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Exploring Human Factors in Context Aware Services

Xiaohui Zhang

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Abstract

As microchip and sensing technologies have developed, more and more context aware applications have been introduced to our daily lives. Many of the applications have been proposed to improve the quality of life, and furthermore, to engage the end users with a richer or augmented environment. However, although many researchers bring innovative ideas to the field of context aware computing, there is still a lack of human factors research in many projects, which could reduce the envisaged user acceptance and adoption.

This research takes a human-centred perspective, which mainly aims to explore the human factors and their relationships involved in context aware activities. Both deductive and inductive methods were used to achieve this aim. More specifically, qualitative methods like focus groups and interviews were used to identify the human factors in context aware activity. Quantitative methods like survey and empirical experiment were used to examine the relationships between the identified factors. The results of this research provided empirical evidence of the effects of different motivations on user's preference and behaviour in context aware adaptation. This influence was observed during the empirical experiment. A conceptual framework for the human factors involved in context aware activities was proposed and developed based on literature review and the results from the empirical studies, which consists of four sub-domains relating user's motivation, perception, preference and subjective experience.

In addition, the results also show the capability of the empirical method used for this research. The revised method was further reviewed by digital designers from local companies. The method is presented to help designers to identify and evaluate the human factors involved in context aware activities, and therefore to materialize their good ideas to real pleasant part of our lives.

Candidate's Statement

During the course of my PhD, I wrote the following papers in conjunction with my supervisors:

XIAOHUI, Zhang and URUCHURTU, Elizabeth (2011).A User Experience Perspective of Design for Context-Aware Adaption. In: IE 2011 : 7th International Conference on Intelligent Environments, Nottingham, 25-28 July 2011. IEEE, 322-325.doi : 10.1109/IE.2011.47.

XIAOHUI, Zhang (2011). A User's Perspective of Design for Context-Awareness.In :UbiComp '11 : 13th international conference on Ubiquitous Computing, Beijing, 17-21 September 2011. New York USA, ACM, 531 - 534.doi : 10.1145/2030112.2030199.

CHRISTOPHER, Roast and XIAOHUI, Zhang (2012). Exploring the motivations involved in context aware services. In: HCI 2012 : 26th BCS Conference on Human Computer Interaction, Birmingham, 12-14 September 2012. Birmingham UK, BISL, 274-279.

1 Introduction

1.1 Introduction to the research

As microchip and sensing technologies have developed, more and more context aware applications have been introduced to our daily lives. The use of context aware sensors and wireless connectivity, like GPS and WIFI, provides many opportunities for data rich responsive applications, integrated with a variety of products. Many of the applications have been proposed to improve the quality of life, and furthermore, to engage the end users with a richer or augmented environment, such as the GPS navigator and augmented reality. However, although many researchers bring innovative ideas to the field of context aware computing, there is still a lack of human factors research in many projects, which could reduce the envisaged user acceptance and adoption. Unlike many desktop applications, context aware services support users in dynamic situations by utilizing surrounding context to help them manage and utilise technology. It is by its nature highly dynamic since it responds to changes in context of use, and this brings new challenges to interaction design.

Context aware adaptation is one of the most important concepts in context aware computing. In general, contextual information is monitored and when it changes the application or device configuration is changed to suit the new situation. As a simple example, many portable devices use light sensors to automatically adjust the backlight brightness for power saving. In this example, the environmental brightness has been used as an indicator for adaptation. Similarly, adaptation strategies for Quality of Service have been used by many context aware applications to generate alternative reconfigurations when a change in the context occurs. The problem here is that as well as systemic and environmental factors, end users' internal states such as motivation may also be unstable and produce different user preferences in context aware activities. For instance, in the above example, an instantaneous adjustment of the backlight brightness may not always make the user happy - people may not be able to follow such adjustment because of both physical limitations (for example changes in pupils' size) and psychological characteristics. Accordingly, the question of interest here is do such automated methods help users when designers wish to take account of human factors. On the other hand, abrupt

adaptations of system configuration may raise user's awareness of the system, or interrupt the user's ongoing activity and experience (see section 2.1.3).The research of the user's experience continues to increase in both academia and industry. In addition to traditional components of usability, concepts such as subjective experience have drawn increasing attention, as stated in the user experience white paper (Roto et al., 2011) that "*UX*(user experience) *is not the same as usability, although usability, as perceived by the user, is typically an aspect contributing to the overall UX*". User experience of context aware applications, compared with desktop applications, may be influenced by various factors involved in dynamic environments. Therefore, for the development of context aware service, it is important to understand the relevant human factor issues in order to promote the user experience.

Portable context aware devices, like GPS, have experienced a rapid development in recent years. Such devices are usually limited by the lack of size and ergonomic methods, which makes it difficult for the end users to manage, for example the well-known fat-finger problem. In this regard, a better understanding of the human factor issues involved in a context aware service may contribute to the development of more effective interaction, by helping the designers to optimize the interactive elements and processes.

1.2 Research aim and objectives

1.2.1 Research Aim

The aim of this research is:

"Exploring human factors in context aware activities."

1.2.2 Objectives

The specific objectives to achieve the above aim are identified as follows:

Objective 1:

Review the history and development of context awareness, and to identify the major components of human factor issues involved in context aware activities through literature review.

Measurement:

A conceptual framework will be proposed based upon the identified components at the end of Chapter 2.

Objective 2:

Identify the human factors in a specific context aware activity based on the above-identified components, using qualitative methods: focus groups and interviews.

Measurement:

The identified factors will be listed in section 5.2.1, and used to help conduct follow-on empirical experiment.

Objective 3:

Assess the relationships between the identified human factors through empirical experiment. The data gathered by surveys will be statistically analysed, along with the data collected in experimental task.

Measurement:

The relationships between the identified human factors will be revealed at the end of this stage. This will be demonstrated in section 6.4 and 7.3.

Objective 4:

Further develop the proposed conceptual framework based on the above-identified relationships. This stage aims to provide a conceptual framework for the human factor issues involved in context aware activities, which illustrates the identified components and their relationships.

Measurement:

The framework will be presented and interpreted in section 9.1.1.

Objective 5:

Develop an empirical approach to help the identification and evaluation of the human factors involved in context aware activities. The developed approach and the conceptual framework will be reviewed by interaction designers in a workshop, in order to gain practical feedback.

Measurement:

This approach will be attached to this thesis as Appendix C, and the workshop will be discussed in section 9.3.

These objectives will be evaluated in Chapter 8.

1.3 Research strategies

This research mainly consists of the following three phases:

1. Contextual Review - this phase will review the history and development of ubiquitous computing and context aware applications, and then focus on recognizing the challenges of context aware services from a user centred perspective, and also exploring the human factors involved in dynamic context aware adaptation through a literature review. This phase aims to provide a fundamental basis for the following empirical studies by reviewing related works in the field of human computer interaction and psychology (see Chapter 2 and 3).
2. Identification of the influencing factors of user's preference - this phase aims to identify the influencing factors of users' preference involved in the proposed domain (see section 4.1) by using focus group discussion. The identified influencing factors will be used to help conduct the following between-group experiment (see section 4.2-4.3 and Chapter 6).
3. Evaluation of the effects of different motivations on user's preference - this phase aims to examine the effects of different motivations on user's preferences in digitally-assisted wayfinding activity. A controlled between-group experiment will be designed and implemented in this phase (see section 4.1, 4.3 and Chapter 6). Also, the results and empirical findings from the experiment are expected to contribute the understanding of human factor issues related to the design of context aware applications (see Chapter 6 - 8).

1.4 Contribution

Based on the review of current knowledge in the field of ubiquitous computing, context aware applications, human computer interaction and psychology, this research proposes a conceptual framework for the human factors involved in context aware activities, which mainly consists of four sub-domains including user's motivation, perception, preference and subjective experience. The following empirical study examines the impacts of different motivations on user's preferences in context aware adaptation, and further helps the understanding of the relationships between the proposed sub-domains. Based on the findings, the proposed framework was further developed.

As a result of the conducted research, the framework provides a better understanding of the major human factors and their relationships involved in context aware activities (see the section 9.1.1).Specifically the studies showed that users' preferences for different adaptation plans are greatly influenced by their motivational states and subjective perceptions of situational/environmental factors. But the influencing factors, such as user's personal historical experience, are difficult to detect and assess automatically. Therefore it is worth considering ways to help end users express their expectations and policies in context aware adaptation, and to observe what is happening in the system, especially where context aware services which aim to promote subjective user experience in dynamic situations (see the section 2.1.3, 9.1.1 and 9.1.2.2). The empirical findings also imply that poorly designed interaction might cause interruptions to user's experience of on-going activity (see the section 9.1.2.2). In this sense, a good understanding of the human factors involved in a context aware service will help designers to create more efficient interactions for user-involved context aware adaptation.

In order to evaluate the effects of different motivations on user's preference in context aware adaptation, a two-phase empirical study in the domain of digitally-assisted wayfinding activity was developed and employed in this research. The results show the capability of the used empirical approach in identifying and evaluating the human factors and their relationships involved in the proposed domain. The results also show the potential of the employed approach for human factors assessment in other domains of context aware

application. Therefore, this empirical approach was presented with the purpose of helping researchers and designers to gain a better understanding of the human factors involved in an activity, and thereby to develop more effective and pleasant context aware services (see the section 9.3 and Appendix C).

1.5 Thesis structure

1. **Introduction - Introduction to the research**

   This chapter briefly introduces the background, objective, strategies and contributions of this research.

2. **Context review**

   This chapter introduces the history and development of ubiquitous computing and context aware applications, and then illustrates a conceptual framework of context aware adaptation, including the role of end users. The following sections discuss one of the major challenges of context aware services facing dynamic situation and users' internal state, which is how to ensure the user's satisfaction. The last section reviews the related psychological literatures and preliminarily provides a conceptual framework for the human factors involved in context aware activities.

3. **Research methodology**

   This chapter presents the paradigms and data collection methods that are used in this research.

4. **Approach and design of the studies**

   This chapter presents the design and approach of the studies that are used in this research.

5. **Identification of the influencing factors in route selection**

   This chapter presents the identification of the influencing factors of people's preferences in the proposed domain, through a focus group discussion.

6. **Evaluation of the effects of different motivations on user's preference**

   This chapter presents the preparation and results of the controlled between-group experiment.

7. **Enhanced study**

The implemented between-group experiment provided preliminary evidence of the impacts of participants' motivation on their preferences. However, some weaknesses of the empirical method were identified during the data analysis. The initial method was therefore analysed and improved to address the identified weaknesses. This chapter presents the design, evaluation and results of the enhanced empirical method.

8. **Review**

   This chapter presented a detailed review of this research, which mainly includes how well the work presented in this thesis meets the initial research objectives. The research process and the difficulties that were encountered are also discussed. Based on that, recommendations for similar research are given in the last section of this chapter.

9. **Conclusion**

   This chapter concludes the present research with the summary, findings, contributions and recommendations. It discusses the details, insights, and rationale of the proposed framework for the human factors involved in context aware adaptation. Also, other findings that emerged in the empirical studies are presented and discussed in this chapter.

2 Context Review

2.1 Ubiquitous computing and context awareness

2.1.1 History and development

Context awareness is usually linked to the term "Ubiquitous Computing". Ubiquitous computing was first used in 1991 by Xerox PARC Chief Scientist Mark Weiser. It has been initially defined as "*the nonintrusive availability of computers throughout the physical environment, virtually, if not effectively, invisible to the user*" (Weiser, 1993). In the early days of ubiquitous computing, many research efforts were focused on Location-Based services, such as outdoor navigation (for example GPS) or "*a richly equipped network environment*" that "*the user-interfaces of the applications themselves can follow the user as they move, using the equipment and networking resources available*" (Harter et al, 2002).

Along with the development of microchip and sensing technologies, more and more new concepts and applications have been introduced in the field of ubiquitous computing to improve the quality of our daily life and work, such as the sensor-network-based smart home/health care system evaluated by Jakkula et al (2007). More specifically, context aware applications use various sensors to utilize the context changes and resources available through physical environments. For example in the study by De Silva (2009) on smart home, four different active sensors (temperature, motion, height, and pressure) have been used to detect the human activities in a room. A video based analysis has been used to understand the human actions in a home environment, such as entering, walking, exiting, standing, sitting, using a PC, taking an object, placing an object and any other unusual event including falling. De Silva states that these activities can also be used by an automatic agency to control the room lighting, air-conditioning etc. to reduce the cost of electricity.

The term "Context-Awareness" has been introduced to describe the link between changes in environment with computer systems, and context aware system including any devices or applications which are able to adapt themselves to improve the system efficiency or user experience according to dynamic context aware entities (Nilsson et al., 2006). As one the most important infrastructural elements of context aware applications, Calvary et al. (2002)

suggested contextual attributes (entities) can include "*The attributes of the physical and software platform used for interacting with the system*", such as data flow, screen size or network bandwidth, and "*the environmental attributes that describe the physical surroundings of the interaction*", such as user actions or light conditions (for example the human actions in De Silva's study).

Apart from smart environments, context aware applications are also highly related to mobile computing. As Häkkilä et al. (2009) states, Context-Awareness is one of the rising trends of future mobile technology, and they further define the Context-Awareness in a mobile technology domain as:

> "*A state where the device is aware of the situation in which it is used, can be harnessed to serve numerous different types of use cases where the system adapts its behaviour according to the circumstances.*"

For example, some mobile phones with integrated brightness sensor like Nokia e71 can automatically adjust the backlight to save the batteries.

In recently years, many research efforts have focused on the development of Location-based applications, as Häkkilä et al. suggested that:

> "*Location-based applications form a significant area within mobile Context-Awareness, and have great potential for future commercial applications; this is particularly relevant with today's GPS-enabled mobile devices with mobile maps. Common applications demonstrating location-awareness are tour guides in the city, campus or museum environments, shopping assistants, messaging systems, and location-sensitive reminders*". (Häkkilä et al. 2009)

Other context aware location-based services, such as augmented reality, provide great opportunities for everyday use and entertainment of the future.

2.1.2 The conceptual framework of context aware adaptation

An important concept in many emerging context aware applications is utilizing the context changes and resources available through physical environments. In this regard, Strand and Linnhoff-Popien (2004) argued that context dependency

is "*a major issue in recent research work in the area of ubiquitous computing systems which are specialisations of mobile, distributed systems*", as shown in figure 2.1.

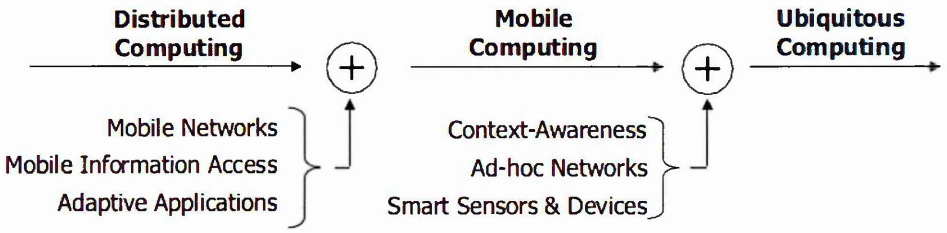


Figure 2-1 Evolution Chain taken from Strand and Linnhoff-Popien (2004)

At the infrastructure level, Geihs et al. (2009) concluded a conceptual functional model for context aware systems, consisting of the following three components:

1. Context Monitor - monitors the context, detects context changes and reason about the relevance of these changes;
2. Adaptation Decision Management (ADM) - make decisions about what adaptation to perform;
3. Implementation - implements the adaptation choices, i.e. reconfigure the user interface or attributes of applications.

2.1.3 Context aware adaptation: model and challenges

Unlike many desktop applications, ubiquitous computing supports users in dynamic situations by utilizing surrounding context to help them manage and utilise technology. It is by its nature highly dynamic since it responds to changes in context of use, and this brings new challenges to interaction design. Contextual information is monitored and when it changes the application or device configuration is changed to suit the new situation; therefore, context aware adaptation is usually more opportunistic rather than well planned task. It is, in fact, very similar to many everyday tasks, which the goals and intentions are not well specified: they are opportunistic rather than planned. As Norman (1988) has stated, opportunistic actions are those in which the behaviour takes advantage of the circumstances. Rather than engage in extensive planning and analysis, the person goes about the day's activities and performs the intended actions if the relevant opportunity arises. On the other hand, people's internal

state like motivation and preference are also highly dynamic and influenced by environmental factors; therefore, the question of interest is: how can we ensure that dynamic context aware adaptations are able to meet end user's changeable internal state? Those difficulties are also emerging at the infrastructure level of context aware applications, as Angermann and Robertson (2005) argued that "*A major issue in most context-aware systems is how to deal with uncertain, incomplete or ambiguous data*", such as end user's internal state.

In order to clarify the influential factors that affect user's preference in context aware adaptation, a more complete conceptual framework of context aware adaptation has been developed which consists of context aware system, environment and end user, as shown in figure 2.2. The end user not only interacts with context aware systems but also with environment. For example, a driver needs to react to both GPS navigator and dynamic situations on road (e.g. road condition). Meanwhile, users' internal state, such as motivation, perception, preference and emotional state can also be influenced by environmental and situational factors. The interaction of all these factors makes it very difficult to detect user's needs. This problem is very hard to solve even from a static point of view. In regard to user interface consistency, Grudin (1989) described how difficult it will be to organize interface in accordance with the rule that "consistently default to the item the user is most likely to select next" - It requires a detailed knowledge of target users and their tasks.

A possible solution to this problem, as Angermann and Robertson (2005) suggested, is the actual end user could be treated as an additional domain expert for human issues because "*he or she is the person who often has the best understanding of the personal domain*". In a study of the most relevant current approaches to modelling context for ubiquitous computing by Strand and Linnhoff-Popien (2004), a number of existing approaches have been evaluated according to six requirements. A problem with their evaluating standards is the absence of end users, as Salehie and Tahvildari (2009) summarized that much of the self-adaptive software do not have a human in the loop for policy changing or tracing adaptation processes. They further stated that the user involvement includes either express their expectations and policies, or to observe what is happening in the system, and a main challenge for self-

adaptive software is to provide an appropriate mechanism for collecting user policies, and establishing a proper mechanism to involve humans in the adaptation loop.

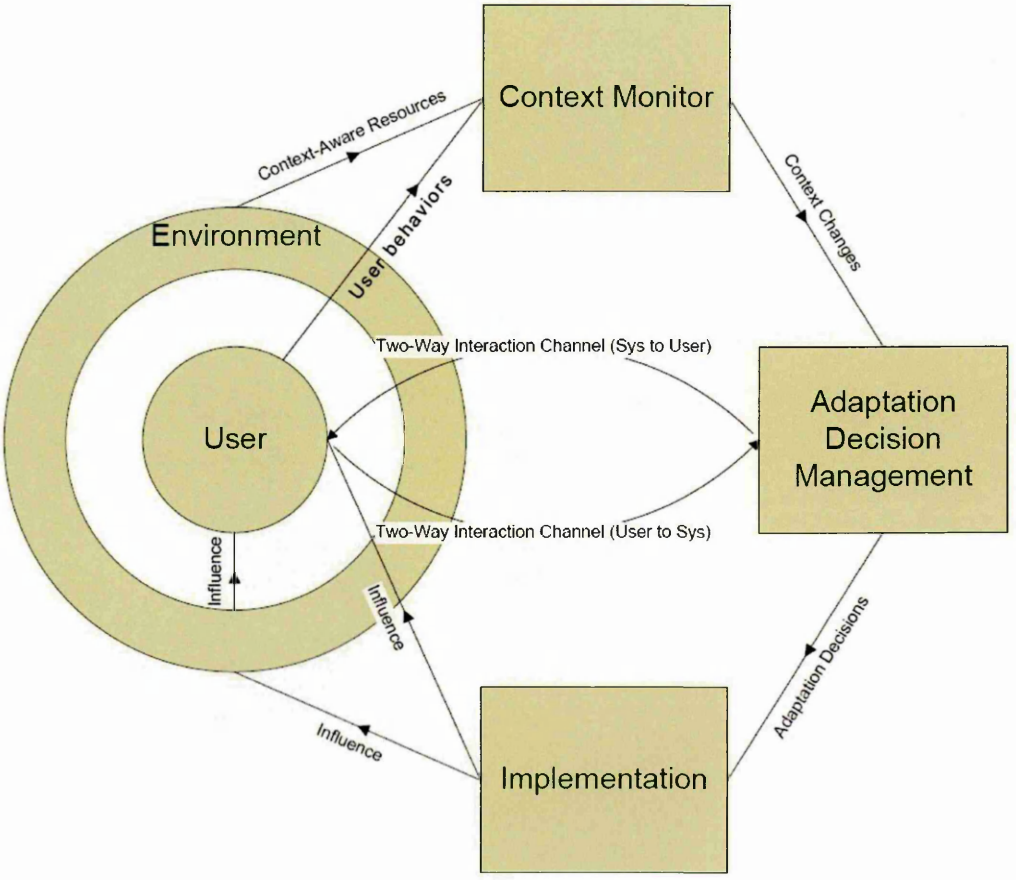


Figure 2-2 Conceptual framework for context aware adaptation

But it does not mean that designers should use end user as a "human-processor" in context aware adaptation decision-making process. Poor designed, complicated monitoring and control usually leads to low efficiency and poor user experience. As Scott Jenson (2002) suggested that there are four types of blindness within consumer product design, including user blindness, feature blindness, innovation blindness and implementation blindness. Feature blindness refers to:

> "*being awash in sophisticated features. Usually, so many must be crammed into the product, the design becomes muddled and hard to understand. While the sheer number of features is a large part of the problem, the real cause of the trouble is the implied need to show them all at once. By creating a*

cornucopia of features, the product ends up overwhelming the users, so they don't know where to start with the product." (Scott Jenson, 2002)

In simple terms, end users are not computer processor that is able to effectively handle multiple tasks at the same time. On the other hand, poor designed monitoring and control for user-involved context aware adaptation may interrupt user's experience of on-going activity, or as Csíkszentmihályi (1975) argued, interrupt the "*flow*" (which a person is fully immersed in a feeling of energized focus, full involvement, and enjoyment in the process of an activity). Therefore, designers must have an in-depth understanding of the human factors involved in a context aware activity, in order to develop more effective interaction techniques for helping end users express their expectations in dynamic context aware adaptation, and to observe what is happening in the system.

2.2 Human factors

In order to study the human factors involved in context aware adaptation, it's necessary first to understand the underlying foundation behind user's preference and behaviour. In 1988, Donald Norman (pp. 47-49) proposed in his book that human action consists of two aspects, execution and evaluation. Execution involves doing something and Evaluation is the comparison of what happened in the world with what we wanted to happen. Evaluation starts with our perception of the world and this perception must then be interpreted according to people's expectations and then compared with respect to both their intention and their goals. The following sections will explore the relevant literature with a specific focus on people's motivation (reasons behind goal), perception, preference (reasons behind intention) and emotion (refers to subjective user experience).

2.2.1 Motivation and preferences

In general, motivation can be classified into two types: intrinsic and extrinsic. Intrinsic motivation refers to motivation that is driven by pleasure or satisfaction that comes from the task itself, and extrinsic motivation generally refers to activities that could only be prompted from outside of the individual, such as reward or punishment (Gerrig and Zimbardo 2002).

One of the earliest theories of motivation that considered both psychological and physical factors was Drive-reduction Theory (Friedman and Schustack, 1999, pp. 201-202), which argued that a physiological need creates an aroused state that drives the organism to reduce their needs, such as food and drink. When a need is satisfied, drive is reduced and the organism returns to a state of homeostasis - the maintenance of a steady internal state. On the other hand, people are not only pushed by our "need" to reduce drives, but also by incentives - positive or negative stimuli that lure or repel us.

Another important development in this field is the Reversal Theory, created and developed by K.C.P. Smith and Michael Apter (2013), in order to account for observations of psychological, emotional and motivational states reversals, in child and family clinics. This early work led to the description of a dynamic system, based on the concept of the "reversal": the switching between opposed motivational states. For example, you can eat being serious and pursuing a goal in eating, or being in a spirit of seeking pleasure in the moment. Thus, "serious, future-oriented" and "playful, focused on the present" are two possible (and opposite) motivational states that can be associated with the activity of eating. The theory is structured around four domains of experience, each corresponding to two opposed motivational states:

- Means-Ends - The two states in the first pair are called "Telic" (or "Serious") and "Paratelic" (or "Playful") and refer to whether one is motivated by achievement and future goals, or the enjoyment of process in the moment.
- Rules - The next two states are called "Conforming" and "Rebellious" (or "Negativistic") and refer to whether one enjoys operating within rules and expectations; or whether one wishes to be free and push against these structures.
- Transactions - The next two states are called "Mastery" and "Sympathy" and relate to whether one is motivated by transacting power and control; or by care and compassion.
- Relationships - The final two states are called "Autic" (or "Self") and "Alloic" (or "Other") and refer to whether one is motivated by self-

interests (personal accountability and responsibility) or by the interests of others (altruism and transcendence).

The key concept of the Reversal Theory is that *only one state in each pair can be active at a time*. Therefore a person can only be either goal or pleasure oriented at a time. Goal Directed Selection (Yantis, 1993) may provide some support for the Reversal Theory, which people are more likely to focus their attention on goal-related parameters when they are goal motivated - one side or the other.

In recent years, the relationship between user's motivation and preference has drawn increasing attention from HCI researchers. Hassenzahl (2003, 2008) suggested that people perceive interactive products along two different dimensions, which are Pragmatic quality – refers to the fulfilment of task-related "do-goals" (e.g. make a phone call, usability) and non-instrumental Hedonic quality – refers to the fulfilment of "be-goals" (e.g. novelty, beauty or being competent). He argued that the perceived quality of interactive products heavily depends on features of the context of use, such as whether an individual has to perform a specific task or not (2003). Hassenzahl and his colleagues (2008, 2010) have conducted a series of studies showing that the user's preference for different music players can be influenced by pre-set scenarios. The studies provided further support to the idea that:

> "*hedonic quality being a ''motivator'', capturing the product's perceived ability to create positive experiences through need fulfilment and pragmatic quality being a ''hygiene factor'', enabling the fulfilment of needs through removing barriers but not being a source of positive experience in itself.*"

A relevant argument regarding their findings that of Abraham Maslow (1997), suggesting that deficiency need is a need which creates a negative feeling if not fulfilled, but does not contribute much to a positive feeling. In order to understand the different priorities of human needs, Maslow (1943) described a hierarchy of needs, as shown in the figure 2.3. He also argued that only when our lower-level needs are met, then we will be prompted to satisfy our higher-level needs.

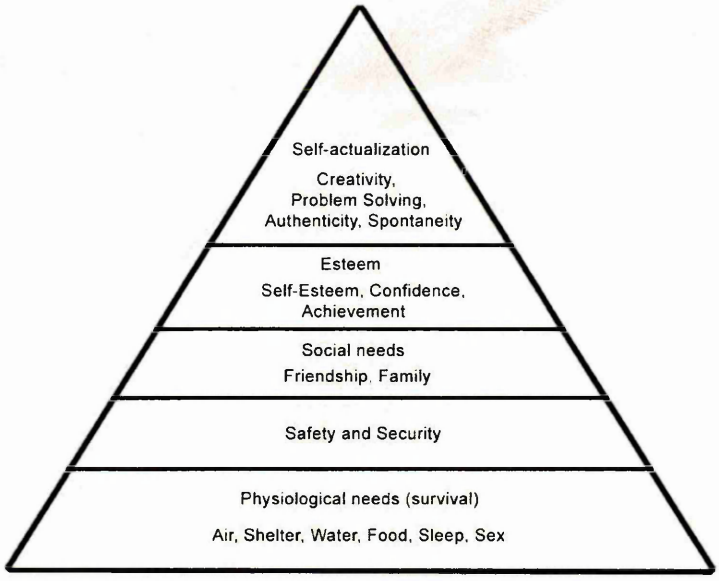


Figure 2-3 Maslow Hierarchy of Needs Diagram (Myers, 2009)

In summary, motivation is the major driving force behind our behaviours (see Drive-reduction Theory), and it largely determines what we will do when we face opportunities. On the other hand, our preferences may be influenced by different factors depending on the type of motivation (see the Reversal Theory and Hassenzahl's studies).Therefore, in order to understand users' expectations in dynamic context aware adaptation, it's necessary to first clarify the relationship between user's motivation and preference.

2.2.2 Perception

Perception is a very important and complex process that identifies and interprets the sensory information in order to understand the environment. Depending on our learning, the aroma of good food can motivate our behaviour. So can the sight of things we find attractive or threatening (Myers, 2009). For example, children may be scared by the image of snakes if they have learned that snakes are dangerous. In another words, our preference can be influenced by different perceptions (caused by different learning histories).The two main forms of perception are: one, bottom-Up process which refers to sensory analysis that starts at the entry level (e.g. touch and smell) and two, top-down effects which refers to the interpretation of sensory detection by the human minds - Human construct perceptions drawing both on sensations coming bottom-up to the brain and on our experience and expectations. Norman (1988,

pp. 47-49) proposed seven stages of action to describe the process of human behaviours, which consists of Forming the Goal, Forming the Intention, Specifying an Action Sequence, Executing an Action, Perceiving the State of the World, Interpreting the State of the World and Evaluating the Outcome, as shown in the figure 2.4 (1988, p. 47). As described earlier, he also proposed that human action consists of two aspects, execution and evaluation. Execution involves doing something and Evaluation is the comparison of what happened in the world with what we wanted to happen (Norman, 1988).

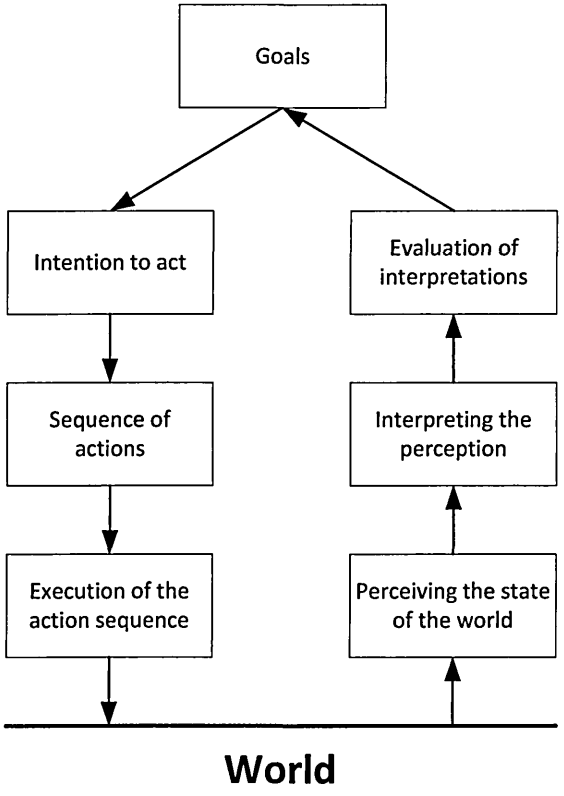


Figure 2-4 Seven Stages of Actions (Norman, 1988)

Evaluation starts with our perception of the world and this perception must then be interpreted according to our expectations and then compared with respect to both our intention and our goals. In summary, perception is usually the beginning of our daily activities, and user's role in context aware activities is beginning with the perception of context.

2.2.3 Subjective experience

As one of the most important components of user experience, subjective experience and emotion have drawn more and more attention in the field of HCI. As described in section 2.2.1, subjective experience can be promoted through need fulfilment and removal of barriers. At a very basic level, human behaviours and preferences can be manipulated by reinforcements. The two types of reinforcers are primary (e.g. getting food when hungry) and conditioned reinforcers. Conditioned reinforcers, also called secondary reinforcers, get their power through learned association with primary reinforcers. Our lives are filled with conditioned reinforcers - money, good grades or a pleasant tone of voice - each of which has been linked with more basic rewards (Myers, 2009, p. 307). The secondary reinforcers are greatly influenced by our personal historical experience - we only respond to a conditioned stimulus if we have already learnt it.

One of the most important developments in the field of emotion research is the Two-Factor theory proposed by Stanley SchAchter and Jerome Singer (1962). The Two-Factor theory suggests that our physiology and our cognitions - perceptions, memories, and interpretations - together create emotion. It argues that our emotions have two ingredients: physical arousal and a cognitive label. Like James and Lange (Cannon, 1927), Schachter and Singer presumed that our experience of emotion grows from our awareness of our body's arousal, as shown in the figure 2.5. They also believed that emotions are physiologically similar. In summary, an emotional experience requires a conscious interpretation (refers to reinforcers) of the arousal (Myers, p. 498). Research in the field of HCI also suggested that people "can have indirect experience before their first encounter through expectations formed from existing experience of related technologies, brand, advertisements, presentations, demonstrations, or others' opinions" (User Experience White Paper, 2011). Therefore, both perception and personal historical experience play important roles in the generation of subjective emotional experience.

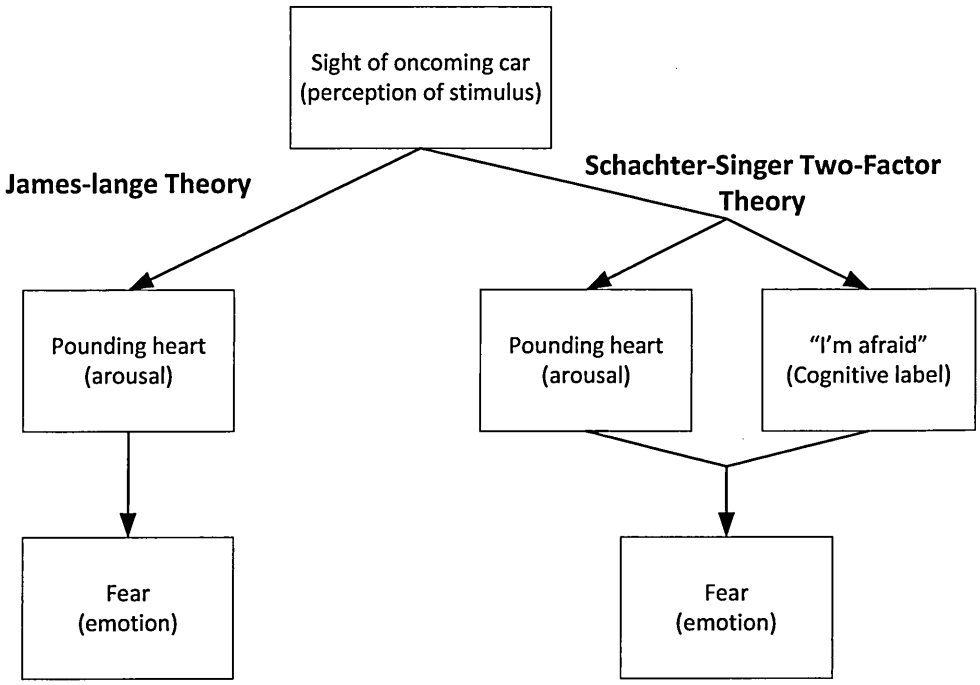


Figure 2-5 Theories of Emotion (Myers, 2009)

Emotion is also closely related to performance. Csikszentmihalyi (1975) argues that there is a balance of skill and challenge to achieve positive experience ("enter the flow"). A similar argument has been proposed by Edward L. Walker, and he argued that subjective complexity determines preference (also known as a hedgehog theory, Russell, 2008). Furthermore, he indicated that organisms prefer to do things that are neither too simple nor too complex but at an optimum level of complexity, as shown in the figure 2.6.

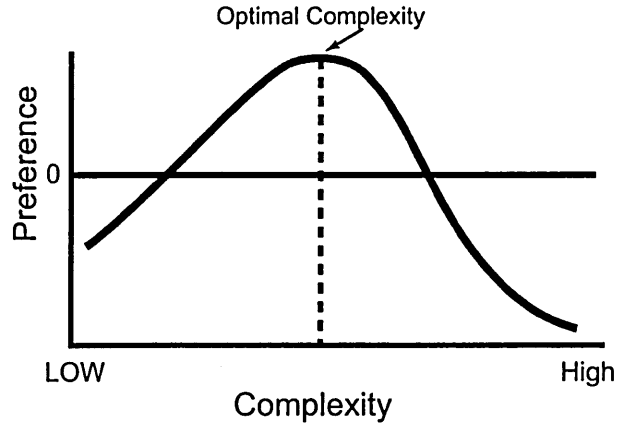


Figure 2-6The inverted-U function in Walker's Hedgehog theory taken from Russell (2008)

The problem is that people's ability to execute a task is unstable - it increases along with the increase of arousal level until they reach a point when they are

too aroused, and then their performance falls off sharply (Yerkes and Dodson, 1908), as shown in figure 2.7. On the other hand, psychologically well-practiced tasks are carried out by using automatic processing rather than controlled processing, which required less attentional resources and usually provides better performance (Birnboim, 2003). Therefore, in order to promote user's subjective experience, designers at least need to pay attention to three pairs of relationships, including skill-challenge, arousal-performance and skill-practice.

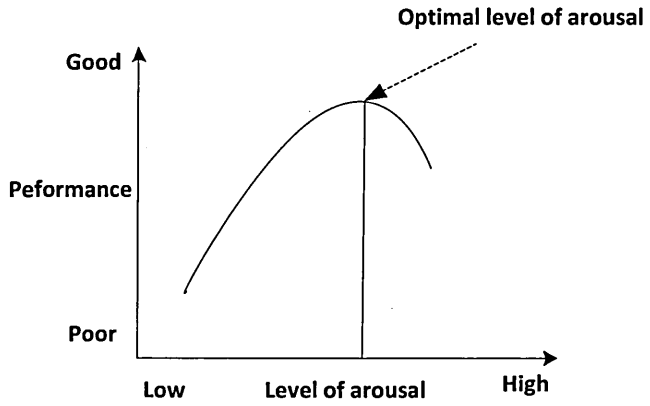


Figure 2-7The Yerkes-Dodson Law

2.3 Participatory design and human factors

As discussed earlier, people's preferences may be influenced by their motivations. It may bring new challenges to interaction design and research. Participatory design (PD) is a widely used technique and also a maturing field of research (Kensing&Blomberg, 1998). These years, PD has been introduced to the field of ubiquitous computing and context awareness. While some recent projects have attempted to put configuration into the hands of users, there is still much work to do on integrating PD with ubiquitous computing (Hornecker et al., 2006).

Participatory design generally helps designers and researchers understand their potential users and objective domain, as Clay Spinuzzi states:

> *"It attempts to examine the tacit, invisible aspects of human activity; assumes that these aspects can be productively and ethically examined through design partnerships with participants, partnerships in which researcher-designers and participants cooperatively design artefacts,*

workflow, and work environments; and argues that this partnership must be conducted iteratively so that researcher-designers and participants can develop and refine their understanding of the activity. The result of the research typically consists of designed artefacts, work arrangements, or work environments." (2005)

On the broader perspective, the skills and experiences of workers need to be present in the design and organizational implementation of computer systems, in order to ensure a better fit between technology and the ways people perform their work (Kensing & Blomberg, 1998). An example of participatory design is Plastic Interface for Collaborative Technology Initiatives through Video Exploration (also known as PICTIVE) that developed by Michael J. Muller (1991). PICTIVE usually use simple instruments like paper mock-up to create representations of graphical user interface, in order to show participants how a system will look like and how it will behave once it is finished. Participants will be required to manipulate the mock-up so it becomes easier for them to use. The participant's behaviours will be recorded by designer or researchers to explore the potential tacit issues.

An important concern involved in participatory design is how to obtain an accurate understanding of potential users' abilities, requirements and preferences. The success of a participatory design can therefore be influenced by many factors. For example, in the early days of participatory design, managers from workplace rarely participated with workers in such projects. The reason for this was that management's participation would silence the voices of workers and undermine the goal of increasing worker's say over their working conditions (Kensing & Blomberg, 1998). A possible solution, as Törpel (2006) stated, was to separate the weak and the strong parties from each other, so that the strong parties could not dominate the situation, exert their power of shaping and defining topics, functionality, meaning, relevant work/life conditions. Participatory design can also be influenced or even misled by culture issues. Heike argues that participatory design methods are highly cultured and not universally applicable. True participatory design, especially in a cross-cultural context, can only be achieved if the participatory process itself is appropriated by the participants themselves (Dearden et al., 2008).

The design game, an important method in participatory design, is a highly collaborative technique. Participants in design game will explore various design possibilities within a game setting. A potential problem of the method, as Törpel (2006) argued, is:

> *"The variety of dealing with concrete forms of work and organization of taking for granted when using the design game can take the forms of mistakenly assuming certain features of work and organization that are not present, or seemingly neutrally notice the existing form of work or organization, without taking into account possible meanings, implications, historical changes and development potentials."*

From a dynamic point of view, this problem may emerge in various forms - if participants' preferences are influenced by their motivations to participate, then the inconsistency between motivations in real-life task and experimental task will result in misunderstanding of real-users' needs. In this respect, it's important to clarify the influence of different motivations on participants' preferences in order to promote participatory design in ubiquitous computing and context aware applications.

2.4 Conclusion

Unlike many desktop applications, ubiquitous computing engages the end users with a richer environment by utilizing surrounding context to help them manage and utilise technology. Accordingly, context aware adaptation by its nature is highly dynamic since it responds to changes in context of use. A major issue in most context aware systems is how to deal with uncertain, incomplete or ambiguous data, which includes not only systemic and environmental factors, but also user's internal states like motivation and perception. Such human factors are dynamic and may produce different user's preferences in context aware activities. Similarly, subjective user experience is influenced by many dynamic factors, but the influencing factors like personal historical experience or arousal, are difficult to detect and assess automatically. Therefore it is worth considering ways to help end users express their expectations and policies in context aware adaptation, and to observe what is happening in the system, especially where context aware services which aim to promote subjective user

experience in dynamic situations. Accordingly, an in-depth understanding of the human factor issues involved in a context aware activity may help develop more effective interaction techniques. As a simple example, the parameters that have been identified as less influential in user's decision making could be moved to the advanced options, in order to simplify the user interface design.

However first of all, it's necessary to understand the components and their relationships to the human factor issues involved in context aware activities. As stated and discussed in section 2.1.3 – 2.2.3, the human factors involved in context aware adaptation consists of perception, motivation, preference and subjective experience (PMPE). In order to provide a more solid theoretical basis for the proposed PMPE framework, follow-up studies will be done to evaluate the effect of different motivations on user's preference, and also to study user's perception and subjective experience involved in context aware activities.

3 Research Methodology

3.1 Overview

Based on the review and discussion in Chapter2, this chapter first presents the main question that this research attempts to answer. The following sections discuss the research paradigm and approach that are used in this research. The last section of this chapter introduces the data collection methods that are used according to the research objectives.

3.2 Research question

As discussed in Chapter 1 and 2, the main research question is:

> Do different motivations affect users' preference in dynamic context aware adaptation?

Accordingly, the null and alternative research hypotheses under investigation are as follows:

- Null hypothesis: There is no difference in preference between intrinsically and extrinsically motivated users.
- Alternative hypothesis: There is a difference in preference between intrinsically and extrinsically motivated users.

If the null hypothesis is rejected, then the following investigation will consider how different motivations influence users' preference.

3.3 Research paradigm

Research paradigm is an interpretative framework that guided by "*a set of beliefs and feelings about the world and how it should be understood and studied*"(Guba, 1990).The two widely accepted research paradigms are positivism and interpretivism. Positivism, as Bryman (2012, p. 27) argues, its doctrine "*is difficult to outline in a precise manner, because it is used in a number of different ways by authors. For some writers, positivism is a descriptive category taking a philosophical position that can be adopted in research; for others, it is used to describe crude and often superficial data collection.*" The term Interpretivism "*subsumes the*

view of writers who have been critical of the application of the scientific model to the study of the social world"- they believe that there is a fundamental difference between people and the objects of the natural sciences (Bryman, pp. 28-30). An important point to be clear about is that each of the two paradigms – positivism and interpretivism – has its own advantages in some areas (Saunders *et al.*, 2007). Therefore this section will focus on the distinction between these paradigms with regard to the nature of this research.

In order to understand positivism as a paradigm of human knowledge, two related suppositions were identified by Giddens (1975). First, the methodological procedures of natural science may be directly applied to the social sciences. Second, the end-product of investigation by social scientists can be formulated in terms parallel to those of natural science. Positivism generally claims that science provides us with the clearest possible ideal of knowledge. Accordingly, positivism in social and human sciences usually tries to create law-like theories to explain human behaviours in social activities. However, it is "*less successful in the study of human behaviour where the immense complexity of human nature and the elusive and intangible quality of social phenomena contrast strikingly with the order and regularity of the natural world*" (Cohen *et al.*, 2003, p. 9). By contrast, interpretivism has been critical of the application of the scientific model to the study of the social world and who have been influenced by different intellectual traditions. It is "*predicated upon the view that a strategy is required that respects the differences between people and the objects of the natural sciences and therefore requires the social scientist to grasp the subjective meaning of social action*" (Bryman, 2012, pp. 28-30).

According to the proposed research question that "do different motivations affect users' preference in dynamic context aware adaptation", positivistic methods can be used to examine the relationship between the two human factors (motivation and preference), mainly including survey and empirical experiment. On the other hand, this research also attempts to investigate user's perception and subjective experience in context aware activities, and both of the factors may be greatly influenced by different learning histories between different users (see section 2.2.2 and 2.2.3). In consideration of that, focus groups, interviews and observation will also be used in follow-on studies.

3.4 Research approach

In the early days of HCI research, measurement was based on standards for human performance from human factors and psychology. Accordingly the metrics are very much based on a task-centred model, including task correctness, time performance, error rate, time to learn, retention over time, and user satisfaction. These metrics are still well-accepted, however many of the phenomena that interest HCI researchers cannot be measured in a quantitative way (Lazar, 2010, p. 5). New ways of research and forms of measurement are needed to answer questions like "why people no longer used a specific interface" or "how people use portable/mobile technology".

Research can be quantitative or qualitative or a mix of both. Quantitative can be construed as a research strategy that emphasizes quantification in the collection and analysis of data. It entails a deductive approach to the relationship between theory and research, in which the accent is placed on the testing of theories. By contrast, qualitative research can be construed as a research strategy that usually emphasizes words rather than quantification in the collection and analysis of data. It predominantly emphasizes an inductive approach to the relationship between theory and research, in which the emphasis is placed on the generation of theories (Bryman, 2012, pp. 35-36). The key issue when choosing a correct research approach to examine or explore a particular research problem is the suitability of the selected method to accomplish and address the research objectives (Saunders *et al.*, 2007, p. 610).According to the main research question, a quantitative approach will be employed to examine the relationships between user's motivation and preference through empirical experiments. Self-reported surveys will be used as source of quantitative data, mainly including user's motivational level and preference. In order to conduct the empirical experiments in the domain of a specific context aware activity (wayfinding, see section 4.1 for the further details), a focus group study will first be used to identify the human factors in the activity. Unstructured interview may also take place in the empirical experiments, the information gathered is hoped to be used to explain user's internal states and behaviours. In summary, both quantitative and qualitative approach will be employed in order to achieve the proposed research objectives.

3.5 Data collection and analysis

This section discusses the data collection and analysis methods used in this research in regard to the proposed research question and objectives, which focuses on user's motivation, preference and subjective experience. In the field of affective science multiple methods have been developed to measure people's emotions and subjective experiences, such as surveys and monitoring of physiological symptoms (changes in breath and heartbeat, stomach troubles, muscles relaxing, et al.). The monitoring of physiological symptoms usually requires specific experience and specialized equipment. Comparatively speaking, measures for people's motivations are more relied on self-reported surveys that developed based on existing theories (see section 3.5.1). Considering the research aim and resources available, it was decided to use self-reported surveys as the main measuring tools in the following experiments. The details are discussed in the following sections.

3.5.1 Motivation

The main aim of context aware computing is to support users in highly dynamic situations, so the evaluation method for users' motivational states should be able to assess their instant motivations, rather than long-term life goals. Based on self-determination theory, Vallerand (1997) proposed a hierarchical model which consists of global, contextual and situational level for different terms of motivations. Motivation at the global level reflects how an individual generally interacts with his or her environment, be that in an intrinsic, extrinsic, or amotivated fashion (Vallerand & Rousseau, 2001, pp. 389-416). At the contextual level, motivation pertains to a relatively stable motivational disposition that one adopts toward a particular context, such as sport, work, or education. Motivation at the situational level reflects why individuals engage in a specific activity at a particular time (Vallerand, 1997, pp. 271-360). In the intention to assess motivational states at the situational level in different contexts, Guay and Vallerand have developed the Situational Motivation Scale (SIMS, Guay and Vallerand, 1995; Guay et al., 2000, pp. 175-213). The SIMS is a 16-item self-report inventory (see Appendix A) designed to measure the constructs of intrinsic motivation and extrinsic motivation (including identified

regulation, external regulation, and amotivation) in both laboratory and field settings.

- Identified regulation - refers to relatively autonomous behaviours that occur when individuals come to value a certain activity as important to their personal goals (e.g., "I participate in exercise for my own good");
- External regulation - refers to non-autonomous behaviours that are underpinned and dictated by externally controlled factors such as reward, payment, or threats (e.g., "I participate in PE because I have to");
- Amotivation - refers to individual does not perceive contingencies between his or her behaviour and subsequent outcomes (e.g., "I participate in sport but I'm not sure it's worth it").

The reliability of the SIMS has been assessed by Standage et al. (2003, pp. 19-43) in two studies. Both studies consisted of a large sample size (n1=978, n2=1008) and as the authors concluded, the SIMS represents a promising measure of motivation at the situational level applicable to both field and laboratory settings. For the pre-post experimental design, results from multiple regression analyses (Guay et al., 2000, pp. 175-213) showed that the SIMS was sensitive enough to detect intraindividual changes in motivation. The SIMS was further assessed by Standage et al. (2003). Their studies showed that two items produced scores that did not conform to the hypothesised factor structure. Following their suggestions, the scores of the two items should be removed before the data analysis. The two advantages of the SIMS are that: 1) the scale is short and versatile that makes it possible to capture ongoing motivational regulations at the psychological state level and 2) it is not restricted to one context and it can be readily applied to many field and laboratory settings. Both of the above advantages make the SIMS suitable for the assessment of motivational states in context awareness research. Therefore the SIMS was chosen to be used in follow-up experiment.

3.5.2 Subjective Experience

For the purpose of exploring participant's subjective experience and its relationship with other human factors, a competent evaluation method for user's subjective experience was also required for this research. In recent years,

ethnographic and emotional study has become an important trend in the field of human computer interaction. Many research efforts have been devoted to develop a universal definition of user experience. Although it's hard to generalize because different aspects and landscapes have been chosen, many researchers agree that user experience is dynamic, context-dependent and subjective (Lai-Chong Law, et al., 2009). However, several psychological methods have been introduced into the field. Two commonly used methods for subjective experience evaluation are Positive Affect and Negative Affect scales (Watson, et al., 1988, pp. 1063-1070) and Pleasure-Arousal-Dominance emotion scales (Mehrabian and Russell, 1974, 1977).

The Positive Affect and Negative Affect scales (PANAS) consists of 20 verbal descriptors of different affective experiences, including afraid, scared, nervous, jittery, irritable, hostile, guilty, ashamed, upset, and distressed for negative affect and active, alert, attentive, determined, enthusiastic, excited, inspired, proud, strong and interested for positive affect. Participants indicated how much they experienced the particular effect on a five-point scale ranging from not at all to extremely. The PANAS allow researchers to examine the user experience of a product as a whole, rather than numbers of irrelevant fragments. In a study on the relationship between universal psychological needs fulfilments and emotional affects by Hassenzahl, Diefenbach and Goritz (2010), the PANAS was successfully used for the evaluation of the emotional effects on interactive products.

The Pleasure-Arousal-Dominance emotion scales (see Appendix A) is a three-dimensional emotion state measurement that developed by Mehrabian and Russell (1974, 1977). In their three dimensional model, Pleasure-Displeasure refers the positive-negative emotion state; Arousal-Non arousal refers to how active a person is (e.g. sleep or excited) and Dominance refers to the extent to which a person feels unrestricted or free from outside control. The PAD emotion scales consist of a set of 18 bipolar adjective pairs. Each of the three dimensions has been measured by six pairs. The PAD scale scores can be used to indicate the accurate emotional state for the participants, such as bored (P--, A--, D-), curious (P+, A++, D-) or unconcerned (P-, A--, D+). With respect to the PANAS, the PAD emotion scales provide an extra dimension (Dominance)

for the measurement of emotional state, which made it become possible to assess the user's internal states in that domain. Therefore the PAD emotion scales were chosen to be used in follow-up empirical experiment.

3.5.3 Preference

According to the research objectives, fist the influencing factors of user's preference in a context aware activity will be identified through a focus group study. The influence of the identified factors on user's preference will be evaluated in follow-up experiments. A measurement was therefore needed to evaluate the influence of the identified factors. Surveys are one of the most commonly used research methods. They are frequently used to describe population, to explain behaviours, and to explore uncharted water (Lazar *et al.*, 2010, p. 100). The two main types of survey question are open-ended question and close-ended question. Open-ended questions are useful in getting a better understanding of phenomena, and they give respondents complete flexibility in response. By contrast, close-ended question with an ordered response, like rating scales, is used when a number of choices can be given (Lazar *et al.*, 2010, pp. 111-112). A semantic differential is a variation of a rating scale which operates by putting an adjective at one end of a scale and its opposite at the other (Cohen *et al.*, 2003, p. 253). As stated by Osgood (1957), semantic differential scales are useful in three contexts: evaluating (e.g. good-bad); potency (e.g. light-heavy) and activity (e.g. active-passive).Semantic differential scales can be classified based on whether or not there is a mid-point. The use of an odd number of points on a scale suggests a five-point scale may be broken down into three categories (e.g. good-neutral-bad). By contrast, Forced-choice scales with even number of points on a scale do not give respondents the option of neutral. In this research, only a limited number of clearly identified influencing factors that directly involved in experimental task will be presented to respondents. In order to make respondents more discriminating in their judgements, four-point semantic differential scales will be used to evaluate the influence of identified factors on user's preference in follow-up experiment.

3.5.4 Statistical analysis

The statistical tests can be generally divided into two categories: parametric statistical tests and nonparametric tests. There are several general assumptions required to use parametric tests. One of the most important assumptions is that the variables should be at least scaled by intervals, which the distance between any two adjacent data units should be equal (Lazar *et al.*, 2010, p. 91). Therefore the data collected by semantic differential scales (e.g. feelings) are usually deemed inappropriate to be analysed by parametric statistical tests. The statistical methods used in this research mainly consist of two non-parametric tests in accordance with the hypothesis and the type of variables:

- In order to check participants' motivational states in follow-up experiments, the Wilcoxon signed-rank test was proposed to be used to compare their pre-post motivational levels measured using the SIMS (within-group). The test was also proposed to be used to compare participants' pre-post emotional levels measured using the PAD scales. The significance level was set to 0.05, which is widely accepted by most social researchers (Bryman, 2012, p. 348).
- In order to compare the different influence of the identified influencing factors on different motivated participants, the Mann–Whitney U test was proposed to be used to evaluate the data measured (between-group) using the proposed semantic differential scales (see section 3.5.3). The significance level was also set to 0.05.

3.6 Conclusion

This chapter has presented a detailed account of research paradigms, approaches and data collection methods according to the proposed research objectives. Both positivism and interpretivism are employed as research paradigms. More specifically, qualitative methods like focus group are used to explore the specific human factors involved in context aware activities, and quantitative methods like semantic differential scales and statistical analyses are used to evaluate the relationships between the identified human factors. The main research question under investigation is do different motivations affect users' preference in dynamic context aware adaptation? Three main measures

were identified according to the research question and other objectives, including SIMS motivational scales, PAD emotional scales and the proposed semantic differential scales for participant's preference. The following studies will be conducted within the framework established in this chapter.

4 Approach and Design of the Studies

4.1 Overview

The review of the related literatures in Chapter 2presented a conceptual framework of context aware adaptation (see section 2.1.2), which consists of three major domains: system, environment and end-user. Furthermore, the human factors involved in context aware activities were preliminarily classified into four sub-domains: perception, motivation, preference and subjective experience (PMPE).One of the main objectives of the following empirical study was to explore the interactions between the proposed sub-domains by evaluating the impact of motivational factors on users' preference in context aware adaptation. The other sub-domains beside user's motivation and preference will also be observed with the goal of helping develop a better understanding of the human factors and their relationships involved in context aware activities. The research hypotheses under investigation are as follows:

- *Null hypothesis: There is no difference in preference between intrinsically and extrinsically motivated users.*
- *Alternative hypothesis: There is a difference in preference between intrinsically and extrinsically motivated users.*

A two-phase empirical study was proposed in order to test the above hypotheses, which consists of a focus group study (phase one) and a between group experiment (phase two). As stated in Chapter 2, Location-awareness is one of the major trends in today's mobile industry; hence the empirical study was conducted in the domain of digitally-assisted wayfinding activity. As the major independent variable of the proposed between group experiment, participants' motivational state by its nature is dynamic and difficult to be influenced by using experimental settings. Therefore the experimental settings were proposed to be evaluated and developed iteratively, in order to produce expected input variables (motivations) for testing the research hypothesis. An unexpectedly weakness of the initial experimental settings was identified after the between group experiments had been completed. The initial method has therefore been revised along with the implementation of an enhanced study with

the aim of addressing the identified weaknesses (see section 4.4).Figure 3.1 shows the flowchart of the approach that has been undertaken in this research.

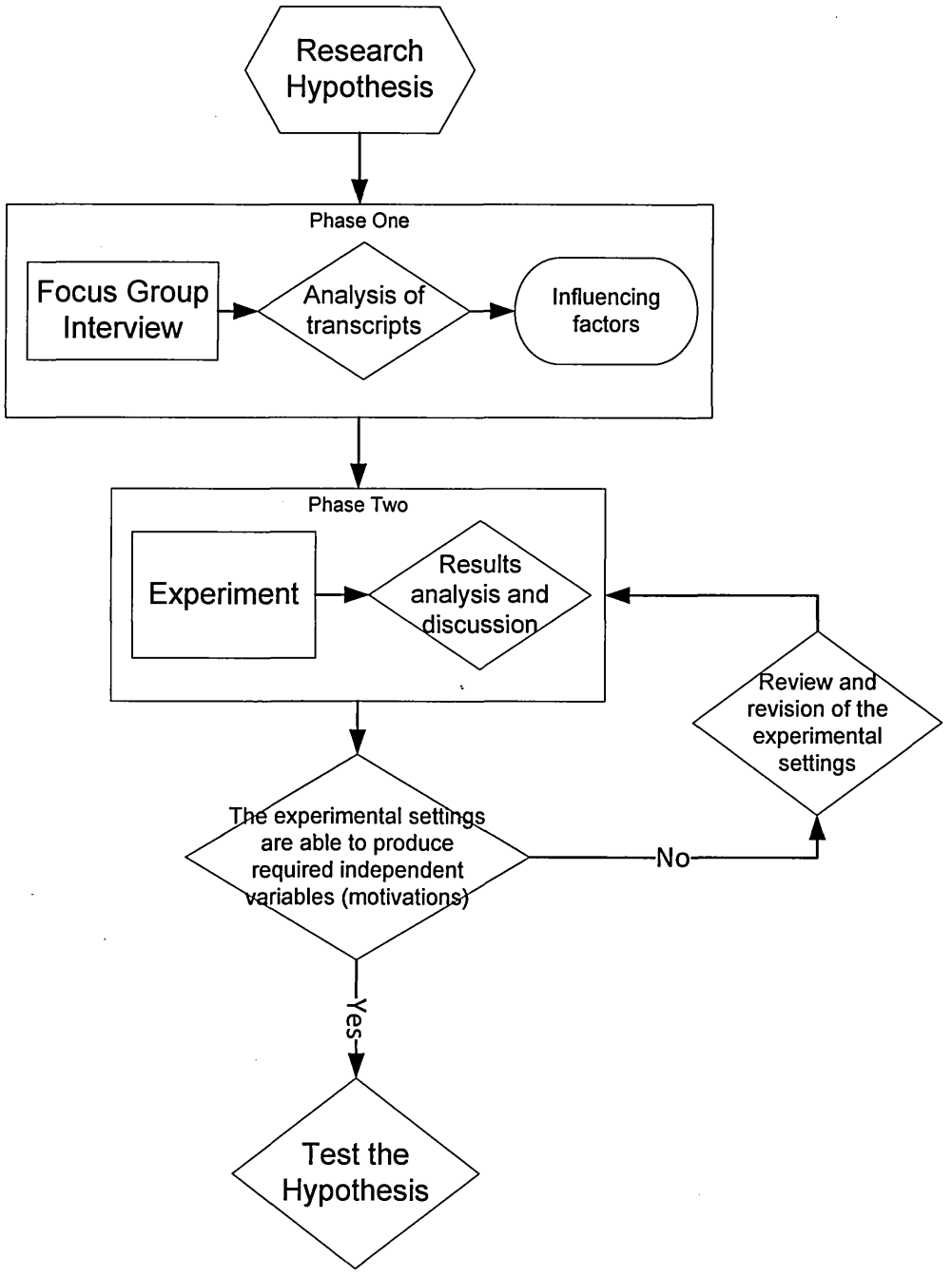


Figure 4-1 Research process flowchart

The main aim of context aware computing is to support users in dynamic situations by utilizing surrounding context, and to engage the end users with a richer or augmented environment. In order to develop an efficient context aware application, it's necessary to understand its context of use. More specifically, how does a context aware application assist users in a certain activity or task?

Does the application attempt to deliver hedonic enjoyment to its end users? These questions must be answered before the development can be started.

Accordingly, in order to assess the impact of motivations on user's preference in context aware activities, it's important to first clarify the influencing factors of users' preferences. In an attempt to understand the proposed domain (wayfinding activity), a focus group discussion was proposed as the study phase one (see section 4.2 for the further details). The focus group study was mainly aimed to identify the major influencing factors of people's preference in the proposed domain, and the results were expected to be used to help the design of the following experiments (the phase two study, see the next paragraph and Chapter 6for the further details).

The phase two study was mainly aimed to examine whether different motivations produce different effects on users' preference. In this phase of study, a controlled between-group experiment was designed to compare the influence of the identified influencing factors on participants' preference between intrinsic and extrinsic motivational states. Accordingly, two scenarios were designed in accordance with several psychological bases, and aimed to lead participants into different motivational states (See section 4.3.1.1 for the further details). The major dependent variables of this empirical experiment are the influencing factors that have been identified in the phase one focus group study. In order to check the validity of this controlled between-group experiment, participants' motivational states have been measured to evaluate whether the designed scenarios can produce the expected independent variables (different motivational states between groups, see section 4.3.1.1 for the further details).

As a result of the between-group experiment, a statistical analysis of the data collected has shown some interesting findings, which provided preliminary evidence of the impacts of participants' motivation on their preferences (See section6.4 for the further details). The statistical analysis of the participants' motivational states showed that one of the designed scenarios exerted the expected effect on the participants' intrinsic motivational levels. However, there was no statistically significant difference found in extrinsic group's motivational levels between before and after the experiments, which indicates that one of the scenarios is not able to produce the expected independent variables (See

section 4.4 for the further details). An improved scenario was therefore developed based on a systematic analysis of the previous findings, in order to address the weaknesses of the initial method. Accordingly, an enhanced study was proposed to answer the research hypotheses (See section 4.4, 6.4.1, 6.4.6 and Chapter 7 for the further details).

4.2 Identification of the influencing factors of user's preference in the proposed domain

4.2.1 Objectives

- To investigate preliminarily the effects of different motivations on people's preference through a focus group study.
- To identify the influencing factors of people's preference in the proposed domain. The identified influencing factors will be used to conduct the follow-up controlled experiment that runs to evaluate the impact of motivational factors on users' preference.

4.2.2 Focus group design

All participants were required to fill out a pre-survey before the discussion was started (see Appendix A), which was mainly intended to help the participants to recall their experiences, and arrive at a real characteristic description of their feelings. Participants in the survey were asked to write down a recent experience with regard to the proposed domain. They were also required to identify and name at least three factors that influenced their preference, and answer four introductory questions (based on scales) to summarily assess their subjective experiences and motivational states at that time. The results were intended to be used by the investigator to lead the following discussion. After the participants finished the pre-survey, a short review of the results had been undertaken by the investigator to classify the reported activities according to motivational states (see section 5.1 for the further details).

The main discussion was proposed to be divided into two sessions regarding to the types of motivation (intrinsic and extrinsic motivations). The topic of each session can be selected from the reported experiences (if available), or proposed by the investigator. In order to eliminate the mental influence of the

first discussion session, a coffee break with drinks and refreshments was taken before the start of the second discussion session.

Each of the sessions was aimed to discuss the proposed domain according to one motivational state (intrinsically motivated and extrinsically motivated). The guiding questions were designed with the following aims:

- To understand the participants' motivational states in topical circumstance - Questions like "Do you think it's important?" and "Do you feel like you have no choice but to do so?" were used.
- To identify the influencing factors of participants' preference in topical circumstance - "What things influenced your choice?" Also, questions like "would you treat (influencing factor) differently if (contextual changes)?" were used to investigate the correlation and dependence between influencing factors and motivational states.
- To understand the participants' subjective experience in topical circumstance - Questions like "Do you get excited/happy when...?", "Do you get (emotional states) when (events or activities)?" were used.

4.2.3 Participation

This focus group discussion was intended to investigate preliminarily the effects of different motivations on people's preference in the proposed domain, and to identify the major influencing factors of people's preference. The minimum requirement for the participants is that they have to have relevant experience in the proposed domain.

4.2.4 Data collection and analysis

Both discussion sessions were recorded by voice recorder. All records were transcribed to text transcripts. In accordance with the aims of this focus group discussion, the coding procedure of the text transcripts was based on the following three categories:

- Influencing factors - refers to the factors that can influence people's preference in the proposed domain;

- Motivational states - refers to the motivational components such as "I have to..." or "I like to...";
- Subjective experience - refers to the emotional components such as happy, scared, exciting or tired.

4.3 Evaluation of the effects of different motivations on user's preference

The main goal of this experiment is to evaluate the effects of different motivations on people's preferences, and the results were also expected to help better understand other human factors involved in context aware adaptation, mainly including user's perception and subjective experience. During the experimental process, participants were required to carry out a given task individually with a provided context aware device (see section 6.1). Two different scenarios were designed and deployed in order to lead participants into different motivational states (see section 4.3.1.1). The effects of the identified influencing factors on participants' preferences were measured by using a self-report survey after the given task was completed. The self-report survey was developed based on the influencing factors that identified in the phase one focus group study. Each of the identified influencing factors is listed on the self-report survey with a four-point scale (see Appendix A). Participants in the survey were asked to use the scales to assess how much their preference was influenced by each of the factors.

4.3.1 Experimental design

4.3.1.1 Scenarios

In the proposed between-group experiment, participants were randomly assigned to two groups under different experimental scenarios. Each of the scenarios was intended to lead subjects into a certain motivational state (intrinsic and extrinsic motivational states).The experimental scenarios were designed based on the earlier literature review, which according to the following three aspects:

- Goal and objective - to be extrinsic motivated an individual must have the perception that a certain activity is important to him/herself (see Chapter

2 and section 5.2). Therefore, for the extrinsic group, selected background information was given to the participants to indicate the significance of the experiment before the task was started. Also, a clear goal was given to the extrinsic group (see the following paragraph).

- External Promotion - intrinsic motivation refers to motivation that is driven by pleasure or satisfaction that comes from the task itself, and extrinsic motivation generally refers to activities that could only be prompted from outside of the individual (see section 2.2.1), such as reward or punishment. Therefore, an external promotion can be used to improve participant's extrinsic motivation level by rewarding their accomplishment (see section 6.2.2).
- Balance between skills and challenges - as described in section 2.2.3, there is a balance of skill and challenge to achieve positive experience, so barriers should be used to ensure that the optimal balance could not be achieved by extrinsic group (see section 6.2.2).

4.3.1.2 Procedures

In the between-group experiment, participant was required to carry out a given task individually with a provided context aware device (see section 4.5). Also, both pre-surveys and post-surveys were proposed to be used to evaluate subjects' motivational and emotional states, and also the effects of the identified influencing factors.

4.3.2 Instrument

The instrument for this study consists of two parts: self-report surveys and a context aware device (GPS Navigator) with regard to the proposed domain (see section 4.5). Participants were required to fill out the SIMS and PAD emotion scales before the experimental task was started (see Appendix A). An introduction of the task and a consent form were also given to the participants (see Appendix A). After the completion of the task, all participants were asked to fill out the SIMS and PAD emotion scales again that used to evaluate the intraindividual changes in their motivational and emotional states. Also, the self-report survey for the evaluation of the effects of the identified influencing factors was given to the participants.

4.3.3 Data collection

Besides the pre-post surveys, user's task accomplishment and interactions with the given device were also recorded, in order to provide their preference and behaviours under different motivational states. The records mainly including time spent on the given task, number of clicks and time spent on information reading (see section 5.2.4for the full details).

4.4 Enhanced study

In the controlled between-group experiment, two scenarios were designed to lead participants into different motivational states. Correspondingly, the independent variables (participant's motivational level) have been measured in order to examine the validity of this empirical experiment. The results showed that although one of the scenarios revealed its ability to raise participants' intrinsic motivation levels, the other one has failed to deliver significant impact on participants' extrinsic motivation levels (see Chapter 6 for the further details). The independent variable has therefore been further studied (see section 6.4.1 for the further details), and then a revised scenario was designed to raise the participant's extrinsic motivational level (see section 7.1 for the further details). Accordingly, an enhanced study was designed with the aim of increasing the strength of the initial method in influencing participants' motivational levels. As a result, the revised scenario showed statistically significant influence on the participant's extrinsic motivational level (see section 7.3 and 7.4 for the further details).

4.5 Design and implementation of the GPS Navigator

As shown in the figure 4.2, a handheld GPS navigator was developed based on windows mobile smartphone and HP Mediascape (DfES and HP labs). The smartphone used is Acer S200 with a 3.8-inch touch screen (resolution of 800x480 pixels).

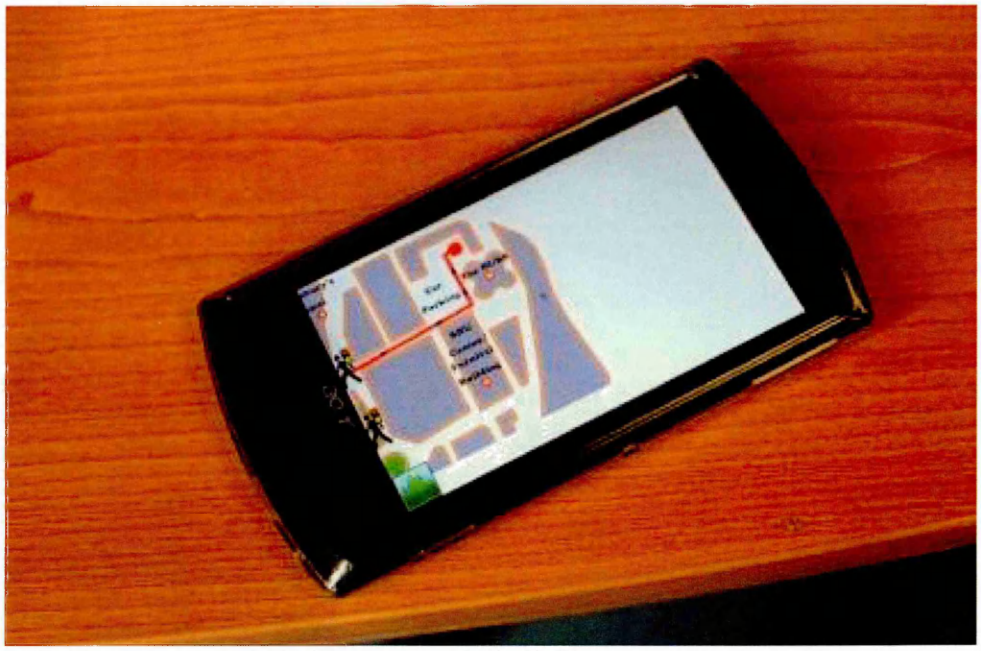


Figure 4-2 Acer S200 with HP Mediascape, modified according to this study

4.5.1 Functional requirements of the Navigator

In accordance with the proposed hypotheses and experimental procedure (see section 6.1 and 6.2), the GPS navigator was developed to be used by participants during the empirical experiments. The main functions of the navigator are listed as follows:

- GPS navigation - the navigator should be able to show the map of experimental area and the real-time position of itself;
- To trigger an event by GPS coordinates or timing - the navigator should be able to trigger a certain event by pre-set GPS coordinates or timing, such as forced interruptions to the task (see section 4.3.1.1) or selection between two different routes;
- Interaction - the navigator should be able to provide the information of different routes on participant's request;
- Data recording - the navigator should be able to record the required experimental data such as actual route taken by participant, task duration and interaction with participant.

In addition to the self-reported surveys, the following data recorded by the navigator for the purpose of interpreting the participants' behaviours:

- Duration – how many minutes a participant spent to complete the given task;
- Actual route – the actual route taken by a participants (route 1 or 2);
- Number of clicks – the number of clicks that have been made on the navigator during route selection;
- Time spent on information reading - how many seconds a participant spent on information reading during the route selection.

4.5.2 Implementation of the Navigator

During the development stage, first a map of the experimental area was drawn and then the GPS coordinates were given to the map. This work was done through the use of HP Map Aligner, which is provided by HP along with Mediascape. The figure 4.3 – 4.6 shows how the key functions is achieved using Mediascape. As shown in figure 4.3, two events (show an image and play an audio clip) were created and given to the CircleRegion05 (GPS coordinates) so that the events will be triggered once the participant has entered the region.

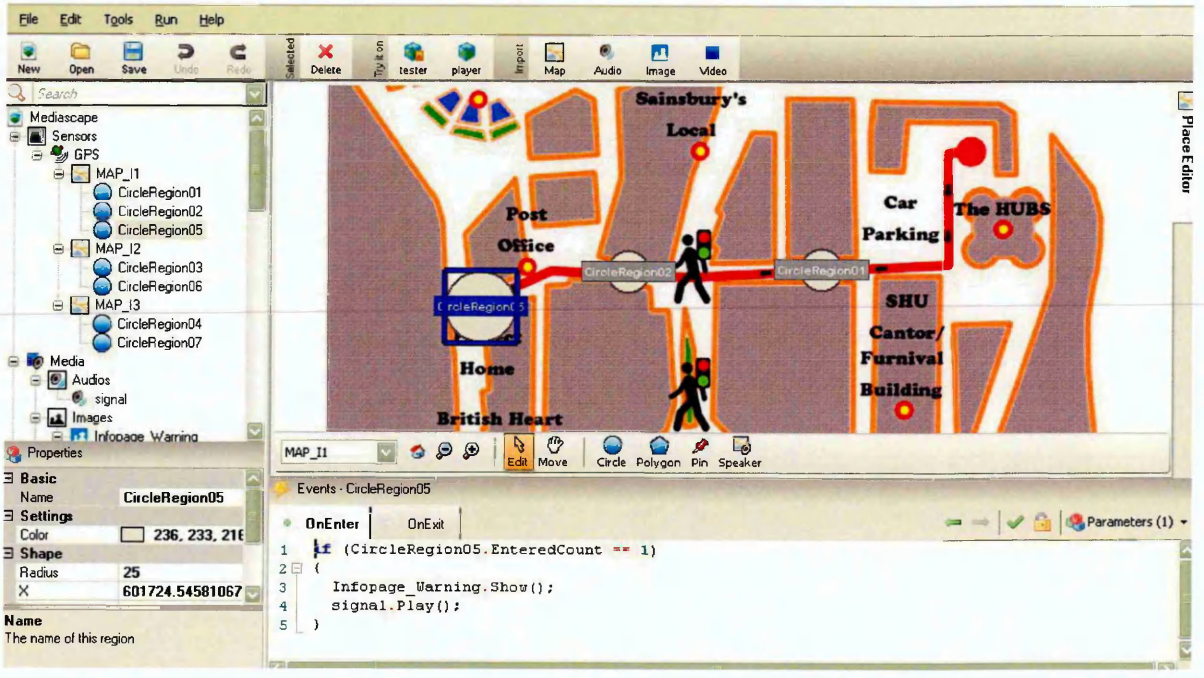


Figure 4-3Trigger event by GPS coordinates

The figure 4.4 shows how to create an interruption to the experimental task by using GPS coordinates and timing: a timer was created and given to the CircleRegion02 along with the other two events (show the image "Searching" and play the audio clip "Alarm02"). Once a participant walked in the CircleRegion02 and triggered these events, the map will be replaced by the image "Searching" for several seconds as the timer was set.

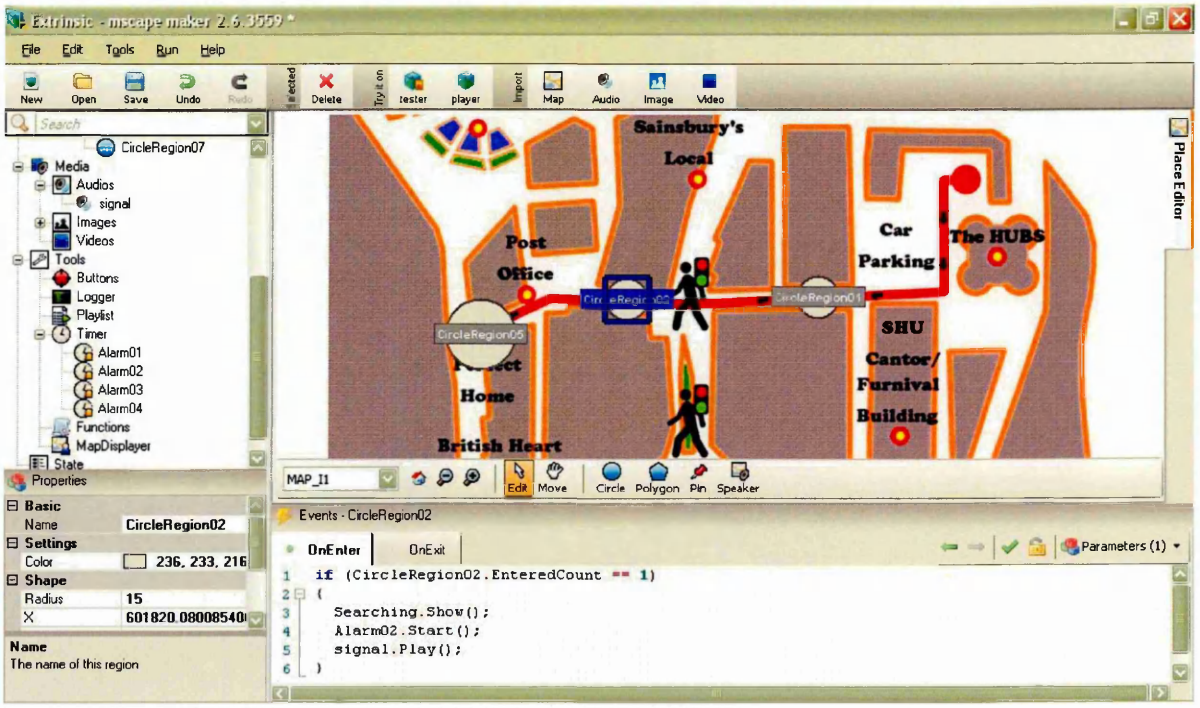


Figure 4-4Use a timer

The figure 4.5 shows how to configure a timer: two events (stop playing the audio clip "Signal" and display a new map "MAP_I1") were created and given to the timer "Alarm01" that was set to ring after 25 seconds, so that the two events will be triggered once the time is up.

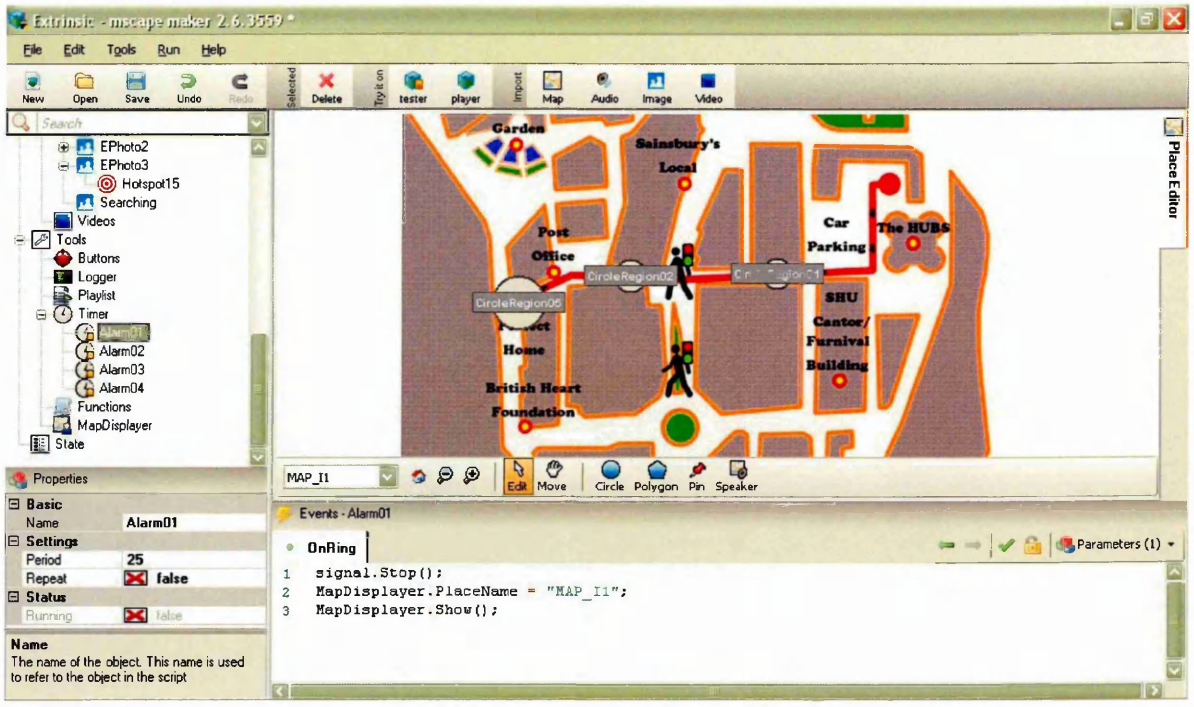


Figure 4-5 Configure a timer

The figure 4.6 shows how to create a graphic user interface for the navigator: first a picture was created and imported into Mediascape, and then a hotspot (Hotspot 16) was defined on the picture. The final step is to give the event (show the map "MAP_I2") to the hotspot so that it will be triggered once the hotspot (button "Click to choose Route 2 for the rest of the way") has been clicked.

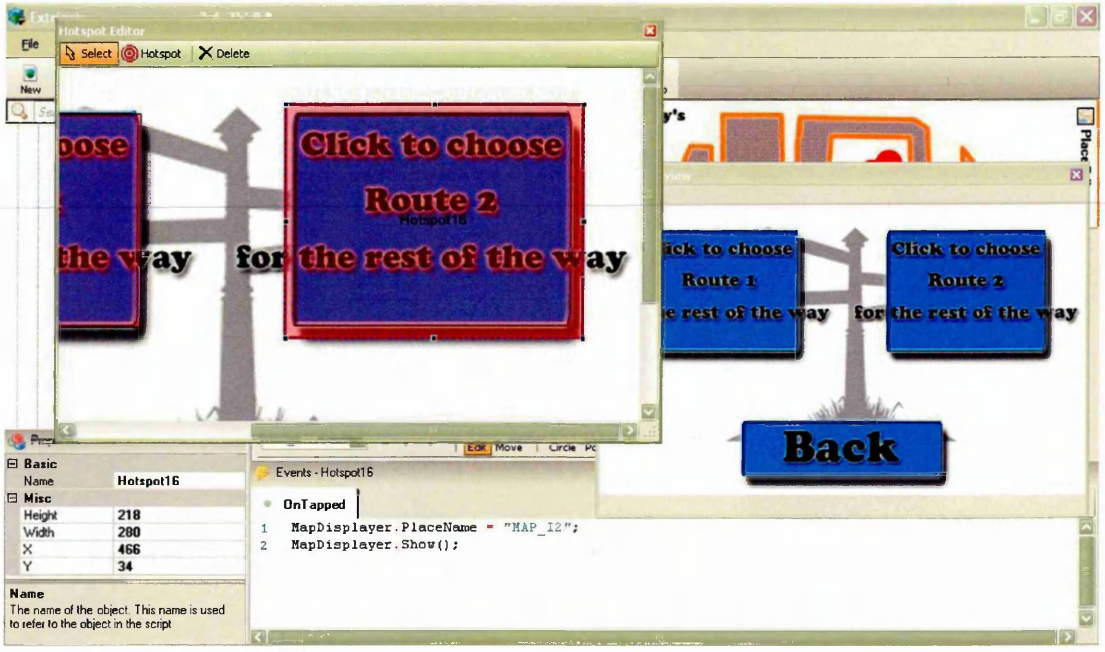


Figure 4-6 Create a user interface

4.5.3 Development and testing of the Navigator

The first functional prototype of the GPS navigator was tested by the investigator to check its built-in functions (see section 4.5.1), signal accuracy and reliability. It was further developed after several rounds of task walkthrough and debugging. Then the navigator was tested by inviting testers from the investigator's social and research networks. An unstructured interview had been held with each of the testers after the experiment was completed. Overall, the developed navigator showed adequate ability to guide the participants to complete the given task. However, two problems with the first prototype were identified as follows:

- The navigator is a little difficult to use for some testers because it's difficult for them to recognize their current positions and surroundings on the map (as shown in figure 4.7).
- The layout of the navigator is changeable and difficult to follow - The navigator only show a small area of the map, and the peephole will follow the user's movement.

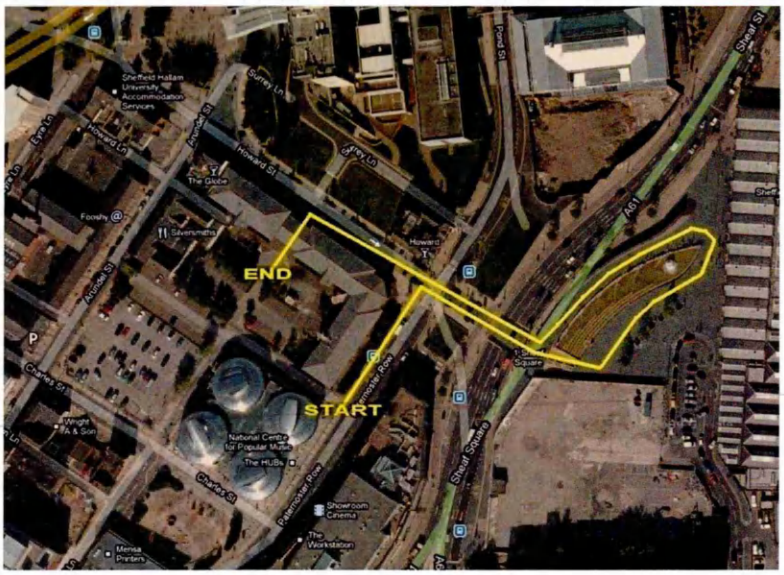


Figure 4-7 Initial map layout

The identified problems were studied according to the following aspects:

1. Peephole Navigation –mainly refers to static peephole navigation (The peephole is static and we move the spatial layout behind it) and dynamic peephole navigation (the spatial layout is static and we move the

peephole across it). A previous study (Mehra, Werkhoven and Worring, 2006) showed that dynamic peephole navigation results in a significant improvement in discrimination performance and speed;

2. The consistency between digital map and real world should be improved to help user to recognize his/her current position and surroundings, by the use of photos (A.K. Beeharee and A. Steed. 2006, Sarjanoja et al. 2009);
3. The mental workload for users should be minimized (Schreiber, J. 2009), therefore the layout of the navigator should be simple and easy for participants to distinguish between building and streets.

A new version of the navigator was therefore developed according to the above aspects, which uses a fixed layout. As shown in figure 4.8, buildings and streets are clearly distinguished on the map. Also, instructions are given to help users recognize their position and route, in the form of text and graphics.

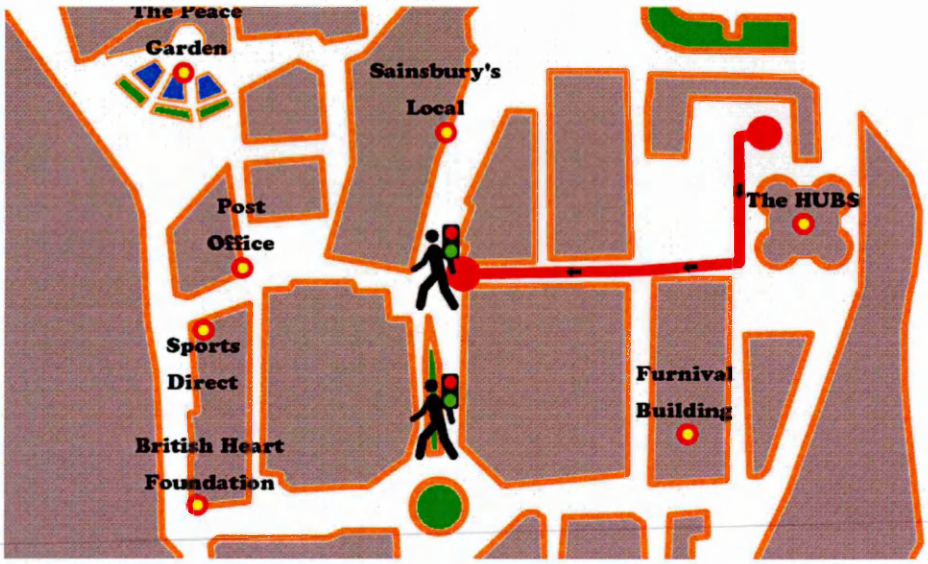


Figure 4-8Screenshots of the navigating screen

4.6 Ethics review

The ethical aspects of the proposed research studies have been approved by ACES faculty research ethics committee of Sheffield Hallam University. On the basis of research ethics policy of Sheffield Hallam University (2012), the main ethical issues for consideration are as follows:

Autonomy - All participants in this research are completely voluntary and above 18 years of age. A consent form was given to each participant before the start of studies (see Appendix A). Participants were informed that they may withdraw at any time without penalty by informing the investigator that they no longer wish to participate, and no questions will be asked.

Risk - Research should be preceded by careful assessment of predictable risks in comparison with foreseeable benefits to the participants or to others, and to prevent serious risk and irreversible harm to participant. In this research, participants may encounter time pressure and the stimulation of cash rewards during the experiment (see the section 5.2.2 and 6.1). In order to prevent serious emotional and mental harm to the participants, they were informed before the experiments that they may withdraw at any time (see also the section below).

Benefit - Concern for the interests of the participant must always prevail over the interests of science and society. In this regard, a payment of 15 - 25 pounds in cash has been given to each of the participants. The whole process of the experiment would cost each participant about 45 minutes, so the remuneration is three/four times more than the British minimum wage rate for 2012 (apprentices over 20 is £6.19 per hour).

Confidentiality - Details that would allow individuals to be identified should not be published, or made available, to anybody not involved in the research. In this regard, the participants were informed before the experiment that any information gathered during this research which could identify them will be kept strictly confidential, and will be known only to the investigator (see Appendix A).

Integrity - In the controlled between-group experiment, two scenarios were designed to produce the expected independent variables (different motivational states). Accordingly, participants' motivational states were measured using SIMS in order to ensure the validity of this empirical experiment. Although the study provided preliminary evidence of the impacts of participants' motivation on their preferences, the results show that the initial experimental setting for the extrinsic group failed to produce statistically significant increase in the participants' extrinsic motivational levels. The experimental setting has therefore

been further studied and enhanced for a follow-up experiment, in order to produce the expected independent variable and to ensure the validity of this research.

4.7 Conclusion

This chapter presents the detailed approach that was used to address the research question and objectives, including a focus group study and a between-group experiment. While this research followed this methodology, an enhanced study was also introduced as a supplement – this is described in detail in Chapter 7. As the main instrument of the proposed experiment, a GPS navigator was designed and developed according to the experimental settings (see section 4.5.1). The implementation of the navigator was briefly introduced in this chapter, along with the testing and improvement stages. Finally, this chapter presents the details of the ethical issues adopted to ensure this research was conducted in an ethical manner.

5 Identification of the influencing factors in route selection

5.1 Overview of the study

In order to develop an efficient context aware application, it's necessary to first understand its context of use. With regard to the nature of wayfinding activity, when starting point and destination are fixed, people's route planning will be mainly determined by individual's preference. For example, travellers may prefer routes that pass by famous buildings and landscapes. Accordingly, the designers of location-based services need to know the influencing factors of user's preference, so that they can provide users with meaningful contextual information and control when different routes are available.

This present focus group discussion mainly aims to identify the influencing factors of people's preference in the chosen domain (wayfinding activity). The identified factors will be used to help design the following between-group experiment which mainly attempts to examine the effects of motivations on users' preference in digitally-assisted route selection.

The duration of this focus group study was 90 minutes (see section 4.2). Four participants from the investigator's social and research networks attended the discussion (see section 4.2.3). During the study, the investigator first explained the definition of wayfinding activity, and then asked the participants to fill out a pre-survey (see Appendix A) before the discussion was started. The pre-survey was mainly intended to help the participants to recall their experiences, and arrive at a real characteristic description of their feelings. Participants in the pre-survey were asked to write down a recent experience of walk or travel, and to also identify and name at least three factors that influenced their choice of route (see section 4.2 and Appendix A). A short review of the results had been undertaken by the investigator to classify the reported activities according to motivational states (intrinsically motivated and extrinsically motivated). Two of the four respondents reported a recent experience of walking to office and the other half were about travelling to strange places. Both types of experience were discussed in the following sessions according to the proposed guiding questions (see section 4.2.2 for further details).

5.2 Results & discussion

The discussion session was recorded by voice recorder. The audio records are confidential and restricted to the consent forms (see Appendix A) that were given to the participants before the start of the focus group discussion. According to the consent form, any information gathered during the study which could identify participant's private information will be kept strictly confidential, and will be known only to the investigator. In this regard, only the audio records that helped to clarify the influencing factors are available in the attached disk. All records were transcribed to text transcripts. The coding and analysis for the transcripts were based upon the pre-defined categories (see the section 4.2.4). In summary, the results showed a possible correlation between people's motivation and preference in wayfinding activities, although there are several aspects that need to be clarified.

The findings show that, in a long-term perspective, it seems motivation will eventually be internalized by people to become their attitude towards an activity, and such attitude can greatly influence their engagement with the activity (According to the flow theory, engaged with an activity refers to people are completely concentrate on the activity, and lose partial things, such as time, people, and even basic bodily needs). For example, for the question that "*Do you usually enjoy the walking from home to work place*", one participant responded "*nothing to do with that (enjoyment), you just get to work.*" Also, compared with intrinsic motivational factors such as subjective enjoyment, extrinsic motivations are more likely to be internalized by people in wayfinding activities, especially the motivators regarding external regulation (as one participant stated, "*I don't be there on time, I don't get my salaries.*") and identified regulation ("*if you take go to work as part of your practice", "if you walk, you feel well of your body, so every day I try to walk myself instead of take a bus.*"). As stated in User Experience White Paper (2011), user experience can "refer to a specific change of feeling during interaction (momentary UX), appraisal of a specific usage episode (episodic UX), or views on a system as a whole, after having used it for a while (cumulative UX). And Anticipated UX may relate to the period before first use." Accordingly, the results of this focus group study show that user experiences in different time periods are not isolated from each other. For example, a

momentary delight in the use of a device can help to promote the user's cumulative experience of the device.

The findings suggest that motivation could influence people's engagement with an activity in a short time span (as one participant stated, "*whether I enjoy or not depends on the situation*"). Generally speaking, intrinsic motivation usually improves people's engagement with an activity (as one participant stated, "*I am on the way to A but I see B and it's interesting, I can just go to B and spend half an hour to see what's in there.*") and extrinsic motivation has opposite effects (as one participant stated, the subjective experience *"depends on the importance of work or meeting", "of course I wouldn't be spending my time to see all the buildings, trees, of course not, but I wouldn't say that I don't enjoy the walk, I still enjoy the walk, but it's not like when I have a lot of free time*"). In conclusion, the more purposeful an activity is, the less likely the people will enjoy and engage with it, and the less likely the hedonic factors will influence their preferences and behaviours.

5.2.1 Factors identification

As a result, ten major factors that influence route choice in wayfinding activities were identified. Most of the identified factors are straightforward like distance and time limitation, but the rest of them are relatively complex, such as social factors and knowledge. The following section presents the identified influencing factors and the interpretations.

1. Safety was agreed by all participants to be the primary influencing factor. (Refers to Maslow Hierarchy of Needs Diagram, see Chapter 2).
2. Time limitation - time pressure has been identified as a major factor that influence people's engagement with wayfinding activities, as one participant stated, "*If I have a time pressure, I don't think I will enjoy the walk.*"
3. Distance - usually related to time limitation and physical capabilities.
4. Weather Condition - weather has also been identified as a major factor that influence route choices and people's engagement with wayfinding activities. As one participant stated, "*if it's raining, I'd rather take a bus", "if it's a very light rain, I can just take my umbrella*".

5. Surroundings - as two of the participants stated, the desire to see "*new*", "*interesting*" or "*beautiful*" things can be a very strong motivator.
6. Cost - refers to transport fares.
7. Physical capabilities - refer to two aspects. Firstly, as one participant explained "*when my kids were small they can't walk too far*". Secondly, it's also related to people's subjective experience, as one participant stated "*if two hours is too long then you are not going to enjoy the walk*".
8. Convenient - mainly refers to road quality.
9. Social factors - refer to two aspects: the people that directly involved in same activity and the social influence of ongoing activities, as one participant stated, "*you will be upset if I am late* (to attend the focus group study)".
10. Knowledge or Familiarization - related to various issues, such as knowledge of directions, safety issues and landscapes. In summary, the effects of knowledge can emerge in various forms - on one hand, knowledge may help reduce people's negative feelings like nervous or fear, as one participant stated "*if you plan well, you don't get nervous*", "*safety may coming to it then you do this journey twenty times and something else coming*". But on the other hand, knowledge will also reduce the attraction of "*new things*".

5.3 Methodology review

This focus group study brought a number of participants with considerable experiences of similar activities, so they can inspire each other about the influencing factors involved in the proposed domain, and the investigation on each factor can be further extended if needed. However, as Weinschenk (2011) stated that "Just because decisions are made in a group setting doesn't mean that the entire group really made the decision", a common risk of focus group study is that a discussion can be dominated by a dominant personality and leads to wrong results. In order to control this potential confounding factor, participants in the pre-survey (see section 4.2.2 and Appendix A) were asked to identify and name at least three factors that influenced their choice of route, and answer four introductory questions to assess summarily their motivational states and subjective experiences with regard to their reported experiences. A short review of the reported surveys was undertaken by the investigator before the

start of discussion, and the information gathered from the pre-surveys was used for both guiding the discussion and analysing the final results.

5.4 Conclusion

The present focus group study was established to discover the influencing factors that determine people's preferences in wayfinding activities. The results primarily reveal the correlations between people's motivation and preference in wayfinding activities. The ten identified influencing factors were intended to be used to help design the follow-up between-group experiment that mainly attempts to examine the effects of different motivations on users' preference in digitally-assisted navigation.

6 Evaluation of the effects of different motivations on user's preference

6.1 Overview of the study

The first section of this chapter introduces the preparation for the proposed between-group experiment (study phase two), which was designed according to the plan as presented in Chapter 4 and treating the findings from the earlier focus group study as parameters. The second section presents an analytical discussion of the results and findings. The controlled between-group experiment was implemented to examine the effects of different motivations (intrinsic and extrinsic motivations) on users' preference in context aware adaptation (in the domain of digitally-assisted navigation). The relationships between the proposed human factors involved in context aware adaptations were also studied, including user's perception, motivation, preference and subjective experience. During the experiment, participants were asked to carry out an outdoor navigation task individually with a provided GPS navigator (context aware device). The GPS navigator was developed to provide a realistic setting for research subjects. Two different scenarios were designed and deployed in order to lead participants into different motivational states (see section 4.3.1.1). Also, two different routes were chosen to represent different qualities according to the influencing factors that identified in the earlier focus group study. Both pre and post surveys were used as described in section 4.3.3. Figure 6.1 shows the flowchart of the approach that has been undertaken in this study:

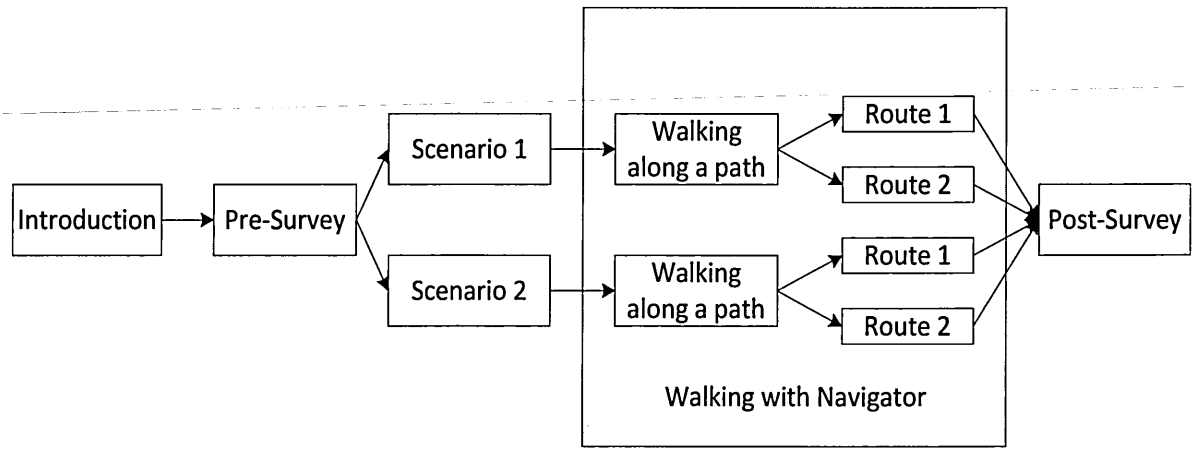


Figure 6-1 Experimental procedure diagram

6.2 Preparation for the experiment

6.2.1 Experimental task procedure

The study took place in the centre of Sheffield. The participants were required to carry out an outdoor navigation task individually with a provided GPS navigator (context aware device). During the experimental task, the participants were asked to choose between two different routes provided by the Navigator when they reached a pre-set location (about halfway to the destination). Both groups were given the same choices. The two alternative routes were chosen by the investigator to represent different route characteristics. According to the results from the earlier focus group study, the major pragmatic route characteristic involved in wayfinding activities is distance (one of the identified influencing factors), and the major hedonic route characteristics landscape (another identified influencing factor). Therefore, the Route One was expected to be perceived as a short and convenient way by the participants; it was taken a distance of 580 meters mainly through narrow streets; The Route Two was expected to be perceived in direction opposite to the route one - long, inconvenient but beautiful and pleasant; it was taken a distance of 750 meters that through a public garden and the main pedestrianized street of the city. Detailed information of the routes was provided to the participants by the navigator in the form of text (e.g. distance) and image (e.g. landscape).

6.2.2 Scenarios

The participants were randomly assigned to two groups under different experimental scenarios. The two scenarios were intended to lead subject into a certain motivational state (intrinsic or extrinsic). People's motivational state can be determined by several factors, such as goal and reward (see the section 4.3.1.1). The earlier focus group study further showed that the more purposeful an activity is, the less likely the people will enjoy and engage into it, and the less likely the hedonic factors will influence their preferences and behaviours. Therefore, a clear objective was given to the extrinsic group that they need to complete the given task in a limited time period to provide a meaningful contribution to this research. Meanwhile, in order to emphasize the significance of the given objective, the extrinsic group were told before the start that this experiment is a part of an important research study on the use of Ubiquitous

Computing technologies, and their participation and efforts will greatly improve the research process and quality. The above experimental setting was intended to improve participant's extrinsic motivational state. Accordingly, the intrinsic group was given an opposite setting, which has no time limit and background introduction.

An incentive of 20 pounds in cash was used in this study. This was based on roughly four times the national minimum wage rate for 2012 (the experimental task took about 45 minutes to complete). In order to create different motivational states, the payment was given to the intrinsic group before the task was started so that their intrinsic motivation would not be undermined by the expectation of external rewards (see section 4.3.1). But for the participants in extrinsic group, the payment was given after the post survey was completed. Table 6.1 shows the different experimental settings for intrinsic and extrinsic groups.

	Intrinsic Group	**Extrinsic Group**
Payment	Given before the task was started	Given after the task was completed
The given time limit for completing the task	None	25 minutes
Significance of the experiment	Not informed	Informed before the task was started
Interruptions during the task	None	Three times during the task

Table 6-1The experimental settings for intrinsic and extrinsic groups

In an attempt to prevent intrinsic motivation that caused by the optimal balance (see section 4.3.1.1), the participants in extrinsic group were told that they have to complete the given task in 25 minutes to make meaningful contribution to the study (time limit). The participants were also given interruptions to reduce the likelihood of the close engagement with the task as one would expect with intrinsic motivation. The unpredictable interruptions served the purpose of undermining confidence in task performance. Operationally the GPS navigator would ask the participants in extrinsic group to stop for a few seconds when

they reach the pre-set locations (two interruptions before they made the choices of routes and one time after).

6.2.3 Instruments

The instrument for this experiment mainly consists of two parts: pre/post surveys and a GPS navigator (context aware device, see section 4.5). The surveys that were used in this study include SIMS motivation scales; PAD emotion scales and the self-reported survey that used to evaluate how much a participant's choice of routes was influenced by each of the identified influencing factors (see section 3.5.3).

6.3 Participation and duration

Twenty participants were stratified at baseline by gender, and randomly assigned to two groups. All participants were students (both undergraduate and postgraduate) from the Sheffield Hallam University and the University of Sheffield between the ages of 20 to 40. The participants were mixed gender (including 13 male and 7 female) and nationality (mainly from Asia and Africa, including China, Indonesia, Libya and Vietnam). Participants whose first language is not English were required to have IELTS 6.0 or equivalent (all the participants had been studying in UK for more than one and half year). The empirical experiment consisted of 20 independent experimental sessions according to the number of participants, and each session took approximately 40 - 50 minutes. In order to minimize the influence of confounding variables in the outdoor navigation task, all sessions were conducted during normal days, which no large special events are held on the pre-set paths. Also, all of the experimental sessions were held between 10:00am and 1:00pm and under largely similar conditions (All experimental sessions were pre-booked and confirmed with the participants the day before, according to the weather conditions). The participants were also required by the investigator not to discuss the experiment with any other person until all experimental sessions are completed. All participants had confirmed before the experiment that they were directly recruited by the investigator, and have no pre-knowledge of the experiment. Besides the pre-set measurements, other empirical phenomena were also identified (see section 6.4.4). Once the post survey was completed, it

will be briefly reviewed by the investigator. A short discussion was held at the end of each experimental session. An interesting finding is that a few participants who reported that their choices were most influenced by time limit and distance, have chosen to take the longer route, correspondingly, there is also a few participants who reported that their choices were most influenced by landscapes, have chosen to go through the narrow streets rather than the public garden. The reason for this was explored in the discussion sessions and reported in section 6.4.4.

6.4 Results and discussions

6.4.1 Motivational states

Table 6.2 shows the participants' motivational states measured by SIMS before and after the given task (*+/- indicates the change after task). Statistical analyses were performed to determine if the scenarios are able to lead the participants' motivational states. The Mann-Whitney test showed that there was no significant difference in the motivational levels between the two groups. However, a Wilcoxon signed-rank test indicated that the Intrinsic Motivation levels of the Intrinsic Group (df = 10)were significantly higher on Post-test (Mdn = 0.82) than on Pre-test (Mdn = 0.735), z = - 2.818, p = .005, r = −.63; but for Extrinsic Group, there was no significant difference in Intrinsic Motivation levels between Post-test and Pre-test have been found. The results suggest that the experimental settings have indeed prevented the extrinsic group to be intrinsically motivated.

One problem with the initial experimental settings is that, the Wilcoxon signed-rank test showed that there was no significant change in extrinsic motivational state (Integrated Motivation and External Motivation) between pre-test and post-test for both groups. The results suggest that the initial experimental setting for the extrinsic group did not have the adequate strength to increase the participants' extrinsic motivational levels. One possible reason for this weakness is that extrinsic motivation generally refers to activities that could only be prompted from outside of the individual, such as reward or punishment. But in the present empirical study, both intrinsic and extrinsic groups were informed before the experiment that they will receive a payment of 20 pounds for their participation. The difference is that the participants in extrinsic group had

received their payments after the task was completed. Accordingly, the participants would not be punished if they can't complete the task. By the results, we can see that the design was not enough to convince the participants that the given objective (complete the task as soon as possible) is important to them.

Another possible basis for this lack of extrinsic motivation, as Zimbardo and Gerrig (2002) stated, motivation is not derived from subjective goals, but from our objective explanations of such goals. For example, when the investigator asked about *Method of Travel to Work* on the previous focus-group discussion, one of the participants reported it would "*depends on the importance (of work), if the meeting is very important, you mustn't be late*". In other words, participants are hardly to be extrinsically motivated if the investigator can't convince them that the given goal is important to them. In fact there are two of the participants in the extrinsic group have totally ignored the influencing factors that directly related to the goal. Both of them reported that their choices of routes haven't been influenced by time and distance at all, but Landscape- this was rather surprising since the investigator had carefully explained to them how important it is to complete the task as soon as possible. In addition to this, all participants have completed the task in 25 minutes, including those in the intrinsic group who haven't received the time limit. It implies that the lack of extrinsic motivation may also be caused by the given time limit - 25 minutes was too long.

Participants of Extrinsic/Intrinsic Group	Intrinsic Motivation (before)	Intrinsic Motivation (after)	Identified Regulation (before)	Identified Regulation (after)	External Regulation (before)	External Regulation (after)	Amotivation (before)	Amotivation (after)
No. 5 (Extrinsic Group)	0.79	0.75 (-*)	0.67	0.71 (+)	0.67	0.67	0.64	0.54 (-)
No. 3 (Extrinsic Group)	0.57	0.68 (+)	0.57	0.71 (+)	0.29	0.33 (+)	0.32	0.21 (-)
No. 4 (Extrinsic Group)	0.86	0.75 (-)	0.62	0.76 (+)	0.19	0.29 (+)	0.46	0.18 (-)
No. 10 (Extrinsic Group)	0.64	0.82 (+)	0.67	0.67	0.24	0.24	0.46	0.25 (-)
No. 11 (Extrinsic Group)	0.57	0.32 (-)	0.62	0.62 (+)	0.19	0.24 (+)	0.71	0.79 (+)
No. 8 (Extrinsic Group)	0.57	0.54 (-)	0.19	0.14 (-)	0.14	0.14	0.43	0.54 (+)
No. 7 (Extrinsic Group)	1.00	1.00	0.71	0.86 (+)	0.19	0.29 (+)	0.4	0.36 (-)
No. 15 (Extrinsic Group)	0.96	1.00 (+)	0.95	1.00 (+)	0.71	0.71	0.61	0.14 (-)
No. 18 (Extrinsic Group)	0.57	0.57	0.57	0.38 (-)	0.29	0.14 (-)	0.18	0.29 (+)
No. 19 (Extrinsic Group)	0.89	0.54 (-)	0.81	0.76 (-)	0.95	0.81 (-)	0.57	0.46 (-)
Wilcoxon signed rank test within group	No significant difference		No significant difference		No significant difference		No significant difference	
No. 6 (Intrinsic Group)	0.82	0.93 (+)	0.62	0.48 (-)	0.14	0.14	0.25	0.25
No. 2 (Intrinsic Group)	0.68	0.75 (+)	0.76	0.81 (+)	0.48	0.43 (-)	0.43	0.5 (+)
No. 12 (Intrinsic Group)	0.61	0.68 (+)	0.29	0.33 (+)	0.19	0.14 (-)	0.43	0.46 (+)
No. 1 (Intrinsic Group)	0.39	0.61 (+)	0.14	0.29 (+)	0.14	0.29 (+)	0.5	0.5
No. 9 (Intrinsic Group)	0.79	0.93 (+)	0.67	0.86 (+)	0.76	0.86 (+)	0.39	0.21 (-)
No. 13 (Intrinsic Group)	0.93	0.96 (+)	0.81	0.81	0.67	0.67	0.39	0.5 (+)
No. 14 (Intrinsic Group)	0.86	0.89 (+)	0.71	0.43 (-)	0.43	0.43	0.46	0.32 (-)
No. 17 (Intrinsic Group)	0.68	0.71 (+)	0.43	0.38 (-)	0.24	0.29 (+)	0.57	0.43 (-)
No. 16 (Intrinsic Group)	0.79	0.89 (+)	0.95	0.9 (-)	0.71	0.62 (-)	0.61	0.75 (+)
No. 10 (Intrinsic Group)	0.68	0.75 (+)	0.29	0.29	0.43	0.29 (-)	0.39	0.43 (+)
Mean (n=10)/(Extrinsic Group)	0.742	0.697	0.638	0.661	0.386	0.386	0.478	0.376
Mean (n=10)/(Intrinsic Group)	0.723	0.81	0.567	0.558	0.419	0.416	0.442	0.435
Range (n=10)/(Extrinsic Group)	0.43	0.68	0.76	0.86	0.81	0.67	0.53	0.65
Range (n=10)/(Intrinsic Group)	0.54	0.35	0.81	0.61	0.62	0.72	0.36	0.54
Wilcoxon signed rank test within group	Significant difference (p = .005)		No significant difference		No significant difference		No significant difference	
Mann-Whitney test between groups	No significant difference	No significant difference	No significant difference	No significant difference	No significant difference	No significant difference	No significant difference	No significant difference

Table 6-2The participants' motivational states before and after the given task (* Changing trends in motivational levels)

6.4.2 Preferences

Table 6.3 shows the effects of the influencing factors measured by the self-report survey (see section 3.5.3 and Appendix A) after the given task. A Mann-Whitney test showed that there were significant differences in effects of two influencing factors between groups (df = 20) including Time Pressure ($z = -2.330$, $p = .02$) and subjective Body State ($z = -2.337$, $p = .019$).The results showed that the extrinsic group had been influenced by goal-related factors (Time Pressure) more than the intrinsic group. It indicates that the null hypothesis is rejected. Hence, the failure to reject the alternative hypothesis suggests that there is a difference in preference between intrinsically and extrinsically motivated users.

An interesting finding is the different influences of subjective Body State between groups. The possible reason, as Csíkszentmihályi (1975) stated that a lack of awareness of bodily needs is one important factor for the experience of flow - the increase of intrinsic motivation leads to a decreased influence of awareness of general body state.

Participants of Extrinsic/Intrinsic Group	Distance	Safety	Route Conditions	Weather	Surroundings	Time Pressure	Investigator's Attitude*	Body State
No. 5 (Extrinsic Group)	4	2	3	3	4	1	1	2
No. 3 (Extrinsic Group)	3	4	3	4	2	3	3	3
No. 4 (Extrinsic Group)	4	1	1	1	1	4	1	2
No. 10 (Extrinsic Group)	2	3	4	3	4	2	2	3
No. 11 (Extrinsic Group)	3	1	1	1	1	4	2	2
No. 8 (Extrinsic Group)	4	1	1	1	1	3	1	1
No. 7 (Extrinsic Group)	1	3	4	1	4	1	1	3
No. 15 (Extrinsic Group)	1	1	1	1	3	4	1	4
No. 18 (Extrinsic Group)	1	1	1	1	4	1	1	1
No. 19 (Extrinsic Group)	3	2	3	1	3	2	4	3
No. 6 (Intrinsic Group)	1	1	1	1	4	1	1	1
No. 2 (Intrinsic Group)	1	2	3	1	3	1	1	1
No. 12 (Intrinsic Group)	1	1	1	1	4	1	4	3
No. 1 (Intrinsic Group)	2	2	2	1	1	1	1	2
No. 9 (Intrinsic Group)	3	2	4	1	4	2	1	1
No. 13 (Intrinsic Group)	1	3	1	1	4	1	1	2
No. 14 (Intrinsic Group)	3	3	4	1	2	1	2	1
No. 17 (Intrinsic Group)	4	4	2	1	1	3	1	1
No. 16 (Intrinsic Group)	1	2	2	1	3	1	4	1
No. 10 (Intrinsic Group)	2	2	2	1	1	1	1	1
Mean (n=10)/(Extrinsic Group)	2.60	1.90	2.20	1.70	2.70	2.50	1.70	2.40
Mean (n=10)/(Intrinsic Group)	1.90	2.20	2.20	1.00	2.70	1.30	1.70	1.40
Range (n=10)/(Extrinsic Group)	3	3	3	3	3	3	3	3
Range (n=10)/(Intrinsic Group)	3	3	3	0	3	2	3	2
Mann-Whitney test between groups	No significant difference	No significant difference	No significant difference	No significant difference	No significant difference	Significant difference (p = .02)	No significant difference	Significant difference (p = .019)

Table 6-3The effects of the influencing factors on participants' preference (* see Appendix A)

6.4.3 Emotional states

Table 6.4 shows the participants' emotional states measured by PAD scales before and after the given task (see section 3.5.2 and Appendix A). Statistical analyses were performed to assess the difference in emotional states between groups. The Mann-Whitney test showed that there was no significant difference in emotional levels between the two groups. However, a Wilcoxon signed-rank test showed that there was a significant change in Arousal level before (Mdn = 0.62) and after (Mdn = 0.74) the task for the intrinsic groups (df = 10), z = -2.501, p = .012. In addition, the results of the PAD scales also showed that half the participants in extrinsic group were happier after they completed the tasks. A possible reason for this, based on the Two-Factor theory (see section 2.2.3) is that the participants' arousal levels had been improved by the outdoor navigation task (walk), but it appears unlikely that the experimental setting was able to change the participants' cognitive labelling. As a result, many of the participants felt happier (see table 6.4) since they had higher arousal levels after walking.

On the other side, as Isomursu et al. (2007) stated that "there is controversy on whether facial expressions are perceived categorically, or if a set of emotions which can be called “basic emotions” exists." The results showed that the PAD emotional scale is sensitive enough for one of the parameters to be measured (user's arousal level), but might not be adequate for the others (user's Pleasure and Dominance level) in the present domain. The emotional factors and the evaluation method will be further discussed in section 9.1.2.4.

Participants of Extrinsic/Intrinsic Group	Pleasure (before)	Pleasure (after)	Arousal (before)	Arousal (after)	Dominance (before)	Dominance (after)
No. 5 (Extrinsic Group)	0.69	0.67 (-)	0.48	0.57 (+)	0.67	0.45 (-)
No. 3 (Extrinsic Group)	0.86	0.88 (+)	0.69	0.83 (+)	0.74	0.67 (-)
No. 4 (Extrinsic Group)	0.67	0.9 (+)	0.74	0.95 (+)	0.62	0.36 (-)
No. 10 (Extrinsic Group)	0.62	0.81 (+)	0.64	0.69 (+)	0.6	0.71 (+)
No. 11 (Extrinsic Group)	0.71	0.6 (-)	0.43	0.64 (+)	0.6	0.43 (-)
No. 8 (Extrinsic Group)	0.64	0.52 (-)	0.74	0.62 (-)	0.64	0.43 (-)
No. 7 (Extrinsic Group)	0.64	0.93 (+)	0.62	0.74 (+)	0.79	0.98 (+)
No. 15 (Extrinsic Group)	0.81	0.9 (+)	0.83	0.95 (+)	0.57	0.67 (+)
No. 18 (Extrinsic Group)	0.71	0.69 (-)	0.52	0.69 (+)	0.69	0.67 (-)
No. 19 (Extrinsic Group)	0.88	0.64 (-)	0.57	0.45 (-)	0.62	0.55 (-)
Wilcoxon signed rank test within group	No significant difference		No significant difference		No significant difference	
No. 6 (Intrinsic Group)	0.88	0.81 (-)	0.64	0.76 (+)	0.74	0.76 (+)
No. 2 (Intrinsic Group)	0.88	0.88	0.79	0.74 (-)	0.76	0.83 (+)
No. 12 (Intrinsic Group)	0.81	0.86 (+)	0.81	0.83 (+)	0.67	0.86 (+)
No. 1 (Intrinsic Group)	0.64	0.69 (+)	0.57	0.74 (+)	0.52	0.5 (-)
No. 9 (Intrinsic Group)	0.92	0.93 (+)	0.62	0.74 (+)	0.79	0.62
No. 13 (Intrinsic Group)	0.5	0.69 (+)	0.62	0.71 (+)	0.74	0.83 (+)
No. 14 (Intrinsic Group)	0.95	0.88 (-)	0.6	0.76 (+)	0.62	0.62
No. 17 (Intrinsic Group)	0.62	0.71 (+)	0.48	0.52 (+)	0.52	0.38 (-)
No. 16 (Intrinsic Group)	0.86	0.83 (-)	0.62	0.79 (+)	0.6	0.74 (+)
No. 10 (Intrinsic Group)	0.67	0.79 (+)	0.45	0.69 (+)	0.57	0.69 (+)
Mean (n=10) (Extrinsic Group)	0.723	0.754	0.626	0.713	0.654	0.592
Mean (n=10) (Intrinsic Group)	0.773	0.807	0.620	0.728	0.653	0.683
Range (n=10) (Extrinsic Group)	0.26	0.41	0.40	0.50	0.22	0.62
Range (n=10) (Intrinsic Group)	0.45	0.24	0.36	0.31	0.27	0.48
Wilcoxon signed rank test within group	No significant difference		Significant difference (p = .012)		No significant difference	
Mann-Whitney test between groups	No significant difference	No significant difference	No significant difference	No significant difference	No significant difference	No significant difference

Table 6-4The participants' emotional states before and after the given task

6.4.4 Perceptions

Participants' perceptions of the given routes were explored in the discussion sessions (see section 6.3). Even though the expected perceptions (see section 6.2.1) for the two different routes had been generally accepted by the participants, there were still some participants who believed that the longer route could be faster to go through. There were also two participants from the intrinsic group who reported that their choices of routes had mainly been influenced by judging narrow streets to be more attractive than the public garden. These findings indicate that different users can have different perceptions of the same situation or thing (event or physical/digital object). Hence individual's perception is one of the most important factors that determine users' preferences, which refers to two aspects. First, motivation is not derived from objective goals, but from people's subjective explanations of such goals. In other words, different people may perceive a same situation differently, therefore be motivated differently (see section 6.4.1). Second, users' perception of the same thing (event or physical/digital object) may be quite different based on various factors such as personal historical experience. Therefore even the users who have experienced a similar situation can have very different feelings and behaviours.

6.4.5 Other findings

Table 6.5 shows the participants' number of clicks on the navigator and time spent on information reading during the route selection stage. As stated in section 4.3 and 6.2, six photos were provided by the navigator during the route selection stage, and participant can click thumbnail to see the large images (see Appendix B). An interesting finding is that a Mann-Whitney test showed that there was a significant difference in Number of Clicks between intrinsic and extrinsic group ($df = 20$), $U = 20.5$, $z = -2.256$, $p = .024$. It suggests that the extrinsic group actually clicked more than the intrinsic group during the route selection stage - even though they were under time limits. The reason of why the extrinsic group made more clicks, as a few participants stated in the post-test discussion sessions, is that they were convinced that the given task is important, so they attempt to prevent mistakes by exploring the given

information as much as they can - by contrast, the intrinsic group had no such concerns.

Participants of Extrinsic/Intrinsic Group	Time spent on information reading (seconds)	Number of Clicks	Number of Clicks/Second
No. 5 (Extrinsic Group)	56	16	0.286
No. 3 (Extrinsic Group)	57	10	0.175
No. 4 (Extrinsic Group)	23	8	0.348
No. 10 (Extrinsic Group)	70	16	0.229
No. 11 (Extrinsic Group)	74	24	0.324
No. 8 (Extrinsic Group)	41	6	0.146
No. 7 (Extrinsic Group)	93	18	0.194
No. 15 (Extrinsic Group)	51	16	0.314
No. 18 (Extrinsic Group)	81	18	0.22
No. 19 (Extrinsic Group)	20	4	0.2
No. 6 (Intrinsic Group)	52	14	0.269
No. 2 (Intrinsic Group)	37	4	0.108
No. 12 (Intrinsic Group)	31	6	0.194
No. 1 (Intrinsic Group)	55	12	0.218
No. 9 (Intrinsic Group)	14	4	0.286
No. 13 (Intrinsic Group)	101	6	0.059
No. 14 (Intrinsic Group)	51	13	0.255
No. 17 (Intrinsic Group)	18	4	0.22
No. 16 (Intrinsic Group)	44	10	0.227
No. 10 (Intrinsic Group)	10	4	0.4
Mean (n=10)/(Extrinsic Group)	56.6	13.6	0.244
Mean (n=10)/(Intrinsic Group)	41.3	7.7	0.224
Range (n=10)/(Extrinsic Group)	73	20	0.202
Range (n=10)/(Intrinsic Group)	91	10	0.034
Mann-Whitney test between groups	No significant difference	Significant difference (p = .024)	No significant difference

Table 6-5 Number of clicks on the navigator and time spent on information reading

6.5 Conclusion

This chapter presents the detailed description and analysis of the phase two empirical study. The conducted experiment provides evidence of the effects of motivation on participant's preference in context aware adaptation, which is aligned with the initial expectation. In addition, the findings further show that among extrinsically motivated users, the pragmatic factors (e.g. time limit) that directly related to task and goal exerted a greater influence on their preferences and behaviours. By contrast, the intrinsically motivated users were usually more influenced by the non-instrumental hedonic factors. An unexpected finding is that sometimes, even the application itself (i.e., the GPS navigator) was ignored by the intrinsically motivated participants to some degree.

One identified weakness of the initial experiment settings is that, although the scenario for the extrinsic group can prevent the participants' intrinsic motivational level to be increased, it does not provide the adequate strength to increase the participants' extrinsic motivational levels. Over half of the extrinsic group reported (six participants) being influenced by Landscapes - in contrast, whereas half of the participants reported being influenced by Time Pressure. Some of the participants believed that the longer route would be easier and faster to go through but at least two of the participants who picked the longer route were just wanted to see the city's Peace Garden. As discussed in section 6.4.1, one possible explanation for this lack of extrinsic motivation is that motivation is not derived from objective goals, but from our subjective explanations of such goals. In this regard, the importance of the given task has been perceived differently by the participants, and thus results in different users' motivations and preferences. Based on the reported analysis, an improved scenario was developed to raise participants' extrinsic motivational levels, in order to address the weaknesses of the initial method (see Chapter 7).

7 Enhanced Study

The results from the earlier between-group experiment provided evidence of the effects of different motivations on participant's preference in context aware adaptation. However, the results also showed weaknesses of the used scenario approach. In the between-group experiment, two scenarios were designed and intended to produce the expected independent variables (different motivational states, see section 4.3.1 and 6.2). Accordingly, participants' motivational states were measured using SIMS in order to ensure the validity of this empirical experiment. The results showed that although one of the scenarios revealed its ability to raise participants' intrinsic motivational levels, the experimental setting for the extrinsic group has failed to produce statistically significant increase in the participants' extrinsic motivational levels. The independent variable (participant's motivation) has therefore been further studied (see section 6.4.1), and then a revised scenario was designed to raise participants' extrinsic motivational levels (see section 7.1), in order to address the weaknesses of the initial method.

7.1 Methodology revisions

The revised scenario was designed to address the issues that were identified in section 6.4.1; the detailed discussion is as follows:

External Promotion - As previously discussed, the initial scenario approach was not able to convince the participants that the given objective (complete the given task in 25 minutes) is important to them, which caused a lack of extrinsic motivation. Therefore, an extra reward (or a relative deprivation) was used in this enhanced study. In the aim of creating an effective external promotion, the payment for participation of this enhanced empirical study was reduced to 15 pounds, but the participants were informed after they completed the pre-survey that "Besides the basic payment, an extra reward of 10 pounds will be given to the participants who can complete the task in 15 minutes" (see the following paragraph for the discussion on the given time limit).

Time limit - another possible weakness of the initial experimental setting is the relatively long time required to complete the experiment (25 minutes), which resulted in a lack of external motivation. In the earlier between-group

experiment, 60% of the participants completed the given task in less than 18 minutes and the best record is 15 minutes. According to the self-determination theory, in order to be intrinsically motivated, one must have a certain level of competence (White, 1959). Vallerand and Reid (1984) further indicate that intrinsic motivation can be decreased by taking away people's need for competence. The results imply that 25 minutes is a relatively long period of time for the given task, so the extrinsic group was still able to enjoy the activity. Therefore the time limit was adjusted to 15 minutes as the best record.

Table 7.1 shows the different experimental settings for the phase two between group experiment and this enhanced study.

	Intrinsic Group	**Extrinsic Group**	**Enhanced Group**
Payment	20 pounds was given before the task was started	20 pounds was given after the task was completed	15 (+10) pounds was given after the task was completed
The given time limit for completing the task	None	25 minutes	15 minutes
Significance of the experiment	Not informed	Informed before the task was started	Informed before the task was started
Interruptions during the task	None	Three times during the task	Three times during the task

Table 7-1The experimental settings for intrinsic and extrinsic groups

The rest of the experimental settings were remained the same. The participants were required to carry out an outdoor navigation task individually with a provided GPS navigator and both pre/post surveys were used in this enhanced study (see section 6.1 and 6.2).

7.2 Participation and duration

Ten participants were recruited for this study. All participants were students (both undergraduate and postgraduate) from the Sheffield Hallam University and the University of Sheffield between the ages of 20 to 40. The participants were mixed gender (including 7 male and 3 female) and nationality (mainly from Asia, including China, Indonesia and Vietnam). Participants whose first language is not English were required to have IELTS 6.0 or equivalent (all the participants had been studying in UK for more than one and half year). The empirical experiment consisted of 10 independent experimental sessions according to the number of participants, and each session took approximately 40 - 50 minutes. In order to minimize the influence of confounding variables in the outdoor navigation task, all sessions were conducted during normal days, which no large special events are held on the pre-set paths. Also, all of the experimental sessions were held between 10:00am and 1:00pm and under largely similar conditions (All experimental sessions were pre-booked and confirmed with the participants the day before, according to the weather conditions). The participants were also required by the investigator not to discuss the experiment with any other person until all experimental sessions are completed. All participants had confirmed before the experiment that they were directly recruited by the investigator, and have no pre-knowledge of the experiment. A short discussion was held at the end of each experimental session as same as the between-group experiment. The results show that there are still two of the participants chose to take the longer path even though they were more influenced by time pressure and distance. The reason, as reported in section 6.4.4, is that they believed that the longer route could be faster to go through.

7.3 Results and discussions

Table 7.2 shows the participants' motivational states measured by SIMS before and after the given task (see section 3.5.1). Statistical analyses were performed to determine if the revised scenario is able to lead the participants' motivational states. The Mann-Whitney test showed that there was no significant difference in the intrinsic and extrinsic motivational levels between each two of the three groups (intrinsic, extrinsic and enhanced group). However, a Wilcoxon signed-

rank test showed that for the participants of the enhanced study, Identified Regulation (Extrinsic Motivation) levels (df = 10) were significantly higher on Post-test (Mdn = 0.595) than on Pre-test (Mdn = 0.545), z = - 2.035, p = .042. By contrast, for the Extrinsic Group in the earlier between-group experiment there was no significant difference in participants' extrinsic motivational levels between Post-test and Pre-test have been found. The results indicate that the revised experimental setting for the enhanced study has met the goal in raising participants' extrinsic motivational levels.

Table 7.3 shows the participants' emotional states measured by PAD scales before and after the given task (see section 3.5.2). Statistical analyses were performed to assess the difference in emotional states between groups. The Mann-Whitney test showed that there was no significant difference in the data between each two of the three groups. However, a Wilcoxon signed-rank test showed that the participants' arousal levels (df = 10) were significantly higher on Post-test (Mdn = 0.69) than on Pre-test (Mdn = 0.62), z = - 2.033, p = .042.

Table 7.4 shows the impact of the influencing factors on the participants' preferences in the enhanced study and the comparisons between each two of the three groups. Statistical analyses were performed to assess the effects of influencing factors between groups. A Mann-Whitney test showed that there was significant difference in the effect of Time Pressure (df = 20) between the participants in the enhanced study and the earlier intrinsic group, z = -3.224, p = .001; and there was no significant difference between the enhanced group and the earlier extrinsic group. Correspondingly, every participant in the enhanced study was influenced by at least one factor of Distance (7 out of 10) and Time Pressure (7 out of 10). The result provides further evidence of the difference in user's preference under different motivational levels.

Participants	Intrinsic Motivation (before)	Intrinsic Motivation (after)	Identified Regulation (before)	Identified Regulation (after)	External Regulation (before)	External Regulation (after)	Amotivation (before)	Amotivatic (after)
No. 21 (Enhanced Group)	0.71	0.86 (+)	0.81	0.86 (+)	0.29	0.24 (-)	0.29	0.5 (+)
No. 22 (Enhanced Group)	0.86	0.86	0.33	0.52 (+)	0.14	0.14	0.29	0.18 (-)
No. 23 (Enhanced Group)	0.71	0.75 (+)	0.43	0.57 (+)	0.19	0.24 (+)	0.39	0.43 (+)
No. 24 (Enhanced Group)	0.82	0.82	0.67	0.67	0.38	0.52 (+)	0.68	0.71 (+)
No. 25 (Enhanced Group)	0.71	0.82 (+)	0.57	0.48 (-)	0.24	0.19 (-)	0.25	0.25
No. 26 (Enhanced Group)	0.96	0.93 (-)	0.14	0.48 (+)	0.24	0.52 (+)	0.21	0.29 (+)
No.27 (Enhanced Group)	0.57	0.86 (+)	0.52	0.62 (+)	0.14	0.14	0.14	0.14
No. 28 (Enhanced Group)	0.89	0.86 (-)	0.81	0.86 (+)	0.48	0.57 (+)	0.14	0.14
No. 29 (Enhanced Group)	0.82	0.82	0.81	0.81	0.71	0.81 (+)	0.36	0.36
No. 30 (Enhanced Group)	0.57	0.64 (+)	0.43	0.52 (+)	0.38	0.52 (+)	0.5	0.32 (-)
Wilcoxon signed rank test within enhanced group	No significant difference		Significant difference ($p < .05$)		No significant difference		No significant difference	
Wilcoxon signed rank test within intrinsic group	Significant difference ($p < .05$)		No significant difference		No significant difference		No significant difference	
Wilcoxon signed rank test within extrinsic group	No significant difference		No significant difference		No significant difference		No significant difference	
Mean (n=10)/(Enhanced Group)	0.762	0.822 (+0.06)	0.552	0.639 (+0.087)	0.319	0.389 (+0.07)	0.325	0.332 (+0.007)
Mean (n=10)/(Extrinsic Group)	0.742	0.697 (-0.045)	0.638	0.661 (+0.023)	0.386	0.386 (0)	0.478	0.376 (-0.037)
Mean (n=10)/(Intrinsic Group)	0.723	0.81 (+0.087)	0.567	0.558 (-0.009)	0.419	0.416 (-0.003)	0.442	0.435 (-0.007)
Range (n=10)/(Enhanced Group)	0.39	0.29	0.67	0.38	0.57	0.67	0.54	0.57
Range (n=10)/(Extrinsic Group)	0.43	0.68	0.76	0.86	0.81	0.67	0.53	0.65
Range (n=10)/(Intrinsic Group)	0.54	0.35	0.81	0.61	0.62	0.72	0.36	0.54
Mann-Whitney test between intrinsic and extrinsic groups	No significant difference	No significant difference	No significant difference	No significant difference	No significant difference	No significant difference	No significant difference	No significan difference
Mann-Whitney test between intrinsic and enhanced groups	No significant difference	No significant difference	No significant difference	No significant difference	No significant difference	No significant difference	Significant difference ($p < .05$)	No significan difference
Mann-Whitney test between extrinsic and enhanced groups	No significant difference	No significant difference	No significant difference	No significant difference	No significant difference	No significant difference	Significant difference ($p < .05$)	No significan difference

Table 7-2The participants' motivational states before and after the given task

Participants	Pleasure (before)	Pleasure (after)	Arousal (before)	Arousal (after)	Dominance (before)	Dominance (after)
No. 21 (Enhanced Group)	0.83	0.88 (+)	0.64	0.74 (+)	0.62	0.69 (+)
No. 22 (Enhanced Group)	0.71	0.64 (-)	0.62	0.67 (+)	0.5	0.6 (+)
No. 23 (Enhanced Group)	0.86	0.81 (-)	0.45	0.79 (+)	0.64	0.62 (-)
No. 24 (Enhanced Group)	0.6	0.83 (+)	0.57	0.81 (+)	0.4	0.57 (+)
No. 25 (Enhanced Group)	0.83	0.83	0.55	0.62 (+)	0.57	0.67 (+)
No. 26 (Enhanced Group)	0.76	0.83 (+)	0.62	0.79 (+)	0.76	0.9 (+)
No.27 (Enhanced Group)	0.83	0.88 (+)	0.71	0.71	0.52	0.52
No. 28 (Enhanced Group)	0.95	0.95	0.67	0.64 (-)	0.71	0.67 (-)
No. 29 (Enhanced Group)	0.93	0.83 (-)	0.67	0.62 (-)	0.6	0.45 (-)
No. 30 (Enhanced Group)	0.57	0.62 (+)	0.4	0.4	0.5	0.48 (-)
Wilcoxon signed rank test within enhanced group	No significant difference		Significant difference ($p < .05$)		No significant difference	
Wilcoxon signed rank test within intrinsic group	No significant difference		Significant difference ($p < .05$)		No significant difference	
Wilcoxon signed rank test within extrinsic groups	No significant difference		No significant difference		No significant difference	
Mean (n=10)/(Enhanced Group)	0.787	0.810 (+0.023)	0.590	0.679 (+0.089)	0.582	0.617 (+0.035)
Mean (n=10) (Extrinsic Group)	0.723	0.754 (+0.031)	0.626	0.713 (+0.087)	0.654	0.592 (-0.062)
Mean (n=10) (Intrinsic Group)	0.773	0.807 (+0.034)	0.620	0.728 (+0.108)	0.653	0.683 (+0.030)
Range (n=10)/(Enhanced Group)	0.38	0.33	0.31	0.41	0.36	0.45
Range (n=10) (Extrinsic Group)	0.26	0.41	0.40	0.50	0.22	0.62
Range (n=10) (Intrinsic Group)	0.45	0.24	0.36	0.31	0.27	0.48
Mann-Whitney test between intrinsic and extrinsic groups	No significant difference	No significant difference	No significant difference	No significant difference	No significant difference	No significant difference
Mann-Whitney test between intrinsic and enhanced groups	No significant difference	No significant difference	No significant difference	No significant difference	No significant difference	No significant difference
Mann-Whitney test between extrinsic and enhanced groups	No significant difference	No significant difference	No significant difference	No significant difference	No significant difference	No significant difference

Table 7-3The participants' emotional states before and after the given task

Participants	Distance	Safety	Route Conditions	Weather	Surroundings	Time Pressure	Investigator's Attitude	Body State
No. 21 (Enhanced Group)	4	2	2	1	1	4	1	1
No. 22 (Enhanced Group)	3	3	2	1	3	2	1	1
No. 23 (Enhanced Group)	4	1	1	1	2	4	1	2
No. 24 (Enhanced Group)	3	1	4	1	4	3	1	3
No. 25 (Enhanced Group)	1	1	1	1	2	4	1	1
No. 26 (Enhanced Group)	4	1	1	1	1	3	1	1
No.27 (Enhanced Group)	3	1	1	1	3	1	1	4
No. 28 (Enhanced Group)	1	4	4	3	4	3	1	3
No. 29 (Enhanced Group)	3	4	4	2	4	3	2	3
No. 30 (Enhanced Group)	1	2	3	4	2	3	2	2
Mean (n=10)/(Enhanced Group)	2.70	2.00	2.30	1.60	2.60	3.00	1.20	2.10
Mean (n=10) (Extrinsic Group)	2.60	1.90	2.20	1.70	2.70	2.50	1.70	2.40
Mean (n=10) (Intrinsic Group)	1.90	2.20	2.20	1.00	2.70	1.30	1.70	1.40
Range (n=10)/(Enhanced Group)	3	3	3	3	3	3	1	3
Range (n=10) (Extrinsic Group)	3	3	3	3	3	3	3	3
Range (n=10) (Intrinsic Group)	3	3	3	0	3	2	3	2
Mann-Whitney test between intrinsic and extrinsic groups	No significant difference	No significant difference	No significant difference	No significant difference	No significant difference	Significant difference ($p < .05$)	No significant difference	Significant difference ($p < .05$)
Mann-Whitney test between intrinsic and enhanced groups	No significant difference	No significant difference	No significant difference	No significant difference	No significant difference	Significant difference ($p < .05$)	No significant difference	No significant difference
Mann-Whitney test between extrinsic and enhanced groups	No significant difference	No significant difference	No significant difference	No significant difference	No significant difference	No significant difference	No significant difference	No significant difference

Table 7-4The effects of the influencing factors on participants' preference

Table 7.5 shows the participants' Number of Clicks on the device (NoC) and Time Spent on information reading (Tvl) from the earlier between-group experiment and this enhanced study. Statistical analyses were performed to assess the difference in NoC and Tvl between groups. A Mann-Whitney test showed that there was a significant difference in Tvl between the earlier extrinsic group and the enhanced group (df = 20), z = -2.005, p = .045.The result indicates that the participants in the enhanced study spend less time on the information provided by the GPS navigator, which is consistent to the findings in participant's preference (see table 7.4) - they were highly influenced by the time pressure.

An interesting finding is the downward trend in standard deviations of Tvl, as shown in table 7.6. It suggests that the extrinsically motivated participants' behaviours during the route selection stage tend to become more similar to each other. A possible reason for this is that the intrinsically motivated participants may behave quite differently because of individual differences (e.g., different personalities or habits), by contrast, be extrinsic motivated the participants will focus on limited goal-related factors so their behaviours will be more convergent.

Participants of Earlier between-group experiment/Enhanced study	Time spent on information reading (seconds)	Number of Clicks	Number of Clicks/Second
No. 5 (Extrinsic group)	56	16	0.286
No. 3 (Extrinsic group)	57	10	0.175
No. 4 (Extrinsic group)	23	8	0.348
No. 10 (Extrinsic group)	70	16	0.229
No. 11 (Extrinsic group)	74	24	0.324
No. 8 (Extrinsic group)	41	6	0.146
No. 7 (Extrinsic group)	93	18	0.194
No. 15 (Extrinsic group)	51	16	0.314
No. 18 (Extrinsic group)	81	18	0.22
No. 19 (Extrinsic group)	20	4	0.2
No. 21 (Enhanced group)	34	8	0.235
No. 22 (Enhanced group)	36	4	0.111
No. 23 (Enhanced group)	40	8	0.200
No. 24 (Enhanced group)	17	5	0.294
No. 25 (Enhanced group)	32	9	0.281
No. 26 (Enhanced group)	54	10	0.185
No.27 (Enhanced group)	40	8	0.200
No. 28 (Enhanced group)	66	20	0.303
No. 29 (Enhanced group)	51	4	0.078
No. 30 (Enhanced group)	18	4	0.222
No. 6 (Intrinsic group)	52	14	0.269
No. 2 (Intrinsic group)	37	4	0.108
No. 12 (Intrinsic group)	31	6	0.194
No. 1 (Intrinsic group)	55	12	0.218
No. 9 (Intrinsic group)	14	4	0.286
No. 13 (Intrinsic group)	101	6	0.059
No. 14 (Intrinsic group)	51	13	0.255
No. 17 (Intrinsic group)	18	4	0.22
No. 16 (Intrinsic group)	44	10	0.227
No. 10 (Intrinsic group)	10	4	0.4
Mean (n=10)/(Extrinsic group)	56.6	13.6	0.244
Mean (n=10)/(Enhanced group)	38.8	8	0.211
Mean (n=10)/(Intrinsic group)	41.3	7.7	0.224
Range (n=10)/(Extrinsic group)	73	20	0.202
Range (n=10)/(Enhanced group)	49	16	0.225
Range (n=10)/(Intrinsic group)	91	10	0.034
Mann-Whitney test between intrinsic and extrinsic groups	No significant difference	Significant difference ($p < .05$)	No significant difference
Mann-Whitney test between intrinsic and enhanced groups	No significant difference	No significant difference	No significant difference
Mann-Whitney test between extrinsic and enhanced groups	Significant difference ($p < .05$)	No significant difference	No significant difference

Table 7-5Number of clicks on the navigator and time spent on information reading

intrinsic group	N	Range	Minimum	Maximum	Mean	Std. Deviation	Variance
Tvl	10	91	10	101	41.30	26.583	706.678
Valid N (listwise)	10						

extrinsic group	N	Range	Minimum	Maximum	Mean	Std. Deviation	Variance
Tvl	10	73	20	93	56.60	23.913	571.822
Valid N (listwise)	10						

enhanced group	N	Range	Minimum	Maximum	Mean	Std. Deviation	Variance
Tvl	10	49	17	66	38.80	15.303	234.178
Valid N (listwise)	10						

Table 7-6 Deviations and variances of the NoC and Tvl

7.4 Conclusion

This chapter presents the detailed description and analysis of the enhanced study. As shown in table 7.7, the revised scenario effectively increased participants' extrinsic motivational level. Accordingly, the enhanced study provided further evidence of the difference in user's preference between intrinsic and extrinsic motivations. The table also shows the changing trend in Time Spent on information reading and Number of Clicks, which implies different users' behaviours between the motivational states (see section 7.3 for further details). In summary, the participants who were highly extrinsically motivated were more focused on goal-related factors like time pressure, and their behaviours were less likely to be influenced by personal interests. By contrast, compared to the goal-related factors involved in an activity, users' personal interests may be quite different from each other, which make the extrinsically motivated participants' behaviours more convergent than the intrinsically motivated participants.

In addition, this enhanced study shows that subjects' motivational states can be greatly influenced by situational factors such as external promotion or time limit, and cause further impacts on their preferences and behaviours. It suggests that the designers who attempt to use participatory design should be careful to determine how to motivate their participants (see section 9.1.2.1 for a more detailed discussion). More detailed discussion on the human factors involved in

context aware adaptation will be presented along with the empirical findings in Chapter 9.

Difference between groups/Groups		Comparison of the earlier Between-Group Experiment (see Chapter 6)		Comparison of the earlier Between-Group Experiment and the Enhanced Study (see Chapters 6 and 7)			
		Intrinsic Group	Extrinsic Group	Intrinsic Group	Enhanced Group	Extrinsic Group	Enhanced Group
Intrinsic Motivational state	Intrinsic Motivation	Significantly increased after the task	No significant increase	Significantly increased after the task	No significant increase	-	
Extrinsic Motivational state	Identified regulation	-		No significant increase	Significantly increased after the task	No significant increase	Significantly increased after the task
Preference	Time pressure	The extrinsic group was significantly more influenced by Time pressure		The enhanced group was significantly more influenced by Time pressure		-	
	Body state	The extrinsic group was significantly more influenced by Body state		-		-	
Behaviours	Number of clicks	The extrinsic group significantly clicked more than the intrinsic group		-		-	
	Time spent on information reading	The data distribution of the extrinsic group is more centralized		The data distribution of the enhanced group is more centralized		The enhanced group spend more time, also the data distribution of the enhanced group is more centralized	
Emotion	Arousal level	Significantly increased after the task	No significant increase	Significantly increased after the task	Significantly increased after the task	No significant increase	Significantly increased after the task

Table 7-7 Results comparison

8 Evaluation of research

8.1 Evaluation of objectives

This section reviews how well the work presented in this thesis meets the initial research objectives:

Objective 1

The objective of stage one is to identify the major components of human factor issues involved in context aware activities through literature review, and to propose a conceptual framework based upon the identified components.

Evaluation of objective

The related works are reviewed in Chapter 2 according to the above objective, which mainly include the conceptual framework of context aware adaptation and the possible related human factors (see section 2.2). The objective was met by proposing the conceptual framework (PMPE) for the human factor issues involved in context aware activities at the end of Chapter 2.

Objective 2

The objective of stage two is to identify the human factors in a specific context aware activity using focus group.

Evaluation of objective

As the result of the proposed focus group study, ten influencing factors that determine people's preferences in wayfinding activities were identified and presented in section 5.2.1.

Objective 3

The objective of stage three is to assess the relationships between different human factors through empirical experiment.

Evaluation of objective

A between-group experiment was conducted to examine the relationships between the major components of the proposed PMPE framework, which mainly focuses on user's motivation, preference and subjective experience. The results provide evidence of the effects of different motivations on participants' preference in context aware adaptation (see section 6.4.1 and 6.4.2). However, a weakness of the initial approach in influencing participant's extrinsic motivational levels was identified. An enhanced study was therefore performed to address this weakness. The results show that the enhanced approach is capable of increasing participant's extrinsic motivational levels, and provide further evidence of the difference in user's preference under different motivations (see section 7.3).

Objective 4

The objective of stage four (goal one) is to further develop the proposed conceptual framework based on the above-identified relationships.

Evaluation of objective

This stage aims to provide a conceptual framework for the human factor issues involved in context aware activities, which illustrates the identified components and their relationships. The objective was met by further developing and presenting the PMPE framework in section 8.1.1.

Objective 5

The objective of stage five (goal two) is to develop an empirical approach to help the identification and evaluation of the human factors involved in context aware activities.

Evaluation of objective

The empirical approach was developed based upon the conducted experiments, and it was reviewed by interaction designers in a 90 minutes workshop, along with the PMPE framework. The feedback from the workshop are presented and discussed in section 9.3, and the empirical approach is attached to this thesis as Appendix C.

8.2 The research process

This research can be roughly divided into four steps, as shown follows:

8.2.1 Literature review

Unexpectedly, the literature review is the most time consuming part of this research – it has taken more than one-third of the total time. It's not difficult to identify the conceptual framework for context aware adaptation, and it's simple to see how end-users can fit in. However, it's relatively confusing to identify the possible human factors related to context aware activities, and it's mostly because of that human factors have been explained from very different perspectives. The final concept of this research has been greatly inspired by the works of Norman and Hassenzahl, as discussed in Chapter 2.

8.2.2 Focus group study

The focus group study is one of the least time consuming parts of this research. As warned by many researchers, it's indeed not easy to effectively guide a focus group study. All participants in this phase are from the investigator's social and research networks, therefore confusing questions can be clarified repeatedly in an exuberant and talkative mood. The pre-survey used in the focus group is discussed in length in Chapter 5.

8.2.3 Empirical experiments

This stage consists of several coherent tasks, which mainly includes the design of experimental application, participant recruitment and implementation of experiment. Overall, the initial plan was followed and completed according to schedule. However, an unexpected problem was identified in this stage, which will be discussed in section 8.3.

8.2.4 Results analysis

The results analysis provides more information than expected – it last several months until after the first draft of this thesis was completed. A rich set of data was collected during the empirical experiments, and the analysis has revealed many interesting phenomena, which will be discussed in length in section 9.1.1 and 9.1.2.

8.3 Unexpected issues and what could be done differently

As discussed in the early sections, more than one-third of the total time has been spent on the literature review in order to develop the proposed conceptual framework. The bright side of this is that a detailed plan was made before the start of main study. The potential difficulties, like how to effectively lead the proposed focus group or participant recruitment, have been carefully considered and prepared. Overall, all the main objectives are met according to the initial plan. However, there are still some unexpected difficulties that were encountered during this research.

A practical difficulty is that the chosen development tool kit for experimental device, HP Mediascape, is relatively old and itself is actually a platform/product of a large research project. Although it's not too hard to find a windows CE Smartphone that would work with HP Mediascape, considerable time and efforts have been spent to identify an adequate device according to the requirements (backlight level, screen size, speaker volume and touch screen sensitivity). So a more modern GPS development tool kit would be considered if the research could be started over.

The other unexpected issue, as discussed in Chapter 6 and 7, is that the initial experimental setting has failed to deliver significant impact on participants' extrinsic motivation levels. This weakness has therefore been further studied in several aspects (see section 7.1), and then a revised setting was designed to raise participants' extrinsic motivational levels. Accordingly, an enhanced study was employed in order to verify the modifications. One thing worth to mention is that the enhanced study has provided additional findings, rather than just verifying the revised setting. The data collected from all the three groups (intrinsic, extrinsic and enhanced study) were analysed and compared with each other, and the results have provided many insights into the proposed framework (see section 9.1.1). Therefore, in this regard, although the enhanced study has cost as much as one-third of the experimental effort, nothing would has to be redone if the research could be start over.

8.4 Contribution to knowledge

The major contributions of this research are discussed in length in Chapter 1 and 9. Briefly speaking, this research reveals the specific human factors that can influence user's preference in context aware adaptation, which are motivation and perception (see section 6.4, 7.3 and 9.1.1). Users' motivation, as the driving-force of why they get involved in an activity or task, usually has a dominant impact on their preference. The conducted experiment showed that among extrinsically motivated users, the pragmatic factors that directly related to task and goal exerted a greater influence on their preferences. By contrast, the intrinsically motivated users were usually more influenced by the non-instrumental hedonic factors. The empirical findings also suggest that users' motivational states may also have a great impact on their behaviours. To be specific, users who are highly extrinsically motivated tend to be more focused on goal-related factors, and their behaviours will less likely to be influenced by personal interests. By contrast, compared to the limited goal-related factors involved in an activity, users' personal interests can be quite different from each other, which make the extrinsically motivated users' behaviours more convergent than the intrinsically motivated users (see section 7.3 and 7.4).

Consistency is one of the most important concepts in the field of Human computer interaction. It describes in general how and why interaction design should fit users' existing knowledge and experience. In this research it has been revealed that user's perception of influencing factors has a great impact on their preference and behaviour (see section 6.4, 7.3 and 9.1.1). This finding provides further evidence of the importance of consistency in interaction design.

8.5 Recommendation for similar research

Human factors involved in context aware activities are not easy to be studied. One of the challenges is the confusion about its definition. As discussed previously, different from traditional indicators in the field of HCI such as error rate or response time, human factors have been interpreted from many different perspectives. For example, the concept of motivation can be diverse among different time scales. Needless to say that a universal definition of user experience still requires many research efforts. Therefore, future research into

human factors involved in context aware activities should first clarify the meaning and nature of the factors that are going to be studied. According, one "trap" here is that although it's very interesting to explore different human factors that are encountered, research studies would normally be limited by time. So researchers need to keep reminding themselves of their main objectives.

8.6 Conclusion

This chapter presented a detailed review of this research. The first section reviews how well the work presented in this thesis meets the initial research objectives. The following sections discuss the whole process of this research, including the difficulties that were encountered. Based on that, recommendations for similar research are given in the last section of this chapter.

9 Conclusion

9.1 Summary of the research

This research focused upon understanding the human factors influencing the usability and user experience with context aware adaptive systems. The key purpose of context aware services and ubiquitous computing is to support users in dynamic situations by utilizing surrounding context to help them manage and utilise technology. It is by its nature highly dynamic since it responds to changes in context of use. Such attributes bring new challenges to interaction design, especially when promoting user experience became a key feature. Many research efforts have focused on the development of automatic mechanism in the field of ubiquitous computing, but besides environmental objects and changes, human factors such as user's motivation are also dynamic and relevant to design effectiveness. The present research shows such human factor issues will further influence user's preference and experience in context aware activities.

In this research, the human factors involved in context aware adaptation were studied according to the proposed sub-domains including users' motivation, perception, preference and subjective experience. The empirical studies showed that there is a significant difference in users' preferences between intrinsic and extrinsic motivations, and furthermore, the findings from the studies have provided additional insights into the proposed sub-domains of human factor issues (discussed in detail in the following sections), which will add to human factors research in the field of ubiquitous computing and context aware applications.

9.1.1 A further development of the proposed PMPE framework

As reported in section 6.4 and 7.3, participants' selection of route was greatly influenced by their motivational state and subjective perception of influencing factors. An interesting finding is that although the participants were motivated differently and their choice of route were affected by different influencing factors, there was no significant difference found in route selection between groups.

A flowchart (see figure 9.1) was drawn based on the experimental data and the findings from the discussion sessions (see section 6.3 and 7.2) in order to

illustrate the participants' responses to the experimental conditions. As shown in figure 9.1, the participants' choices of route were mainly influenced by contextual and situational factors in two stages, including perception of the given task and perception of the route qualities. The dashed arrows and squares represent the unexpected participants' responses to the experimental conditions. The arrows in this diagram are independent of each other. For example, participants who thought that the given task is important can still have different perceptions about the route qualities, no matter which group they were in.

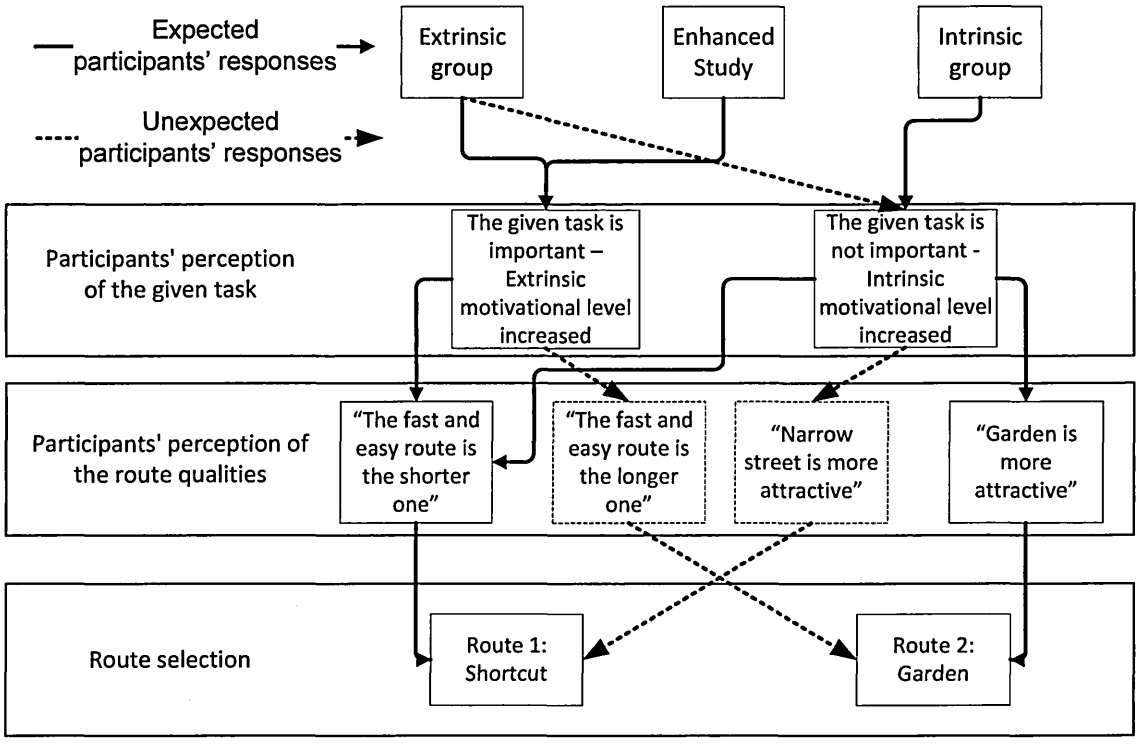


Figure 9-1Participants' responses to the experimental conditions

The first major element that influenced participants' choices of route is their perception of the given task. The participants who internalized the importance of the given task were more likely to be extrinsically motivated and influenced by the goal-related factors (e.g. time pressure). The results show that there are three participants in the extrinsic group were not influenced by either distance or time pressure. Accordingly, one of them even experienced a decrease in extrinsic motivational level. The lack of extrinsic motivation indicates that the initial extrinsic scenario is not enough to convince the participants that the task objective (complete the given task in 25 minutes) is important to them.

The second major influencing element is the participants' perceptions of the route qualities. An interesting finding from the empirical studies is that a few participants who reported that their choices were most influenced by time limit and distance, have chosen to take the longer route, correspondingly, there is also a few participants who reported that their choices were most influenced by landscapes, have chosen to go through the narrow streets rather than the public garden. The reason, as identified in the discussion sessions (see section 6.3 and 7.2), is that the participants' have different perceptions of the given information about the two routes - some of them believed that the longer route could be faster to go through, and two participants thought that the narrow streets are more attractive than the public garden.

Based on the findings described above, the proposed conceptual framework (PMPE, see section 2.4) for the human factors involved in context aware activities was further developed. Figure 2.2 in Chapter 2 demonstrates the relationships between user, environment and context aware adaptive system, and how different information is transmitted during context aware adaptation. In order to present more details of the user domain, figure 9.2 was drawn to show the components and their relationships of the proposed PMPE (perception, motivation, preference and emotion) framework.

The PMPE framework illustrates the internal state of end user in context aware activities. The three major flows in this framework are discussed as follows.

First, *situational information - perceived objective - subjective motivation*: user's perceived objective of an activity is not only influenced by situational information

but also by individual's characteristics, such as personal historical experience or personality, and the perceived objective will largely determine how the user will be motivated in the activity. For example, in the earlier empirical experiments, all participants in the same group received the same instruction on the given task (*Situational information*). But the instructions were further interpreted by the participants in accordance with their characteristics, and then determined how different participants were motivated to perform the task. For example, participants will be extrinsically motivated (*Motivational state*) if they believe that the given objective (e.g., to win a reward) is important to themselves (*Perceived objective*).

Second, *contextual object/event - perceived qualities of contextual object/event - influencing factors - user behaviours*: One of the main goals of context aware services is to expand user's awareness by using contextual information. For example, a location-based context aware application should be able to provide the information of different routes (e.g., distance or landscape), so that the users can choose between routes according to different situations (e.g., shortcut for a business meeting or wide avenue for a walk). Similar to the earlier discussion on different perceptions of task objective, user's perceived qualities of contextual object or event is not only influenced by the information that is provided by context aware system, but also by individual's characteristics, such as personal historical experience and body condition. Another point to mention is that the perceived quality of an object or event can become an influencing factor of user's preference only if it is consistent with the user's motivational state. For example, most extrinsically motivated (*Motivational state*) participants in the earlier between-group experiment chose to take the shortcut based on the information provided by the GPS navigator (*Contextual information*), but a few of them chose to take the longer route because they believed that the longer one would be faster or easy to go through (*Perceived qualities of contextual object or event*).

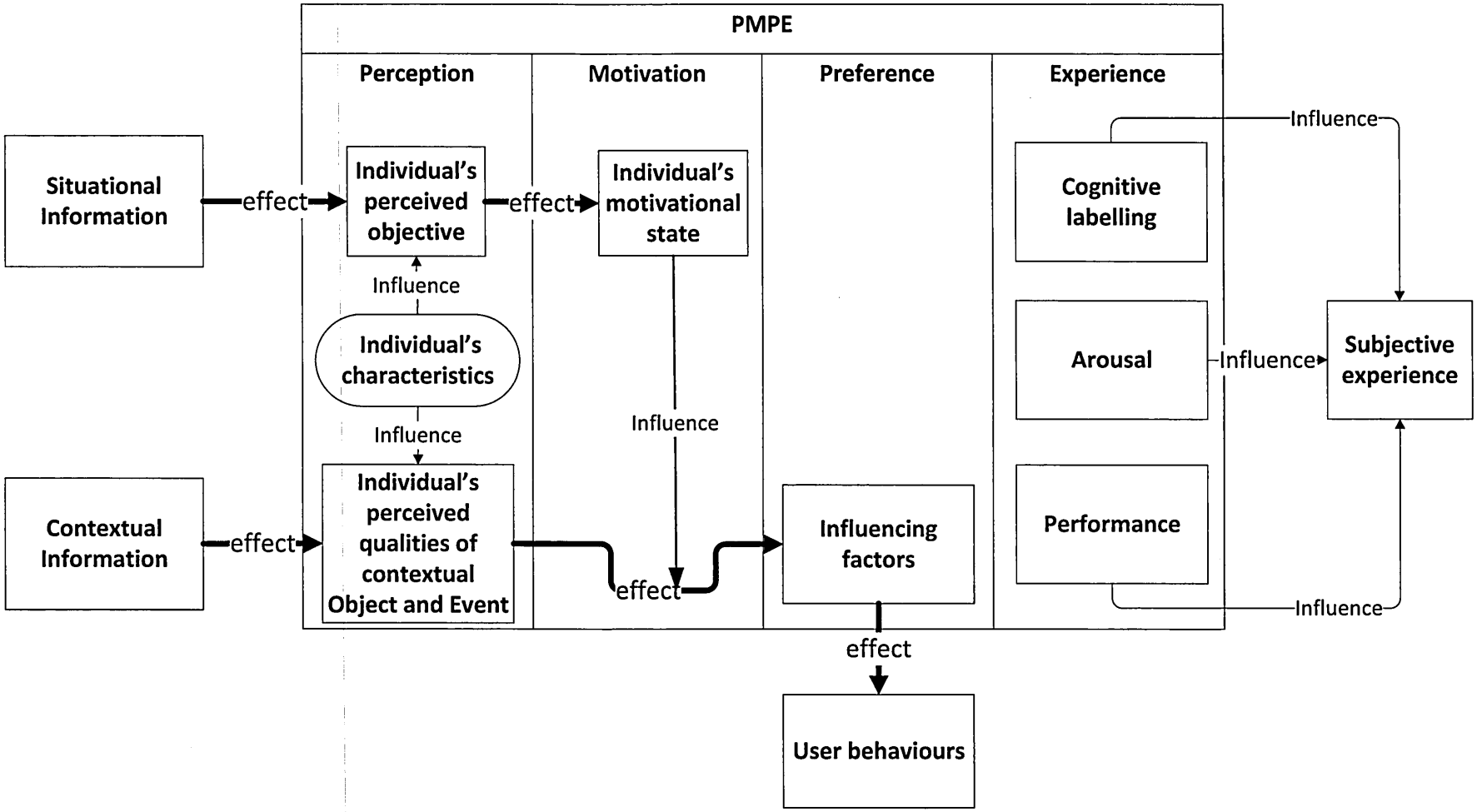


Figure 9-2 PMPE framework for the human factors involved in context aware activities

Third, *subjective experience*: According to the two-factor theory, experience of emotions arises from the cognitive labelling of physiological arousal. More specifically, cognitive labelling determines which types of emotion the end user will respond to a stimulator and arousal determines how strong the emotion will be. As reported in Chapter 6 and 7, there was no significant difference found in the participants' pleasure and dominant level between before and after experiments. The results also showed that even for the extrinsic group, half the participants were happier after the experiments. A possible reason for this is that their physiological arousal has been improved by the given task with the cognitive labelling remaining the same. Hence for some context aware services, like augmented reality entertainment, designers can amplify the users' experience by increasing their arousal levels. For example, motion games on Nintendo Wii and Microsoft Xbox 360 with Kinect.

Performance is another important factor that may influence user experience. Theoretically, organisms prefer to do things that are neither too simple nor too complex but at an optimum level of complexity (see section 2.2.3). It implies the relationship between subjective experience and task performance. The problem is that people's ability to execute a task is unstable - in a short period of time it will increase along with the increase of arousal level until people reach a point when they are too aroused, and then their performance falls off sharply, as shown in figure 2.7 (see section 2.2.3). On the other hand, in a long period of time well-practiced tasks will be carried out by using automatic processing rather than controlled processing, which required less attentional resources and usually provide better performance. Therefore, in order to promote user's subjective experience, designers at least need to pay attention to three pairs of relationships, including skill-challenge (instant), arousal-performance (short term) and skill-practice (long term).

9.1.2 Critical considerations on the findings from the research

9.1.2.1 User's internal state and participatory design

As described in Chapter 1, unlike traditional components of usability, things like subjective experience have drawn more and more attentions in the academic field. As one way to ensure usability and user experience, participatory design

(PD) is widely used to examine the tacit, invisible aspects of human activity (see section 2.3). A problem with PD is that the inconsistency in users' motivation between real-life activity and participatory design may lead to wrong understanding of users' preference and behaviour. Based on empirical evidence, this research showed that users' motivation and perception can be greatly influenced by various factors (see section 9.1.1), such as personal historical issues, and further impact the users' preference, behaviour and subjective experience. More specifically, participants will have different preferences and behaviours in the same activity if they are motivated differently. The results of the empirical study (see section 6.4 and 7.3) show that among extrinsic motivated users, the pragmatic factors that directly related to task and goal exerted a greater influence on their preferences and behaviours. By contrast, the intrinsically motivated users were usually more influenced by the non-instrumental hedonic factors such as landscape, sometimes even the application itself (the GPS navigator) was ignored by the participants to a certain extent. The results also show that the behaviours of the extrinsically motivated participants are more convergent than the intrinsically motivated participants (see section 7.3). A possible reason for this is that the intrinsically motivated participants may behave quite differently because of the individual differences (e.g., different personalities or habits), but be extrinsically motivated the participants will focus on limited goal-related factors so their behaviours will be more similar to each other. Therefore, PD brings new challenges to user-centred design whereas the participants need to be more user-centred.

9.1.2.2 User in context aware adaptation decision-making processes

As shown in the present empirical studies, the dynamic factors involved in context aware adaptation, like situational context and individual learning histories, are difficult to detect and assess (see figure 9.1 and section 9.1.1). So even with the PMPE framework it's still hard to predict user's preference. Therefore it is worth considering let end users express their expectations and policies, and to observe what is happening in the system, especially in cases where it is important to promote subjective user experience. For example, in the present empirical studies, it's difficult to predict whether a GPS user will enjoy a public garden or an alley, so a reasonable strategy for designers is to provide the information about the routes for user selection.

But it does not mean that context aware system should simply convey all available contextual information to its user, because an information overload may interrupt user's experience (see section 2.1.3). In this sense, a good understanding of the human factor issues involved in a context aware activity may help to facilitate the interactions for the end users to monitor the situations and express their expectations. More specifically, the parameters that have been identified as less influential in user's decision-making process could be moved to the advanced options, in order to simplify the user interface design.

9.1.2.3 Personal historical experiences and internalization

People's emotional responses to stimulators are greatly influenced by different individual learning histories (see section 2.2.3). The results of the present empirical studies further show that personal historical experience had a great impact on participants' preference (see section 9.1.1). Based on the empirical findings, this section discusses how personal historical experience may relate to user's preference and subjective experience.

Consumer digital products have experienced a great development during the last 20 years. Some of them have transcended beyond just tools, but become symbols of lifestyle or culture - not only for young people. On the other hand, a product that gives one user a huge pleasure may only appears as a few pieces of plastic and circuit board in the eyes of others. There is an obvious difference between product quality and user's perceived quality of product, and it seems that an objective quality will only be responsible for user experience as long as the user internalized its characteristic. On the other hand, user's perception of objective qualities can be manipulated by external information, such as advertisement or public praise. As stated in section 2.2.3, user can have indirect experience before their first encounter through expectations formed from existing experience of related technologies, brand, advertisements, presentations, demonstrations, or others' opinions.

Such internalizations can be represented but not limited in the following forms:

- Internalization of device qualities - refers to the user's perceived quality of a device or application. A controversial example is that in early days

some of the Mac users were convinced that one-button mouse is a component to promote their user experience (Edwards, 2005).

- Internalization of external objects/events - refers to the user's perceived quality of contextual objects and events that they encountered in a task or activity. For example, in the earlier empirical studies, some of the participants believed that the longer route would be easier and faster to go through, and there were also two participants from the intrinsic group who reported that their choices of routes had mainly been influenced by judging the narrow streets to be more attractive than the public garden.

Furthermore, users' perception of an external object/event can be constantly manipulated by contextual information. Therefore the above internalizations are highly dynamic and can be changed by accident or design, such as public reputation and advertising. Sometimes the dynamic aspect of such internalization may lead to a dramatic result: a system crash during an important task may cause worse impact on the user experience than a crash during a less important task.

9.1.2.4 Emotion and evaluation

Emotion is one of the major components of user experience, and there is still much efforts required to develop effective evaluation method for user's emotional level. As stated in section 6.4.3, there is still controversy on whether facial expressions are perceived categorically, or if a set of emotions which can be called "basic emotions" exists. The results of the earlier experiments (see section 6.4.3) showed that the PAD emotional scale is sensitive enough for some parameters to be measured such as participant's arousal level, but might not be adequate for the others (Pleasure and Dominance). From another point of view, should we define the types of users' emotion that need to be measured for a proposed domain? After all, different types of application deliver different types of experience – most likely the users of MS Word hardly enjoy the software as much as they enjoy games. The second difficult is closely related to the first one. Many existing evaluation methods for user's emotional level are based on self-report survey. The problem is that a survey itself may be treated as a task by experimental subjects, and a self-report survey consists of 16 scales may change the users' emotional states and also interfere with their

emotional recall. In this regard, nonverbal scale may be able to help. To sum up, accuracy and weight are the two keys to a successful evaluation method for users' emotional level.

9.2 Contribution

The results of this research provided empirical evidence of the effects of different motivations on user's preference and behaviour in context aware adaptation. Furthermore, the empirical findings provided a more in-depth understanding of the human factors and their relationships involved in context aware services. Based on these findings, a conceptual framework (PMPE) was developed to help understand the human domain of context aware services.

As stated in section 2.1.3, many self-adaptive applications do not have a human in the loop for policy changing or tracing adaptation processes. The present empirical experiments illustrate the complexity of the human factor issues involved in dynamic context aware adaptation. As discussed in section 9.1.2, there are many challenges facing the human domain of context aware services. One of the main challenges is that the influencing factors of user's motivation (e.g. contextual situation) and perception (e.g. personal historical experience) are difficult to detect and assess, which makes it difficult to predict user's preference in context aware adaptation. Therefore, a possible solution is to get end user into context aware adaptation decision-making process, for expressing their expectations and observing what is happening in the system.

In order to evaluate the effects of different motivations on users' preference in context aware adaptation, a two phase empirical study in the domain of digitally-assisted wayfinding activity was developed and employed in this research. The results show the capability of the proposed method in identification and validation of the human factors involved in the chosen domain. In addition, an enhanced study was also performed to address the weaknesses of the initial method (see section 6.4.1, 6.5 and 7.1). The results in general show a significant improvement of the revised method (see section 7.3 and 7.4). The overall results demonstrate the potential of the employed empirical approach for human factors study in other domains of context aware application. The empirical approach is presented with the aim of helping designers to understand

the human factors involved in their projects, and thereby to develop more effective interaction techniques for helping end users express their expectations and policies in context aware adaptation, and to observe what is happening in the system (see following section and Appendix C).

9.3 Expert review of the PMPE framework and empirical approach

The PMPE framework and empirical approach (see Appendix C) are intended to help designers to better understand the underlying human factors behind users' behaviour and experience, and therefore deliver more user-centric designs. The empirical approach was reviewed by designers from software and interaction backgrounds in a 90 minutes workshop, in order to obtain feedbacks.

The empirical approach is relatively complex, so the workshop was divided into four parts in consideration of prior presentation experiences at academic conferences and discussions with the supervisory team. Participants were recruited through contacting local LinkedIn networks of SMEs working in the digital and creative industries. The workshop started with a 30 minutes presentation that introduced the PMPE framework and the empirical approach, and then all participants were involved in a short focus group discussion that used to show how factor identification works (see section 4.2). A demonstration was also conducted, using examples from this research to show the participants how to evaluate the effects of identified influencing factors according to different motivational states. A free discussion was carried out after the demonstration. The participants were then asked to fill a feedback form (see Appendix D) to evaluate the present work. At the end of the workshop, a hand-out (see Appendix C) on human factors assessment for context aware design was given to each participant as a supplement to the workshop.

The workshop was held as planned in September 2013. The present work was discussed in depth by the attendees according to their experience. Overall, the participants showed a strong interest in users' motivation and preference during the discussion session. Such interests were further confirmed by the results of the feedback form. In the feedback form, the participants were asked to rank eight basic concepts of the PMPE framework and the empirical approach in order of their interests. The three most interesting concepts for the participants

are: "The relationship between users' motivation and preference", "The relationship between users' perception and motivation", and "How to identify and evaluate users' motivational states". Also, participants from software development background showed interests in "Participants' motivation in participatory design" and "The identification of the influencing factors using focus group discussion".

A major aim of the empirical approach is to help designers evaluate the effects of influencing factors according to different motivational states. An interesting reflection to extract from the workshop is that, some participants suggested that it will be useful to them if they can identify users' motivational states by assessing the effects of different influencing factors. The difference between the original aim and the participants' proposal is that real designers usually need to improve old designs to make them more effective or user-centric. This research showed that users will be influenced by different types of influencing factors if they are motivated differently. So it may be possible to clarify target users' motivational states by assessing current user profiles and data. One potential advantage of this is that it can be carried out with a much larger sample size than focus group discussion, which may provide a more accurate assessment for target users' motivations. Therefore, in future research it would be interesting to explore how influencing factors can be used to help assess users' motivational states.

9.4 Limitations and suggestions for future work

This research had several potential limitations. First, a major potential limitation of this research is that the number of sample size was relatively small -there are a total of 30 subjects participating in the empirical experiments. The possibility of the identified significant correlations arising by chance cannot be ignored, and therefore the results must be treated with caution. Future work should include replications of the empirical experiments with a larger sample size. On the other hand, it would be interesting to see if there are any other relationships that can be identified in a larger scale.

Second, this research focused on developing an understanding of the human factors involved in dynamic context aware adaptation through empirical

explorations. One of the major outcomes from this research is that a number of insights into the human factors involved in digitally-assisted wayfinding activity were identified. Furthermore, the results from the earlier empirical studies demonstrate the potential of the employed approach for the human factors study in other domains of context aware application. In recent years, context aware technologies have become more and more important in our daily life, which create great opportunities for both producers and consumers - but also give rise to new problems. In order to promote the acceptability of a context aware application and the end user experience, it would be helpful for designers to have in-depth understanding of the human factor issues involved in the relevant activity. More specifically, how does a context aware application assist its users in a certain activity or task? Does the application attempt to deliver hedonic enjoyment to end users? Such questions must be answered properly before the development of a context aware application can be started. In this sense, it would be necessary to make further research efforts to clarify the empirical approach we've shown (see Appendix C) to ensure it can serve as a general approach for future research in this area.

Third, a conceptual framework (PMPE) was developed in this research with the aim of improving the understanding of human factor issues involved in context aware activities (see section 9.1.1). Based on the findings from the empirical studies, the relationships between user's motivation, perception and preferences were primarily demonstrated. However there are still many issues that need to be further investigated, such as the relationships between user's arousal level, performance and user experience that were discussed in section 9.1.1. Moreover, besides personal historical issues, there are other factors that may also influence user's perceived quality of contextual information, such as physical body state. In this regard, further research is needed to clarify the details of the mechanism of the proposed framework, in order to promote a better understanding of the human factors involved in context aware activities, and therefore to help designers materialize their good ideas to real pleasant part of our lives.

9.5 Conclusion

The proposed PMPE framework was further developed in this chapter, based on the findings and analysis from the earlier empirical studies. The following section presents several reflections on the empirical experiments along with the suggestions to context aware designers. The review of the PMPE framework and the empirical approach was reported and discussed as the final step of this research. The rest of this chapter reviews how well the initial objectives were achieved. The potential limitations of this research and the suggestions for future work are presented by the end of this chapter.

Consent form for the focus group discussion

Consent Form

First of all, thank you very much for your time, your participation is very important to the success of this study. Please be aware that your participation in this study is completely voluntary, and you may withdraw at any time without penalty. You may withdraw by informing the investigator that you no longer wish to participate (no questions will be asked). The following information is provided for you to decide whether you wish to participate in this research.

The purpose of the study is to investigate and identify the factors that influenced user's choice of different routes within Wayfinding activities.

Participation will take approximately 120 minutes to complete. You will need to think of a recent experience of Wayfinding activity, and write it down. The discussion on the reported experiences will be video recorded with your permission for further analysis. However, please rest assured that any information gathered during this study which could identify you will be kept strictly confidential, and will be known only to the investigator.

There are no known risks and/or discomforts associated with this research. Your signature will certify that you have voluntarily decided to take part in this study. It will also certify that you have had an adequate opportunity to discuss the study with the investigator. Please do not hesitate to contact the investigator if you are interested in any further details.

Name of Participant (in block letters): _____

Signature of Participant: _____ Date: _____

Signature of Investigator: _____ Date: _____

Xiaohui Zhang

PhD Research Student

Communication and Computing Research Centre

Sheffield Hallam University

Xiaohui.Zhang2@student.shu.ac.uk

Pre-survey for the focus group discussion

Experience

Please identify and name at least three most important factors that influenced your choice of different routes:

_____

_____

_____

Please circle the response that best describes your feelings:

- How much did you enjoy this activity?

Not at all	Just a Little	Quite a Bit	A Lot

- Did you feel under control or any kind of pressure during this activity?

Not at all	Just a Little	Quite a Bit	A Lot

- Do you think this activity is important or good for you?

Not at all	Just a Little	Quite a Bit	A Lot

- Do you think the reason why you were engaged in this activity is because of you don't have any choice?

Not at all	Just a Little	Quite a Bit	A Lot

Participants No:

Consent Form

First of all, thank you very much for your time, your participation is very important to the success of this study. Please be aware that your participation in this study is completely voluntary, and you may withdraw at any time without penalty. You may withdraw by informing the investigator that you no longer wish to participate (no questions will be asked). The following information is provided for you to decide whether you wish to participate in this research.

Participation will take approximately 45 minutes to complete. You will need to take a short walk with provided GPS device, and fill out a survey questionnaire once the task is completed. Please rest assured that any information gathered during this study which could identify you will be kept strictly confidential, and will be known only to the investigator.

The risks and/or discomforts associated with this study are unpredictable traffic and weather condition, so please be careful while crossing roads. Your signature will certify that you have voluntarily decided to take part in this study and pay any Income Tax. It will also certify that you have had an adequate opportunity to discuss the study with the investigator. Please do not hesitate to contact the investigator if you are interested in any further details.

Name of Participant (in block letters): _____

Signature of Participant: _____ Date: _____

Signature of Investigator: _____ Date: _____

Xiaohui Zhang, PhD Research Student

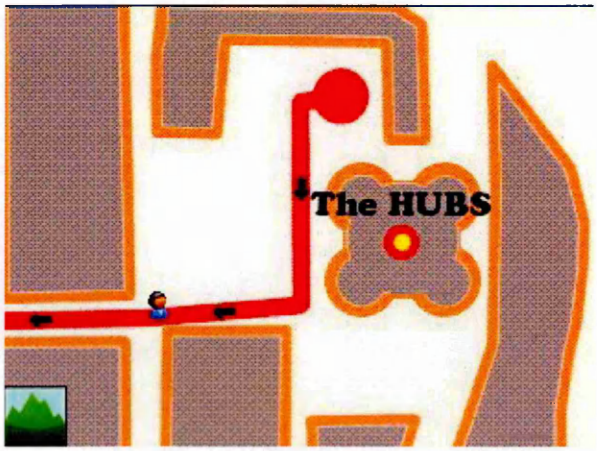
Communication and Computing Research Centre, Sheffield Hallam University

Xiaohui.Zhang2@student.shu.ac.uk

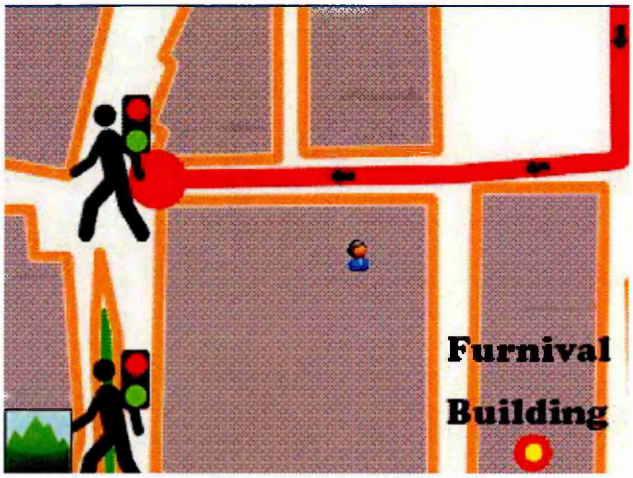
Task introduction

1. This experiment is a part of an important research study on the use of Ubiquitous Computing technologies, and your participation and efforts will greatly improve the research process and quality. In order to make a meaningful contribution to this research, it's important to complete the Navigation task in 25 minutes.*

2. Follow the route as shown on the navigator - RED Line with BLACK ARROWS:



3. **The little Head Portrait shows your instant location, it will drift out of the route when the GPS signal is blocked by buildings around you, please ignore the drift and keep following the route:**



**The first paragraph was only shown to the extrinsic group.*

4. The **Buildings** and **Shops** as shown on the navigator can help you determine which direction you need to go:

5. **The Navigator will provide you the information of the rest of the way when you reach the BIG Red Point, read the information and follow the instructions until you get to your destination:**

6. **Please make sure you always walk on the Pavement/Sidewalk. Always be careful when you need to cross a road/street and Never cross a road/street if you cannot find a Traffic Light!**

Evaluation of the influences of the identified factors

You have been asked to choose between Route 1 and Route 2 during the experiment. Show how much your decision has been influenced by each of the following factors, using X:

a) Different Route Distances:

Not at all					**Very Much**

b) Different Safety Conditions:

Not at all					**Very Much**

c) Different Traffic/Route Conditions, i.e. Road Quality:

Not at all					**Very Much**

d) Weather Condition:

Not at all					**Very Much**

e) Different Surroundings, i.e. Landscape:

Not at all					**Very Much**

f) Time Pressure:

Not at all					**Very Much**

g) Investigator's Attitude:*

Not at all					**Very Much**

h) Your General Body State, i.e. Tiredness/Fatigue:

Not at all					**Very Much**

*How the investigator will respond to participant's accomplishments, refers to Social factors.

SMIS

Directions: Read each item carefully. Using the scale below, please circle the number that best describes the reason why you are going to engage/was engaged in the GPS Navigation task. Answer each item according to the following scale: 1 = correspond not at all; 2 = correspond a very little; 3 = correspond a little; 4 = correspond moderately; 5 = correspond enough; 6 = correspond a lot; 7 = correspond exactly.

Why are you currently engaged in this activity?

Because I think that this activity is interesting.

7	6	5	4	3	2	1

Because I am doing it for my own good.

7	6	5	4	3	2	1

Because I am supposed to do it.

7	6	5	4	3	2	1

There may be good reasons to do this activity, but personally I don't see any.

7	6	5	4	3	2	1

Because I think that this activity is pleasant.

7	6	5	4	3	2	1

Because I think this activity is good for me.

7	6	5	4	3	2	1

Because it is something that I have to do.

7	6	5	4	3	2	1

I do this activity but I am not sure if it is worth it.

7	6	5	4	3	2	1

Because this activity is fun.

7	6	5	4	3	2	1

By personal decision.*

7	6	5	4	3	2	1

Because I don't have any choice.*

7	6	5	4	3	2	1

I don't know; I don't see what the activity brings me.

7	6	5	4	3	2	1

Because I feel good when doing this activity.

7	6	5	4	3	2	1

Because I believe this activity is important for me.

7	6	5	4	3	2	1

Because I feel that I have to do it.

7	6	5	4	3	2	1

I do this activity, but I am not sure it is a good thing to pursue it.

7	6	5	4	3	2	1

*The scores were removed before the data analysis

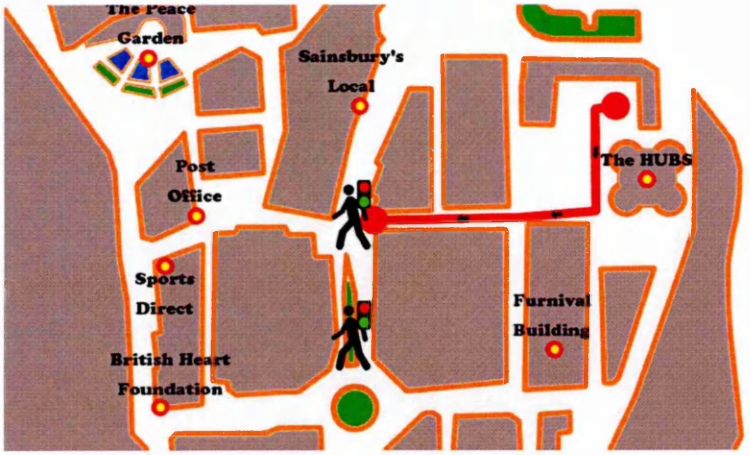
PAD emotional scales

Each pair of words describes a feeling dimension. Some of the pairs might seem unusual, but you may generally feel more one way than the other. So, for each pair, put a check mark, (Ex.: ___:_X_ :___) to show how you feel now.

Please take your time so as to arrive at a real characteristic description of your feelings:

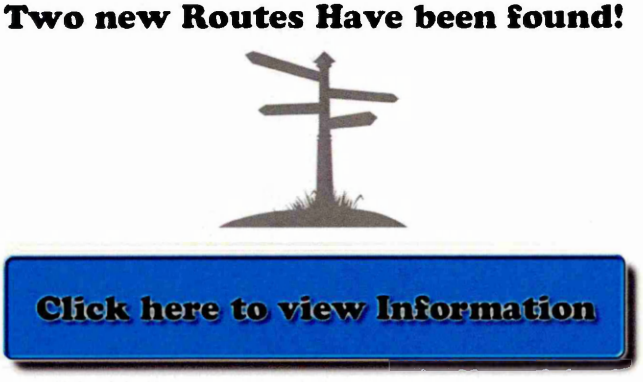
Happy								**Unhappy**
Stimulated								**Relaxed**
Controlling								**Controlled**
Pleased								**Annoyed**
Excited								**Calm**
Influential								**Influenced**
Satisfied								**Unsatisfied**
Frenzied								**Sluggish**
In control								**Cared for**
Contented								**Melancholic**
Jittery								**Dull**
Important								**Awed**
Hopeful								**Despairing**
Wide awake								**Sleepy**
Dominant								**Submissive**
Relaxed								**Bored**
Aroused								**Un-aroused**
Autonomous								**Guided**

Appendix B – The screenshots of the navigator

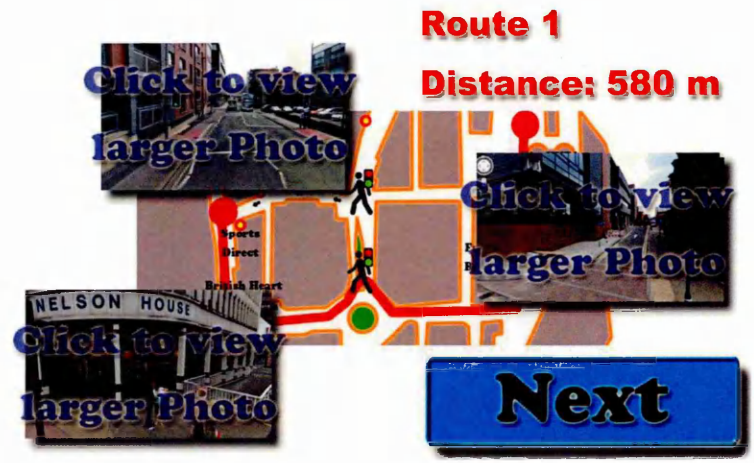


Screenshot of the navigating screen

Screenshot of the interrupting screen



Screenshot of the selecting screen (1)



Screenshot of the selecting screen (2)

Screenshot of the selecting screen (3)

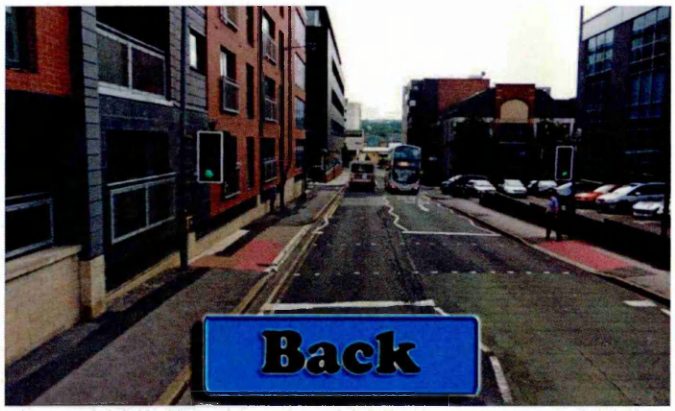
Screenshot of the selecting screen (4)

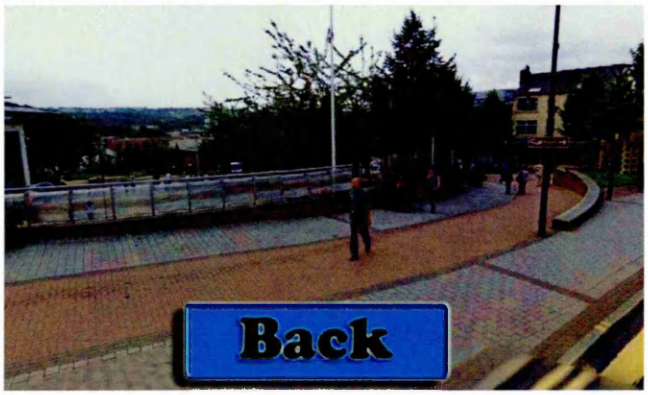
Route Selection

- Route 1 takes a distance of 580 meters, mainly through narrow streets.
- Route 2 takes a distance of 750 meters, through a public garden and the main pedestrianised street of the city.

Three landscape photos for each route were shown as follows.

Route 1

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Human factors assessment for context aware design

Xiaohui Zhang, Dr. Chris Roast
Culture, Communication and Computing Research Institute
Sheffield Hallam University
153 Arundel Street
Sheffield, S1 2NU
xiaohui.zhang2@student.shu.ac.uk, c.r.roast@shu.ac.uk

1 Introduction

Unlike many desktop applications, context aware applications support users in dynamic situations by utilizing surrounding context. Context aware adaptation, as one of the main concepts of context aware application, is by its nature opportunistic since it responds to changes in context of use, and this brings new challenges to interaction design. Besides systemic and environmental factors, user's internal states like motivation are also relevant to design effectiveness. Our research has shown that user's internal states, such as motivation and personal historical experience, have a great influence on their preferences and behaviours. The identified human factors and their relationships are described here, along with an empirical approach for identifying and evaluating such human factors in specific context aware domains.

2 What are the human factors

The main human factors involved in context aware activities are concluded and discussed as follows:

- Motivation - refers to how users are motivated to perform a task or be involved in an activity, it can be broadly classified into two types:
  - Intrinsic motivation refers to motivation that is driven by pleasure or satisfaction that comes from the task itself;

- Extrinsic motivation generally refers to activities that could only be prompted from outside of the individual, such as reward or punishment.

- Perception - refers to users' subjective perceptions of devices, surroundings, and situations.
- Preference - refers to users' preferred context aware adaptation plans, for example different routes for digitally-assisted route planning services.
- Subjective experience - refers to users' subjective experiences, more specifically, their emotional responses and states.
- Influencing factors - refers to the contextual factors that can influence user's preference. Influencing factors can also be broadly classified into two types:
  - Pragmatic influencing factors (task-oriented), for example distance will usually be a pragmatic factor in digitally-assisted route planning services;
  - Hedonic influencing factors (pleasure-oriented). For example, landscape will usually be a hedonic factor will usually be a pragmatic factor in digitally-assisted route planning services.

3 Why do we need to assess these factors

The most important reason for assessing human factors is that users' preferences and behaviours are greatly influenced by their motivations. Our research showed that the pragmatic influencing factors exerted a greater influence on the extrinsically motivated users' preferences. By contrast, the intrinsically motivated users were usually more influenced by the hedonic influencing factors.

The second reason for assessing human factors is that different users' perceptions can also influence their preferences and behaviours, which can be summarized into three aspects:

- First, how users will be motivated to perform a task is not dependent on any given exterior objectives, but on the importance of such objectives to themselves. In the case where an objective is important to them they are

likely to be more extrinsically motivated and less likely to enjoy the activity itself;

- Second, one of the main goals of context aware applications is to expand users' awareness of their surroundings. Our research showed that users' perceptions of the same influencing factor can be very different between individuals. Such perceptions will further influence their preferences and behaviours - especially if the perceived quality of an influencing factor aligns with their motivational state (see the first paragraph of this section).
- Third, different users' perceptions can also influence their subjective experience. According to the two-factor theory, experience of emotions arises from the cognitive labelling of physiological arousal. More specifically, cognitive labelling determines which types of emotion the end user will respond to a stimulator and arousal determines how strong the emotion will be.

3.1 A little more about user's subjective experience

Performance is another important factor that may influence user experience. Theoretically, people prefer to do things that are neither too simple nor too complex but at an optimum level of complexity. The problem is that people's ability to execute a task is unstable - in a short period of time it will increase along with the increase of arousal level until people reach a point when they are too aroused, and then their performance falls off sharply. On the other hand, in a long period of time well-practiced tasks will be carried out by using automatic processing rather than controlled processing, which require less mental effort and usually cause less error (better performance).

3.2 User involvement in context aware adaptation decision-making process

Our research showed that it's difficult to predict users' preference and behaviours. Therefore, it is worth considering let end users express their expectations to systems, especially in cases where it is important to promote subjective user experience. But it doesn't mean that context aware system should simply convey all available contextual information to its user, because too much information may interrupt user's experience of being fully immersed in

a task or activity. In this sense, a good understanding of the human factor issues involved in a context aware activity may help to facilitate the interactions for the end users to monitor the situations and express their expectations. For example, in our experiments, weather condition was identified as a relatively less influential factor in the participant's decision-making process, so for a real-life location-based service the designers may need to consider whether it's necessary to provide weather forecast for a short travel in city.

3.3 Participants' motivation and participatory design

Participatory design (PD) is a widely used technique for identifying tacit, invisible aspects of human activity. Our experiments show that participant's preferences and behaviours are greatly influenced by different motivations. This finding suggests that in order to get accurate understandings of potential users' preferences and behaviours, the investigators of PD should ensure that their participants can be motivated as same as the users in real-life tasks (see section 8.1.2.1).

4 An empirical approach to human factors assessment for context aware services

This empirical approach provides a method for identifying the influencing factors of user's preference with context aware adaptation. It then evaluates the influence of these factors according to different motivations. So this will help you as a designer to ensure that designs can be facilitated according to potential users' motivational states. The identification stage (Phase one) should be conducted at the beginning of a design process, and the influencing factors identified will be used to help inform a conceptual design. The evaluation stage (Phase two) should be conducted with at least a low-fidelity prototype that allows participants to complete realistic tasks.

4.1 Phase one: Identification of the influencing factors

4.1.1 Objective

The phase one is mainly aimed to identify the factors that may influence people's preference among different plans in an activity, through using focus group discussion.

4.1.2 Participation

The minimum requirement for participation is that the potential participants have to have relevant experience in the proposed domain. For example, for the design of a GPS navigator, the participants should have some experience in wayfinding activity (which by its nature has been carried out by most human beings every day). This approach is mainly aimed to identify the potential factors that may influence user's preference in order to help the design of relevant digital assistant, so the potential participants do not necessarily need to be experienced in any similar applications.

4.1.3 Procedures

The discussion session should be focused on the topics and activities that proposed by investigator (or reported by participants) according to the proposed domain. Investigator should use guiding questions to clarify what influenced participants' preferences in these activities (e.g., "What things or events most influenced your choice?"). The discussion session should be recorded by camera or voice recorder and transcribed to text transcripts, and the text transcripts should be further separated and coded in order to identify the influencing factors. The key points are discussed as follows:

- This focus group discussion can also be used to preliminarily clarify how people are motivated to be involved in proposed domain. In this regard, investigator should use guiding question like "Do you enjoy it?", "Do you feel like you have no choice but to do so?" and "Would you estimate (potential influencing factor) differently if (contextual/situational changes)?"
- A major risk of focus group study is that a discussion can be dominated by a dominant personality and leads to wrong results. Using pre-survey

before the start of discussion may help investigator to address this problem. Participants in the pre-survey should be asked to report a recent experience according to the proposed domain, and to identify and name a few factors that influenced their preferences. Participants can also be asked to answer some introductory questions to summarily assess how they were motivated in the reported activities. A short review of the reported surveys should be undertaken by investigator before the start of discussion, so the data gathered from the pre-surveys can be used for both guiding the discussion and analysing the final results.

4.2 Phase two: Evaluation of the influence of identified factors according to different motivations

4.2.1 Objectives

The phase two is aimed to empirically evaluate the influence of identified factors on participant's preference according to different motivations.

4.2.2 Procedures

As described earlier, different motivations can produce different user's preferences and behaviours. This approach is focused on user's motivations, and mainly aimed at helping designer and researcher to create more realistic experimental settings for evaluating the identified influencing factors from previous focus group discussion.

First of all, how potential users will be motivated (intrinsically or extrinsically) in the proposed domain should be clarified by using focus group discussion (as stated in section 4.2). The next step is to ensure that participants can be motivated as same as the users in real-life tasks. As stated earlier, intrinsic motivation refers to motivation that is driven by pleasure or satisfaction that comes from the task itself, and extrinsic motivation generally refers to activities that could only be prompted from outside of the individual, such as reward or punishment. Therefore in order to ensure that the participants can be intrinsically motivated to perform an activity or task, the investigator should try to minimize the influence of goal-oriented factors. For example, participants should be informed that there are no time limits or error records for the given task, so they can enjoy without worrying their performance. Also participants must be

paid before the task if a payment was offered in the recruiting stage, in order to ensure that participants do not consider the payment as a reward for high performance (or take away the payment as a punishment). In contrast, in order to ensure that participants can be extrinsically motivated, investigator must set clear goal for the given task (e.g. time limits or error rates). Also, connecting participants' performances to extra rewards or punishments (e.g. a cash payment) will enhance their extrinsic motivational level.

The last important thing to note is that the proposed experimental settings must be evaluated to determine if it is able to lead participants into required motivational states. Our suggestion is that if an iterative design is affordable then this evaluation can be conducted as a part of main experiment, if it's not, then a pilot study with a small sample size should be conducted first to evaluate the initial experimental settings. In practice, the Situational Motivation Scale (a.k.a. SIMS) can be used for such evaluation. In this case both pre and post survey (SIMS) must be undertaken to evaluate the intraindividual changes of participant's motivational states. The pre-survey must be given at the very beginning of an experiment before any instruction and the post-survey must be filled as soon as the given task is completed, and then the intraindividual changes of participant's motivational states can be analysed using the Wilcoxon signed-rank test. So we will know if participants are intrinsically or extrinsically motivated in the experiments.

The identified influencing factors from previous focus group discussion should be reflected in different adaptation plans regarding experimental tasks. For example if distance has been identified as a major influencing factor in wayfinding activities, then different plans should be generated by context aware route planning system (e.g. GPS navigator) based on distance. Self-report scales should be used after experiment to evaluate how much participant's preference was influenced by different influencing factors. User's behaviours can also be recorded according to the purpose of study.

The last thing to note is that user's preference and behaviour are determined by not only motivation, but also by other factors like perception and individual differences, therefore participants can have different preferences and behaviours even if their motivational states are similar. For example, intrinsically

motivated travellers may choose different routes because of different interests, and extrinsically motivated travellers may also choose different pathways because of they believe that their choices will be easier or faster to go through. In this regard, the section 2 and 3 can be used as a map to help designers to determine whether different user's preferences and behaviours are caused by perceptions or motivational factors.

Appendix D – Feedbacks on the proposed framework and approach

Feedback Form

1. Part I - Please rank the following eight concepts in order of your interest by numbering them from 1 to 8, with the most interesting concepts being ranked "1":

   [1] The relationship between users' motivation and preference;

   [1] The relationship between users' perception and motivation;

   [2] Different users' perception of influencing factors;

   [4] Users' role in context aware adaptation;

   [5] Participants' motivation in participatory design.

   [1] The identification of the influencing factors using focus group discussion;

   [6] How to motivate participants in empirical study;

   [2] How to identify and evaluate users' motivational states.

2. Part II - Do you have any other questions or suggestions about this work, if so, please write down.

I think the concept of adapting a users motivation from extrinsic to intrinsic temporarily during a task is an interesting direction for research E.g. Introducing the element of suprise + delight to a routine task.

Feedback Form

1. Part I - Please rank the following eight concepts in order of your interest by numbering them from 1 to 8, with the most interesting concepts being ranked "1":

   [3] The relationship between users' motivation and preference;

   [2] The relationship between users' perception and motivation;

   [6] Different users' perception of influencing factors;

   [7] Users' role in context aware adaptation;

   [8] Participants' motivation in participatory design.

   [4] The identification of the influencing factors using focus group discussion;

   [5] How to motivate participants in empirical study;

   [1] How to identify and evaluate users' motivational states.

2. Part II - Do you have any other questions or suggestions about this work, if so, please write down.

Can we desire users motivations from their actions?

Feedback Form

1. Part I - Please rank the following eight concepts in order of your interest by numbering them from 1 to 8, with the most interesting concepts being ranked "1":

   [4] The relationship between users' motivation and preference;

   [6] The relationship between users' perception and motivation;

   [5] Different users' perception of influencing factors;

   [7] Users' role in context aware adaptation;

   [3] Participants' motivation in participatory design.

   [2] The identification of the influencing factors using focus group discussion;

   [8] How to motivate participants in empirical study;

   [1] How to identify and evaluate users' motivational states.

2. Part II - Do you have any other questions or suggestions about this work, if so, please write down.

Appendix E –Attached CD

- The developed modification of HP Mediascape for experimental navigation task (See the attached CD);
- The voice record of the focus group discussion (See the attached CD).

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