, obviously somebody could be sleeping, nobody there. Entered the room because I had a key and he was not in his bed" [P4]

	• Health issues (6)		
Enlist Help of Friend or Peer Reference Frequency Sources 5, References 25 Sequence Order Typically, immediately follows “Search Position of Last Sighting” Most Prevalent Global Theme: Responsibility/Meta-Cognition Least Prevalent Global Theme: Safety, Wellbeing and Risk	The decision to enlist the help of a friend or peer was typically taken immediately following a confirmed absence. In the case of professional carers, this decision did not amount to an official report of absence or the involvement of management. Sub-Themes • Assistance (12) • Reassurance (8) • Policy (3)	Participants reported enlisting the help of a friend or a peer to ascertain whether anybody else had seen the absent person and to seek both material assistance and reassurance that they were conducting a sensible course of action considering the circumstances. This decision also resulted in the absenteeism being publicly acknowledged and represents the first escalation that participants began to worry.	“well, yeah also, an...an and also I thought, I'm gonna need some help now, like I said to you this is the point at which, I need help, I can't do this on my own. because he's obviously wandered off farther than I can check on my own” [P1] “I think because I was still quite new I did get help immediately. Because I was panicking, and I got this other person and said. I am sure it's ok, but X is not in her room, is that ok or should we start looking for her to see if she's about? So I think the other member of staff helped me at that point.” [P3] “that would be standard procedure, you would let your team know” [P4]

Search Nearby Area Reference Frequency Sources 5, References 61 Sequence Order: Immediately after, enlisting help. Most Prevalent Global Theme: Astral Travelling and Hypothesis Generation Least Prevalent Global Theme: Responsibility and the role of a carer.	This set describes the decision to search the further areas surrounding the position of last sighting on foot. It is limited to searches on foot no more than a fifteen minute walk from the position of last sighting. Sub-Themes • Location and Environment specific considerations (41) • Person-Specific Considerations (34) • Establish person is "missing" (40)	At this point in the incident, the participant (usually accompanied by a friend or peer) begins to search areas further afield from the position of last sighting, generating and ruling out hypotheses as to where the person is likely to be. Participants use their knowledge of the missing person and the context of their disappearance to generate hypotheses of where the person may be. Stress and worry begin to increase as participants begin to acknowledge the person is 'Missing' rather than merely absent.	"I knew it would be closed because of course they don't open till 11" [P1] "It is literally next door, erm so of course I knew it would be closed because of course they don't open till 11, so I knew it would be closed but I just thought he might be standing in there's a little porch out the front I thought he might be standing in the porch. I also I suppose I thought if I could stand in the road, I could look down the road I might be able to see him" [P1] "I said stay where you are, check the bus stop, the bus station...I said have one person stay in the vinicinity where he ran off and one person go and check at the bus stop. I'll come out to you and I got there within about 15minutes." [P2]
Tell Senior Member of Staff Reference Frequency	This decision applied only to paid carers in a professional context and represents the	The issue of responsibility was prominent in the commentary about this decision and carers	"I'd probably tried to call her three or four times over the space of about 10-15minutes." [P3]

Sources 4, References 19 Sequence Order This decision was often made after the care facility had been thoroughly searched and additional searches would need to be conducted off site. Most Prevalent Global Theme: Responsibility and the Role of a Carer Least Prevalent Global Theme: Safety/Astral Travelling	decision to officially report the missing person to a senior member of staff or management. Sub-Themes • Communications, Operations and Policy (9) • Timing and Shift Considerations (8) • Acknowledgement of the Problem (7)	often felt like they had failed in their duties. Whilst there was often guidance about when to report this incident in each care facility, often carers would use their own initiative to decide the most appropriate time to report the incident, based on the perceived severity of the situation and operational concerns.	"Yeah, by that time the management would have come in so they would have come in at 9oclock" [P4] "Because I'd spent the day with her I felt personally like I'd lost her. I remember shitting myself about having to ring my manager, like 'I'm really sorry it's a Friday night, I'm really sorry I've got to bother you at home but I've lost so-and-so. It was quite terrifying" [P3]
Initiate Wider Search Reference Frequency Sources 5, References 43 Sequence Order	The wider search was often conducted with a car along the major roads close to the position of last sighting and usually involved teams of	At this stage in the incident, participants reported feeling extremely worried. Generally, they report finding it difficult to generate plausible hypotheses as	"Is he, is he making his way back up to college is he walking back to college because we know he likes to walk." [P2]

This often occurred after the areas surrounding the position of last sighting had been searched, or in the case of professionals, following the incident being reported to management. Most Prevalent Global Theme: Astral Traveling and Hypothesis Generation Least Prevalent Global Theme: Safety, Wellbeing and Risk	people working together communicating via mobile phone. Sub-Themes • Knowledge of Missing Person and Past Behaviour (22) • Assistance of Others (17) • Ruling out Possibilities/Doubt (14) • Responsibility (13)	to where the missing person might be, but often felt that that this step was required due diligence and that they needed to rule out all possible places the person might be, no matter how unlikely the considered these possibilities.	"we just looked around the area where he was gone and made the decision to just get back in the car and we just had a drive round." [P2] "and then basically widened our search and by this time other staff members had some in so we were able to put two staff members in a bus, I'd say about 9 o'clock, sorry, in a vehicle to patrol around the area by road in case he was walking somewhere by road." [P4] "So as I say were checking the woods with two people and there's two people out in the vehicle as well having a look." [P4]
Call the Police Reference Frequency 62 References, 5 Sources	This set details the decision to call the emergency services to report the person as missing	Participants were often reluctant to call the police and often saw this as failing in their responsibilities as a carer and	"Again, risk assessment wise if we've not found [x] you know we would contact parents and the police" [P2]

Sequence Order This was the last decision reported by carers in the immediate aftermath of discovering a person is missing. After this point, the carers are no longer the principle decision makers in the missing person search strategy. Most Prevalent Global Theme: Responsibility and the Role of a Carer Least Prevalent Global Theme: Astral Travelling and Hypothesis Generation	and provide material assistance to the search. Sub-Themes • Policy and Operations (24) • Transfer of Responsibility (22) • Lack of Credible alternatives • Attitudes towards the police (22) • Barriers (21)	also failing to find the person once missing. Participants were also reluctant to call the police as this action, in their view “made it real”; the person was no longer merely absent, but truly missing. Attitudes towards police involvement were ambivalent, with participants feeling relived that professional help was on the way, but often found it frustrating that they were no longer in control of the situation.	“You dial 999, and the voice on the other end says, which service do you require, what telephone from the other end are you calling from. and that's it. They have taken over.” [P1] “you've GOT to call the emergency services in on this. You CANNOT rely on odds and sods just wandering around, y'know willy nilly.” [P1] “I wondered that if I did it too often, would they come and think that actually I wasn't 100% balanced either” [P1]

APPENDIX B.4

Global Theme	Description	Examples
Responsibility and the Role of a Carer Reference Frequency: References 177, Sources 5 Most Frequently Mentioned in: Call the Police Sub-Themes: • Barriers and Difficulties (43) • Carers Support and Psychological Needs (39) • Relationship and Duty of Care (177) • Respect for Personhood (46)	One of the most pervasive themes which was identified during the analysis was the issue of perceived responsibility. The relationship between the carer and care recipient was discussed in detail in each incident. Often carers reported a trade-off between ensuring the care recipients' safety and the wish to preserve their autonomy. Barriers and conflicting concerns of responsibility also played a role in decision making. For example, in one of the incidents the concern for the immediate safety of the care recipient was often at odds with what the guardians believed to be in that person's long term psychological interests.	We had a really nice day together and I think we went out shopping and I helped her tidy her room and like general sort of bonding stuff like that." [P3] "The difficulty was that it was his home and I didn't feel able, certainly during the day to lock the front door" [P1] "I suppose that's the point at which, y'know you kind of want somebody to help and hold your hand abit and say, it's ok, y'know it'll be ok." [P1]
"Astral Travelling" and Hypothesis Generation Reference Frequency: References 161, Sources 5	This theme relates to carers trying to generate possible hypotheses of where the absent person might be by taking the perspective of the absent person. This theme was the most prominent	"we got together and thought about possible places where this person could be from his past behaviour and one of the past behaviours" [P4]

Most Frequently Mentioned in: Search surrounding Areas on Foot Sub-Themes: • Hiding and Avoidance (21) • Knowledge of the missing person (79) • Recent Events and Mood (13) • Risk Related Hypotheses (20) • Situation Specific Considerations (53)	during the typical "searching" tasks, such as searching the surrounding and wider areas. Carers used knowledge of the person's preferences, past behaviours and current mood when generating hypotheses as to where the absent person might be. In the initial stages of the incident, participants were able to easily generate a variety of possible places to search, yet as the incident progressed, they found this increasingly difficult.	"if he wanted to abscond and not be found that was pretty, you know it's countryside, it's quite easy to do that" [P4] "She could just be hiding and winding us up. [laughter] making us look for her behind a tree or something like that." [P3] "it's usually an incident that's happened either the night before or he's worried about something or there might be a change in the routine" [P2]
Safety, Wellbeing and Risk Reference Frequency: References 140, Sources 5 Most Frequently Mentioned in: Call the Police Sub-Themes:	This category refers to stated concerns about the care recipient's physical and mental wellbeing and the risks they may be facing. Risks identified included pre-dispositions towards injuries, such as mobility problems and medications. Psychological risks included stranger anxiety and conversely an propensity to trust strangers too much. External risks	"he used to experience quite extreme mood swings and therefore he would leave the premises without informing anybody" [P2] "The procedure is, we can't take any of our learners in our own cars. But I just felt at that moment in time, to keep, to keep the young man safe, I said he could

• External Risk (28) • Medical Conditions (Physical) (33) • Past Behaviours (42) • Policy and Routine (33) • Psychological Vulnerability (56)	identified included traffic, environmental risks and risks from adverse weather conditions.	go in and it were just weighing up the situation really." [P2] "y'know a fairly typcial pub carpark, and had potholes that you could bury half a roman legion in" [P1]
Metacognition Reference Frequency: References 135, Sources 5 Most Frequently Mentioned in: Search surrounding areas (on foot) Sub-Themes: • Anxiety (39) • Certainty and Uncertainty (61) • Flow (19) • Lack of alternatives (24) • Regret and guilt (27)	Metacognition, refers to the act of thinking about one's own cognitive and decision making processes. This theme refers to sections of the transcripts where people comment on their decisions or on their overall awareness of the situation, as well as on their own responses. Comments about certainty and uncertainty were the most common in this category, with participants often questioning whether they had engaged in the optimal course of action.	"Is he safe? Is he ok? Because the longer it goes on, anxieties build with everybody really." [P2] "I suppose that's the first kind've thing, is - I should have stayed where I could see him.." [P1] "I suppose I didn't want to bother someone at home if there wasn't actually an issue instead of trying to sort it out myself. If that makes sense. It was almost sort of as a last resort." [P3]

APPENDIX C

Brief, Screening and Consent

Thank you for your interest in this interactive questionnaire study investigating the attitudes around missing people. This work is part of a larger body of work investigating the role assistive technology may play in helping to find people with care and support needs who go missing. This work is funded by the EPSRC and Philips Research and conducted at the University of Nottingham and will form part of a PhD project. This study has received ethical approval from the internal ethical review board at the University of Nottingham.

- I have been made aware of the study's aims and methods.
- I realise that this study will use personal information to inform hypothetical scenarios which may be distressing to some individuals.
- I consent that data from this study (excluding personally identifying information) may be published and stored for up to seven years after publication in accordance with University Policy.
- I am responsible for the care of another person.
- I have been made aware of my right to withdraw.
- I realise I am under no obligation to answer any question in the study.
- I am over 18.
- I consent that the above information is correct and agree to participate in the study as outlined to me

Background Questions

1. What is your age?
2. Are you responsible for the care of another person?
3. You...

   are a parent or guardian / are responsible for the care of another person in your professional duties (e.g. carer, teacher) / care for a friend or relative
4. You are…

   Male / Female / Other/Prefer not to say
5. Do you have access to your own vehicle?

   Yes / No
6. The person that is dependent upon me is…

A child / An adult

7. The person dependent upon me is…

   Male / Female / Other/Prefer not to say

8. Please enter the first name, nickname or pseudonym of a person that you care for. (e.g. "David", "Jill", "Mum")
9. What level of independence does this person have?

   Very Dependent. This person requires constant supervision and needs to be within eyesight of either myself or a designated adult at all times. / **Dependent.** This person cannot leave the house without my supervision or the supervision of a trusted adult. / **Somewhat dependent**. This person may under certain circumstances leave the house unescorted but I need to know where they are. / **Independent**. This person often leaves the house without the need of an escort and very occasionally might stay with somebody else with my permission. / **Very independent**. The do not always sleep in the same house as me but I like to know where they are. / **Almost entirely independent.** Sometimes I will not see them for a few days and I don't always know where they are.

10. What level of mobility does this person have?

    Mobility is not an issue. This person can walk around outside with no significant difficulties / This person can walk around unaided outside but at a slow pace, or needs to take regular breaks / This person has difficulties moving around outside and may require the assistance of a mobility aid / This person can only move around for short periods of time and requires a great deal of assistance / This person cannot move around at all and requires either myself or another designated person to move from place to place

11. Does this person have access to any means of transportation? [Choose all that apply]

    This person can use public transport / This person has a car and/or a motorbike / The person has a bicycle

12. Does this person have a mobile phone?

    Yes / No

13. Aside from the house, please list a single place that the person you care for likes to go, or frequently visits. "David likes to go to _____"
14. Which of the following activities might you perform which may leave the person you care for unattended? [Choose as many as apply]

    Shopping / cooking / having a wash / sleeping / performing household tasks

15. Please enter the name of a trusted friend, family member, colleague or spouse on whom you can depend upon in an emergency regarding the person you care for.

Scenarios

- **Initial Scenario.** "You finish [Activity] and come back to realise that [Care recipient] isn't where they were before you left. There are no signs as to where [Care recipient] has gone."
- **Call Mobile Phone.** You decide to call (care recipient)'s mobile phone. The phone doesn't ring and it goes straight to the answer phone message. The phone is either turned off or has no signal.
- **Search Nearby.** You search the neighbourhood and surrounding areas. You call out [Care recipient's] name in the street and ask passers-by if they have seen anybody matching that description. Nobody has seen [Care recipient]
- **Get in Car.** You get in the car and drive down the roads next to your house and all the roads [Care recipient] is likely to walk down. Unfortunately you don't see [Care recipient] or any indication that they have been there.
- **Check Likely Place.** You decide [Care Recipient] could have gone to [Likely place] so you go over to [Likely place]. But there is no sign of [Care Recipient] there.
- **Call Trusted Friend.** You call up [Trusted friend], who promises to rush back, but unfortunately [Trusted friend] is out of town and will take over an hour to get back.

Probing Questions

1. How are you feeling at this point? (Open Text)
2. On this scale please rate your level of surprise and worry at this point in time from 0-100 where 0 represents not at all worried/surprised.* - Level of Surprise
3. On this scale please rate your level of surprise and worry at this point in time from 0-100 where 0 represents not at all worried/surprised.* - Level of Worry
4. How concerned are you for [Care Recipient Name] safety and wellbeing at this point?*
5. What is your PRIMARY safety concern at this point?
   Physical Risk (e.g. Risk of Injury or Accident) / Psychological Risk (e.g. Stress, anxiety, Social difficulties) / Health Related (e.g. Pre-existing medical condition)
6. Could you describe any specific risk you think the person is in at this point?
7. What do you think is most likely to have happened to [Care Recipient Name]?
8. Given the following choices, which option are you most likely to do next?

Check to see if [Care Recipient] has gone to [likely place] / Enlist the help of [Trusted friend] / Get in the car and drive down the major roads nearby. / Call the Police / Search the neighbouring and surrounding areas. / Call [Care recipient's] mobile phone.

9. How confident are you that this is the most appropriate course of action? (1-100)
10. If you would intend to do something else at this point not listed above, please say so here. (Scenario will unfold according to your previous selection)
11. Is there anything that might help you come to a better decision at this point?

Call the Police

- You decide to call the police. The Police ask you a series of questions about [Care Recipient] including a description and any medication that [Care Recipient] may have been taking. They keep you on the phone for approximately 10 minutes and ask you to remain at the residence.

1. How are you feeling at this point?
2. Are you feeling better or worse after contacting the Police?
    a. Better / Worse / The same
3. How and why?
4. On this scale please rate your level of surprise and worry at this point in time from 0-100 where 0 represents not at all worried/surprised.* - Level of Surprise]
5. On this scale please rate your level of surprise and worry at this point in time from 0-100 where 0 represents not at all worried/surprised.* - Level of Worry
6. How likely is it that you would be able to provide an appropriate description of [Care Recipient] that would help the police search activities? (1-100)
7. How confident are you that the Police will do all they can? (1-100)
8. How confident are you that [Care Recipient] will be found in good health? (1-100)

- Two police cars pull up in front of your house. You go to the window and see [Care recipient] get out of the car with the police. Luckily, a patrol car had passed someone matching [Care Recipient's] description almost immediately after your call. [Care Recipient] seems a little embarrassed but is otherwise in good health.

1. How are you feeling now?
2. How are you feeling towards [Care Recipient] after their disappearance?
3. Is there anything you might do differently if such an event were to occur in real life?

Prize Draw and Contact

1. Do you wish to be contacted regarding the results of this study?
   Yes / No
2. Do you wish to enter the prize draw?
   Yes / No
3. Please enter your email address if you wish to be contacted regarding the results of the study or enter the prize draw. Your email address will not be used for any other purposes.

Attitudes towards Assistive Technologies

1. Do you think the person you care for would comply with wearing a location-based tracking device?

Yes / No / Maybe / Unsure

2. Would YOU be comfortable with using a location-based tracking device for the person you care for?
   Yes / No / Maybe / Unsure
3. Which of the following technologies do you think would be helpful in this situation? [Choose as many as you think would be appropriate]
   Smart Watch with GPS / Security Cameras in the House / Tracking Device Pendant / Alarm System on Doors / Smart Phone / Other
4. Please comment on your choices

Debrief

Thank you very much for participating in this study. Your responses have been saved and will help inform the development of assistive technologies in the future. We hope that you have enjoyed this study and that it was not too distressing. If the study has caused you extreme emotional or Psychological distress, you are encouraged to phone the NO PANIC Hotline on 0844 967 4848 (10am-10pm) or contact the researcher directly at:

Kyle.Harrington@Nottingham.ac.uk. You can also contact Kyle.Harrington@Nottingham.ac.uk if you wish to have your results removed from the study or have any further questions.

The advice given on by the UK Government is:

“If someone goes missing, contact anyone you think may know their whereabouts – if you’re still concerned, contact your local police.- You don’t have to wait 24 hours before contacting the police.”

For further information on missing people, or for help, advice and support. Please visit <Missing People>

APPENDIX D.1

Information for Participants – Study into Real-World Search Behaviour

Student: Kyle Harrington – Kyle.Harrington@Nottingham.ac.uk

Supervisors: Sarah Sharples– Sarah.Sharples@Nottingham.ac.uk

James Pinchin – James.Pinchin@Nottingham.ac.uk

Ethical Approval for this study granted by University of Nottingham, Department of Engineering

Thank you for your interest in participating in this study. This purpose of this study is to investigate how people working in teams conduct search tasks in a real-world environment. This study is part of a larger PhD project at the University of Nottingham investigating informal missing person search prior to police involvement. The PhD project is funded by the Engineering and Physical Sciences Research Council and Philips research.

The study involves teams of four people working together in an attempt to find as many "search targets" as possible within a half an hour period. Once signing up to this study you and your teammates will be allocated a start time and randomly assigned to one of four conditions.

You will be asked to meet the researcher at a specified location at your allocated start time. **PLEASE ENSURE ALL YOUR TEAMMATES ARE WEARING SENSIBLE SHOES AND CLOTHING ON THE DAY.** (Trainers and generic sports/gym clothing is preferable, no high heels). At this point all of your team members will be asked to read this document before signing a consent form. You will then be given an android device and (possibly) a two-way radio for use in the experiment and told how to use these. You will be asked to keep these devices on at all times and only use them in the way specified by the researcher. At this point you will be asked not to communicate with your team mates as you make your way to designated starting positions.

Once in these designated positions you will be informed that the trail has started. You will have half an hour in which to find as many "search targets" as possible. The search targets will be sports cones with NFC tags attached to them. These search targets will need to be scanned in with the android device you have been given. Your team will be awarded a score based upon how many search targets you have found in total. However, during any given trial, only a certain amount of these targets will be "active" and count towards your final score. You should

not run during the trial or do anything else that may put yourself or others in danger. During the trial, your location will be monitored, as well as other information relating to your use of the app, an audio recording will also be made via the android phone. You will also be asked to follow any instructions given to you by the researcher.

Once the trial is over you will be asked to return to the researcher and not to communicate with your teammates. At this point you will be asked to complete a written questionnaire relating to the task.

Finally, you will be asked a few open-ended questions as a group and an audio recording will be made. The search task itself will take half an hour, but the total trial time will take around an hour and no more than half an hour.

Once the study is finished, you may elect to submit your team's score to the leader board. If you decide to submit your team's score to the leader board, your teams score will be made public and displayed physically around the HQ, and made available online. The winning team in each of the four conditions will be awarded a prize of £100 worth of Amazon vouchers per team. If you wish you may also have a certificate printed and a team picture taken for the study's facebook page. No other reimbursement will be given for the study.

Your voice recordings will be transcribed and analysed using a thematic analysis approach and your location data will be used in additional analysis to test for search efficiency and other metrics.

Your participation in the study is voluntary and you may stop the experiment at any time. All of the data stored on you will be stored securely in line with University policy and in accordance with the data protection act.

In accordance with those principles personal data shall be:

1. Processed fairly and lawfully
2. Processed for specified purposes only
3. Adequate, relevant and not excessive
4. Accurate and up to date
5. Not kept longer than necessary
6. Processed in accordance with data subjects' rights

7. Processed and held securely
8. Not transferred outside the countries of the European Economic Area without adequate protection.

(Available at http://www.nottingham.ac.uk/governance/records-and-information-management/data-protection/data-protection-policy.aspx)

APPENDIX D.2

Consent form for Study into Search Behaviour

Please read each statement carefully and mark the corresponding box to indicate your agreement. When you are finished please print your name and sign and date the document.

Student: Kyle Harrington – Kyle.Harrington@Nottingham.ac.uk

Supervisors: Sarah Sharples– Sarah.Sharples@Nottingham.ac.uk

James Pinchin – James.Pinchin@Nottingham.ac.uk

Ethical Approval for this study granted by University of Nottingham, Department of Engineering

Participant Eligibility

- O I am over the age of 18
- O I am a smart phone user
- O I do not have any significant visual or auditory impairments that would hinder my ability to use a smartphone or search for items
- O I do not have any significant mobility issues that would prevent me from accessing hills, grassland or shrubbed areas.
- O I suffer from no other health issues that would put me at high risk when conducting physical activity

Rules

- O I will not run during the task
- O I will not knowingly or intentionally give myself or my teammates an unfair advantage in the trial
- O I will take care not to damage any equipment I am given

- O I will not alter any of the settings on the device I am given unless directly asked by the researcher and I will use the device in a manner explained to me by the researcher
- O I am happy to leave my personal mobile phone with the researcher during this task if requested
- O I will take due care during the task and I will behave in a manner which does not endanger myself or others nor cause damage to university property or grounds
- O I will oAsssbey all reasonable requests by the researcher for the duration of the study
- O I will not remove the search targets from their locations

Consent

- O I have read the information sheet and been made aware of the study's aims. I understand what is required of me
- O I am happy for my location data to be recorded during this task
- O I am happy for an audio recording of me to be made throughout the duration of my participation the study
- O I understand my participation is voluntary and have been made aware of my right to withdraw
- O I have been given the opportunity to ask questions
- O I am happy for my data to be stored securely for up to seven years after the study in accordance with University Policy and the Data Protection Act (1998).
  (Available at http://www.nottingham.ac.uk/governance/records-and-information-management/data-protection/data-protection-policy.aspx)

- O I am happy for the results of any analysis of my data to be shared with third parties and used in any publications arising from the study
- O I understand that no personally identifying information will be published or shared with third parties other than information (pictures, score) I have explicitly chosen to share
- O I agree to participate in the study as outlined to me

Optional

- O I wish for my team's score to be entered into the league table in compensation for my time (optional)
- O I am happy to have pictures of me and my team mates that have been taken during the trial to be displayed on social media (optional)
- O I am happy to wear a video camera during the trial so that videos of the study can be used in demonstrations and presentations (optional)

Print Name

_____

_____

Signature Date

_____

_____/_____/_____

APPENDIX E

Participant: Condition: Trial:









How many TOTAL targets (repeats or otherwise) did each participant find?

1)

2)

3)

4)

How many unique targets did each participant find?

1)

2)

3)

4)

How many meters did each participant walk (meters)?

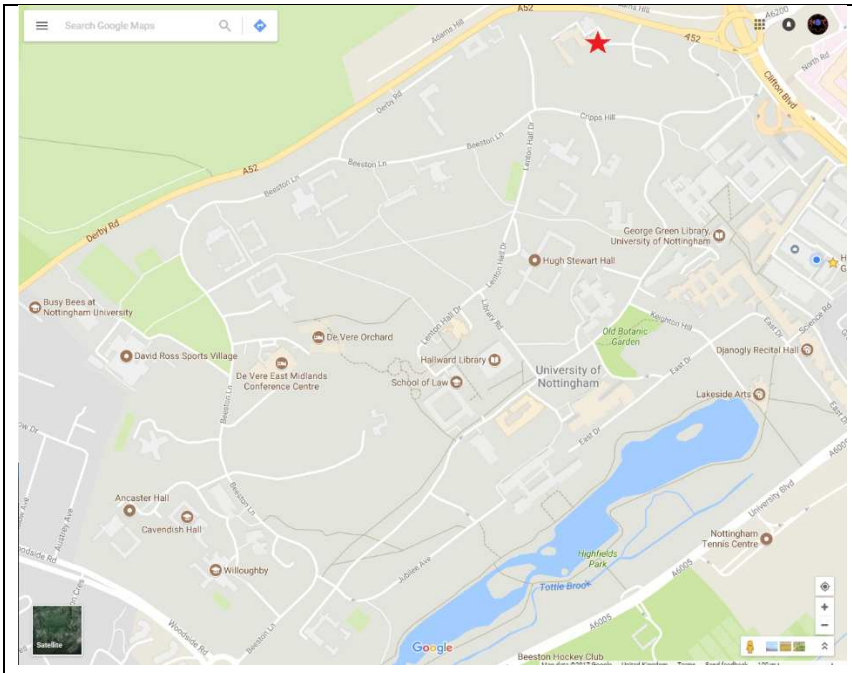
1)

2)

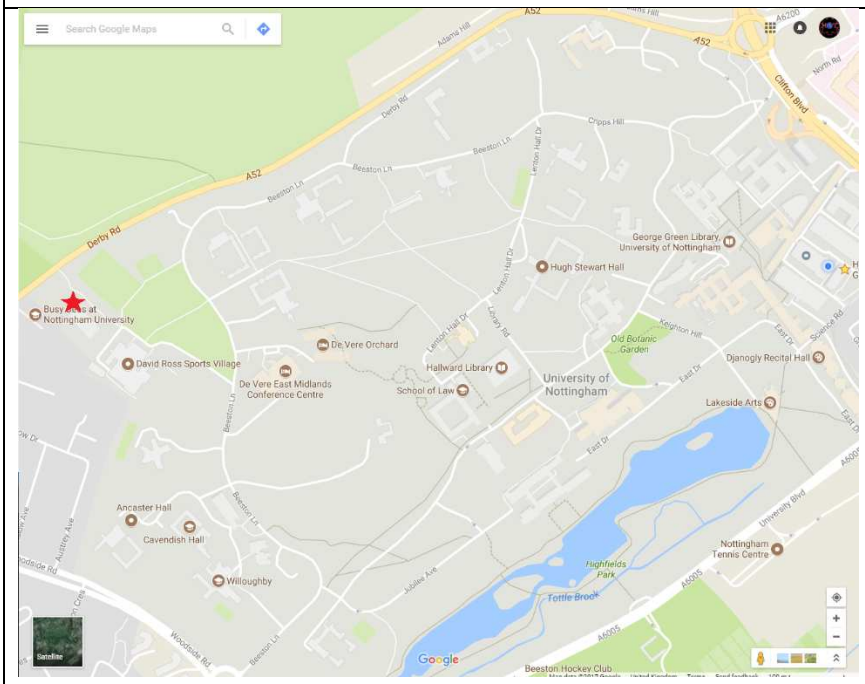
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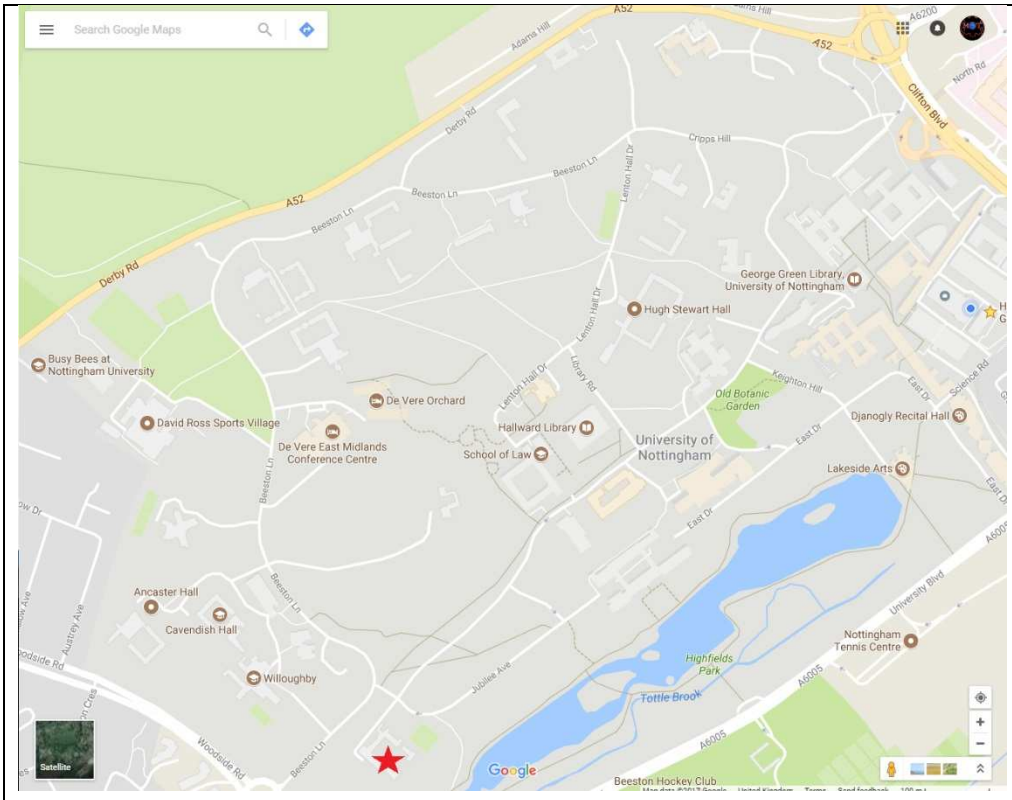
Which participant was closest to the red marker?



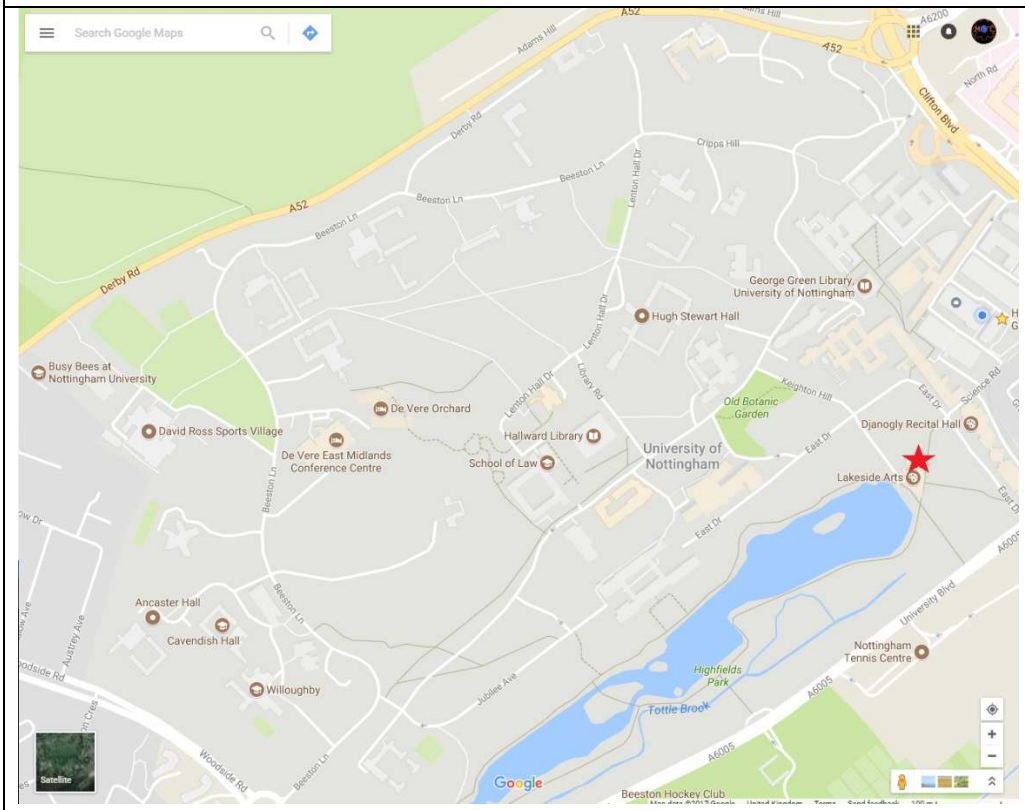
Answer)



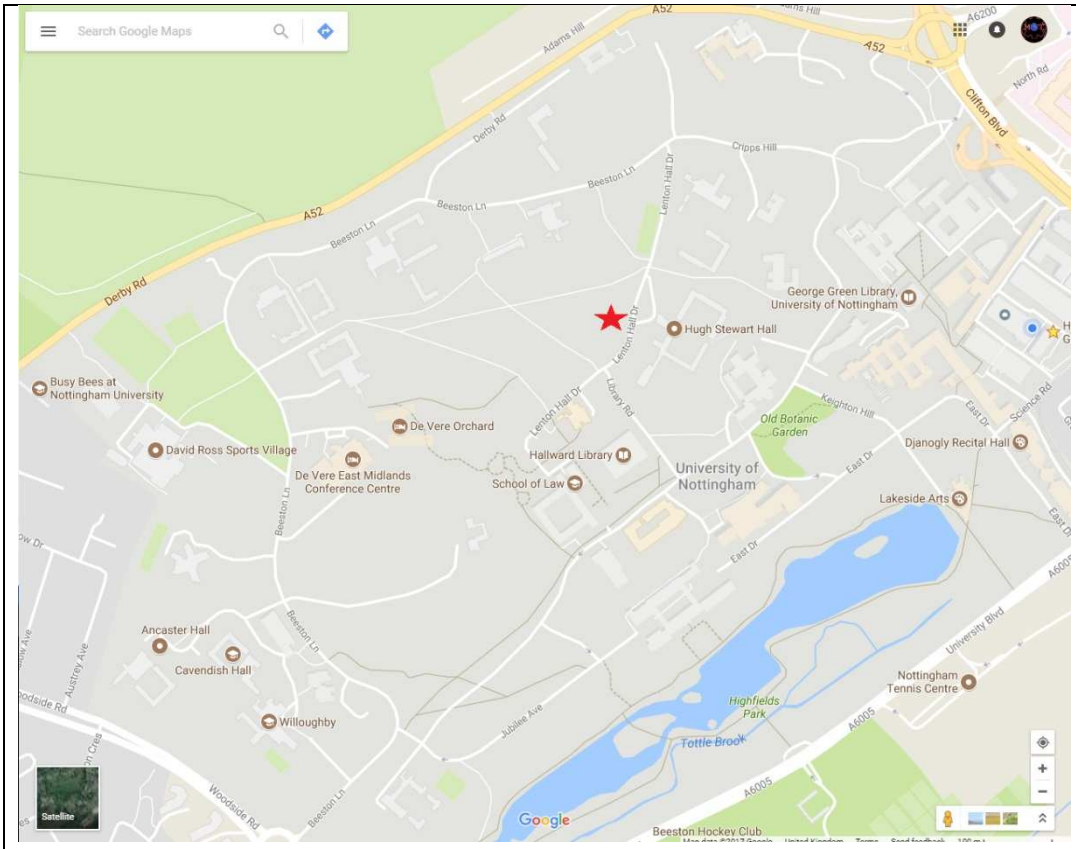
Answer)



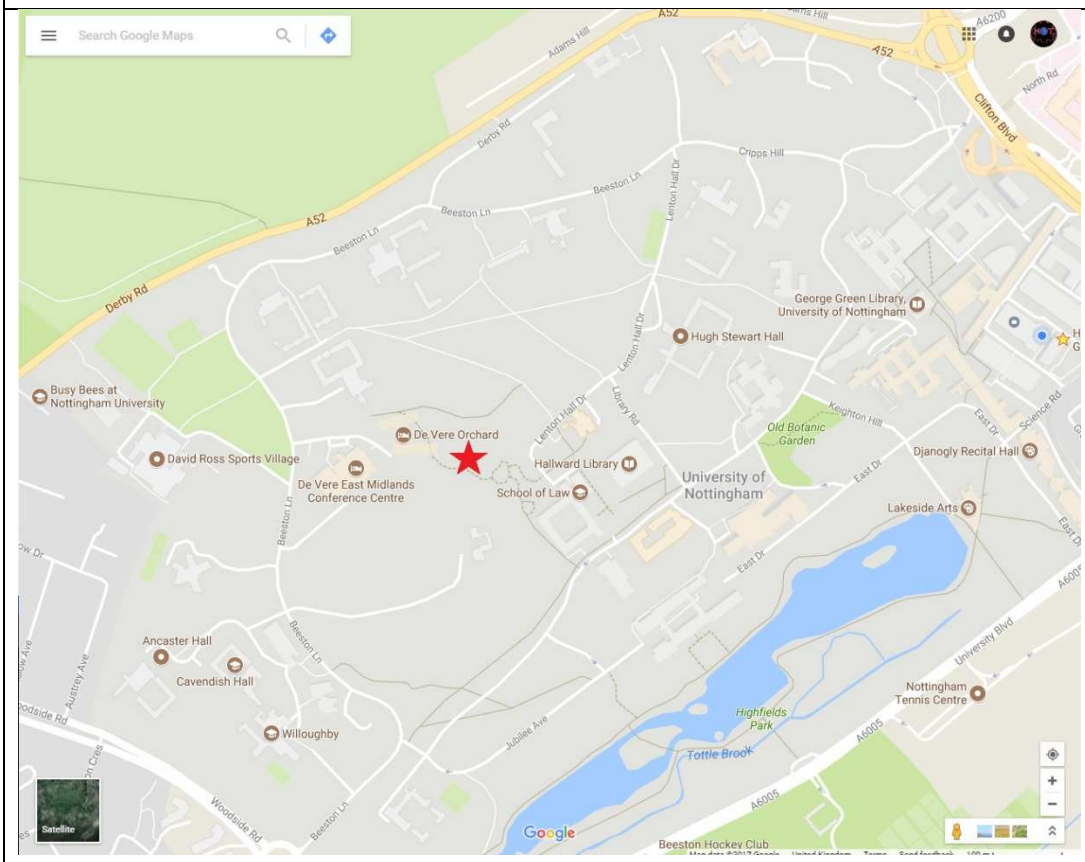
Answer)



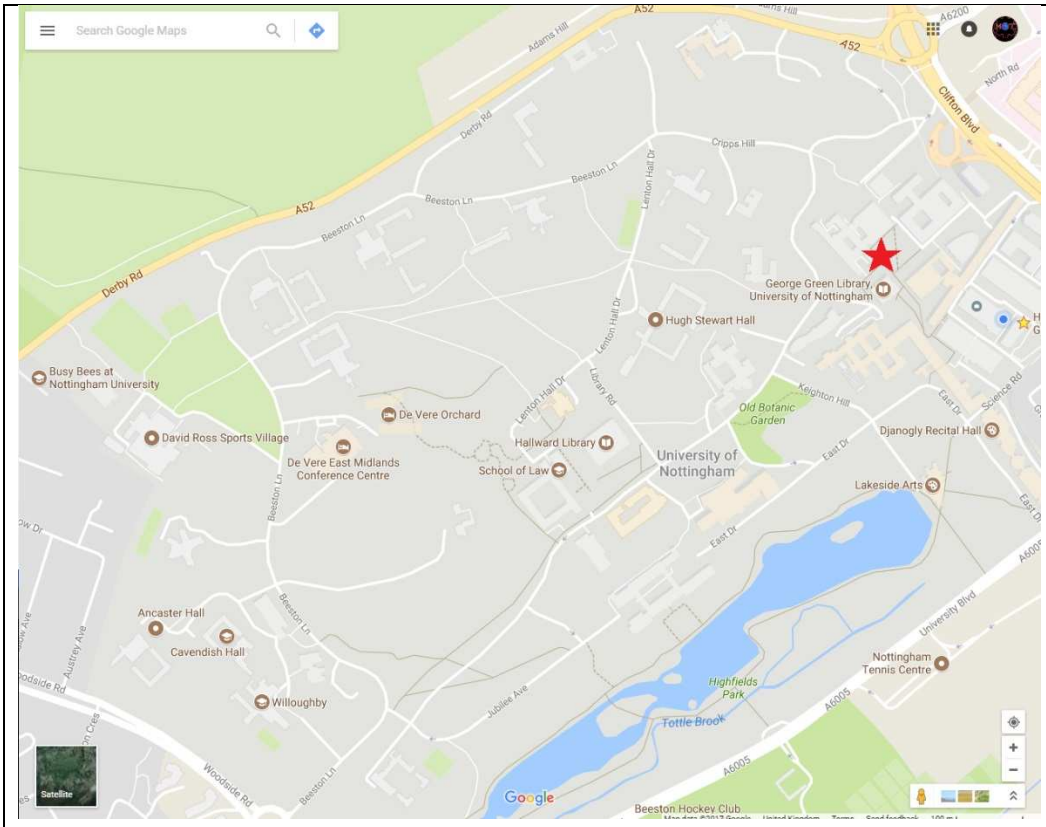
Answer)

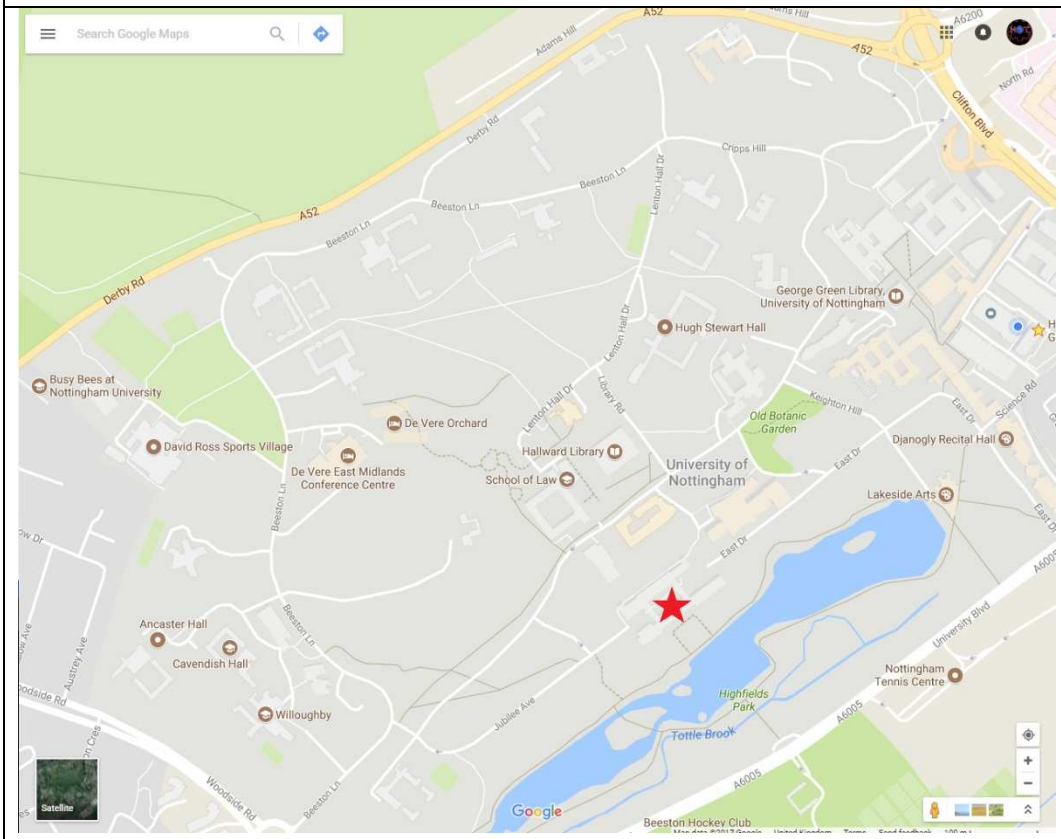


Answer)

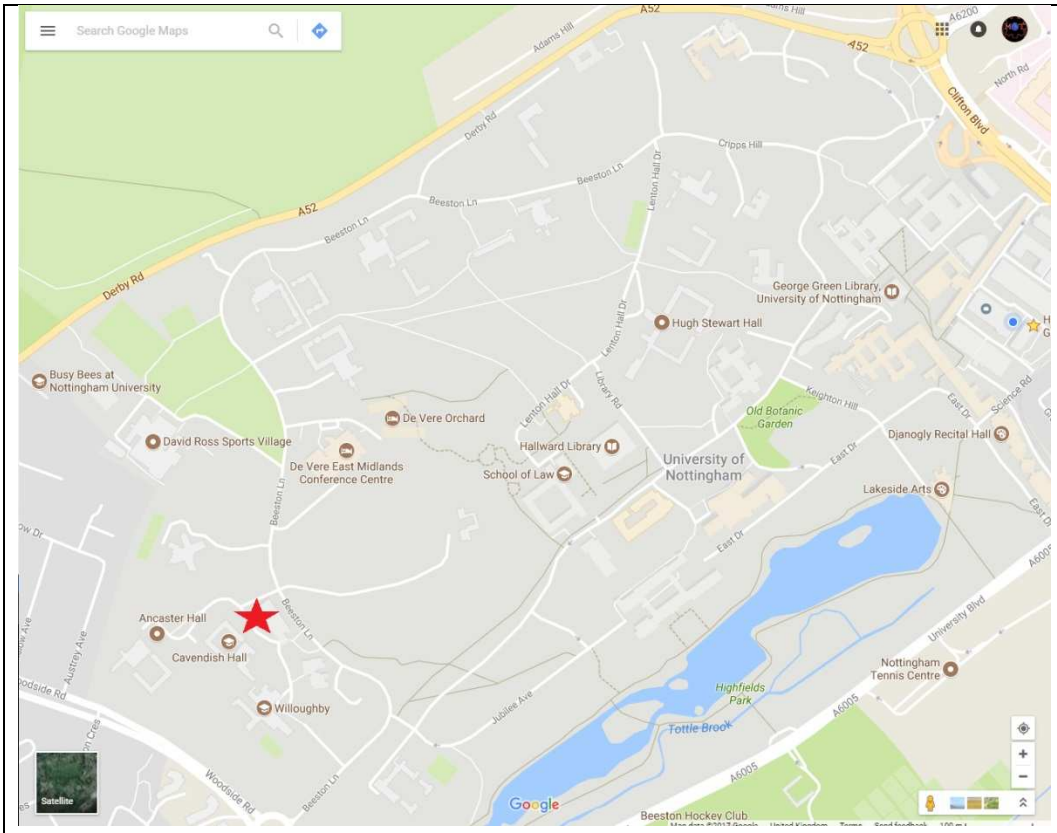


Answer)

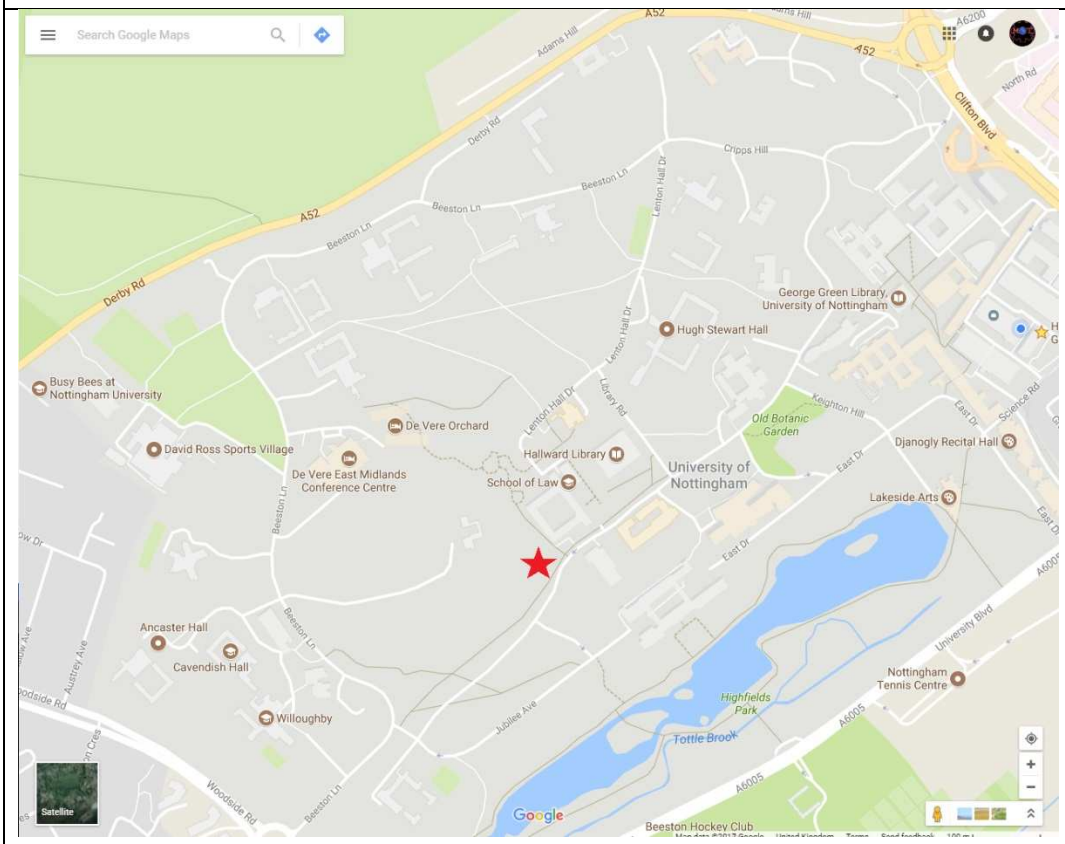

Search Google Maps
A52
Derby Rd
Beeston Ln
Adams Hill
Cripps Hill
Lenton Hall Dr
Library Rd
A6200
North Rd
Clifton Blvd
George Green Library, University of Nottingham
Hugh Stewart Hall
Busy Bees at Nottingham University
David Ross Sports Village
De Vere Orchard
De Vere East Midlands Conference Centre
Hallward Library
School of Law
University of Nottingham
Old Botanic Garden
Keighton Hill
East Dr
Science Rd
Djanogly Recital Hall
Lakeside Arts
Ancaster Hall
Cavendish Hall
Willoughby
Austrey Ave
Woodside Rd
Jubilee Ave
Highfields Park
Tottle Brook
A6005
University Blvd
Nottingham Tennis Centre
Beeston Hockey Club
Satellite
Google


Search Google Maps
A52
Derby Rd
Beeston Ln
Adams Hill
Cripps Hill
Lenton Hall Dr
Library Rd
A6200
North Rd
Clifton Blvd
George Green Library, University of Nottingham
Hugh Stewart Hall
Busy Bees at Nottingham University
David Ross Sports Village
De Vere Orchard
De Vere East Midlands Conference Centre
Hallward Library
School of Law
University of Nottingham
Old Botanic Garden
Keighton Hill
East Dr
Science Rd
Djanogly Recital Hall
Lakeside Arts
Ancaster Hall
Cavendish Hall
Willoughby
Austrey Ave
Woodside Rd
Jubilee Ave
Highfields Park
Tottle Brook
A6005
University Blvd
Nottingham Tennis Centre
Beeston Hockey Club
Satellite
Google

Answer)



Answer)



Answer)

APPENDIX F

Participant Number	Visual Map	Shared Audio	Distance	Cones Found	Repeats	Map Score	SARTScore
1	Yes	Yes	2444	3	0	8	21
2	Yes	Yes	3737	4	0	7	27
3	Yes	Yes	2685	8	0	10	21
4	Yes	Yes	3344	3	0	6	19
5	Yes	Yes	3067	3	1	8	18
6	Yes	Yes	2582	10	0	10	23
7	Yes	Yes	2570	0	0	8	14
8	Yes	Yes	3225	5	0	7	20
9	Yes	Yes	3456	12	3	4	25
10	Yes	Yes	3523	14	2	4	20
11	Yes	Yes	3122	9	2	7	33
12	Yes	Yes	3093	20	2	6	18
13	No	Yes	2870	10	1	8	12
14	No	Yes	3352	2	0	10	17
15	No	Yes	2769	2	0	9	17
16	No	Yes	3325	12	5	9	30
17	No	Yes	2249	12	3	9	19
18	No	Yes	2563	10	4	8	18
19	No	Yes	2694	17	5	5	15
20	No	Yes	2796	13	0	6	22
21	No	Yes	2539	14	1	8	19
22	No	Yes	2747	4	5	2	14
23	No	Yes	2279	3	0	2	17
24	No	Yes	2616	8	0	6	20
25	Yes	No	3264	12	0	3	19
26	Yes	No	3232	5	0	9	22
27	Yes	No	2778	10	0	3	25
28	Yes	No	2398	6	0	6	15
29	Yes	No	3220	3	0	5	22
30	Yes	No	2779	4	0	6	22
31	Yes	No	2879	0	0	3	8
32	Yes	No	2476	4	0	2	21
33	Yes	No	2539	14	1	2	22
34	Yes	No	2747	4	4	6	20
35	Yes	No	2279	3	0	4	16
36	Yes	No	2619	8	3	9	11
37	No	No	2548	17	3	6	18
38	No	No	2799	8	1	4	22
39	No	No	2929	14	0	6	15
40	No	No	1989	8	2	4	17
41	No	No	2600	8	1	5	20

42	No	No	2621	10	1	4	18
43	No	No	1193	2	0	5	5
44	No	No	2626	15	4	8	14
45	No	No	3020	5	0	5	23
46	No	No	2852	8	0	6	13
47	No	No	2780	5	0	6	22
48	No	No	2877	13	1	7	16