DOCTOR OF PHILOSOPHY

# An Exploration into the Use Of Cognitive Characteristics when Designing for Older Adults

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## Acknowledgements

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## Declaration by the Candidate

I declare that I am the author of this thesis; that, unless otherwise stated, all references cited have been consulted by me; the work which this thesis records is mine; and that it has not been previously presented or accepted for a higher degree.

Michael Crabb

2014

## Declaration by the Supervisor

I declare that Michael Crabb has satisfied all the terms and conditions of the regulations made under Ordinances 12 and 39; and has completed the required 9 terms of research to qualify in submitting this thesis in application for the degree of Doctor of Philosophy.

Professor Vicki L. Hanson

2014

## Abstract

It is now common for people of all ages to use the Internet to access information, with websites being tailored towards their intended audience by focusing on user age. However, very little evidence exists to confirm that age is a valid metric for distinguishing between users. It has been shown that additional metrics such as fluid intelligence and individuals' prior experience in using technology can be used to predict their computing habits. Yet, despite this there is still a need to understand to what extent we can use these additional cognitive metrics to predict individuals' computing habits, and whether adaptations can be made to a user interface by focusing on these alternate factors.

This thesis presents three studies that aim to discover whether age can be used as a suitable metric for distinguishing between older adults, or if other factors can provide a greater insight. Information retrieval tasks are used to test the performance of these factors. First a study is introduced that examines the effect that fluid intelligence and Internet usage has on individuals with both qualitative and quantitative analysis being used. Second, a larger study is reported on that examines a collection of Internet and cognitive factors in order to determine to what extent each of these metrics can account for disorientation in users. This is then expanded on to examine correlations that exist between each of the individual factors and a set of usability guidelines. Finally, a study is presented that examines six individual navigation based web elements and whether the inclusion or exclusion of these can optimize user browsing experience.

By examining user performance and considering age, Internet abilities, and cognitive characteristics, this thesis shows that age is not a suitable metric to distinguish between individuals when compared to other metrics. Factors such as a user's previous Internet experience and fluid based cognitive abilities can be used to gain a better insight into users' reported browsing experience during information retrieval tasks.

## Associated Publications

*Covered in Chapter 5 – Human Factors in Relation to Perceived Disorientation*

Crabb, M, Hanson, V. L. 2014. Age Technology Usage, and Cognitive Characteristics in Relation to Perceived Disorientation and Reported Website Ease of Use. In Proceedings of the 16th international ACM SIGACCESS conference on Computers and accessibility. (ASSETS14)

*Covered in Chapter 5 – Human Factors in Relation to Perceived Disorientation*

Crabb, M.: Human Cognitive Measurement As A Metric Within Usability Studies. *Student Research Competition (First Place). Extended Abstracts of the 2013 annual conference on Human factors in computing systems (CHI '13). ACM, Paris, France.*

*Covered in Chapter 4 – Preliminary Research*

Crabb, M.: Understanding Older Adults' Search Habits. BCS HCI – *Doctoral Consortium – The 26th Annual BCS HCI Conference. Birmingham, UK, September 12 – 14, 2012*

*Covered in Chapter 4 – Preliminary Research*

Crabb, M. , Hanson V. L., Cobley A.: Cognitive Usability: Using Human Factors to Influence Future Online Usability Requirements. *Digital Engagement 2012 – The 3rd Annual Digital Economy All Hands Conference, Aberdeen, UK, October 23 – 25, 2012*

*Covered in Chapter 3 – Research Methods*

Crabb, M. , Hanson V. L., Cobley A.: Aiding Data Gathering in Web Usability Studies. Digital Engagement 2012. *Digital Engagement 2012 – The 3rd Annual Digital Economy All Hands Conference, Aberdeen, UK, October 23 – 25, 2012*

*Covered in Chapter 4 – Preliminary Research*

Crabb, M. , Hanson V. L., Cobley A.: Understanding Older Adults' Search Habits: A Pilot Study. *Digital Engagement 2011 – The 2nd Annual Digital Economy All Hands Conference, Newcastle, UK, November 15 – 17, 2011.*

## Chapter 1. Introduction

The Internet is now a ubiquitous technology that is used to find information, communicate with others, and gain access to online services. Recent Ofcom statistics (2013) state that 79% of UK homes had access to the Internet in 2012. This is a large increase from only six years previously where 54% of homes reported having similar access. In addition to this, the prevalence of Internet usage by older adults is also increasing year on year (Figure 1.1). This increase in Internet uptake is likely to continue the technology allowing this is reduces in price, and methods such as smartphones and tablets are seeing increased adoption rates (Ofcom, 2013, p. 38).

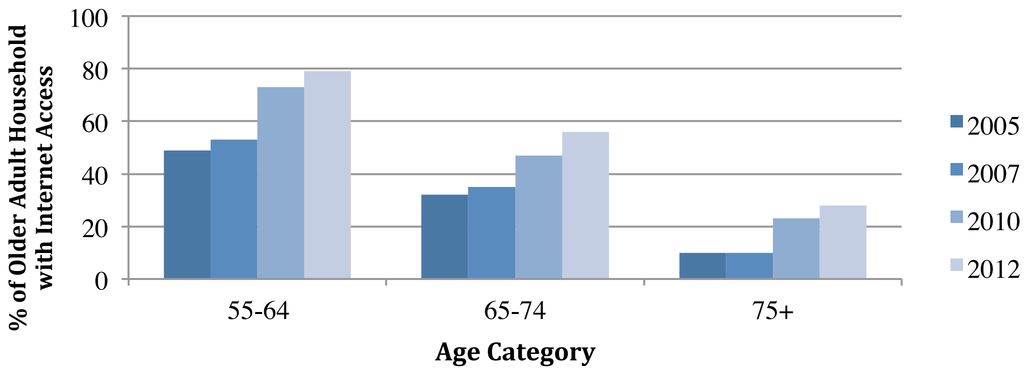


**Figure 1.1 An Increase in Older Adult Internet Uptake Over 7 Years.**

The reliance on the Internet for individuals to obtain information now means that the design of digital services must take into consideration a wide range of ages and abilities. This concept is not new and a large corpus of design guidelines exists that focus on making websites more 'senior friendly' (*Making Your Web Site Senior Friendly*, 2001; Patsoule & Koutsabasis, 2012). These guidelines mainly focus on the physical changes that are associated with aging (e.g. degradation in eyesight and fine motor skills). In turn, this creates websites that stereotypically have larger text and bigger buttons. For example, Figure 1.2 demonstrates the differences between two websites created by the same governmental body. The image on the left shows a website designed for the general public[1], and the image on the right shows a website designed for older adults[2]. Differences between these two sites include aspects such as larger text and button sizes, less information on a page-to-page basis, and increased accessibility options such as text resizing and contrast adjustment. All of these changes are aspects recommended to create a more 'senior-friendly' experience.

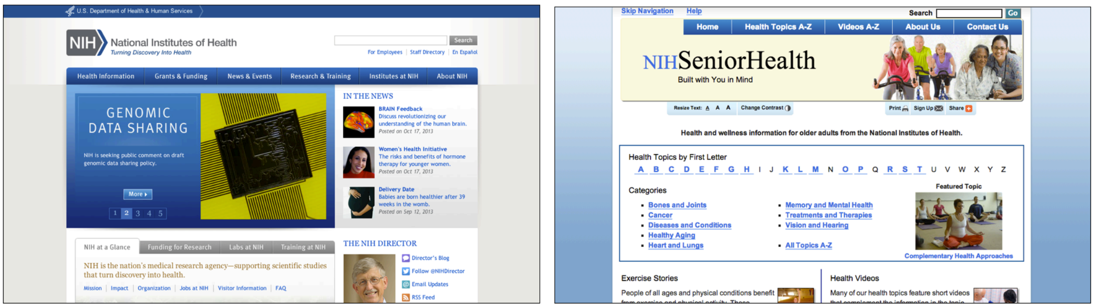


**Figure 1.2 A comparison between two websites, one designed for the general population and one for older adults.**

In addition to the physical changes that accompany aging, there is a large body of evidence showing that cognitive changes also occur (e.g. (Horn & Cattell, 1967)). These cognitive changes can affect many abilities throughout an individual's lifespan. Fluid intelligence (described as the problem solving abilities of an individual) increases until early adulthood before it begins to decline. In contrast, crystallized intelligence, (described as the body of knowledge that individuals acquire over their lifetime) increases until late adulthood before tailing off (Horn & Donaldson, 1980).

[1] http://www.nih.gov
[2] http://www.nihseniorhealth.gov

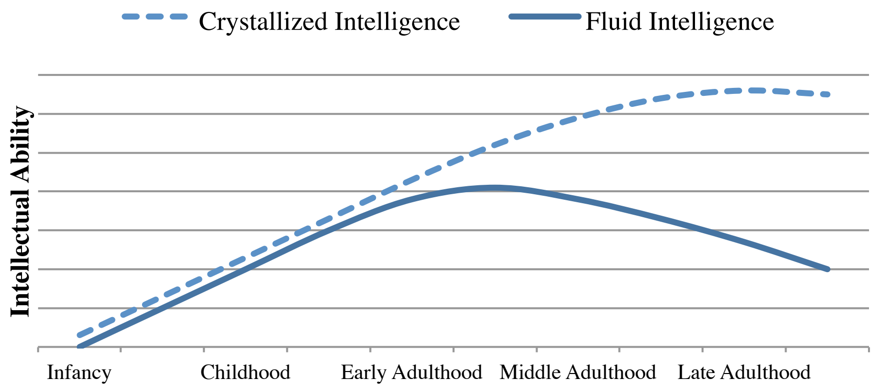


**Figure 1.3 Horn & Donaldson's (1980) overview of cognitive change in aging.**

Despite evidence of the cognitive decline that accompanies aging, there is very little work examining the role of cognitive abilities in relation to the design of digital services. In turn, little is known of how web interfaces can be made when taking individuals' cognitive abilities into account. This thesis focuses on the role of fluid cognitive abilities and their impact on older adults' performance in information retrieval task.

## 1.1 Thesis Aims

The aim of this thesis is to develop an understanding into cognitive metrics that can be used to predict the browsing experience of users when searching for information online. Browsing experience is defined as the perceived ease of use of a website, combined with the level of disorientation reported by an individual after completing an information retrieval task. This aim is accomplished in two ways: first, by examining human factors in an attempt to identify metrics that are suitable in accounting for this browsing experience; and second, by examining individual website elements with a view to understand the relationship that exists between these and the identified human factors. Following these goals, this thesis then analyses these factors to determine whether they can be taken advantage of in order to improve users' overall browsing experience. The following research questions are therefore proposed:

1. *What user-based metrics, apart from age, can be to predict the browsing experience of individuals?*

2. *Can adaptations to website interface elements be made in order to improve the browsing experience for users based on their cognitive and technical experience abilities?*

## 1.2 Research Approach

The approach used in this work is heavily influenced by methods used by the *Centre for Research and Education on Aging and Technology Enhancement* (Czaja, Sharit, Charness, Fisk, & Rogers, 2001a). This takes a very user-centred approach, with research focusing on understanding user abilities and their relationship to the outcomes detailed in Figure 1.4.

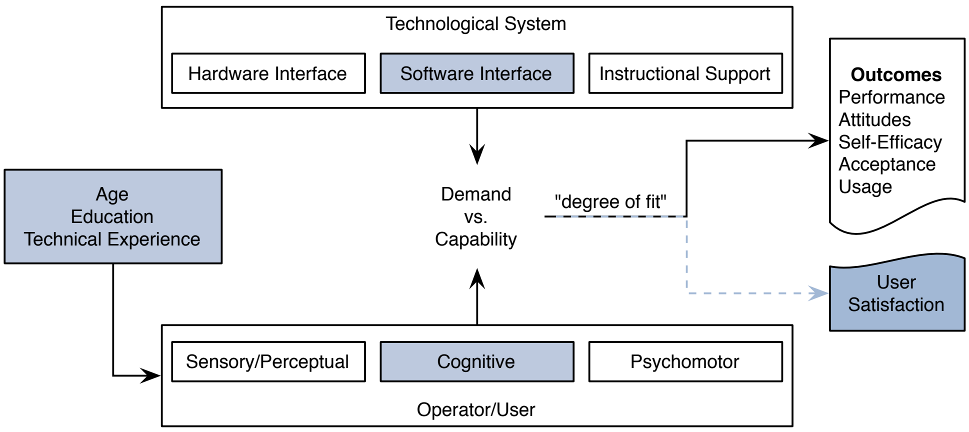


**Figure 1.4 Adapted CREATE Framework (Czaja et al., 2001a) with highlighting indicating factors examined in this thesis.**

Figure 1.4 shows an adapted version of the conceptual framework from the CREATE project (taken from (Czaja et al., 2001a)). The purpose of this framework is to demonstrate a research need in "*understanding the variables that affect human performance and using this information to optimize person/task/environment interactions*". The work in this thesis uses a modified version of this framework, examining variables that are associated with the software interface in technological systems, and the cognitive and technical experience variables attached to operators and users. The modification to this framework is to include user satisfaction as an additional outcome. This is done in order to understand whether changes made based on cognitive differences can affect overall browsing experience for individuals.

## 1.3 Experiment Summary

This section is used to give a brief summary of the three main research studies conducted in this thesis, explain their aims, the variables used and the individual experiment findings.

### 1.3.1 Chapter 4 – Preliminary Research

| **Chapter 4 - Preliminary Research** | |
|---|---|
| Aims: | Investigate browsing behavior of users within an information retrieval task. |
| Independent Factors: | **Inductive reasoning**<br>**Internet usage** |
| Dependent Factors: | **Search engine efficiency** and **Task Speed** *(quantitative analysis)*<br>**Search Process, reasoning** and **participant feelings** *(qualitative analysis)* |
| Findings: | Significant differences found in quantitative analysis when examining Internet usage<br>Subjective differences found in qualitative analysis when examining inductive reasoning. |

**Figure 1.5 A summary of the experiment presented in Chapter 4**

The aim of the research in Chapter 4 was to investigate if two independent measures, inductive reasoning and Internet usage can categorize the browsing behavior of users. This was done using a qualitative and quantitative approach. In the qualitative approach, objective dependent measures of search engine usage efficiency and task speed of users were analyzed to determine if significant difference could be found between these and the independent measures. In the quantitative approach, participant sessions were transcribed and a thematic analysis technique used to examine differences in the search process, search reasoning, and participant feelings. It was found that while significant differences were found in the qualitative approach when examining participant Internet usage, no significant differences were found with participant inductive reasoning. However, qualitative findings suggested that more subjective differences could be found between participants when examining their inductive reasoning.

### 1.3.2 Chapter 5 – Human Factors in Relation to Browsing Experience

| **Chapter 5 – Human Factors in Relation to Browsing Experience** | |
|---|---|
| Aims: | Determine if variance in browsing experience can be accounted for by user Internet and cognitive factors |
| Independent Factors: | **Age**<br>**Internet Usage and Internet Confidence**<br>**Inductive Reasoning, Perceptual Speed, Short-Term Memory, and Long-Term Memory** |
| Dependent Factors: | **Browsing experience (perceived disorientation and reported website ease of use)** |
| Findings: | Perceptual Speed and Internet Confidence can be used to account for a significant amount of variance in user browsing experience |

**Figure 1.6 A summary of the experiment presented in Chapter 5**

Following on from work in the Chapter 4 where it was found that objective differences could be seen between participants when examining their cognitive abilities, the research in Chapter 5 aimed to examine if an subjective dependent variable, browsing experience, could be explained by a selection of demographic, Internet, and cognitive independent factors (age, Internet usage, Internet experience, inductive reasoning, perceptual speed, short-term memory, and long-term memory). It was found that 48.5% of the variance associated with browsing experience could be accounted for by Internet experience and perceptual speed.

### 1.3.3 Chapter 7 – An analysis of Website Interface Elements in Relation to User Browsing Experience

| **Chapter 7 – An analysis of Website Interface Elements in Relation to User Browsing Experience** | |
|---|---|
| Aims: | Determine if individual website elements could be used to improve the browsing experience of users when considering their perceptual speed and Internet confidence |
| Independent Factors: | **Perceptual Speed and Internet Confidence**<br>**Navigation Menu Position, Drop Down Menu Activation, Subpage Menu Usage, Menu Highlighting, Advertisement Usage, and Breadcrumb Usage.** |
| Dependent Factors: | **Browsing Experience** |
| Findings: | No significant findings to suggest that individual interface elements can be used to influence user browsing experience. |

**Figure 1.7 A summary of the experiment presented in Chapter 7**

Finally, the experiment in Chapter 7 set out to determine if individual website elements could create a difference in the subjective browsing experience of participants. Six website elements were selected after a review of governmental usability guidelines (from Chapter 6) and these were tested alongside user perceptual speed and Internet experience (selected from Chapter 4). No significant differences were found between the implementation of these individual website features and the browsing experience of participants.

## 1.4 Thesis Structure

This thesis is organized into eight separate chapters. This section details the structure of the thesis and relates this to the research structure outlined within Figure 1.8.

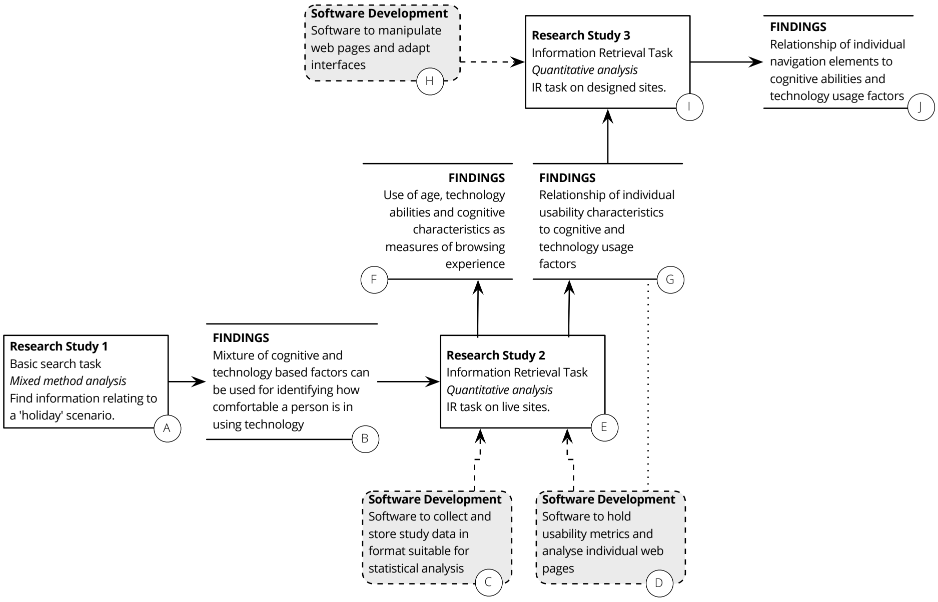


**Figure 1.8 A Summary of the Research Structure of this Thesis**

Following this initial introduction, Chapter 1, a literature review is presented within 0 that examines varying metrics that can be used to compare users and also an examination into the use of Internet usability guidelines.

Chapter 3 details further information about research methods used. This includes an introduction and short discussion on the varying cognitive testing and technology use questionnaires used to gather information regarding participants. This chapter also introduces several pieces of software (C, D, and H within Figure 1.8) that are used throughout the thesis.

Chapter 4 presents a mixed method study and discusses how the combination of factors other than age, in this case Internet usage and fluid intelligence, can be used to understand the browsing experience of users when searching for information online  (A and B within Figure 1.8).

Chapter 5 describes a second research study and provides an analysis into the use of age, cognitive characteristics and Internet use demographics in relation to users' browsing experience (E and F within Figure 1.8).

Chapter 6presents a short review of governmental usability guidelines, and selects a subset of these for use in the final experiment detailed in Chapter 7 (G within Figure 1.8).

*Chapter 7*examines individual web elements within an adaptive web environment to examine correlations between the changes in individual web elements and the cognitive characteristics and technology usage factors attached to users (I and J within Figure 1.8)

Chapter 8 provides a discussion surrounding the results of the experiments presented in Chapters 4-7 as well as discussing the major strengths and limitations of this work, and how these results can be translated into a real world context.

# Chapter 2. Related Work

One of the main aims of this thesis is to develop an understanding of how different metrics can be used to differentiate between users. Secondary to this is to determine if these differences can then be used to aid in design decisions. The work presented can therefore be categorised into two main areas: suitable metrics to compare users, and the use of these metrics to understand Internet usability factors. This chapter is used to introduce both of these concepts and to ground them in current academic literature.

## 2.1 Metrics Used to Compare Users

When comparing users it is important to define reference points in order to understand the similarities and differences that exist between individuals. There are many different measurement characteristics that can be used to accomplish this. In particular, age, technology usage, and cognitive abilities are of interest in this work. This section introduces and examines these metrics, discussing their use in academic literature.

### 2.1.1 Using Age to Distinguish Between Users

It is common in research to distinguish between individuals by using their age as a metric with this being especially prevalent when examining technology usage information for a population. For example, Ofcom regularly produces reports on technology usage information for the United Kingdom. Their recent Media Use and Literacy Report (2013) showed that older adults are in a group that has seen substantial growth in technology usage over the last decade, and are also becoming more confident in its usage. This goes on to state that by 2012 over 50% of older adults age 65-74 had access to the Internet in their home, with 25% of older adults aged 75+ shown to have similar access.

Complementing information regarding Internet uptake, Ofcom also gathers information on the confidence levels of population groups when examining Internet usage. Figure 2.1 shows a large difference in the confidence levels of Internet usage between different age groups of the population. Adults aged 55-64 and 65+ reported to be the least confident groups, however over 75% still reported being either fairly confident or very confident when using the Internet.

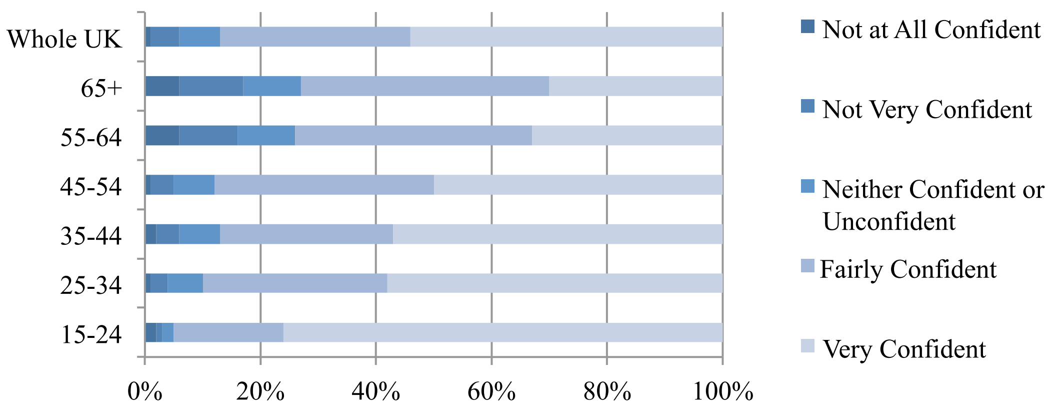


**Figure 2.1 Ofcom UK Population Internet Confidence (2013).**

These differing feelings of confidence in older adults are also present in academic literature. Low levels of technology confidence in older adults may influence the way in which they approach computer based tasks, with users not making the required effort as they believe from the outset that they will fail (Marquié, Jourdan-Boddaert, & Huet, 2002). Older adults that use computers to search for information believe that their ability to do this is significantly lower than reality (Aula & Nordhausen, 2005). It has been found that older adults show more anxiety towards computers than middle aged and younger adults and also show less interest in technologies such as the Internet. Subsequently, their experience in using these sorts of technologies is also lower (Czaja, Charness, Fisk, et al., 2006b).

While this higher level of anxiety regarding using the Internet can affect the experience of older adults, this does not necessarily affect their abilities. An examination into high performing older adults showed that their task performance ability was comparable to that of younger adults (Czaja, Sharit, Hernández, Nair, & Loewenstein, 2010). However, when examining the routes taken when performing search-based activities, differences have been found between these two age groups. Older adults have been shown to take fewer risks to find information, even if this would result in taking more time than by using other methods (Fairweather, 2008). For example, Fairweather (2008) reports that older adults are more likely than younger adults to visit pages on a website that would slowly guide them through a search as opposed to carrying out a more random search on a website.

One of the main barriers to technology update by older adults, could well be down to a lack in training into how technology works. For example, it has been found that older adults are less likely than younger adults to use ATM machines, yet report that they would be willing to do so if they received training (W. A. Rogers, Fisk, Mead, Walker, & Cabrera, 1996). Hickman, Rogers, and Fisk (2007) provide guidance on training methods that can be used to aid older adults in learning new technological skills, showing a one-size-fits-all approach does not work in regards to training and that attention must be paid to the tasks being used in order to facilitate technology uptake.

However, it is apparent that that the stereotypical view of older adults not understanding technology is untrue. It has been discussed that older adults use a wide variety of technology devices, with a large number of these appearing in their homes. It has additionally been shown that older adults also see that the benefits of technology usage outweigh the costs associated with their uptake, believing that the convenience and useful features attached to some technological devices are worth the additional cost (Mitzner et al., 2010). Perhaps one of the main barriers to technology uptake that is associated with cost, then, is an understanding of the large number of tasks that a single technology can cater for? It has previously been discussed that older adults use technology with specific aims for each individual device (Hernández-Encuentra, Pousada, & Gómez-Zúñiga, 2009). This may cause a larger cost barrier to older adults than to younger adults, as while older adults "use the mobile phone to receive and make calls, television to watch programs, and connect to the Internet only through the computer" (p. 239), it is conceivable that younger adults could complete all three of these tasks on all three of these devices, reducing the apparent cost barrier.

It has also been suggested that in order to facilitate this uptake in technology by older adults, perhaps the design of new technology devices should take into consideration the design of technologies that older adults are already used to (Coleman, Gibson, Hanson, Bobrowicz, & McKay, 2010).

It has been discussed that an individuals cognitive abilities have a higher impact on their Web use than just the speed taken to complete online tasks. Freese et. al (2006) discuss how individuals with higher cognitive abilities are more likely to adopt the WWW earlier, and use a larger amount of online activities than those with lower cognitive abilities.

Additionally, an examination into predications of technology usage by older adults, and the population in general, is important. Findings from the CREATE center (Czaja, Charness, Fisk, et al., 2006b) discuss how even though the older adults in their sample population are highly educated, significant age based differences in use of the Web exist. It is also discussed how this low technology uptake by older adults is likely to result in those not using technology to "more likely to become more disenfranchised and disadvantaged" (Czaja, Charness, Fisk, et al., 2006b, p. 346). It is suggested that two of the main barriers to computer usage for older adults is a low-self efficacy and high anxiety attached to computer usage.Older adults that reported computer usage before retirement have been described as using computers to be a negative experience (Aula, 2005). Aula goes on to explain that one possible reason for this negative experience occurring stems from developers blaming users for mistakes made rather than bad system design. This in turn may also decrease individuals' willingness to pick up new technology in the future.

A possible solution to solving older adults anxiety in using technology would be to better educate the younger generation so that they can use technology in later life. However, the problems faced by today's older adults regarding technology use may be replicated in future generations. This can be related to a combination of changes in technology, and also age related changes that are attached to individuals (Hanson, 2011).

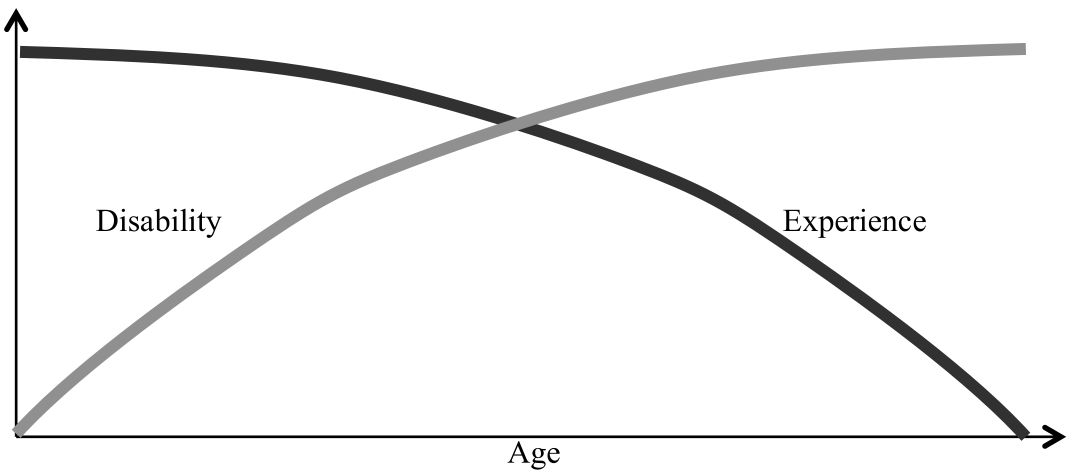


**Figure 2.2 Ability as a Function of Age (Hanson 2009)**

As computers systems continue to evolve, the existing skills that users have in using old technology become obsolete – e.g. move from command driven, to WIMP, to post-WIMP interfaces. Figure 2.2 shows Hanson's (2009) *disability x experience* interaction curve. This demonstrates a reduction in relevant technology experience as age increases, but also shows an increase in users' disability; this includes cognitive, perceptual, and motor disabilities. A key point is that there is no specific age at which these changes occur. It is suggested, "*the trick will be to determine how the lines for experience and disability intersect*" (Hanson, 2009 p.6).

The notion of age being used to distinguish between users now requires analysis in order to examine its suitability, and whether it can be used as a predictor of user performance. Older adults aged 50 are unwillingly placed within the same technological group as those aged 80 and research involving older adults should "*take into account the full continuum of experience and abilities of older users*" (Hanson, 2009).

Marchionini and Shneiderman (1988) discuss different abilities that are essential in online browsing and the effectiveness of a user in completing an information retrieval task. This is split down into search setting, the task being searched on, the search system, and the user doing the search. By acknowledging that 'each user is unique' and separating their ability down into frequency of use, complexity of application, and general computer experience, Marchionini & Shceiderman believe that it is possible to determine how quickly and accurately users will develop mental models for a system and also how effectively they can apply these models. The models created are therefore based on a set of individual user characteristics and not the number of years since birth.

When examining the importance of an individual's abilities, An approach currently gathering momentum is ability-based design (Wobbrock, Kane, Gajos, Harada, & Froehlich, 2011). This concept of design shifts the focus from individual users conforming to the methods of an individual computer system, to the computer system changing to fit the abilities of a user. Ability based design is based on seven key principles, with these focusing on designer stance, the user-interface itself, and systems that an individual is using (Wobbrock et al., 2011, p. 11). Concerning the stance of designers, it is noted that designers should focus on what users *can* do with a system, rather than what they *cannot* do, and should respond to poor performance by changing the system and not attempting to change the users. Regarding interfaces, it is noted that these may be self *or* user adaptable in order to provide the best possible match to users' abilities, and that the interface should make users aware of any adaptions made. Finally, regarding the systems themselves, ability-based design principles state that systems may monitor, measure, model, or predict user performance, may sense the context of a task and act accordingly to aid the user, and may compromise on low-cost, and readily available software and hardware to aid users.

For example, the situation-specific recoloring tool proposed by Flatla and Gutwin (2012a; 2012b) provides a method of quickly modeling an individual's Color Vision Deficiency (CVD) and then using the information gathered from this to recolor information. Flatla and Gutwin (2012b) demonstrate this through the recoloring of graphs for an individual based on their particular CVD requirements. This method is expanded through SPRWeb (Flatla, Reinecke, Gutwin, & Gajos, 2013) , where this method of CVD modeling is used to recolor websites for individuals taking into account unique CVD requirements of a single user. This method allows websites that would normally be unusable to individuals with CVD (or by those where the environment is disabling the user), to adapt to the unique situation and abilities of an individual in order to overcome this disability.

### 2.1.2 Cognitive Characteristics to Compare Users

An alternative method used compare users is examining their cognitive ability. The use of cognitive testing dates back as far as the Sui Dynasty (605AD) with tests created in order to screen individuals before joining the civil service (Wang, 2006). These examinations were based on essay type questions graded using strict guidelines. Cognitive testing has advanced considerably since then, with one of the most famous tests being Binet and Simon's (1904) I.Q. (Intelligence Quotient) test.

Modern intelligence testing methods commonly use a battery of tests to examine many different aspects of an individual's intelligence. This is needed in order to fully examine all parts of individuals' abilities. "*The abilities measured by a speed test with language and mathematics are not identical with, or even very similar to, those measured by a test with picture*" (Thorndike, 1920).

In modern testing, cognitive abilities are measured using a variety of methods with these mostly producing a score as an end result. These scores can then be used as a measurement of individuals' abilities. However, there are many factors that can influence individuals' scoring, apart from their cognitive abilities. These include aspects such as environmental development, cultural closeness (e.g. language based tests), user interest, and also user fatigue (Cattell, Feingold, & Sarason, 1941). Cognitive testing should therefore be used in a manner that highlights individuals' general ability while keeping all other variations to a minimum.

### *2.1.2.1 Selection of Cognitive Abilities and Their Description*

One area of cognition that has shown potential in HCI work surrounds the principle of fluid mental abilities (Dillon & Watson, 1996). This theory is based on initial work that examined the splitting of cognitive functions into two separate areas; fluid and crystallized intelligence (Cattell, 1963). Fluid intelligence is described as the ability to adapt to a particular situation because of an individual's problem solving abilities. Crystallized intelligence is described as adaption based on previous knowledge of a particular domain (Horn & Cattell, 1966).

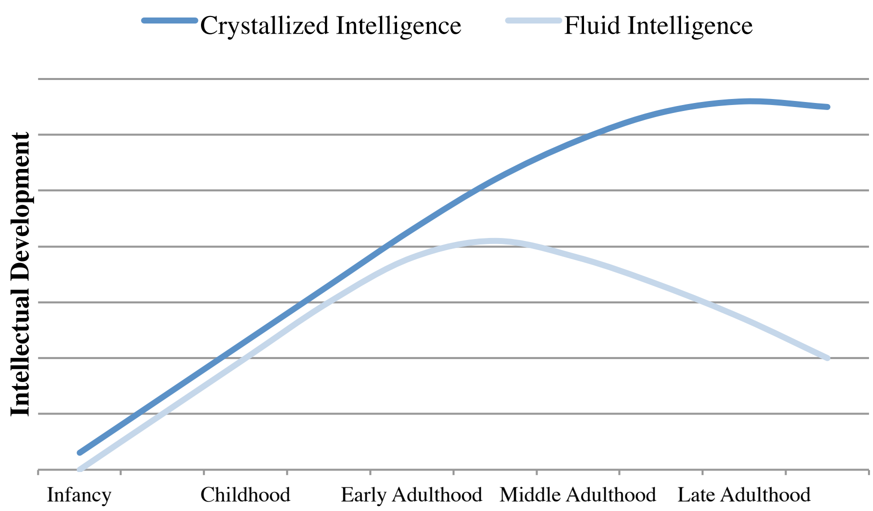


**Figure 2.3 Horn & Donaldson's (Horn & Donaldson, 1980) overview of cognitive change in aging.**

The process of aging results in many changes to individuals' cognitive abilities. Fluid abilities tend to diminish as from early adulthood, but crystallized abilities increase over the lifespan (Horn & Cattell, 1967). Figure 2.3 provides a somewhat simple illustration showing that fluid intelligence starts to decline from early adulthood yet crystallised intelligence tends to level off in late adulthood before gradually declining. It is important to note that these changes do not occur at the same time for every individual and that generalisations such as 'early adulthood' must be used. These changes in cognitive abilities can have a profound effect on how individuals can understand new technologies and successfully carry out tasks. Fluid abilities have been shown to be important in carrying out computer based tasks and are therefore of more interest in this work than crystallized abilities. This, combined with the more prevalent decline in these abilities associated with aging, provides an interesting research area when designing systems for older adults.

Both fluid and crystallized abilities can also be categorized as part of the CHC (Cattell-Horn-Carroll) model of human intelligence (McGrew, 2009). This splits human intelligence into nine separate factors, with these then being split into further sub-factors (Flanagan, Genshaft, & Harrison, 1997). The four fluid based sub-factors examined in this thesis are:

- Fluid Intelligence – *Inductive Reasoning*
- Short Term Memory – *Memory Span and Working Memory*
- Long Term Storage and Retrieval – *Meaningful Memory*
- Processing Speed – *Perceptual Speed*

#### *2.1.2.2 Fluid Intelligence*

Fluid Intelligence is a measure of individuals' ability to use mental operations to complete a task. This mainly involves problem-solving abilities with individuals relying on discerning relationships among patterns, extrapolating information, and the formation and recognition of concepts. The work in this thesis focuses on a particular aspect of fluid intelligence; inductive reasoning. This examines the ability of an individual to discover the underlying rules and concepts that apply to a problem set.

Users with high and low scorings of fluid intelligence have previously been examined in relation to their use of online menu systems in eye-tracking studies. It has been found that although high and low fluid intelligence users would select the same amount of links before completing a task, users with low fluid intelligence would be more likely to re-select items that they had previously visited. It has also been reported that users with low levels of fluid intelligence would rely more on mouse movement prior to clicking, suggesting that it is being used as a marker to aid their movement around a search space (Trewin, Richards, et al., 2012b).

#### *2.1.2.3 Short Term Memory*

Short-term memory is the ability of individuals' to hold and use information within a few seconds of acquiring it. An example of a short-term memory application would be the ability to remember a telephone number for a long enough period to dial it. The work in this thesis focuses on two sub-abilities of short-term memory, memory span and working memory. Memory span is the ability of an individual to immediately recall temporarily ordered objects after being presented with them for a short time. Working memory is similar to memory span in that the recollection of information is required after a short time, but with the addition of a cognitive operation applied to the information, for example – repeating a set of given numbers in reverse order.

When examining the design of information search interfaces for older and younger adults, short-term memory has been shown to influence the efficiency between groups when searching for information. Pak and Price (2008) established that short-term memory can be used as a predictor of performance but this is heavily based on the structure of the data being presented.

### *2.1.2.4 Long Term Storage and Retrieval*

Long term storage and retrieval is described by Horn (1991) as the storage and retrieval of information that is obtained '*minutes, hours, weeks, and years before*'. Again, it is important to note the difference between long term memory and crystallized intelligence: crystallized intelligence represents an indication in *what* is being stored, long-term storage and retrieval is a measure of the *efficiency* with which things are stored (Flanagan, Ortiz, & Alfonso, 2007). This work uses a single narrow ability associated with long-term memory - meaningful memory. Meaningful memory can be described as the ability of an individual to recall a set of items when there is a meaningful relationship present between item sets.

Long-term memory has been used to examine the relationship between users' performance within information retrieval tasks. It has been shown that users with high levels of long-term memory navigate through systems less efficiently than those with low long-term memory. This is not the direction that results would be expected to conform with, however statistical significance occurs nonetheless (Westerman, Davies, Glendon, Stammers, & Matthews, 1995). It could be possible that the reason for this surrounds an additional factor that is affecting the overall outcome as this result seems very unintuitive.

### *2.1.2.5 Processing Speed*

Processing Speed is described as an individual's 'mental quickness' and requires very little complex thinking. Horn (1991) describes processing speed tasks as things that "*almost all people would get right if the task were not … under time pressure*". This work uses a single narrow ability associated with processing speed – perceptual speed. This is a measure of an individual's ability to search and compare visual symbols or patterns in rapid succession.

Chin, Fu & Kannampallil (2009) includes processing speed within a study examining information search, focusing on the strategies used by older and younger adults when answering ill and well defined questions. It was found that older adults compensated for their lower cognitive abilities by spending longer analysing the contents of a web page in order to better understand the information. This in turn aided them in searching for additional information.

#### *2.1.2.6 Cognitive Abilities Not Examined in this Thesis*

As previously mentioned, there are nine abilities in the CHC model of intelligence, of which only four subset abilities are examined in this thesis. While the remaining factors all have a significant role in defining an individual's overall cognitive abilities, their analysis has been omitted from this thesis for a number of reasons.

Crystallized Intelligence can be described as the breadth and depth of a person's accumulated knowledge of a culture and the effective use of that knowledge (Flanagan et al., 1997). The testing of this ability is heavily based on language interpretation and has been successfully used within previous HCI research. However, it is not included in this work due to its focus on cultural knowledge and not the interpretation of information within an Internet domain. The focus of this research is to investigate how the design of web pages can be changed in order to improve the browsing experience for users. While user domain knowledge has been successfully used to show that users can navigate through websites containing topics that they have prior understanding a lot faster than those they do not, very little exists to examine the links between crystallised intelligence and the design of a website independent of topic. For this reason it has been excluded as design methods should translate *across* topic and not be influenced *by* topics.

Quantitative Knowledge is a measure of mathematical knowledge. This is different from crystallized intelligence as the concepts it covers (e.g. geometry and trigonometry) rely more on procedural knowledge rather than the cultural knowledge attached to crystallized knowledge. This factor is not included in this thesis for the same reason as crystallized intelligence. Its primary focus on mathematical knowledge means that it cannot be easily related to Internet searching behaviour and therefore makes it unrelated to information retrieval tasks.

The Reading/Writing Ability is used to describe the skills that are needed for understanding written language and ideas through writing. While sometimes being described as a separate ability, Carroll's Three Stratum Theory (Carroll, 1993) includes this ability within crystallized intelligence.

Visual Processing is described as the ability to understand and manipulate visual patterns and stimuli. This includes the ability to form and store representations of images for recall and also to manipulate objects mentally to understand how they would look under different conditions. This factor was not included as the understanding of visual patterns, while somewhat related to online searching, is more important when moving from one website to another, and not when navigating through a single site where the visual aspects of a page do not change as much.

Auditory Processing measures individuals' ability to use sound as an input and how they can use cognitive ability to understand various auditory signals. This was not included as sound is not a factor used regularly within Internet-based activities, and no sound based websites were included in any of the research completed in this thesis

### 2.1.3 Online Disorientation as a Measure to Distinguish between Users

A popular measure used for analysis in Internet based studies is user performance. This can take many forms that include time spent on a task, number of errors, and improvement of a task over time (Wagner, Hassanein, & Head, 2010). An alternative approach now being used is to examine disorientation; how "lost" users may become when performing tasks online. Disorientation in online systems is a large problem, with the large amount of nodes available to create paths, information can "*easily become hard to find, or even forgotten altogether*". The cognitive overhead attached to this can also lead to "*informational myopia*" with an increased number of paths that can be taken to find information leading to distraction from the main purpose of the topic being searched for (Conklin, 1987). User disorientation, therefore, is a measure that must be considered when analysing user performance in search related tasks.

Literature regarding disorientation in web based systems looks largely at the systems themselves rather than its users (Botafogo, Rivlin, & Ben Shneiderman, 1992; Rodríguez, Gayo, & Lovelle, 2001; Zhang & Greenwood, 2004). While it is easier for a developer to change a website rather than to change the way a user behaves, by examining users' cognitive characteristics a greater understanding of the reasoning behind why disorientation occurs can happen. Shih, Huang, Hsu and Chen (2012) examine disorientation within younger adults, using data mining techniques to uncover patterns. It has also been shown that when examining user flow in web navigation, task performance is majorly affected by disorientation (van Schaik & Ling, 2012). It is also possible to examine both the technological and user cognitive factors to quantify online disorientation. This can be done though analysing the structure of websites and also participants' mental models of websites, examining how this can relate to feelings of disorientation (Otter & Johnson, 2000).

## 2.2 Analysis of Computer Factors

Complementing the human factors outlined in the previous section, it is also important to introduce factors that can be used to influence design decisions. Of particular interest in this work is the concept of designing to improve website usability and also to improve the user experience.

In HCI research, there is a significant focus on designing for older adults; to create technology for the older generation, changes must be made in order to embrace the wide variety of skills and experiences of older adults. Technology needs to be designed to optimize people's capabilities, while also compensating for their weaknesses (Hart, Chaparro, & Halcomb, 2008).

It is important to develop an understanding of what makes the World Wide Web usable for older adults, taking into account their previous experiences and also their cognitive abilities. By doing this, websites can be improved to allow users to accomplish tasks faster and also to have a better experience while carrying out tasks. One of the main methods used to aid in this is a large amount of Internet usability guidelines, created to help developers, and a wide variety of tools that can analyse a website's adherence to these guidelines.

Many systems exist that allow for the analysis of websites. These have various purposes including validation of program syntax (W3C, 2009; 2012), validation of accessibility (TAW, 2005; WebAIM, 1999) and analysis of usability factors (Alonso-Ríos, Luis-Vázquez, Mosqueira-Rey, Moret-Bonillo, & del Río, 2009; FeedbackArmy, 2008). These tools can provide information on various areas regarding Internet usability, yet in essence they mostly approach users with a one-size-fits-all philosophy. This results in adherence to guidelines that have very prescribed pass/fail criteria that do not take into consideration aspects that could affect specific characteristics for individual users.

The testing of usability guidelines can be a relatively simple process; it can be accomplished by turning an individual guideline into a hypothesis and testing it against a dataset to establish if a correlation is present (Spool, 2002). However, usability guidelines themselves have been shown to be vague, and not ‘usable’ for their intended audience (Cronholm, 2009). This can cause great difficulty in their implementation, but also in determining adequate methods for their analysis. Usability guidelines can also be very ambiguous, making them hard to score by a human, let alone the increasingly popular automated analysis tool (Alonso-Ríos et al., 2009).

In contrast to analysing usability aspects of an individual web page, it is also possible to analyse site wide navigation in order to learn more about websites’ usability. Blackmon, Kitajima and Polson (2005) suggest doing this through using an automated ‘cognitive walkthrough’ method. This involves examining the links, headings, and subject matter of a website in order to estimate in number of clicks needed to find information on a single website. Vaucher and Sahraoui (2010) take a similar approach and suggest that by examining how easy an individual page is to navigate and by looking at how easy the website as a whole is to navigate a better understanding of site usability can be achieved.

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# Chapter 3. Research Methods

Many of the cognitive testing methods used in this thesis are repeated in several research studies to show a level of consistency between experiments. This chapter is used to introduce these methods, discuss their usage, and also to give examples of their implementation in other research. Additionally, software created to aid in the data gathering and testing of participants in the thesis is introduced and its functionality explained.

## 3.1 Participant Recruitment and Testing

Older adults recruited to take part in the research studies described in this thesis are all members of the SiDE Research Pool. This is a collection of adults from the local area who have all expressed an interest in participating in academic research. These users have been widely used in various research projects and contact is maintained by a collection of academic researchers. All participants taking part in the studies described in this thesis clarified in pre-screening that they had not taken part in any HCI research studies in the past year. Participants in this research pool are kept informed of activities through newsletters, recruitment mailings, and through a research pool website[3].

A number of participants from this pool have completed a set of questionnaires and cognitive tests either as part of a research study, or as an initial data-gathering exercise used to collect information on the population of the research pool. In this thesis, four different cognitive tests and two Internet skill questionnaires are regularly used to gather information on participants. These tests and information regarding their usage are detailed in this section.

[3] http://side.computing.dundee.ac.uk/

### 3.1.1 Test Battery Administration

Information regarding participant cognitive abilities and computer usage is collected under controlled conditions. Participants are invited to take part in a session where a strict set of questionnaires and cognitive tests are administered. In the case of studies comparing older and younger adults, the testing of these two groups is carried out separately. A summary of the testing battery used is shown in Figure 3.1.

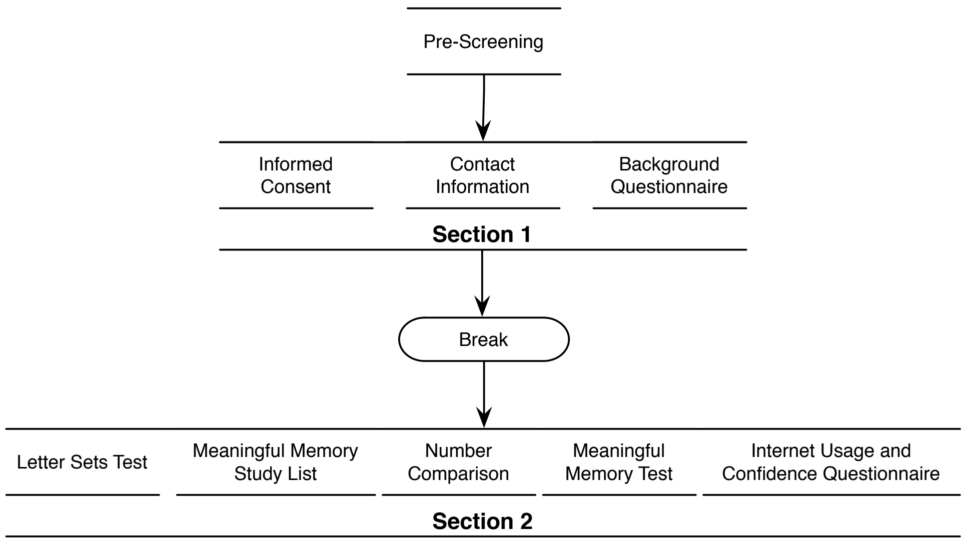



**Figure 3.1 Testing procedure used to gather information on Participant Abilities.**

### 3.1.2 Letter Sets Test (Ekstrom, French, Harman, & Dermen, 1976)

The Letter Sets Test is a test of Induction, a sub-ability of fluid intelligence. This consists of a series of problems with five groups of letters in each. Four of these groups are similar in one way and participants are asked to find the rule that makes them alike, and then to mark the set of letters that is different. An example of this is shown within Figure 3.2. Test A has four sets in consecutive alphabetical order with DEFL being the exception. Example B has four sets containing the letter L with THIK being the exception. Users are given a total of 30 of these problems and have 14 minutes to complete as many as possible. The test is scored as one mark for every question answered correctly.

| | | | | | |
|---|---|---|---|---|---|
| **A** | NOPQ | DEFL | ABCD | HIJK | UVWX |
| **B** | NLIK | PLIK | QLIK | THIK | VLIK |

**Figure 3.2 Example Problems given within the Letter Sets Test**

The Letter Sets Test has been used within a number of HCI studies. Trewin et. al (2012a; 2012b) have used the letter sets task to differentiate between high and low fluid intelligence levels within older adults, using this as a step to create predictive models in search behaviour that take user cognitive factors into consideration. Chin et al. (2009) used the Letter Sets Test, combining it with other cognitive tests to create a generic 'cognition' score. This was done in order to analyse performance between older and younger adults when looking at information online. This test has also been regularly used in cognition based work within the CREATE project where it has been used as a sole identifier of fluid intelligence, a combined identifier of fluid intelligence, and also in combination with other ability measurements to create a generic cognition score.

In this thesis, the Letter Sets Test is used in all experiments as a single measure of Inductive reasoning. Within Chapter 4, participants from the SiDE user pool with previously recorded letter set scorings are used to create high and low fluid intelligence groups. Chapter 5 and Chapter 7 select users that have not previously taken part in a SiDE cognitive testing session, and then include fluid intelligence as one measure of their abilities.

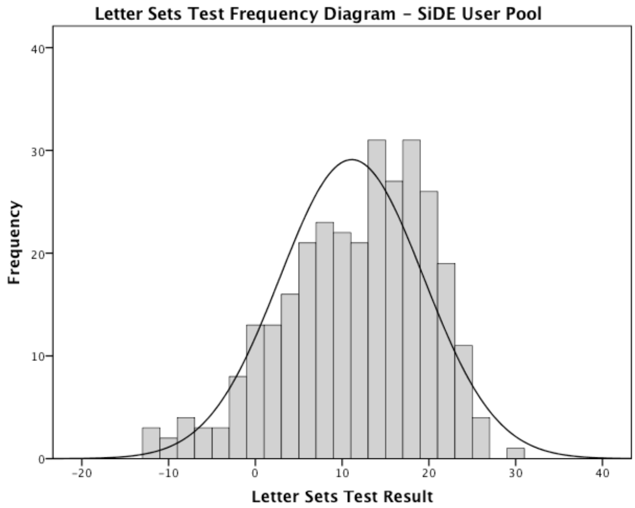



**Figure 3.3 Letter Sets Histogram – SiDE User Pool**

In total, 302 users within the SiDE Research Pool have completed the letter sets test (*M = 11.11 SD = 8.28*), either as part of a group session or within research that relates to the SiDE Project. Distribution for this group is moderate (*Skew. = -.544 SE = 0.14*) according to Bulmer (1979). This indicates a slight bias towards higher scoring participants within the pool.

Kurtosis shows a somewhat platykurtic (broad) distribution (*Kurt. = -.162 SE = .280*) and while this does not pose a problem for the experiments described in Chapter 5 and Chapter 6, Chapter 4 has taken into consideration the higher standard deviation caused by a platykurtic distribution during user recruitment.

### 3.1.3 Meaningful Memory Test (Cattell, 1982)

The Meaningful Memory test is used as a test meaningful memory, a sub-ability of long-term memory. Participants are given a study list of 20 objects linked to 20 descriptors, and then asked to study this for 75 seconds. They are then given a different task before being asked to recall as many of the pairs as possible, but are asked to select a different descriptor word that is the closest to the original. This recall stage of the tests lasts for an additional 4 minutes. Figure 3.4 illustrates a sample study set given to participants to study. Figure 3.5 illustrates a sample test given to participants where they are asked to match up things to the previously given descriptions.

| Thing | Description |
|---|---|
| hammer | excellent |
| rock | rough |
| roof | flat |

**Figure 3.4 Meaningful Memory Example Study Set**

| Thing | Description | | | | |
|---|---|---|---|---|---|
| rock | dirty | smooth | flat | jagged | large |
| roof | level | rough | sloping | leaky | sturdy |
| hammer | big | rough | good | small | heavy |

**Figure 3.5 Meaningful Memory Example Test Set**

This test is used within the studies discussed in Chapter 5 and Chapter 7 as a single measure of long-term memory. In the SiDE user pool, 204 users have completed this test (M = 12.84 SD = 4.95) with the group being moderately skewed (Skew. = -.519 SE = .170). As this test contains a maximum mark of 20 (one mark given for each correct answer), a large number of participants have marks that are at the limit of what this test can measure with this being used to explain (to some degree) the skew present within the data. Kurtosis showed a more platykurtic distribution (Kurt = -.482 SE = .339).

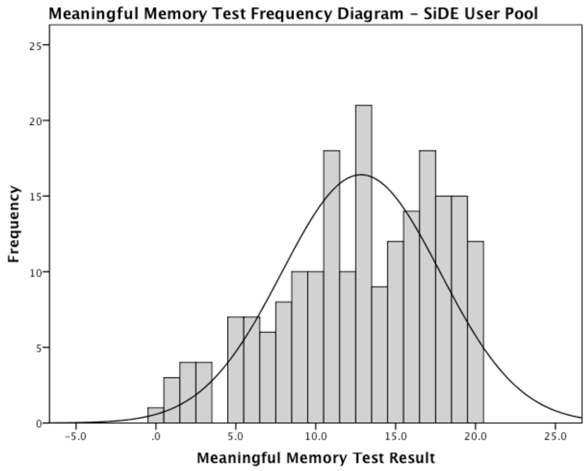



**Figure 3.6 Meaningful Memory Histogram - SiDE User Pool**

### 3.1.4 Number Comparison Test (Ekstrom et al., 1976)

The Number Comparison Test is a test of perceptual speed, a sub-ability of processing speed. The test is designed to look at how quickly a person can identify whether two numbers are the same. This is done by presenting users with a list of 96 number sets (two sets of 48) and allowing three minutes to complete as many as possible. Users have to determine whether two numbers are the same or different, making a mark between pairs that do not match. Scores are calculated as the number of answers correct, minus the number marked wrongly. An example of this test is shown in Figure 3.7.

| | | | | | |
|---|---|---|---|---|---|
| 659 | ✖ | 649 | 7343801 | | 7343801 |
| 73845 | ✖ | 73855 | 18825 | | 18825 |
| 1624 | | 1624 | 5173869 | ✖ | 5172869 |

**Figure 3.7 Example Problems Given within the Number Comparison Test**

Although this test has not been shown to correlate significantly to the speed of a person's search (Allen (1994) reports r = .08) it has been shown to correlate with user learning and recall of data. Allen has also shown that users with high levels of processing speed can take advantage of small adjustments in the user interface. For example, Allen (1994) reported that changing a system in an information retrieval task to first display subject information instead of author information significantly increased users' performance. Allen (1992) also shows that the Number Comparison test can be used as an indicator of search quality and that high scores from this test also aid in 'browse searching' when attempting to find information.

The number comparison test has also been used as part of a composite scoring of individuals' fluid intelligence. Using this scoring method, the test has been used in order to examine performance within customer service based tasks (Nair, Czaja, & Sharit, 2007), and also in the training of older adults in e-health websites (Czaja et al., 2013). In this thesis the number comparison test is used as a single measure of users' processing speed. It is used in the experiments described in Chapter 5 and Chapter 7.

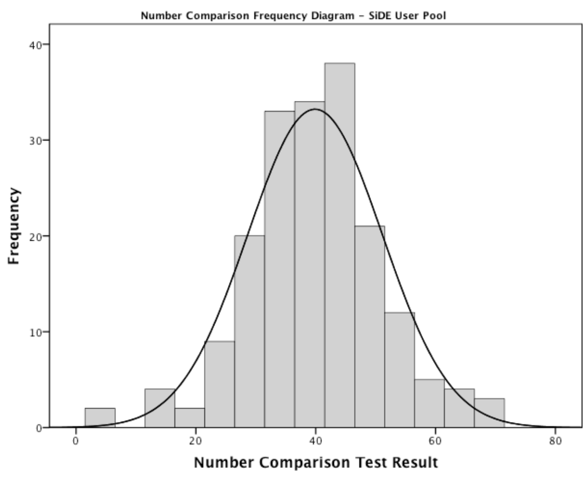



**Figure 3.8 Number Comparison Test Histogram – SiDE User Pool**

Participants who have completed the number comparison test in the SiDE user pool (N = 187, M = 39.88, SD = 11.23) showed to be approximately symmetric (Skew = -.129, SE = .178), with Kurtosis showing a leptokurtic distribution (Kurt. = .754, SE = .354).

### 3.1.5 Internet Usage and Confidence

A common method used to gather information on users is examining their previous technology usage. This can take many forms with the most prevalent being self-reported information. Possible implementations involve using questionnaires to allow participants to report on aspects relating to technology usage, experience and comfort.

It is important to measure both the amount of experience that users have in using technology, and also their expertise as although these items may be correlated, they are both clearly defined separate factors. In order to better understand web experience, more focus must be placed on qualitative web experience, and examining how users learn web skills as opposed to the amount of time spent doing so (Chadwick-Dias, Tedesco, & Tullis, 2004). The Internet Usage and Confidence Questionnaires used in this thesis are adapted from questionnaires used by the CREATE Project[4]. Adaptations were made to the questionnaires to make them more suitable for a UK demographic (L. Gibson, personal communication, October 2013). While the questions used are similar to the original CREATE questionnaires, the differences are sufficient to require an analysis into their composition. Principal Component Analysis (PCA) was conducted separately on both of these questionnaires to understand the links present between questions. PCA used orthogonal rotation (varimax) to maximise the dispersion of loadings within factors, this is done in order to clearly observe the separation of question 'groups' in analysis. This analysis was conducted, therefore, to provide a better understanding into the surrounding constructs that these questionnaires examined, and not as a comparison to the CREATE questionnaires.

[4] http://create-center.gatech.edu/

### *3.1.5.1 Internet Confidence*

The Internet Confidence questionnaire consists of 16 individual Likert scored questions (5 Point: Strongly Agree [5], Agree [4], Neither Agree nor Disagree [3], Disagree [2], Strongly Disagree [1]) that examine users' confidence in using varying aspects of Internet browsing. PCA analysis was conducted on the 16 items and the Kaiser-Meyer-Olkin measure verified the suitability of PCA analysis for all combined variables (KMO = .947) with KMO > .9 for all individual variables. Bartlett's test of sphericity $\chi 2$ (120) = 2379.54, p < .001, also indicated that correlations between factors were sufficiently large for PCA. Two components had eigenvalues over Kaiser's criterion of 1 and explained a combined 72.46% of the variance. Table 3.1 shows the factor loadings with varimax rotation. The items that cluster on the same components suggest that Component 1 represents a confidence in basic Internet abilities and Component 2 represents a confidence in social and new media Internet abilities.

**Table 3.1 Internet Confidence PCA Factor Loading**

| | **1** | **2** |
|---|---|---|
| Confident getting on the Internet | 0.840 | |
| Confident setting home page | 0.690 | |
| Confident using Links | 0.846 | |
| Confident using Back Button | 0.782 | |
| Confident scrolling around a page | 0.850 | |
| Confident using search engine | 0.872 | |
| Confident finding information about a topic | 0.891 | |
| Confident selecting right words for a search | 0.798 | |
| Confident typing in URL | 0.808 | |
| Confident using email | 0.781 | |
| Confident using attachments | 0.642 | |
| Confident in using IM services | | 0.703 |
| Confident viewing online videos | | 0.609 |
| Confident sharing online videos | | 0.830 |
| Confident participating in online chats | | 0.850 |
| Confident using social networking | | 0.803 |

When using this questionnaire in research studies detailed in this thesis, analysis combines all of a participants' answers into a single score, high scores relate to high feelings of confidence and low scores relate to low feelings of confidence. Scorings of the Internet Confidence questionnaire in the SiDE user pool (N = 166 M = 4.51 SD = .785) showed to be approximately symmetric (Skew. = −.091 SE = .188). However, it also showed a slight platykurtic distribution (Kurt. = -.536, SE = .375).

#### *3.1.5.2 Internet Usage*

The Internet Usage questionnaire is loosely based on the Internet Questionnaire used in the CREATE battery of testing (Czaja, Charness, Dijkstra, et al., 2006a). The main difference is a change from a 4 to 6 point scale now using *Everyday [6], Several Times a Week [5], Several Times a Month [4], Every Few Months [3], Less Often [2], and Never [1]*. The number of questions was also increased from 11 to 19, with more granular questions being used and an addition of questions relating to usage of social media.

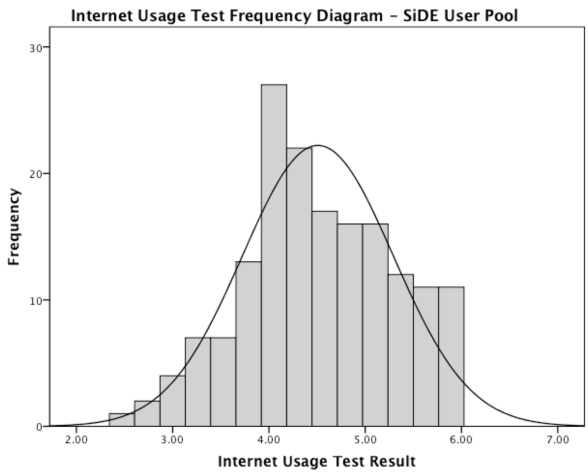



**Figure 3.9 Internet Usage Questionnaire Histogram – SiDE Userpool**

A similar varimax PCA analysis was conducted on the 19 items attached to Internet usage. The Kaiser-Meyer-Olkin measure again verified the suitability of PCA analysis for all combined variables, KMO = .891, with KMO > .75 for all individual variables. Bartlett's test of sphericity $\chi 2$ (120) = 1243.98, p < .001, indicates that correlations between factors were sufficiently large for PCA. Four components had eigenvalues over Kaiser's criterion of 1 and explained a combined 57.37% of the variance. Table 3.2 shows the factor loadings with the varimax rotation. The items that cluster on the same components suggest that Component 1 generally represents information finding based activities; Component 2 represents social and learning based activities, Component 3 represents financial activities, and Component 4 represents religious activities (with this only loading on one variable).

**Table 3.2 Internet Usage PCA Factor Loadings**

| | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Pay bills or do online banking | 0.645 | | | |
| Get financial information | | | 0.677 | |
| Communicate with friends or family | 0.650 | | | |
| Find information about community events | 0.635 | | | |
| Learn something new | | 0.663 | | |
| Search for information about jobs | | 0.545 | | |
| Play games or pursue hobbies | 0.451 | | | |
| Find information about TV or radio shows | 0.738 | | | |
| Visit a local council or government site | 0.574 | | | |
| Get news or weather information | 0.678 | | | |
| Shopping (for example, purchase products) | 0.777 | | | |
| Get travel information | 0.644 | | | |
| Buy or make a reservation for travel | 0.650 | | | |
| Look for new people to meet | | 0.658 | | |
| Use an online social networking site | | 0.683 | | |
| Look up phone numbers or addresses | 0.738 | | | |
| Look for DIY information | 0.525 | | | |
| Look for religious/spiritual information | | | | 0.848 |
| Use online classified adverts | | | 0.714 | |

Similar to the Internet Usage questionnaire, high scores relate to high Internet Usage and low scores for low Internet Usage. In the SiDE Userpool, Internet confidence (N = 172 M = 2.43 SD = .923) showed a slight positive skew (Skew. = .666 SE = .368) and a very small kurtosis level (Kurt. = .074 SE = .368).

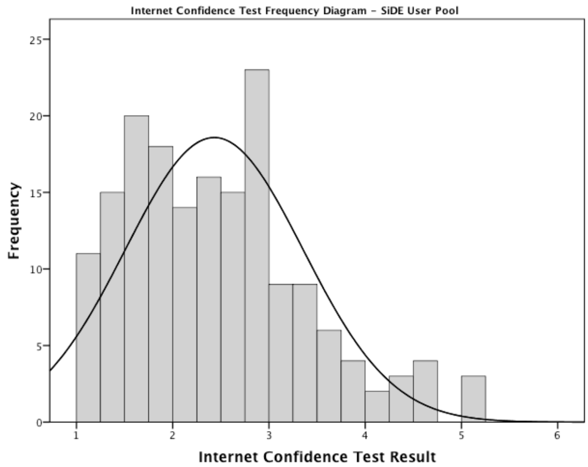



**Figure 3.10 Internet Confidence Questionnaire Histogram – SiDE User Pool**

## 3.2 Developed Software

In order to aid in data gathering and the running of the studies used in this thesis, several pieces of software were developed. Two main pieces of software were used:

- Data collection experimentation software was used to organise the collection of data relating to the information retrieval task used in Chapter 5.
- An adaptable information retrieval system was created to allow individual elements of a websites interface to be adapted and also to collect Likert questionnaire information on a user's browsing experience. This software is used in the research study detailed in Chapter 7.

The remainder of this chapter introduces these software systems and demonstrates their functionality.

### 3.2.1 Experiment Software

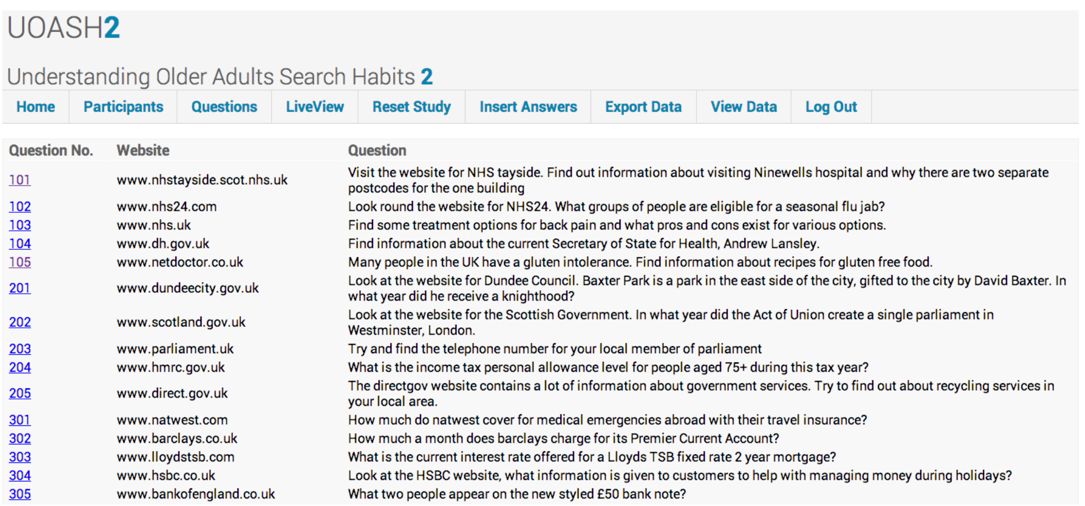
As a large amount of data had to be collected as part of the research study described in Chapter 5, a software suite was created that allowed for experiment information to be set up in advance and also to aid in data gathering during the study itself.

The application suite is a combination of three areas that are key in carrying out web usability studies, these are:

- The collection of data regarding participants and setting out the tasks that they will be completing during a particular study session
- Control of a single user study, keeping participants on track while giving the researcher enough information to direct the study
- Gathering of final data in a format that is suitable for analysis outside of the system

The software was designed to be as unobtrusive to the study environment as possible. Individual aspects of the software focused on creating a simple method to control the experiment, gather data on the participant's navigation through a website, and also to gather information on the characteristics present within web pages themselves.

On creating the user study, multiple tasks were set up and information attached to these either as identifying markers, or as pre-determined analysis points that are unique to each task. These tasks were then assigned to users in random order. This is demonstrated in Figure 3.11 with information retrieval questions attached to various websites.



UOASH2

Understanding Older Adults Search Habits 2

Home | Participants | Questions | LiveView | Reset Study | Insert Answers | Export Data | View Data | Log Out

| Question No. | Website | Question |
|---|---|---|
| 101 | www.nhstayside.scot.nhs.uk | Visit the website for NHS tayside. Find out information about visiting Ninewells hospital and why there are two separate postcodes for the one building |
| 102 | www.nhs24.com | Look round the website for NHS24. What groups of people are eligible for a seasonal flu jab? |
| 103 | www.nhs.uk | Find some treatment options for back pain and what pros and cons exist for various options. |
| 104 | www.dh.gov.uk | Find information about the current Secretary of State for Health, Andrew Lansley. |
| 105 | www.netdoctor.co.uk | Many people in the UK have a gluten intolerance. Find information about recipes for gluten free food. |
| 201 | www.dundeecity.gov.uk | Look at the website for Dundee Council. Baxter Park is a park in the east side of the city, gifted to the city by David Baxter. In what year did he receive a knighthood? |
| 202 | www.scotland.gov.uk | Look at the website for the Scottish Government. In what year did the Act of Union create a single parliament in Westminster, London. |
| 203 | www.parliament.uk | Try and find the telephone number for your local member of parliament |
| 204 | www.hmrc.gov.uk | What is the income tax personal allowance level for people aged 75+ during this tax year? |
| 205 | www.direct.gov.uk | The directgov website contains a lot of information about government services. Try to find out about recycling services in your local area. |
| 301 | www.natwest.com | How much do natwest cover for medical emergencies abroad with their travel insurance? |
| 302 | www.barclays.co.uk | How much a month does barclays charge for its Premier Current Account? |
| 303 | www.lloydstsb.com | What is the current interest rate offered for a Lloyds TSB fixed rate 2 year mortgage? |
| 304 | www.hsbc.co.uk | Look at the HSBC website, what information is given to customers to help with managing money during holidays? |
| 305 | www.bankofengland.co.uk | What two people appear on the new styled £50 bank note? |

**Figure 3.11 Question Display Screen taken from Experiment Design Software**

User information is entered and viewed in a similar interface to the input of questions. This is shown in Figure 3.12, where the interface displays information for a single participant including the research questions that s/he will be given, the related websites that will be visited, and also previously collected user cognitive information.

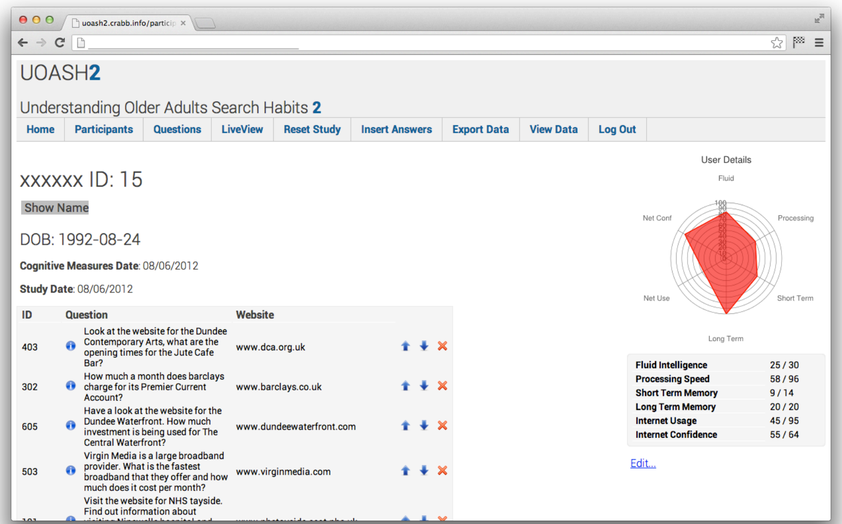



**Figure 3.12 Participant Setup Screen taken from Experiment Design Software**

When a research study takes place, participants are shown instructions for the current task through a small Google Chrome plugin (shown in Figure 3.13). This is set up as an icon next to the address bar that when pressed, displays the current task and any associated information that may be given to the participant. The Chrome plugin also takes a record of the amount of times the current task is displayed to the participant.

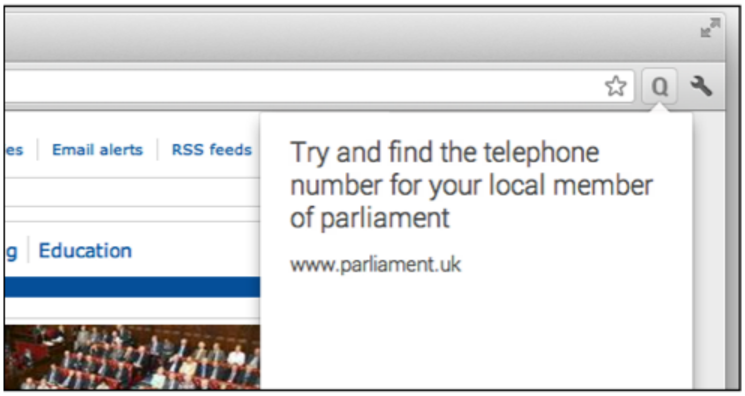



**Figure 3.13Chrome Plugin Displaying Question taken from Experiment Design Software**

In addition to this, a small web application (accessible through either another computer or tablet device) was developed to allow the researcher to control the research session and input data directly into the system database. The application provides the researcher the ability to go forward and back through questions within the study, note if questions have been finished successfully, make notes, and attach specific time points throughout the study.

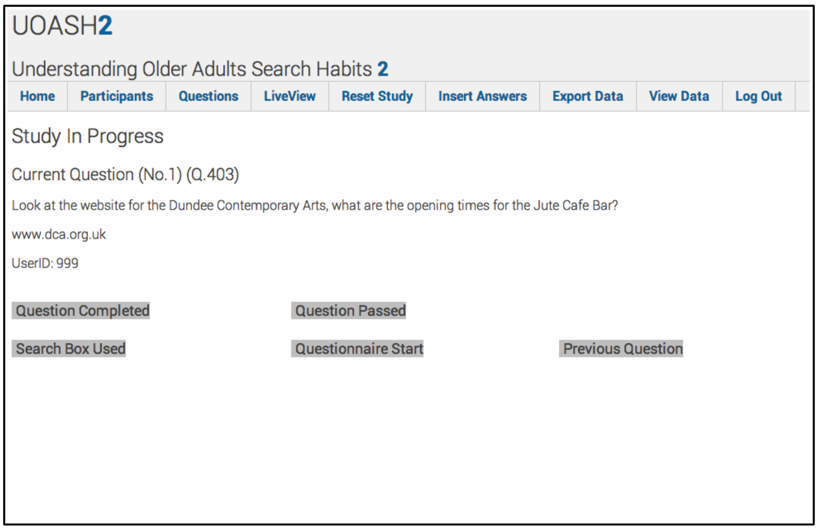



**Figure 3.14 Researcher Control System taken from Experiment Design Software**

The application provides the control over the study, interacting directly with the database, and allowing the study to take place with few or no interruptions for researcher intervention – both saving time and allowing the participant to feel as in control as possible.

When the study is completed and all data collected, various charts are created within the application to allow the researcher to quickly visualise how an individual participant has performed in comparison to the experiment population as a whole. All results can also be exported into a single CSV file for use within more advanced statistical software.

#### *3.2.1.1 HTML Analysis Add-On*

In addition to collecting and organizing information regarding participant navigation throughout websites in a research study, an add-on to this software package was created that allowed for a more in-depth analysis of the web pages visited. This analysis scraped the HTML and CSS of each page visited by participants, recording metrics related to individual usability characteristics. This is done in order to gain a further insight into how individual web metrics can aid users with varying cognitive characteristics when searching for information.

### 3.2.2 Adaptable Information Retrieval System

The study described in Chapter 7 uses a software application that was created to allow for the control of adaptations to a web interface. This software was designed so that individual elements of the website could be changed, allowing for subtle but distinct differences to be made to website navigation properties. It also allowed for different website topics to be swapped in and out of the system.

Six adaptations were created with each of these making a small change in website navigation. These changes consisted of:

- Horizontal or Vertical Navigation
- Drop Down Menus (On or Off)
- Inline Subpages (On or Off)
- Breadcrumbs (On or Off)
- Current Page Highlighting (On or Off)
- Adverts (On or Off)

*3.2.2.1 Topic Based Adaptation*

Six topics were selected from the Wikipedia collection of featured articles[5] in order to create a base set of information that could be turned into individual websites. These articles are described as *"the best articles Wikipedia has to offer, as determined by Wikipedia's editors"* and consisted of:

- HMS Titanic (History)
- San Francisco (Geography)
- Scotland (Geography)
- Jack the Ripper (Culture and Society)
- Maple Syrup (Food and Drink)
- Greek Mythology (Religion, Mysticism, and Mythology)

The menu and sub-menu structure for each created site was duplicated from the Wikipedia article it related to and the main text body content was also unaltered. This allowed for six individual web site topics to be created that all relied on a single web template to adjust additional site elements. Figure 3.15 shows sample interfaces for each of these sites with only colour schemes and site topics being adjusted.

[5] http://en.wikipedia.org/wiki/Wikipedia:Featured_articles

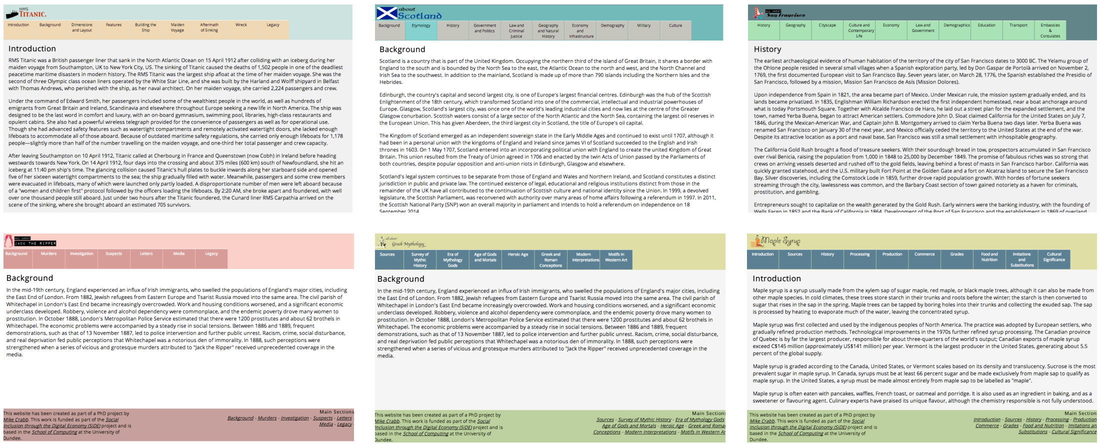



**Figure 3.15 Topic and Colour Scheme Adaptations**

### *3.2.2.2 Menu Location Adaptation*

As shown in Figure 3.16, the navigation of website pages can be set to either a horizontal or vertical position. In addition to the movement of the menu, this also has a slight impact on the size of the typeface used within the menu (with this being slightly smaller in a horizontal menu) and also the width of the main text body.

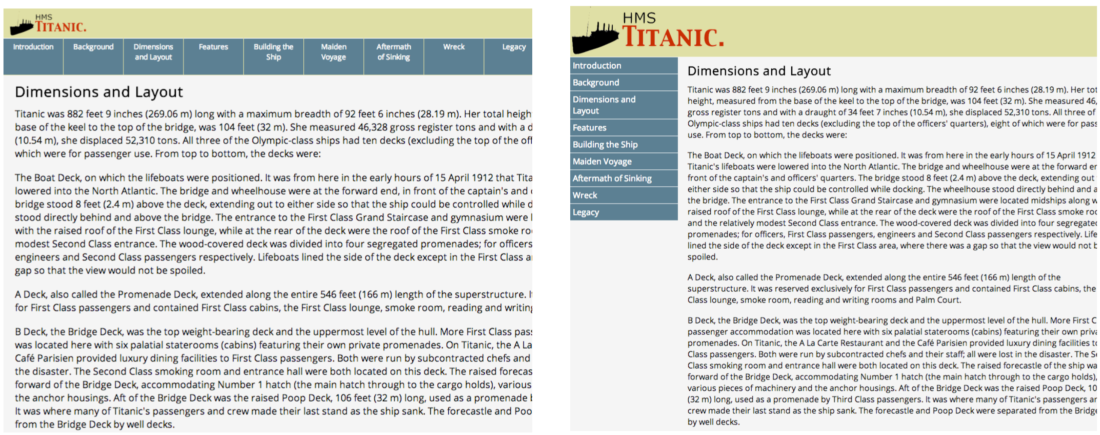



**Figure 3.16 Menu Position Adaptation**

### *3.2.2.3 Drop Down Menu Adaptation*

The use of drop down menus was also used as an adaptation to the website interface. This is demonstrated in Figure 3.17. When drop down menus were disabled, users were required to first visit the main topic section, and then select a sub-topic from the page. With the drop-down menu enabled, users could hover over menu items to view the sub-topic pages, creating a faster method of viewing information. The design of these menus followed the usability principles suggested by Nielson (2009) when discussing the use of drop down elements.

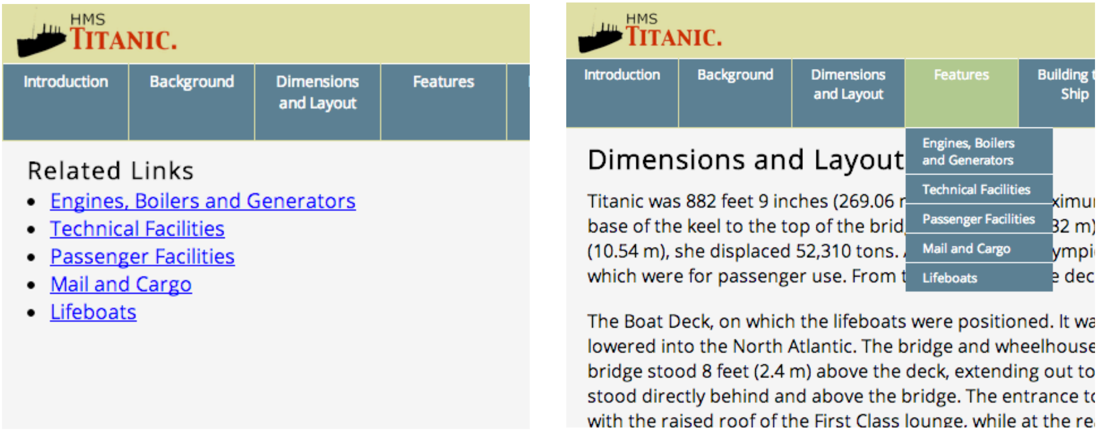



**Figure 3.17 Drop Down Menu Adaptation**

### *3.2.2.4 Menu Size Adaptation*

The overall size of menus was created as a possible adaption to the interface of the website, demonstrated in Figure 3.18. In this adaptation, menus were either set to display top-level menu items only, or all menu items for a site. This in turn created two different menu structures. One was small with a limited amount of items, being quicker to read but not providing a large amount of options. The other was large, taking longer to read but providing a greater amount of navigation options. The latter also has a disadvantage in large menus crossing the fold (i.e. the bottom) of a page, making viewing all items of a page difficult. The style pattern for this adaptation was influenced by van Welie (2008).


**Figure 3.18 Vertical Menu Length Adaptation**

### *3.2.2.5 Menu Highlighting Adaptation*

Highlighting of the current page that a user was visiting in the website menu was also used as an adaptation, shown in Figure 3.19. When this feature was turned off all menu items appeared the same colour, and when turned on the current page was highlighted a different colour. This was designed to be a relatively simple adaptation and the colour chosen for highlighting was based on the colour themes for individual sites, allowing for the adaptation to both be a noticeably different colour to users, but also blend in with the overall theme of the site.

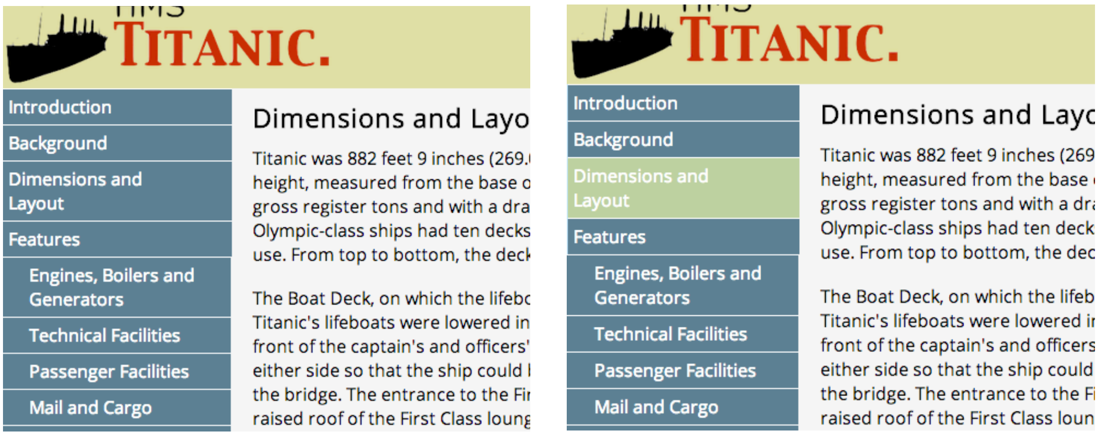



**Figure 3.19 Menu Highlighting Adaptation**

### *3.2.2.6 Breadcrumb Usage Adaptation*

Breadcrumbs were also used to create an adaptation to the web interface. When turned on, a breadcrumb trail was present within the top right hand side of the page header. This indicated the page title, the name of the section that the user was in, and the name of the page s/he was on as well.

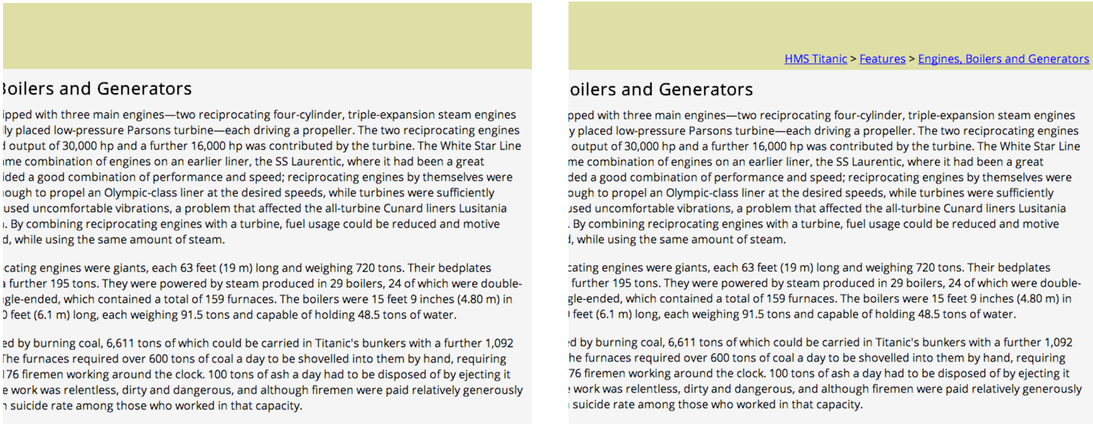



**Figure 3.20 Breadcrumb Adaptation**

### *3.2.2.7 Advert Adaptation*

Finally, an adaptation that focused on adverts was used. This is demonstrated within Figure 3.21. If this adaptation was selected, a panel of adverts would be presented on the right hand side of the website interface. These adverts changed every time a user moved pages and were selected on a rotation of seven different stock images. Adverts did not lead to additional websites and could not be clicked; they were designed only to distract users.

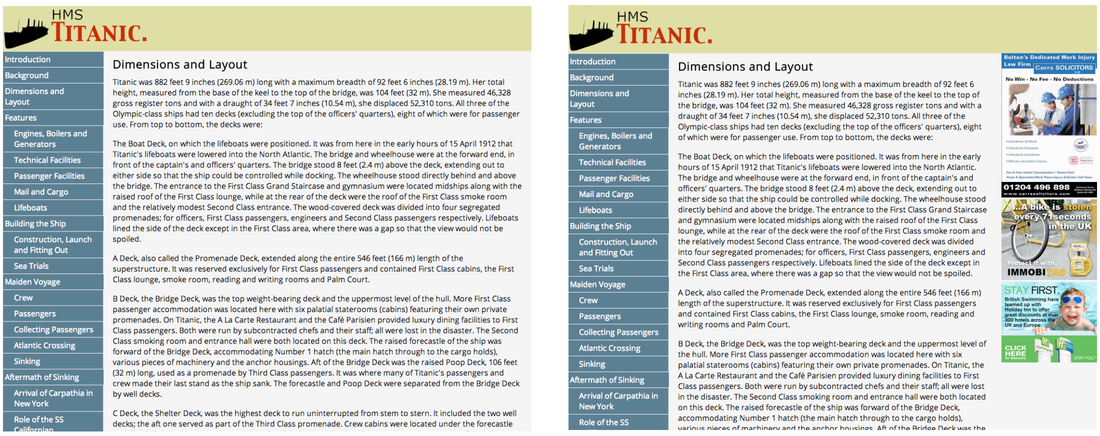



**Figure 3.21 Advert Adaptation**

### 3.2.3 System Controls

Similar to the system described in Section 3.2.1, this software was controlled through a web-interface that could be accessed through a secondary computer (example interface controls are shown in Figure 3.2.2). This allowed for the researcher to control the current question that was being asked to the participant, move between the various websites and adaptations, and also to act as a reminder of the question currently being asked. This interface also created time-markers that could be used within analysis to examine the amount of time taken to answer individual questions.

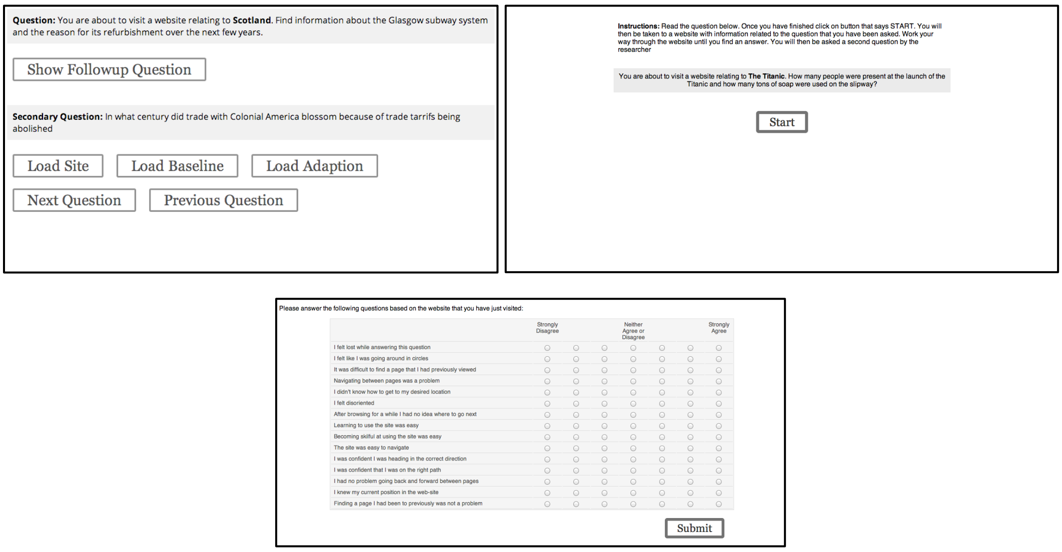



**Figure 3.22 Control System (Top Left), Sample Question (Top Right), and Sample Questionnaire (Bottom)**

During the study and before participants visited a website, they were first shown a screen that provided brief instructions on the task they were being asked to complete; an example is shown in Figure 3.22. This screen also detailed a question that related to the topic of the website they were about to visit. Once each question had been completed participants were presented with a screen to fill in a questionnaire based on their experiences of using an individual website.

# Chapter 4. Preliminary Research

This chapter describes an introductory research study performed in order to gain an insight into techniques that are employed by users when searching for information online. 0 discussed different user-based metrics that can be used to differentiate between users. This research analyses two of these metrics (Internet Usage and Inductive Reasoning) using both a thematic analysis technique, and through statistical analysis.

## 4.1 Introduction

One of the questions asked at the beginning of this thesis regards the usage of metrics that can be used to distinguish between users. This chapter examines fluid intelligence, Internet usage, and age as metrics that may distinguish between users' browsing experience. The approach taken for this examination is completed in two parts. Firstly, a quantitative approach is used to examine whether these factors can differentiate between users' when searching for information online. Secondly, a qualitative approach is taken to examine participant dialogue during the study using a thematic analysis technique. This twin-pronged approach to analysis is carried out in order to both examine the speed and frequency at which users perform tasks, and to examine whether further differences can be found between users by examining the conversations that occur while users are searching for information.

## 4.2 Methodology

### 4.2.1 Experimental Variables

Participant Age Group, Internet Usage, and Inductive Reasoning were used as independent variables in the statistical analysis and for grouping participants in thematic analysis. Statistical analysis used the following as dependent variables:

**Search Engine Usage Efficiency** - This measure consisted of two variables, the mean number of words per search string, and the mean time on a search engine (Google) per search.

- *Mean Web Pages Visited Per Minute* – It is expected that participants with higher levels of Internet Usage would visit a larger number of web pages than participants with low levels of Internet Usage and would produce a higher mean number of web pages visited per minute. For this reason, mean number of web pages visited per minute was included as a measure to examine the speed in which users will navigate through websites during the study.

- *Mean Mouse Clicks Per Minute* – The mean mouse clicks per minute is a metric that is highly correlated to the mean web pages visited per minute; each web page visited would result in an increase in mouse clicks. However, additional mouse clicks may be registered if participants were to click on items that are not links, interact with additional elements on a page, or to repeatedly click on links while new pages are loading. This metric was therefore included to examine if there was any difference between the results obtained between it, and the mean number of web pages visited per minute

**Task Speed** – This measure consisted of two variables, the mean web pages visited per minute, and the mean mouse clicks per minute.

- *Mean Time on Search Engine (Google) per Search String Entered* – Users are very likely to click on the first link in the search engine when looking for information (Granka, Joachims, & Gay, 2004). It is anticipated that users with high Internet Usage would do this more regularly and that users with low Internet Usage would spend more time reading search links before selecting a link. It has also been suggested that 'expert' searchers will behave in the opposite manner, spending more time deciding on what link to select and therefore having an increased mean time for each search string entered. Mean time on a search engine per individual search was therefore included as a measure of how quickly participants could go from entering a search string to selecting a search result that they believed was suitable.

- *Mean Words Per Search String* – While expert searchers may use advanced search strings while searching for information[6], it is anticipated that participants in this work will not attempt to use these more advanced features. Mean words per search string were included as a metric as a measure of how strict participants would be when entering search strings.

### 4.2.2 Participants

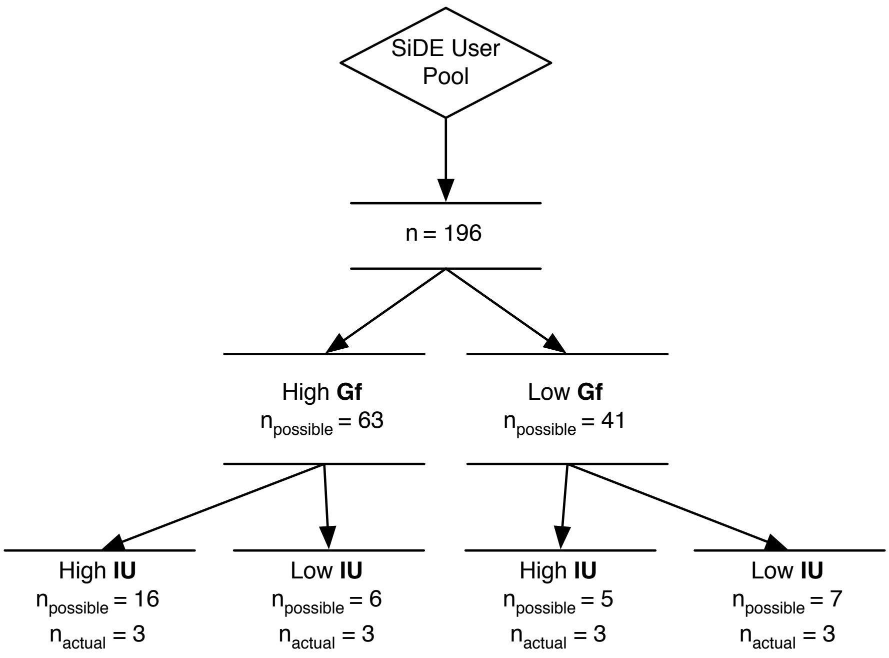
Eighteen participants were recruited for this study. This consisted of 12 older adults ($M = 67.17$, $SD = 5.36$) and six younger adults ($M = 19.83$, $SD = 0.68$). Older adults were recruited from the SiDE user pool, being contacted by the user pool coordinator through either phone or e-mail. Younger adults were recruited through e-mail and university message boards and then added into the user pool database. All clarified in pre-screening that they had not taken part in any HCI research studies in the past 12 months.

Older adults who participated in the study ($M_{age}=67.17$, $SD_{age}=5.36$) had previously completed a number of cognitive tests and questionnaires as part of an information gathering exercise on the population of the SiDE user pool. This allowed participant

[6] http://www.google.com/advanced_search

selection to be based on questionnaires that they had previously completed. Specific user groups were therefore created based on user scorings obtained in the Internet usage and fluid intelligence parts of the testing battery. This resulted in 3 participants were in each category, with a 2x2 between participant design being used, focusing on users with high and low scorings in both fluid intelligence and Internet usage

Recruiting users in this manner proved challenging because of the high platykurtic kurtosis present within both the user pool fluid intelligence and Internet usage test data. This resulted in groups being created that had a mean of 0.7 standard deviations away from the overall user pool mean instead of the preferred 1 standard deviation (recruitment is summarised in Figure 4.1). Despite this, a significant difference was present between high fluid intelligence ($M_{Gf}$ = 17.17, $SD_{Gf}$ = 4.83) and low fluid intelligence ($M_{Gf}$ = 6.0, $SD_{Gf}$ = 3.35) groupings (t(10)=4.65, p < .001) and also between high Internet usage ($M_{IU}$ = 3.64, $SD_{IU}$ = .62) and low Internet usage ($M_{IU}$ = 1.62, $SD_{IU}$ = .42) participant scores (t(10) = 6.55, p < . 001.).




$n_{possible}$ indicates participants that are at least .7 standard deviations away from the overall user pool mean

**Figure 4.1 Recruitment Summary**

The six younger adults ($M_{age}$ = 19.83, $SD_{age}$ = 0.68) were all university undergraduates studying degrees in Law, Medicine or Teaching. All had previously stated that they use search engines on a regular basis and this was confirmed in their Internet Usage questionnaire scorings ($M_{IU}$ = 3.68, $SD_{IU}$ = .496). Younger adults showed a slightly higher Internet Usage score than high Internet usage older adults, but this was not a significant difference.

### 4.2.3 Materials and Equipment

*Demographic Information* —Demographic information including participant age, education and occupational status were collected from participants during the screening process.

*Internet Usage*—A questionnaire examining Internet usage was administered to all participants prior to taking part in the experiment and used in the screening process. This examined how often participant completed a set of different Internet based tasks and consisted of 19 questions, measured on a 7-point scale (Everyday, Several Times a week, Several Times a month, Every few months, Less Often, Never).

*Inductive Reasoning*—The Letter Sets (Gf-I) (Ekstrom et al., 1976) was administered prior to the experiment and also used in the screening process to select participants.

*Task Question Set*—Three different scenarios were created that are similar to activities that would normally be carried out online (Ofcom, 2011, p. 35), allowing for information to be gathered on participants information retrieval abilities and the interactions between users and the websites they visit. Tasks were split into three different categories:

- **Comparative Data:** Tasks in which the user would normally choose to make a direct comparison between two or three different sites before making a decision. In this case it included activities such as finding a hotel, where many different sites exist that can give further information on what is desired.

- **Non-Comparative Data:** Tasks in which the user would only check one website for a piece of information. In this case an activity such as checking local weather was used, as this is information that would not normally be looked at on more than one website.

- **Website Paths:** Tasks in which the participant would search for an individual subject, go deep into a website to find specific information, and then back to a search results page to select another site, this would occur multiple times and a path of visited sites would be created.

**Table 4.1 Study Scenarios and Attached Tasks**

| | Holiday Scenario | Cottage Scenario | Local Area Scenario |
|---|---|---|---|
| Comparative Data | Book flights & hotels | Find a cottage | Pictures of local area |
| Non-Comparative Data | Find weather information | Find weather information | Waterfront regeneration project |
| Website Paths | Local attractions<br>Buy a digital camera | Local pubs/restaurants | Pictures of local area |

*Data Collection*—The software package Screenium (Software, n.d.) was used for data collection during the study. This software was used as a combined screen and voice recorder. All sessions were recorded, with the video feed being taken from the computer desktop and the audio feed recording what was said between the research and the participant. All sessions were then transcribed by the researcher, with both conversation information and mouse click / page information being recorded.

*Experimental Equipment*—The experiment ran on an apple laptop computer (MacBook Pro Mid-2010[7]) with the Google Chrome Browser being used. The laptop was placed in front of the researcher and the participant was given control through a 22" Widescreen Monitor, and a standard Microsoft Keyboard and Mouse.

### 4.2.4 Procedure

Participants were invited to take part in a one-to-one session where they were given a set of information retrieval scenarios to carry out online. Participants were firstly given a broad description of the aim of the study, being told that it was to look at the problems that exist while searching online because of web usability issues and not the individual problems that a particular user may face. Participants were then given different scenarios to work through that are similar to tasks that they might carry out online. At the beginning of each task, the browser was set to the Google home page[8].

Users continued searching for information until 45 minutes had elapsed. This ensured that a relatively similar amount of data was collected for each participant. This method meant that in some cases, participants did not complete all scenarios as the time taken by individuals to complete these information retrieval tasks varied greatly.

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[7] http://support.apple.com/kb/SP584

[8] http://www.google.co.uk

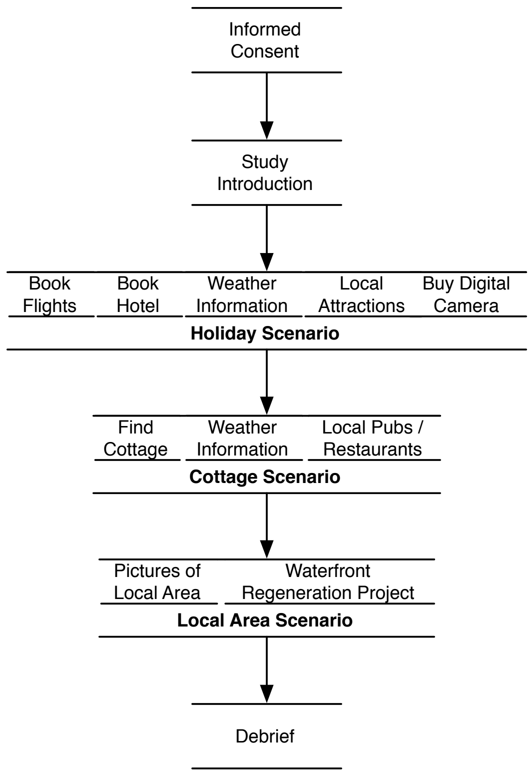


**Figure 4.2 Study Design Summary**

### 4.2.5 Data Analysis

A quantitative and qualitative analysis was conducted separately on the data gathered during the study. In the quantitative analysis, the purpose was to examine any differences that were present between the groups, with Inductive Reasoning and Internet Usage being used as Independent Variables. This resulted in a factorial independent measure ANOVA being used for initial analysis, with this followed by post-hoc t-tests when significance was found. Bonferonni correction was used on all post-hoc testing. All data was standardised using Gelman's (Gelman, 2008) method.

Qualitative analysis was performed with the aid of Dedoose Software Package (Lieber & Weisner, 2010). Data was coded into six different categories and 24 sub-categories with a thematic analysis approach being used (Braun & Clarke, 2006). This process consisted of firstly becoming familiar with the data through transcriptions and through note taking. This was followed by the generation of initial codes that examined individual aspects of the transcriptions. Once all data was coded, themes were identified in order to focus the analysis. Themes were then refined and sub-topics allocated to each. This resulted in themes that focused on participant feelings, participant comments, participant process, and search reasoning.

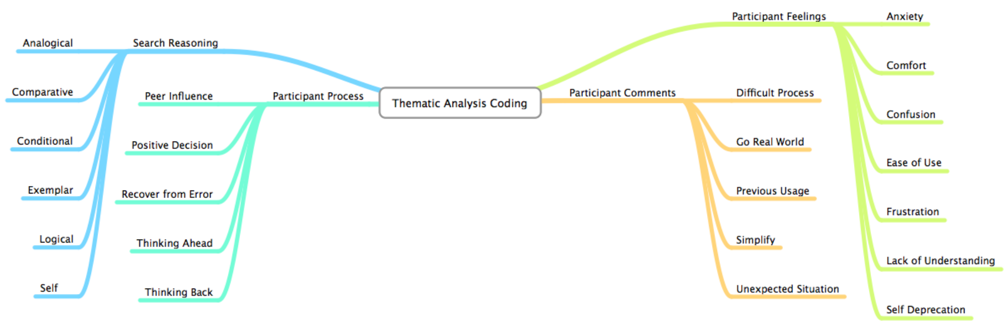


**Figure 4.3 Thematic Analysis Coding**

This analysis used a mixed method approach, with separate analysis occurring in the following groups once all data had been coded:

- High Fluid Intelligence and High Internet-Usage
- High Fluid Intelligence and Low Internet-Usage
- Low Fluid Intelligence and High Internet-Usage
- Low Fluid Intelligence and Low Internet-Usage

## 4.3 Results

The use of one-on-one sessions, accompanied with the detailed logging of computer information, allowed for both qualitative and quantitative results to be produced. Quantitative information is based upon measurements of search ability such as mouse clicks and search string size. Qualitative information is based upon quotes made by participants throughout the study.

### 4.3.1 Quantitative Results

An initial Pearson's Correlation Coefficient showed very little correlation between age and any of the measured dependant variables, with the largest correlation taking place between age and words per search string ($r = -.333$, $p > .25$). No statistical significance was observed in any correlations. These results were created with a small sample but they begin to show the limited capability of age as a metric to distinguish between individuals.

Following on from examining age, analysis turned to examine if differences were apparent between users with high and low Inductive Reasoning or Internet Usage when examining their performance. The groupings between older adult participants were made to highlight high and low dimensions of fluid intelligence and reported Internet usage. Independent sampled t-tests and ANOVA testing were used to examine any interactions that may exist between groupings. Separate analysis occurred between examining the search engine usage efficiency, and overall task speed of participants. Search engine usage efficiency included metrics focusing on the average words entered per search term and the time spent on a search engine (Google) for each search. Overall task speed included metrics focusing on the average pages per minute visited by participants, and the average mouse clicks per minute. Due to this separation of search engine usage and task speed, Bonferroni corrections are applied both to ANOVA and post-hoc testing.

A factorial independent measure ANOVA was firstly used to examine the search engine usage efficiency between users with high and low Internet Usage. In this context, search efficiency includes the time spent on a search engine (Google) for each search, and the number of words per search string. A significant effect was found between these groups [$F(2, 12) = 6.395$, $p = .038$]. Post-hoc between subject analyses showed a significant effect in the time on search engine (Google) per search string [F(1,12) = 12.20, p < .024)] between high (M = .619, SD = .288) and low (M = 1.32, SD = .405) Internet Usage groups, but no significant effect in the average number of words per search string [F(1,12) = 8.843, p = .056)] between high (M = 4.34, SD = .436) and low (M = 3.69, SD = .317) Internet Usage participants.

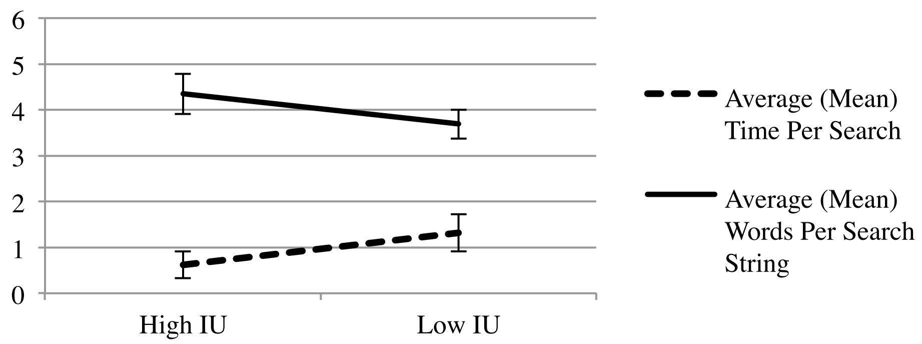


**Figure 4.4 Search Engine Usage Efficiency for High and Low Internet Usage Participants**

These results indicate that the previous Internet usage of participants has an influence on their search engine efficiency. Even though no significant difference could be found in the average number of words per search string that high and low Internet usage participants used when trying to find information, participants with high Internet usage would spend less time on a search engine before selecting a link than participants with low Internet usage. This suggests that while the high Internet Usage older adult population in this work is faster at searching than the low Internet usage population, they are not using the prolonged search selection techniques that may be used by 'expert' searchers.

A second independent measure ANOVA was used to examine task speed between users with high and low Internet Usage. Task speed consists of metrics surrounding the average number of pages visited per minute, and the average number of mouse clicks per minute. A significant effect was found between these groups [F(2,12) = 6.329, p = .038]. Post-hoc between subject analyses showed a significant difference in the average number of pages visited per minute [F(1,12) = 13.73, p = .016] between high (M = 1.65, SD = .465) and low (M = .925, SD = .124) Internet usage groups, but no significant difference in the clicks per minute [F(1,12) =8.856, p = .056] between high (M = 2.19, SD = .466) and low (M = 1.53, SD = .271) Internet usage groups.

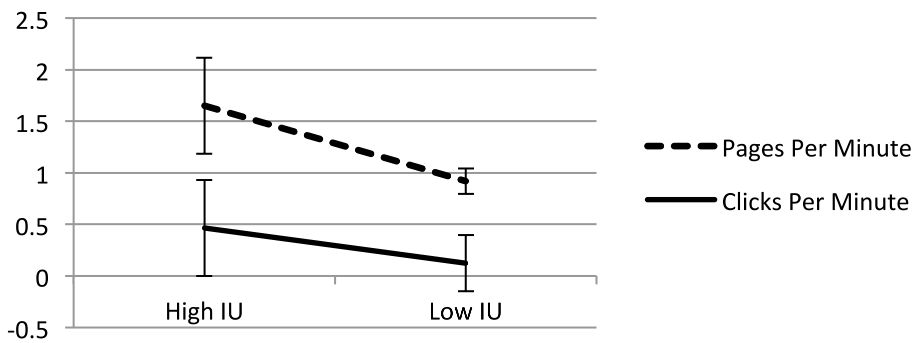


**Figure 4.5 Task Speed Comparison for High and Low Internet Usage Participants**

This indicates that again there is a difference between participants with high and low Internet usage. Participants with high Internet usage visit more pages than those with low Internet usage. Additionally, even though participants with low Internet Usage would visit fewer web pages than users with high Internet usage, their average mouse clicks per minute is comparable. This suggests that users with low Internet usage could be making more 'misclicks' than those with high Internet usage.

Two additional independent measure ANOVA tests were used to examine users with high and low inductive reasoning. No significant effect was found when examining search engine usage efficiency [F(2,12) = .221, p > 1.] and also task speed [F(2,12) = .253, p > 1.]. As no significant effect was found with either of these tests, no post-hoc between subject analyses occurred.

Differences were also examined between younger adults and the six older adults with a high level of Internet usage. This selection included older adults with differing levels of fluid intelligence as no statistical difference was found between high and low fluid intelligence elements within the first part of analysis. Similar analyses to that performed between older adult groupings were performed between older and younger adults.

A first ANOVA was performed examining the search engine usage efficiency between older and younger adults. A significant effect was found between these two groups [F(2,12) = 6.931, p = .030]. However no significant difference was found in the words per search string [F(1,12) = 3.179, p = .210] between younger (M = 2.28, SD = .521) and older (M = 2.75, SD = .381) adults. No significant difference was also found in the time on search engine (Google) [F(1,12) = 6.050, p = .068] between younger (M = .383, SD = .065) and older (M = .971, SD = .581).

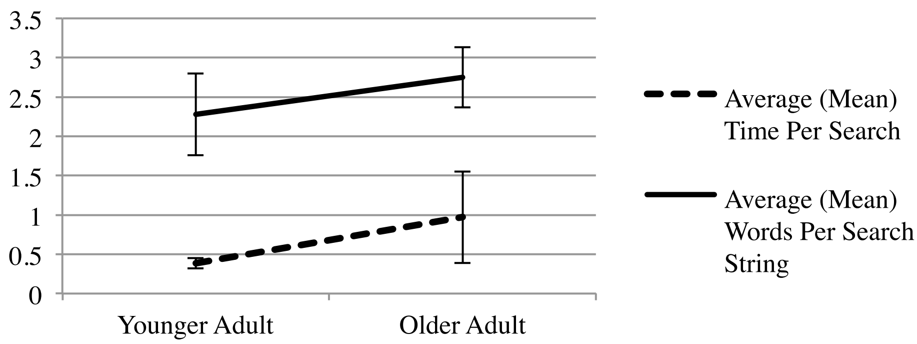


**Figure 4.6 Search Engine Usage Efficiency for Younger and Older Adult Participants**

This indicates that while there is a difference in the search engine usage efficiency between older and younger adults, Bonferroni results report that no individual aspect measured was found to contribute to this in a significant way.

A second ANOVA was then performed examining task speed between older and younger adults. A significant effect was found between these groups [F(2,12) = 12.823, p = .005]. A significant difference was found in the number of pages visited per minute [F(1,12) = 24.47, p = .002] between younger (M = 1.42, SD = .335) and older (M = .616, SD = .216) adults. No significant difference was found in the clicks per minute [$F(1,12) = 5.406$, $p = .168$] between younger (M = 1.429, SD = .538) and older (M = .861, SD = 259) adults.

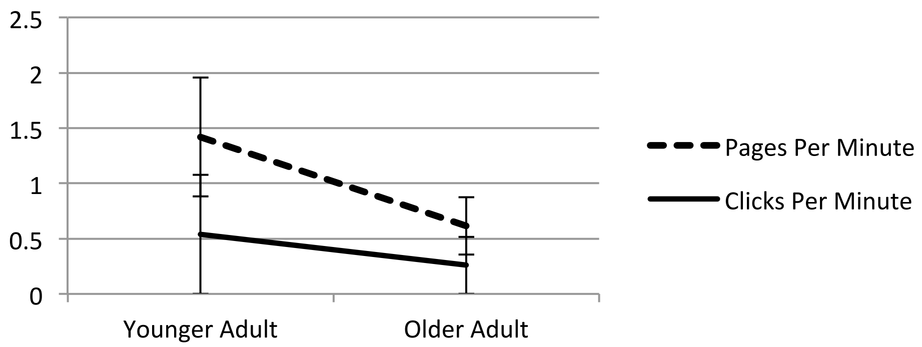


**Figure 4.7 Task Speed Comparison for Younger and Older Adult Participants**

This result is very similar to that found between older adults with high and low Internet usage in that younger adults visited more pages per minute than older adults, yet no difference could be seen between their number of average clicks per minute. This suggests that younger adults could be performing less mis-clicks on a page, or are using less interactive elements on pages and quickly moving between pages.

## 4.3.2 Qualitative Results

### *4.3.2.1 High Fluid Intelligence, High Internet Usage*

When examining the approaches used by $High_{fluid}High_{Internet\text{-}Usage}$ users, several co-occurrences repeatedly occurred between participants. The largest co-occurrence was seen between the reliance on previous technology experience and the ability of participants to think ahead. This demonstrated participants' awareness of their planned path through a website.

> *What I would do now would be to copy the name and then search for it on 'Trip Advisor' for some reviews*

*It's given me in blue highlighting some of the things to look for and I would make a note of them and then would start to see if a local bus would get me to those places*

There was also a large co-occurrence between previous technology use and feelings of ease. This draws on the notion that as you do a task repeatedly, you become more comfortable in performing it. This can also be combined with simplifying of a process, where participants showed a tendency to greatly simplify processes based on their previous experiences.

*I use my computer every day. I've never been on holiday abroad, so the computing should be easier than the holiday planning*

*My sister always says that she doesn't know what to put in as a question. I say you just put in words and it'll come.*

$High_{fluid}High_{Internet\text{-}Usage}$ participants also showed an ability to reason with themselves before making choices, something that was not as apparent in other groups. This was most prominent when in conjunction with thinking ahead and users commenting on possible problems that may occur, and how they would fix them. This combines experience in using computers with the problem solving skills associated with high fluid intelligence.

*What would I do - I don't need that in the search field any more so I'll delete that and then go for cameras.*

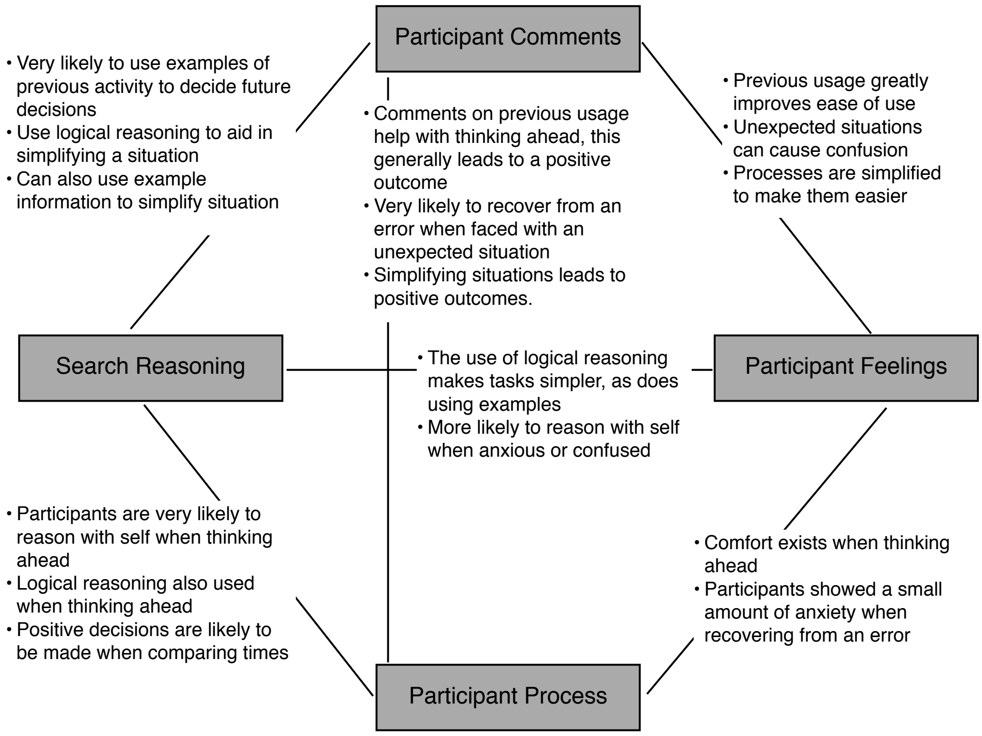


**Figure 4.8 High Fluid Intelligence & High Internet Usage Thematic Analysis Summary**

Participants in the High Fluid Intelligence/High Internet Usage category were the most comfortable when performing tasks. They appeared to be very competent in their ability to navigate both to and around web pages. $High_{fluid}High_{Internet\text{-}Usage}$ participants also demonstrated their ability to use previous experience to help them in online situations. This was shown to benefit both when visiting a website they had previously visited and also in relating past experiences when faced with unexpected situations.

*4.3.2.2 Low Fluid Intelligence, High Internet Usage*

As with $High_{fluid}High_{Internet\text{-}Usage}$ participants, one of the main themes displayed by $Low_{fluid}High_{Internet\text{-}Usage}$ users is an ability to use their previous experiences in order to aid in searching. This generally focused on the recollection of websites that they would trust in a given situation, or by following a set routine for searching.

> *The way I would do this would be first of all to go to Trip Advisor and look for hotels on that.*

*I would normally check on this site first to see if the company is ethical or not.*

Participants in this category also gave up on an activity if it was too difficult, or if the information was unavailable. Their behaviour tended to focus towards attempting to find information on the subject area they were after, but if this proved challenging they would move to a different site – an indicator of low problem solving ability but also an ability to navigate through systems.

*Flies from Heathrow? That's no use. Try a different site?*

*Well we're not going for a walk obviously; it's too difficult to find out how to book it.*

$\text{Low}_{\text{fluid}}\text{High}_{\text{Internet-Usage}}$ participants also showed a lack of interest in using the Internet for shopping, tending to rely on web-based services for information gathering needs, and then visiting a *real-life* shop to buy items. There could be many reasons for this, but as this is a phenomenon that only occurred within the $\text{Low}_{\text{fluid}}\text{High}_{\text{Internet-Usage}}$ group, a possibility could be a compromise between the ease of finding information online and the difficulty in navigating through complex forms required to complete more difficult activities online.

*You could spend hours on this, trying to figure out what each of the options means. It's easier to just go into a shop.*

*If I can physically go and buy something from a shop then I would do that, but if I can't get it I'd buy it online.*

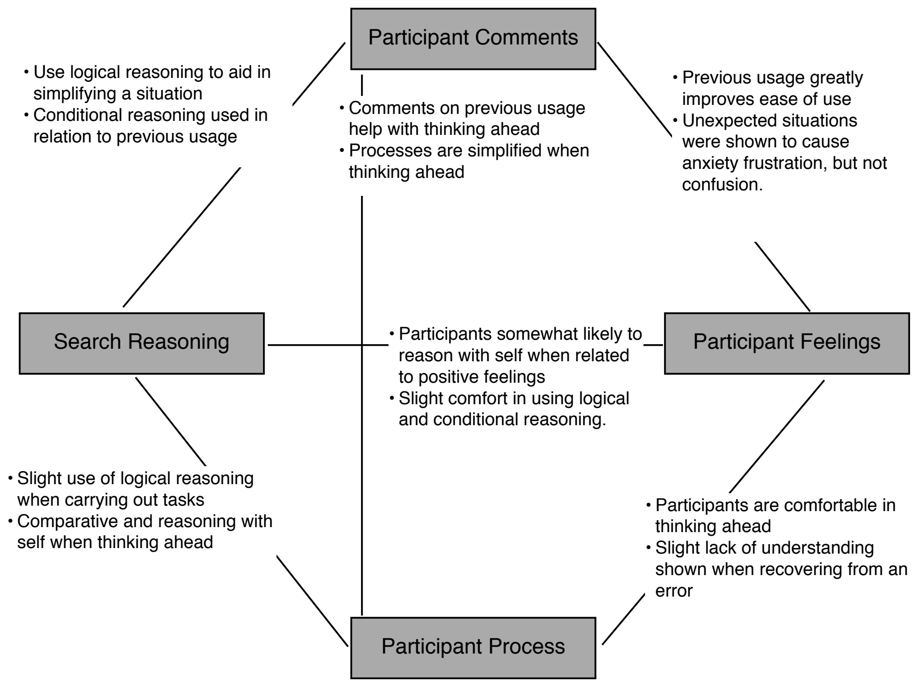


**Figure 4.9 Low Fluid Intelligence & High Internet Usage Thematic Analysis Summary**

While there were a large amount of similarities between $\text{Low}_{\text{fluid}}\text{High}_{\text{Internet-Usage}}$ and $\text{High}_{\text{fluid}}\text{High}_{\text{Internet-Usage}}$ participants, there were also noticeable differences. These centred around the methods used when faced with problems online. High fluid intelligence users would attempt to rectify these issues while low fluid intelligence users were more likely to give up and move to a different website.

#### *4.3.2.3 High Fluid Intelligence, Low Internet Usage*

The main characteristic occurring for $\text{High}_{\text{fluid}}\text{Low}_{\text{Internet-Usage}}$ participants is their ability to use comparative reasoning when faced with complicated information. These users are very likely to compare items before making decisions, with this happening either between sites or on an individual web page. This possibly highlights the higher problem solving ability present in these participants.

> *I'm just away back looking at the other site; they didn't say the price on that one.*
>
> *I'll go for um; well I want to be central so I presume that it's among that big bunch.*

In contrast, these participants also felt very anxious when searching for information, especially so when thinking ahead, potentially demonstrating the low Internet usage presented by these participants.

*This is where the problem starts, I never know which one to go for, have you got to go through them all?*

One of the attributes that appeared very strong in all high Internet usage users was the ability to think ahead and plan out their path in advance of visiting any sites and pages. However, this was not replicated in $\text{High}_{\text{fluid}}\text{Low}_{\text{Internet-Usage}}$ users (and also $\text{Low}_{\text{fluid}}\text{Low}_{\text{Internet-Usage}}$ users). Participants in this group questioned more about how aspects of a page work, and looked for guidance on what pages to visit.

*Do I go into here? Now, do I have to fill that bit in for the dates? How does that bit work?*

An interesting subset of information that only appeared for $\text{High}_{\text{fluid}}\text{Low}_{\text{Internet-Usage}}$ participants surrounded an understanding of their own abilities, commenting that they acknowledge the limitations in what they know about searching for information online (and even using computers in general), but also that they understand that they could improve their experiences through practise.

*I don't want to do an awful lot, I just want to be a bit more efficient at what I do. It's just practise.*

*I suppose if you're maybe used to doing this you'd get used to where you're going.*

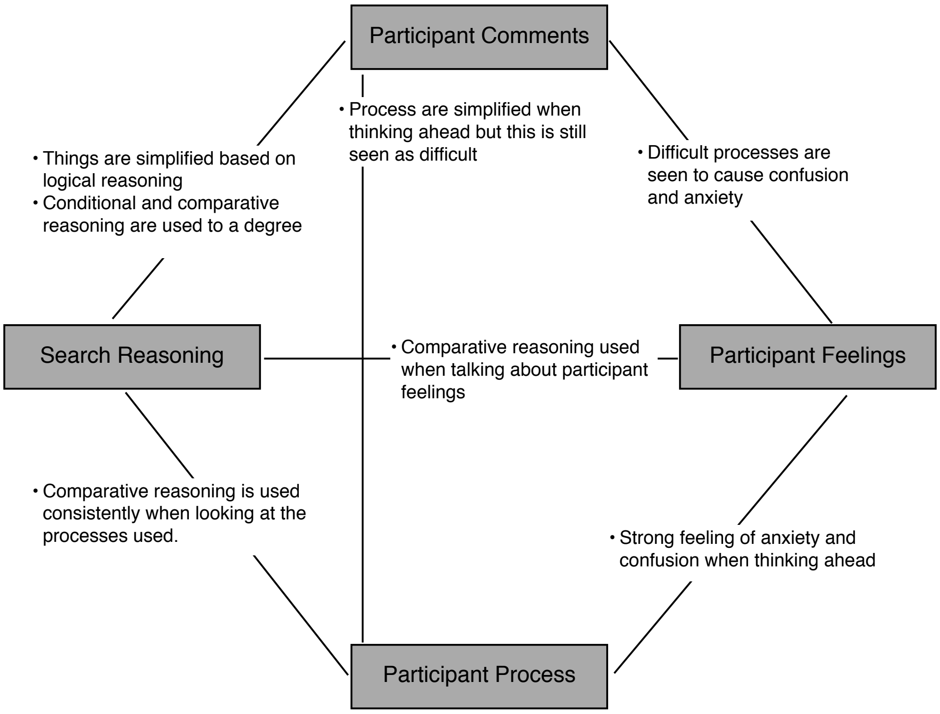


**Figure 4.10 High Fluid Intelligence & Low Internet Usage Thematic Analysis Summary**

In summary, while $\text{High}_{\text{fluid}}\text{Low}_{\text{Internet-Usage}}$ participants were unable to rely on their previous experiences in using the Internet to help guide them through the task, they were able to use a large amount of problem solving methods to aid them in selecting appropriate information. These users were also willing to admit their lack of computer use and how this may be a potential limitation in their ability to find information successfully online.

#### *4.3.2.4 Low Fluid Intelligence, Low Internet Usage*

The main characteristic appearing in $\text{Low}_{\text{fluid}}\text{Low}_{\text{Internet-Usage}}$ participants was an extremely high amount of self-reasoning compared to other types of reasoning identified. Participants were most likely to talk out loud when they were either lost on a page, or did not know where they should go next.

> *It's just an inquiry isn't it? Let's see, I've got to check this as I've never actually learned how to do it*
>
> *So would I put in flights? I'm not very good at finding things, is that ok?*

As well as this, these participants demonstrated low self-confidence when searching for items, often blaming themselves for either searching at a slower speed, or displaying a smaller amount of understanding on how the technology works.

> *Sorry, that's my fault. I was just being stupid.*
>
> *As my granddaughter says, why can't you learn the alphabet granddad? (In reference to his slow typing)*

$Low_{fluid}Low_{Internet\text{-}Usage}$ participants also discussed their difficulty in understanding all of the information that is available. It is possible that the combination of a lower fluid intelligence combined with a lower previous Internet usage puts this group at the greatest disadvantage when attempting to use technology.

> *This is the sort of thing that confuses me. This picture's nice, can we make that one larger?*
>
> *You know what I do find confusing, when stuff comes on that you don't expect. What have I done wrong? You think that you'll make a mess of it.*

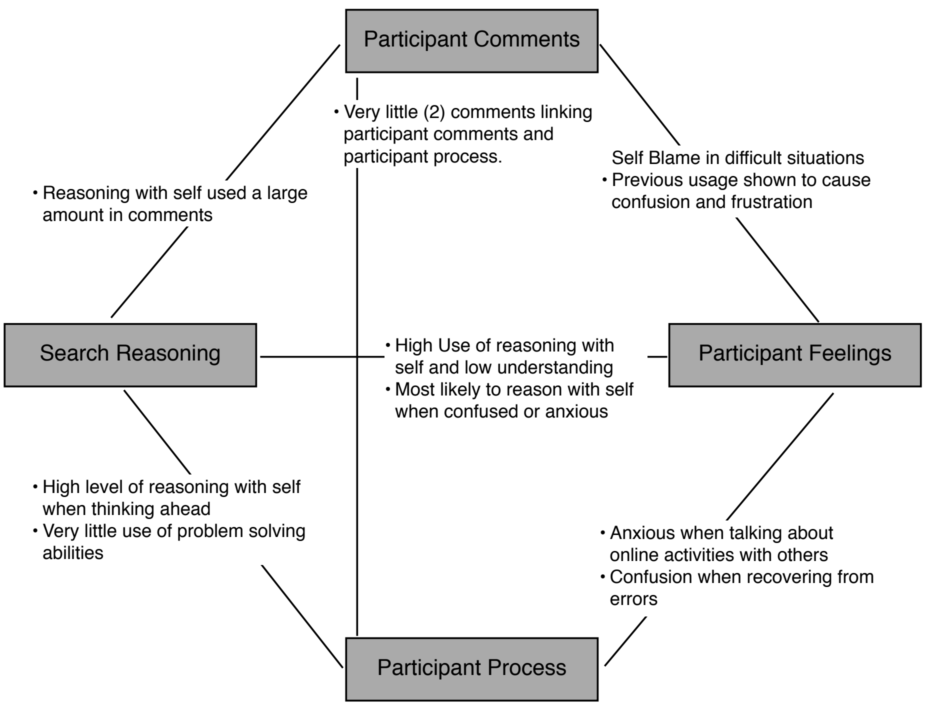


**Figure 4.11 Low Fluid Intelligence & Low Internet Usage Thematic Analysis Summary**

This group struggled the most when searching for information during this study. It was evident that the lack of previous experience in searching for information online, combined with a low problem solving ability caused a large amount of difficulty.

## 4.4 Discussion

Quantitative analysis in this introductory study suggests that the only significant factor in determining older adults' ability to search and navigate for information online relates to their previous Internet usage. It was found that users with a higher previous Internet usage spent less time searching for relevant pages on Google, visited a higher number of pages, yes used a comparable number of mouse clicks to older adults with low Internet experience. No statistical difference was found between groups of high and low fluid intelligence. This is a surprising result as many previous research studies have shown correlations between technology usage and fluid intelligence (e.g. (Charness & Boot, 2009; Czaja, Charness, Fisk, et al., 2006b)). The most likely explanation for no significant results being found in this study is down to the measurements that were taken and the fact that they are all very closely linked to computer based abilities and not a problem solving task.

A significant difference was also found when comparing older and younger adults. It is suggested that younger adults visited more pages per minute than older adults, yet performed a comparable number of mouse clicks for minute, suggesting that they are either being more efficient and accurate in their use of the mouse, or are not using interactive elements on web pages as much as older adults. Interestingly, no difference as found in the average words per search term or the time spent deciding on what link to select in a search engine between older and younger adults.

Although no significant differences were seen between high and low fluid intelligence participants in the quantitative analysis, distinctions were present when performing the qualitative analysis. Users with high fluid intelligence showed more problem solving skills when faced with difficult situations while users with low fluid intelligence focused on finding an alternative solution rather than navigating through a problem. High fluid intelligence users also used a variety of different techniques when deciding on what route to take, relying on comparative reasoning, conditional reasoning and logical reasoning to help guide them. Low fluid intelligence users, however, focused more on being guided by interface prompts to aid in navigating through a site.

## 4.5 Conclusion

This chapter set out to establish whether differences exist between users when examining their age, inductive reasoning, and previous Internet usage. It was not possible to create a distinct correlation between chronological age and user performance when examining older adults, however there was a combination of similarities and differences present when comparing older and younger adult groups. Significant differences between older adult users' online capabilities and their reported previous Internet experience were also highlighted. There were no statistically significant differences noticed when examining users' fluid intelligence, however qualitative analysis allowed for differences to be observed in the problem solving skills employed by users with high and low fluid intelligence. These findings suggest that in general a combination of cognitive and technology usage factors have a larger influence on an individual's ability to use technology than their chronological age, and warrants further investigation.

However, a number of important limitations need to be considered. The small sample size must be taken into consideration. With only six users present in each group and three in each subgroup, the conclusions made regarding the qualitative analysis should be thought of as specific to this individual participant group. A similar argument exists regarding quantitative analysis, where although statistical significance was found in some cases, caution must be applied. To increase the validity of both sets of analysis a much larger sample size is needed. Second, the current work only examined the effect of a single cognitive and Internet experience factor. It would have been more beneficial to include more factors to achieve a more in depth analysis.

What is now needed is a more comprehensive look into the different cognitive abilities that are used by individuals when searching for information, and to what degree these abilities can help or hinder the experience that users have when using the Internet. More information on this would help to establish a greater degree of accuracy when debating the effect that interface changes can have on a users ability to use the World Wide Web.

# Chapter 5. Human Factors in Relation to Browsing Experience

Chapter 4 began an analysis into alternatives to either complement or replace age when examining user performance. It was suggested that a combination of cognitive and technology usage factors can have an influence on users' ability to find information when using the World Wide Web. However, limitations existed in the number of participants used and also in the methods used to assess user performance. This chapter therefore investigates these alternative factors in more detail. It examines the use of age, cognitive characteristics, and Internet usage on the browsing experience of users when searching for information online.

## 5.1 Introduction

This chapter examines the use of age as a predictor of users' perceived disorientation and reported website ease of use. A study is presented in which older and younger adults participated in an information retrieval exercise to examine the perceived disorientation and reported website ease of use experienced when visiting a series of websites. Multiple regression techniques are used to determine the suitability of users' age, cognitive characteristics, and previous technology usage to predict levels of perceived disorientation and reported website ease of use.

## 5.2 Methodology

The main aim of this chapter is to consider how the inclusion of factors other than chronological age could be used to enhance the understanding of user browsing experience, and how this can change between users when searching for information online.

### 5.2.1 Experimental Variables

Participant Age Group, Internet Ability (Internet Usage and Internet Experience), and Cognitive Measures (Inductive Reasoning, Perceptual Speed, Memory Span and Meaningful Memory) were used as independent variables. Browsing Experience (Perceived disorientation and Reported Website Ease of Use) were used as dependent variables.

### 5.2.2 Participants

Twenty participants were recruited for this study. This consisted of 12 older adults ($M$ = 73.66, $SD$ = 9.11, *Range* 63-90) and eight younger adults ($M$ = 22.12, $SD$ = 3.18, *Range* 19-29). Older adults were recruited from the SiDE user pool, being contacted by the user pool coordinator through either phone or e-mail. Younger adults were recruited through e-mail and university message boards and then added into the user pool database. All clarified in pre-screening that they had not taken part in any HCI research studies in the past 12 months.

### 5.2.3 Materials and Equipment

*Demographic Information* —Demographic information including participant age, education and occupational status were collected from participants through a questionnaire.

*Internet Ability*—Two questionnaires examining participant Internet Ability were used. The first of these examined participant Internet *Confidence* and consisted of 16 questions, measured on a 5-point scale (Strongly Agree, Agree, Neither Agree nor Disagree, Disagree, Strongly Disagree). The second examined participant Internet Usage and consisted of 19 questions, measured on a 7-point scale (Everyday, Several Times a week, Several Times a month, Every few months, Less Often, Never).

*Cognitive Measures*—Four cognitive measures were used to gather information on a subset of individuals' abilities. This consisted of the Letter Sets Test (measuring fluid induction) (Ekstrom et al., 1976), Number Comparison Test (perceptual speed) (Ekstrom et al., 1976), Meaningful Memory Test (long-term memory) (Cattell, 1982), and Auditory Memory Span (memory span and working memory) (Ekstrom et al., 1976).

*Browsing Experience*—A questionnaire based on work by Ahuja and Webster (Ahuja & Webster, 2001) was used to gather information on users Perceived Disorientation and Reported Website Ease of Use. This questionnaire consisted of 10 questions, measured on a 7-point scale (Strongly Disagree, Disagree, Somewhat Disagree, Neither Disagree or Agree, Somewhat Agree, Agree, Strongly Agree).

**Table 5.1 Factor Analysis Comparison with Ahuja (2001)**

| | *Ahuja (2001)* | | *Crabb (2014)* | | |
|---|---|---|---|---|---|
| | F.1 | F.2 | F.1 | F.2 | F.3 |
| I felt lost | .70 | | .84 | | |
| I felt like I was going around in circles | .75 | | .85 | | |
| It was difficult to find a page that I had previously viewed | .78 | | | | .89 |
| Navigating between pages was a problem | .75 | | .67 | | |
| I didn't know how to get to my desired location | .80 | | .82 | | |
| I felt disoriented | .72 | | .77 | | |
| After browsing for a while I had no idea where to go next | .73 | | .68 | | |
| Learning to use the site was easy | | .90 | | .78 | |
| Becoming skilful at using the site was easy | | .88 | | .77 | |
| The site was easy to navigate | | .76 | | .79 | |

In order to validate the questionnaire responses gathered, a similar factor loading to that used by Ahuja & Webster (2001) was implemented. This is summarised in **Table 5.1**. The factor loadings of our data set are relatively similar to that of Ahuja and Webster's with the one difference of *finding a page that was previously viewed* loading on an additional third factor. Factor 1 relates to users' perceived disorientation and Factor 2 relates to website ease of use. Factor 3 was removed as it only loaded on a single factor.

*Task Question Set*— 30 questions were created that prompted users to create a path through a website in order to complete an information retrieval task. One question was created for each website, with this creating a total of 30 different websites. Twenty-five of these sites were selected from the top 100 visited websites in the UK (according to Alexa [9] ), split into five categories: health, shopping, news, governmental, and banking. Five additional websites were also selected that included information on attractions in the local area. Each task required participants to visit between two and five pages on the optimum path. However, the number of pages participants would visit increased if they used an alternative route. Questions and their corresponding websites are detailed in Table 5.2

[9] http://www.alexa.com/topsites/countries/GB

**Table 5.2 Experiment Question Set**

| Website | Question |
|---|---|
| www.nhstayside.scot.nhs.uk | Visit the website for NHS Tayside. Find out information about visiting Ninewells hospital and why there are two separate postcodes for the one building |
| www.nhs24.com | Look round the website for NHS24. What groups of people are eligible for a seasonal flu jab? |
| www.nhs.uk | Find some treatment options for back pain and what pros and cons exist for various options. |
| www.dh.gov.uk | Find information about the current 'Secretary of State for Health', Andrew Lansley. |
| www.netdoctor.co.uk | Many people in the UK have gluten intolerance. Find information about recipes for gluten free food. |
| www.dundeecity.gov.uk | Look at the website for Dundee Council. Baxter Park is a park in the east side of the city, gifted to the city by David Baxter. In what year did he receive a knighthood? |
| www.scotland.gov.uk | Look at the website for the Scottish government. In what year did the 'Act of Union' create a single parliament in Westminster, London. |
| www.parliament.uk | Try and find the telephone number for your local member of parliament |
| www.hmrc.gov.uk | What is the income tax personal allowance level for people aged 75+ during this tax year? |
| www.direct.gov.uk | The directgov website contains a lot of information about government services. Try to find out about recycling services in your local area. |
| www.natwest.com | How much do Natwest cover for medical emergencies abroad with their travel insurance? |
| www.barclays.co.uk | How much a month does Barclays charge for its 'Current Account Plus'? |
| www.lloydstsb.com | What is the current interest rate offered for a Lloyds TSB fixed rate 2 year mortgage? |
| www.hsbc.co.uk | Look at the HSBC website, what information is given to customers to help with managing money during holidays? |
| www.bankofengland.co.uk | What two people appear on the new styled £50 bank note? |
| www.edinburghzoo.org.uk | Look around the website for Edinburgh Zoo, find 5 animals that are indigenous to North America? |
| www.mcmanus.co.uk | Look around the website for the McManus Gallery - in what room would you find the 'Dundee and the World" exhibit? |
| www.dca.org.uk | Look at the website for the Dundee Contemporary Arts, what are the opening times for the Jute Cafe Bar? |
| www.camperdownwildlifecentre.com | Have a look around the website for Camperdown Zoo. How long can a snowy owl live for in captivity. |
| www.dundee.com | Look round the dundee.com website. Find out what museums and exhibitions exist within the city. |
| www.amazon.co.uk | Without using the search box, try and find a selection of gardening tools |

| | |
|---|---|
| | on the Amazon website |
| www.sky.com | How many channels are available in the Sky entertainment TV pack? |
| www.virginmedia.com | Virgin Media is a large broadband provider. What is the fastest broadband that they offer and how much does it cost per month? |
| www.bt.com | As well as phone services, BT also offers broadband. What is the cheapest that they offer this service at? |
| www.tesco.com | Tesco lets you swap your clubcard vouchers for days out. Look for some venues that they offer this with |
| www.bbc.co.uk | There are many sports taking place during this year Olympic games. In what venue will all fencing competitions take place in? |
| www.wikipedia.org | Wikipedia is known for its millions of articles about different subjects, but how many languages is wikipedia available in? |
| www.imdb.com | According to IMDB users, what is the most popular movie of all time |
| www.metoffice.gov.uk | What information is available for people during severe weather within the UK? |
| www.dundeewaterfront.com | Have a look at the website for the Dundee Waterfront. How much investment is being used for ‘The Central Waterfront’? |

*Data Collection System*—The data collection system described in Chapter 3 was used during the study session. During an experimental session, this system would display the current question that a participant was required to answer through a browser plugin, and also record URL address, timestamp, and a HTML and CSS scrape of each page visited.

*Experimental Equipment*—The experiment ran on an apple laptop computer (Macbook Pro Mid-2010[10]), with the Google Chrome Browser being used. The laptop was placed in front of the researcher and the participant was given control through a 22” Widescreen Monitor, and a standard Microsoft Keyboard and Mouse. Monitor display was mirrored between the laptop and the additional monitor. Control of the *Data Collection System* was achieved through a tablet device handled bit the researcher. This allowed the researcher to see the current question that is

[10] http://support.apple.com/kb/SP584

being asked, and additionally navigate through questions to control the flow of the study

### 5.2.4 Procedure

Participants were firstly invited to take part in a group session in order to gather data on their *demographic information, Internet Ability,* and *Cognitive Measures.* Four separate sessions were used allowing for participants to be split into smaller, more manageable groups. Younger adults were tested separately to older adults.

After completing the testing battery, participants were then invited to take part in a second individual session where they completed a number of information retrieval tasks taken from the *Task Question Set*. Once an individual questions was completed, participants were given the *Browsing Experience* questionnaire to complete. Task order was randomized between participants in order to reduce ordering effects.

### 5.2.5 Data Analysis

An initial analysis of the two age groups (younger and older adults) showed differences between participants' Internet usage, Internet confidence and Inductive Reasoning. No age-related differences were noticed regarding perceptual speed, memory span / working memory, or meaningful memory. This was unexpected, as previous literature has shown that these metrics deteriorate with age and differences should be seen between these two groups (Horn & Cattell, 1967).

**Table 5.3 Participant Demographic Summary**

| *Ability Measures* | *Younger Adult* M | SD | *Older Adult* M | SD | *t(18)* | *Age Group Comparison (α = .05)* |
|---|---|---|---|---|---|---|
| Age | 22.12 | 3.18 | 73.66 | 9.11 | -15.26* | YA < OA |
| Internet Usage | 48.00 | 10.85 | 29.92 | 12.86 | 3.27* | YA > OA |
| Internet Confidence | 54.88 | 12.59 | 44.25 | 13.38 | 1.78* | YA > OA |
| Fluid Intelligence | 23.63 | 2.26 | 18.17 | 2.82 | 4.57* | YA > OA |
| Processing Speed | 46.63 | 6.04 | 45.08 | 6.94 | .511 | YA ≈ OA |
| Short Term Memory | 6.88 | 2.94 | 7.25 | 1.91 | -.547 | YA ≈ OA |
| Long Term Memory | 13.75 | 5.34 | 14.92 | 4.76 | -.512 | YA ≈ OA |

* $p < .05$

A possible explanation (and additional limitation), can be explained in the educational background of the older adults recruited for this study. 9 of the 12 (75%) older adults reported education of Bachelors Degree or higher, with previous literature showing a link between educational background and these characteristics.

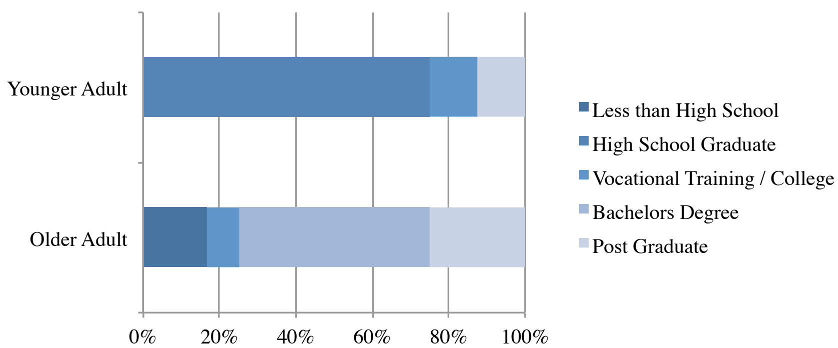


**Figure 5.1 Older and Younger Adult Educational Background Summary**

Analyses was designed to determine the impact that Age, *Internet Ability*, and *Cognitive Measures* had on understanding the *Browsing Experience* of this population. This was done to discover if any additional variance could be uncovered by examining these Internet and Cognitive factors on top of that discovered between age groups. Multiple regression was therefore used to analyse the data. Cognitive

Measures, Internet Ability, and age were split into three separate models during analysis. Cognitive Measures and Internet Ability were normalised by dividing individual participant metrics by two times of the group standard deviation and age groups coded as a dummy variable (Younger Adult = 0, Older Adult = 1). This method, suggested by Gelman (2008), allows for a direct comparison between scalar and binary predictors.

In Model 1 only participant age was included as a measured variable. Model 2 expanded on this by including *Internet Ability*. Model 3 contained all *Cognitive Measures* along with the metrics outlined in Models 1 and 2. The three regression models were performed consecutively, with additional metrics being added with each analysis. Three multiple regressions were performed in total, the first focussing on participants' perceived disorientation, the second on reported website ease of use, and the third on a combined *Browsing Experience* score.

## 5.3 Results

When examining the effectiveness of metrics to predict a user's disorientation and website ease of use, the results gathered indicate that age cannot be used as a metric to understand feelings of disorientation or website ease that occur when carrying out an information retrieval task. In Figure 5.2, Model 1 represents the variance accountable for only age. When examining the models, age cannot account for any variance present when analysing user perceived disorientation or users overall browsing experience. Age was only able to predict 1.6% of any variance when examining user feelings on a websites ease of use. As previously stated, the younger and older adult were coded as 'dummy' variables in analysis, and while using these two dichotomous groups is a limitation in this work as it may over inflate any results comparing these two groups, the results show that only a very small amount of variance regarding users browsing experience can be explained by the differences between these to age categories. This provides initial evidence to support the objectives set out in this chapter – examining the extent to which age accounts for variance in user satisfaction when completing information retrieval tasks. Similar results are reported by Czaja et. al (2006b) who found that including age within the final step of a regression analysis did not significantly help in predicting individuals' technology usage.

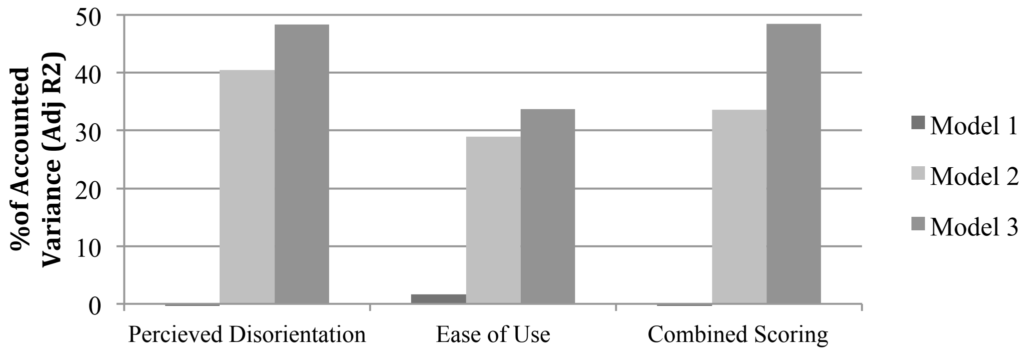


**Figure 5.2 Model Comparison Summary**

Model 2 improves on Model 1 by including participants' previous Internet usage and Internet confidence. This created a noticeable improvement in the amount of perceived disorientation accounted for between groups with this increasing to 40.5%. This indicates that it is possible to understand more about why an individual may feel lost completing information retrieval tasks by examining their previous experiences and confidence in using the Internet rather than relying on their age. Similarly, users feelings of website ease of use increased to 28.9% and their combined browsing experience increased to 33.6%. The inclusion of cognitive characteristics in Model 3 again provided an increase in the amount of variance accounted for.

A summary of regression analysis participant perceived disorientation is detailed in Table 5.4. Age as a single factor accounted for a very small amount of variance (Adj. $R^2$ = -.006) with the addition of technology factors causing an increment in Adjusted $R^2$ to .405. The addition of cognitive factors increases the Adjusted $R^2$ by an additional .008 to .484. In this final regression, it was found that key components, which correlated with perceived disorientation, were Internet confidence and processing speed.

**Table 5.4 Multiple Regression Model – Perceived Disorientation**

| | B | SE B | β |
|---|---|---|---|
| Model 1 | | | |
| Constant | 1.795 | .155 | |
| Age | .189 | .200 | .217 |
| Model 2 | | | |
| Constant | 3.276 | .425 | |
| Age | -.168 | .197 | -.194 |
| Internet Usage | -.238 | .202 | -.272 |
| Internet Confidence | -.552 | .174 | -.632** |
| Model 3 | | | |
| Constant | 4.310 | 1.267 | |
| Age | -.188 | .292 | -.216 |
| Internet Usage | .021 | .220 | .024 |
| Internet Confidence | -.646 | .177 | -.740** |
| Fluid Induction | -.051 | .242 | -.059 |
| Perceptual Speed | -.404 | .170 | -.462* |
| Short Term Memory | -.063 | .190 | -.072 |
| Long Term Memory | .359 | .201 | .411 |

*Note: Adj $R^2$ = -.006 for Step 1, Adj $R^2$ = .405 for Step 2 ($p < .01$), Adj $R^2$ = .484 for Step 3 ($p < .05$).*
**p < .05, ** p < .01, *** p < .001.*

These results suggest that when examining the amount of disorientation that is reported by an individual when carrying out an information retrieval task similar to the ones used in this work, a large amount of variability between participants is down to their confidence in using the technology, and also their current perceptual speed levels.

Summary analysis for reported website ease of use is presented in Table 5.5. Similar to perceived disorientation, age again accounted for a very small amount of variance

(Adj $R^2$ = .016) with the addition of technology factors increasing Adjusted $R^2$ to .289. The attachment of cognitive factors increased Adjusted $R^2$ to .337 with Internet Confidence being the only significant factor present in the model.

**Table 5.5 Multiple Regression Model – Ease of Use**

| | B | SE B | β |
|---|---|---|---|
| Model 1 | | | |
| Constant | 3.060 | .115 | |
| Age | -.170 | .148 | -.261 |
| Model 2 | | | |
| Constant | 2.153 | .348 | |
| Age | .033 | .161 | .051 |
| Internet Usage | .092 | .165 | .141 |
| Internet Confidence | .381 | .142 | .583* |
| Model 3 | | | |
| Constant | 1.044 | 1.075 | |
| Age | .144 | .248 | .221 |
| Internet Usage | -.103 | .187 | -.157 |
| Internet Confidence | .447 | .151 | .683* |
| Fluid Induction | .186 | .205 | .284 |
| Perceptual Speed | .285 | .144 | .437 |
| Short Term Memory | .019 | .161 | .029 |
| Long Term Memory | -.260 | .171 | -.398 |

*Note: Adj $R^2$ = .016 for Step 1, Adj $R^2$ = .289 for Step 2 ($p < .01$), Adj $R^2$ = .337 for Step 3 ($p < .05$).*
*$*p < .05$, $** p < .01$, $*** p < .001$.*

This again suggests that when examining how easy users find a website to use, a large amount of variability exists due to user confidence in the technology. No significant results were found regarding user age, suggesting that the age group a user is in has very little to do with how easy or difficult they find a website to navigate around.

The final regression analysis collated the dependant measures into a single scoring, containing reported website ease of use and perceived disorientation. In this model, summarized in Table 5.6, age produced an Adjusted $R^2$ of -.023. This increased to .336 when including technology factors and again to .485 when including cognitive factors. In this final model, Internet Confidence and Processing Speed were seen to be significant factors.

**Table 5.6 Multiple Regression Model – Browsing Experience**

| | B | SE B | β |
|---|---|---|---|
| Model 1 | | | |
| Constant | 1.177 | .123 | |
| Age | .120 | .159 | .176 |
| Model 2 | | | |
| Constant | 2.258 | .354 | |
| Age | -.129 | .164 | -.188 |
| Internet Usage | -.134 | .168 | -.195 |
| Internet Confidence | -.435 | .144 | -.632** |
| Model 3 | | | |
| Constant | 3.920 | .998 | |
| Age | -.281 | .230 | -.411 |
| Internet Usage | .064 | .173 | .093 |
| Internet Confidence | -.518 | .140 | -.752** |
| Fluid Induction | -.212 | .190 | -.307 |
| Perceptual Speed | -.370 | .134 | -.538* |
| Short Term Memory | -.068 | .149 | -.099 |
| Long Term Memory | .248 | .158 | .361 |

*Note: Adj $R^2$ = -.023 for Step 1, Adj $R^2$ = .336 for Step 2 ($p < .05$), Adj $R^2$ = .485 for Step 3 ($p < .05$). *$p < .05$, ** $p < .01$, *** $p < .001$.*

Similar to a measure of only user perceived disorientation, this suggests that individuals' browsing experience is heavily influenced by their confidence in using technology, and not the overall amount of usage that they may report. Additionally, individuals' perpetual speed has shown to have an effect on the overall browsing experience, while age category does not have any effect.

## 5.4 Discussion

In the analysis, the main factors that could be used to predict levels of perceived disorientation in users were their confidence in using the Internet and also their perceptual speed. Figure 5.3 shows coefficients (*B*) for reported disorientation complete with 95% confidence intervals (an increase in value of 1 from any of the given metrics leads to a related change indicated by the bars, with 'error bars' indicating confidence that 95% of results would be between the two limits). This chart indicates that higher levels of Internet confidence and processing speed lead to reductions in perceived disorientation. From this, it can be inferred that an increase in confidence in using technology has a direct correlation on feelings of low perceived disorientation when completing information retrieval tasks online, with similar results appearing with their processing speed. An interesting point to note here is that no meaningful correlation was found between the amount of previous experience that an individual has in using the World Wide Web and any feelings of perceived disorientation. Significance is placed more on the confidence in using technology.

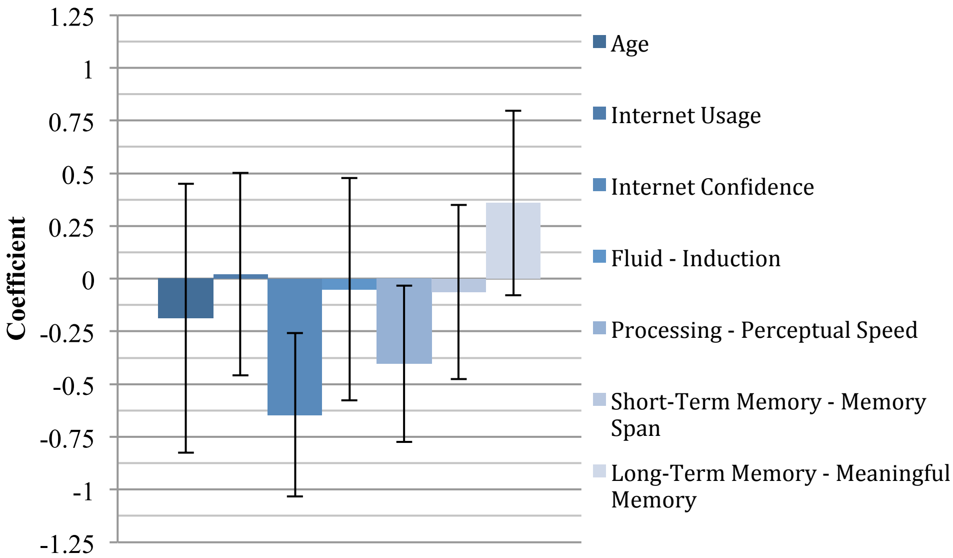


**Figure 5.3 Coefficient for Perceived Disorientation with 95% Confidence Intervals**

A slight difference was found when examining the reported website ease of use of participants. It was found that only Internet confidence played a significant part in determining whether a website was easy to use when performing information retrieval tasks. All other metrics had 95% confidence intervals which spanned both sides of 0, indicating that they could not accurately determine whether they may have a positive or detrimental effect on the reported ease of use of a website.

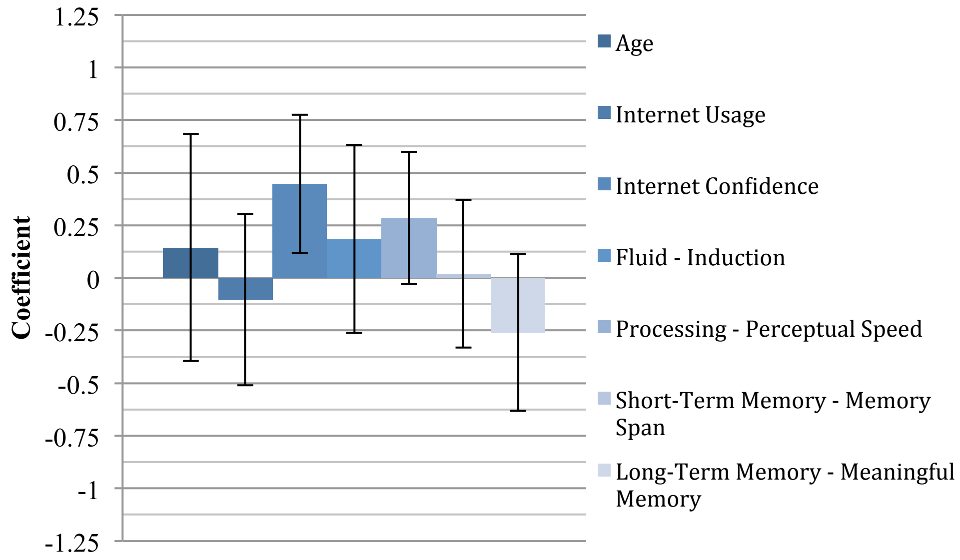


**Figure 5.4 Coefficient for Ease of Use with 95% Confidence Intervals**

Combining perceived disorientation and reported ease of use into one metric examining overall browsing experience creates results similar to that of perceived disorientation, with both Internet experience and perceptual speed producing significant correlations. No other factors contributed significantly in this model. This indicates that when examining the overall browsing experience of an individual when completing information retrieval tasks, a large amount of variance can be accounted for by again focusing on the previous confidence that a user has in using the Internet, and also the mental quickness that is attached to levels of user perceptual speed.

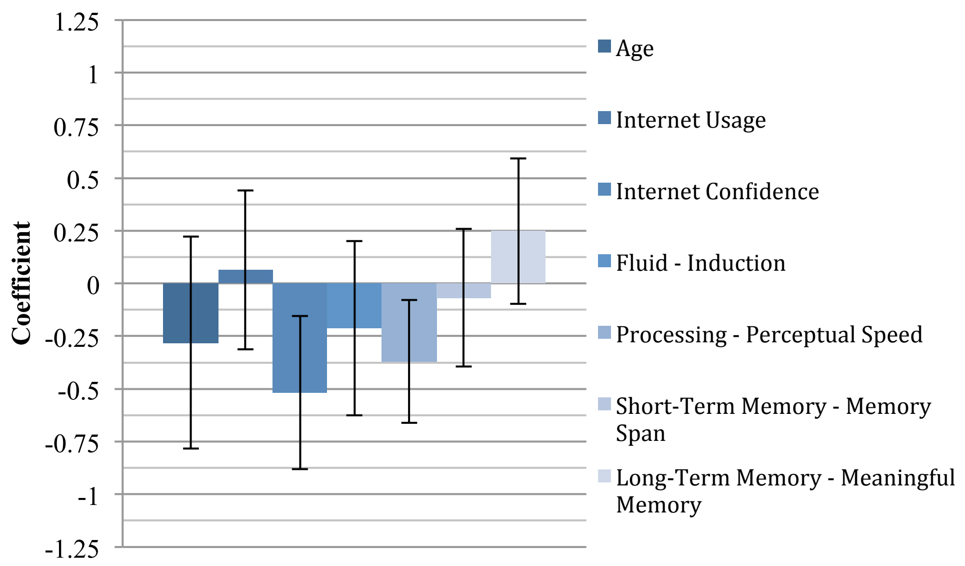


**Figure 5.5 Coefficient for Browsing Experience with 95% Confidence Intervals**

It was found in all three of the regression models that individuals' Internet confidence can account for a large amount of the variance that is associated with the perceived disorientation, website ease of use, and overall browsing experience of individuals when completing information retrieval tasks. Additionally, it was found that individuals' perceptual speed can influence their perceived disorientation and overall browsing experience. However, in all cases, age was unable to account for any variance and could not be used to predict any aspect of users browsing experience when completing this study.

## 5.5 Conclusions

This chapter has shown that when examining the browsing experience of individuals, age alone cannot be used as a suitable metric. Factors such as individuals' previous confidence in using the World Wide Web and their perceptual speed are more significant contributors to understanding feelings of disorientation and perceived website ease of use than age alone. These factors can be used to account for a substantial amount of variance and while this has been examined before regarding user performance (for example (Czaja, Sharit, Ownby, Roth, & Nair, 2001b) and (Sharit, Hernández, Nair, Kuhn, & Czaja, 2011)) the novelty in this approach is that significant differences were found when examining search experience. It was also found that an increase in confidence within younger adults correlates to higher levels of perceived disorientation. The reverse of this was found when examining older adults.

From this, it is recommend that rather than relying purely on user age, cognitive factors and Internet usage demographics should be used within the analysis of user experience when completing online activities. The experiences felt by users in terms of perceived disorientation and reported website ease of use, cannot be predicted by analysing age and instead, users' confidence in using technology, and their perceptual speed have been shown to provide a better explanation. What is now needed is to develop an understanding of how these two metrics influence the browsing experience of individuals when taking into account different characteristics of websites themselves, allowing for an analysis of website features and their possible links to these measures.

# Chapter 6. A Review of Current Governmental Usability Guidelines

Chapter 5 presented an analysis into how cognitive abilities, Internet experience, and age can affect the perceived disorientation, reported website ease of use, and overall browsing experience of individuals when completing an information retrieval task. It was found that while user age could account for a very small amount of variance, the confidence that individuals' have in using the Internet, and their cognitive perceptual speed could account for a much larger amount of variance. However, this analysis did not take into account individual website characteristics and whether any website elements could have a noticeable effect on individuals' browsing experience. This chapter is used to introduce a review of current governmental online usability guidelines, in order to select a subset of these for analysis in Chapter 7.

## 6.1 Introduction

Many sources exist that provide usability guidelines as a method of improving the experience that users may have with various technologies. An review of governmental usability guidelines was conducted to understand current thinking in methods that can be used to assist developers in creating websites that are usable for the general population. A selection of these services (outlined in Table 6.1) was visited and a collection of web usability guidelines collated.

**Table 6.1 Governmental Web Guideline Sources**

| | |
|---|---|
| California State Online Resource for Webmasters | 14 recommended guidelines and several tools and approaches for implementation |
| Michigan Department of IT Usability Guidelines (2003) | Short document on the use of user based design |
| Usability.gov Guidelines (2006) | Large collection (221) of usability guidelines with recommendations for implementation and academic rationale |
| Government of Chile Guide to Digital Platforms (Government of Chilie, 2008) | Focus on using W3C criteria for web usability and accessibility |
| UK Government Digital Service (2010) | Created as part of redevelopment of UK Digital services, focuses on design and content principles rather than set guidelines |
| UK Central Office of Information Usability Toolkit (2008) | Set of basic usability instructions split into 8 sections. Now closed down. |
| Government of the Netherlands Web Guidelines (2012) | 114 guidelines focusing on creating higher quality websites (some focus on usability related issues) |
| Norwegian Ministery of Trade and Industry (2006) | Collection of guidelines more related to the creation of online forms |
| Swedish Government Guidance for Web Development (2012) | Collection of 109 guidelines |
| Japanese NIICT Guidelines (2005) | 12 Main points focusing on creating websites that ‘everyone can use’ |
| Australian Government Accessibility and Usability Web Guide (2012) | Focus on using WCAG 2.0 Guidelines and the benefits of improving web access. |
| Tasmanian Government Web Usability Guidelines | Information on User-Centred Web Design |
| Tasmanian Government Web Design and Navigation Guidelines (2010) | Guidelines on standardisation of elements across governmental sites |
| Queensland Government UX Standard (2011) | Large amount of checkpoints to make make sure there is a consistent UX through governmental sites. |
| Government of Canada Standard on Web Usability(n.d.) | Set standards for Canadian Government Web Presence. Very subscribed guidelines focusing more on standardisation across platforms |

## 6.2 Review of Usability Guidelines

Guidelines from all of the documents described in Table 6.1 were collated and sorted into twelve different categories: Lists, Page Layout, Navigation, Scrolling and Paging, Headings and Titles, Links, Text Appearance, Images, Writing Content, Search, Content Organization, and Web Forms. These guidelines are discussed below, and a full list of 130 guidelines collected can be found in Appendix C

### 6.2.1 Lists

The presence of lists on websites is very common, used as a method of organizing information in a relatively simple structure. The most common usability guidelines regarding lists focus on the order in which items should be placed, with a consensus of the most important items in a list being placed at the top, and least important placed at the bottom. This method forces users to complete a linear styled search where a bias is placed on items higher in the list structure. Lists should also have headings used as an introduction and should not involve complex punctuation ( U.S. Department of Health and Human Services, 2006).

In total, 5 guidelines were identified as being important in creating lists that were usable, all of these guidelines appearing in the United States Usability information (U.S. Department of Health and Human Services, 2006).

**Table 6.2 A summary of Usability Guidelines relating to lists on web pages**

| *Guideline* | *Country* |
|---|---|
| Order elements in a list | United States |
| Place the most important items at the top of a list | United States |
| Give each lits a heading to introduce it | United States |
| Use static menus | United States |
| Capitalise first letters in list | United States |

### 6.2.2 Page Layout

Consistent page layout across a website is more likely to result in users being able to navigate successfully around websites (Becker & Mottay, 2001). Usability guidelines regarding page layout mainly focus on adopting a correct length of a page, with these guidelines ranging from very precise items such as "*Place a header at the top of the page and make it 960px wide"* (Government of Canada, n.d.) to items that are harder to quantify such as "*Have appropriate page lengths"* ( U.S. Department of Health and Human Services, 2006). Page layout guidelines also comment on the position of common website characteristics such as site logos, navigation menus, and adverts, with recommendations on both their position and size in a webpage (Government of Canada, n.d.).

In total, 23 guidelines were identified that related to creating web pages that had a usable page layout. Of interest is guidelines offering differing opinion on the position of website menus between the Canadian guidelines (Government of Canada, n.d.), British guidelines (Government Digital Service, 2010), and Australian guidelines (Australian Government, 2012), where differing opinions into the position of navigation either in a horizontal or vertical method is discussed.

### 6.2.3 Navigation

Navigation systems are an important part of using a website when attempting to find information, and as such, a large amount of usability guidelines exist to aid in designing efficient and usable navigation systems. Navigational aids are encouraged to guide users through a website with this including breadcrumbs, search boxes and sitemaps (U.S. Department of Health and Human Services, 2006). In addition to this a prominent theme regarding navigation elements is that they should be descriptive and have real meaning to the user. The UK Usability Toolkit (2008) recommends that navigation bars should stand out for the users, current pages should be highlighted in menu navigation, the home page should be reachable from any page on the website, and that drop down menus should be avoided. The combination of these methods can aid users in successfully navigating through a website.

Echoing the importance of navigation in websites, a total of 44 different guidelines were identified that related to creating usable navigation on a web page. Of interest in this is the use of breadcrumb information, with governments providing different guidance into their implementation.

**Table 6.3 Navigation guidelines relating to breadcrumb usage**

| *Guideline* | *Country* |
|---|---|
| Don't use breadcrumbs they are ineffective | United States |
| Use breadcrumbs | Australia |
| Use breadcrumbs | Sweden |
| Breadcrumbs are a good idea | United Kingdom |

### 6.2.4 Scrolling and Paging

Scrolling and pagination is becoming more important in web design as display sizes now vary drastically depending on the device that an individual is using This in turn makes it more difficult for developers to create a web experience that can translate across devices. Many guidelines focusing on the scrolling and pagination of websites exist to aid with this. It is recommended that an increased number of pages should be used as opposed to large pages that require scrolling (ServicesUnited States General Services Administration, 2006), and that a fluid design should be used for sites that supports smaller screen sizes (Australian Government, 2012).

In total, seven guidelines were identified that related to scrolling and paging on a webpage. Of interest here, and therefore included for further analysis is the idea of vertical menus that require scrolling past the fold in order to view all items. For this, coupled with previous and subsequent reasons, an analysis of horizontal and vertical menus, and large 'inline subpage' menus are included for further analysis in Chapter 7.

### 6.2.5 Headings and Titles

Headings are a very important aspect in designing usable websites, being used to tell where in a website they are and also to give additional information on the topic of individual sections of a page. It is also important that the links should have a direct relationship with the heading of the page it is linking to (Blackmon, Kitajima, & Polson, 2003). It is recommended that headings should be clear, descriptive, and unique (ServicesUnited States General Services Administration, 2006).

In total, five guidelines were identified that related to headings and titles. These usability guidelines came from the United States (ServicesUnited States General Services Administration, 2006) and Canadian (Government of Canada, n.d.) guidelines and are summarized in the table below.

**Table 6.4 A Summary of Usability Guidelines Relating to Headings and Titles**

| *Guideline* | *Country* |
|---|---|
| Use clear category labels | United States |
| Use descriptive headings | United States |
| Use Unique headings | United States |
| Have a clear title on every page | United States |
| Header at the top of the page, 960px width | Canada |

### 6.2.6 Links

Similar to the navigation of a website, separate guidelines also exist examining the methods used for presenting links. The USA Governmental Research Based Web Design and Usability guidelines (ServicesUnited States General Services Administration, 2006) provide a large amount of guidance surrounding link presentation with this focusing on link color, style, and text. When linking within the main body of a page, links should be long enough to understand but short enough to minimize wrapping. It is also noted that it should only be hypertext links that are underlined and not any other text, and that the same styling of links should be used throughout a site to aid in creating a consistent design.

In total, 39 usability guidelines were identified that focused on the number of links on a page. As links are the primary method used to navigate through a website, a large number of the interface elements selected for subsequent analysis will feature links. Future analysis focus is primarily placed on the use of links in menus, with menu position and menu size being investigated.

### 6.2.7 Text Appearance

It is important to ensure that text on a website be readable. The majority of guidelines surrounding text appearance focus on acceptable fonts that can be used. Common fonts that are recommended include Verdana, Helvetica and Arial (Australian Government, 2012). It is also suggested that colors should not be used to convey information and that black text should be used on high contrast backgrounds. This use of familiar fonts and clear readable text ensures that websites are simple for users to read and also that they do not become distracted by any difficulty that may occur when reading text that is not easily viewable.

In total, 15 different usability guidelines were identified that related to the text appearance on a page. The majority of these guidelines focused on the correct fonts to use, and as such a standard font (Helvetica) was chosen as the only font for use in the final experiment. All other guidelines surrounding text appearance (e.g. not conveying information or meaning through colors) were also adhered to.

### 6.2.8 Writing Content

As well as ensuring that text is readable, it is also important to examine the content of the text being presented, making sure that the language being used is clear for users to understand. It is suggested that when writing content for web pages, jargon should be avoided, and also that any acronyms and abbreviations should be defined (U.S. Department of Health and Human Services, 2006). It is also suggested that the length of the text being presented should be examined, with the UK Government Usability Toolkit (2008) recommending that sentences should be below 21 words, and paragraphs below six sentences. A popular method used to examine the readability of written text in general is to use the Flesch Reading Ease Test (Kincaid, Fishburne, Rogers, & Chissom, 1975) to calculate a score for how readable a document is (shown in Equation 6-1). This test gives a passage of text a score based on the number of words, sentences, and syllables present. Higher scores indicate a passage of text that is easier to read.

$$206.835 - 1.015\left(\frac{total\ words}{total\ sentences}\right) - 84.6\left(\frac{total\ syllables}{total\ words}\right)$$

**Equation 6-1 Flesch Reading Ease Score Formula**

In total, 17 guidelines exist that focus on writing usable content for webpages. In order to create websites for use in the final experiment that had prose of a high quality, topics and associated text were selected from the Wikipedia list of featured articles. This limited the analysis of these guidelines in the final study.

### 6.2.9 Content Organization

It is important that web content is well organized in addition to being in a readable format that is suitable for its intended audience. Guidelines surrounding the organization of website content focus on the grouping of elements that are related and organization using a logical structure. Sorting content in this way minimizes the number of pages users need to visit (ServicesUnited States General Services Administration, 2006).

### 6.2.10 Images

Images are an important part of the modern browsing experience, with images being used to convey further topic information to users and also to aid users. The Government of the Netherlands Web Guidelines (2012) provide guidance stating that image icons should be used to show errors when navigating through a website – of particular interest when completing online forms. As well as providing guidelines for when images should be used, the Swedish Government Guidance for Web Development (2012) provides recommendations on when not to use images. They recommend that images should not be used for navigation and that plain text should be used as an alternative.

In total, 10 guidelines were identified on the use of images on web pages and how this can be made usable. No guidelines surrounding images were chosen for analysis in the final experiment in this thesis as any information that is presented in an image format is very susceptible to individuals visual processing ability (Flanagan et al., 1997). As this ability was not chosen for analysis earlier in this work, image based guidelines are not included for further analysis.

### 6.2.11 Search

An alternative to using links to navigate through a website is to use search functionality. Using this method, users can enter a term into a search box and then use this to view all pages on the website that contain that term. Search functionality is a very useful feature and one that many website visitors will use instead of navigating to find information (Bevan, 1997). Guidelines surrounding search functionality focus on ensuring that search functionality exists on a website and that access to it is consistently shown on each page.

In total, seven guidelines were identified that highlighted a need for search functionality on a website. While this is an important factor of creating a usable interface, search functionality was created, but not implemented in the final study. This was removed due to the bias that would exist if individual's had prior knowledge in a subject being shown and would give them an unfair advantage in using the site.

### 6.2.12 Forms

Forms are a feature of websites that can be used for users to input large amounts of information, with examples of their use being in advanced search functionality, and also for signing up for online services. Usability guidelines surrounding forms suggest that a distinction should be made between required and optional information.

In total, 10 guidelines were identified that examined the use of forms and how to make these usable on a website. No guidelines surrounding forms were included for further analysis as the search tasks created for participants focused on information retrieval tasks and not any aspects that involved online forms.

## 6.3 Conclusions

This chapter has performed a review into usability guideline taken from governmental sources across the world. These guidelines, split into 12 different categories provide guidance to developers into making websites that are usable for their intended audience. This review was undertaken in order to highlight a selection of these guidelines for use within the research study presented in Chapter 7. Six common website elements were selected and will be used in the next chapter to understand if they can be used to improve the browsing experience of users while also taking into consideration an individual's Internet confidence and perceptual speed. These elements are:

- **Menu Position** – It is common for websites to have menus either along the top (horizontal) or along the side (vertical) of a web page. Guidelines surrounding the optimum placement of menus differ between countries with no consensus being reached between them. An analysis into either vertical or horizontal menus improving browsing experience is therefore included in the next chapter.
- **Advertisements** – Advertisements on web pages can take many forms, with one of the most common being an advertisement banner on the right hand side of the screen. These can cause trouble for users because of two reasons, first – they are taking up screen space that should be used for relevant content (discussed in guidelines surrounding content organisation), and second – they can cause distractions to the end user. Advertisements were included for analysis in the final study to examine their effect on the browsing experience of participants because of these reasons.
- **Current Page Highlighting** – Both the United Kingdom and United States have usability guidelines that surround the highlighting of the current page that a user is visiting, with a consensus being that this aids in the navigation of a website. This simple interface adjustment is therefore included to test if this improves the browsing experience of individuals.
- **Inline Subpages** – When a vertical menu structure is selected, an option for showing secondary navigation links is to place them inline with the primary links, but with a slight indentation to signify a slight difference. Guidelines surround the amount of links that should be used on a page focus on their not

being too many links, and that they should avoid crossing the fold (the viewable information on one screen). Inline subpages were selected for further analysis as guidelines surrounding scrolling and paging, links, content organisation, and page layout discuss their usage.

- **Dropdown Menus** – Dropdown menus are very commonly used in vertical navigation menus as a method of displaying secondary navigation elements. When a user hovers over a primary navigation element in the menu, a secondary menu appears with information regarding other pages that are related to this original topic. Dropdown menus are mentioned in usability guidelines surrounding navigation, links and content organisation. The number of links in a vertical navigation menu is examined through 'inline subpages', and this is continued with the inclusion of analysis into dropdown menus.
- **Breadcrumb Usage** – Breadcrumbs on a website is a method for users to navigate back through their previous path on a webpage, with this being presented as a series of small links that are normally placed at the top of a web page. Governmental guidelines from the United States, Sweden, Australia, and United Kingdom have differing opinion into the use of breadcrumbs on a website, either stating that they are or are not effective. Breadcrumbs are therefore included as an interface element in the next chapter to examine their effectiveness in aiding users browsing experience.

These interface elements will now serve as a basis for a final study in this thesis, where their usage and relationship to user browsing experience will be examined.

# Chapter 7. An Analysis of Website Interface Elements in Relation to User Browsing Experience

Chapter 6 presented a review into a selection of governmental usability guidelines and how these are intended to aid developers in creating web services that are easy for populations to use. Six individual website elements were selected for further analysis, with these being highlighted in a number of guidelines as important aspects of website usability. This chapter provides an experiment examining the implementation of these individual website elements in relation to the user factors identified as significant in determining user browsing experience in Chapter 5, Internet confidence, and perceptual speed. This is accomplished through a one-to-one user based study, when information retrieval tasks are used as a prompt to examine browsing experience.

## 7.1 Introduction

The final question asked in this thesis asks whether a web interface could be adapted to individual users based on their cognitive abilities. In this chapter the effect that six interface elements have on the browsing experience of individuals'' during an information retrieval task is examined.

## 7.2 Method

### 7.2.1 Experimental Variables

Participant browsing experience was used as a dependent measure and six different interface elements were selected and used as independent measures. Participant browsing experience was calculated using the same method used in the previous study, with Ahuja's (2001) browsing experience questionnaire being used. The website interface elements chosen for adaption were:

- Horizontal or Vertical Menu Navigation
- Drop Down Menus (On or Off)
- Inline Subpages (On or Off)
- Breadcrumbs (On or Off)
- Current Page Highlighting (On or Off)
- Advertisements (On or Off)

### 7.2.2 Participants

Twenty-four older adult participants were recruited ($M_{age} = 67.6$, $SD_{age} = 3.0$, $Range_{age} = 62\text{-}75$) from the SiDE user pool. All participants had previous experience of using the Internet to search for information and verified in pre-screening that they had not taken part in any HCI based studies in the last 12 months.

### 7.2.3 Materials and Equipment

*Demographic Information* —Demographic information including participant age, education and occupational status were collected from participants through a questionnaire.

*Internet Ability and Cognitive Measures*—Participants Internet confidence was measured through a liker scored questionnaire. This consisted of 16 questions examining how confident an individual was in various aspects of Internet usage, measured on a 5-point scale (Strongly Agree, Agree, Neither Agree nor Disagree, Disagree, Strongly Disagree). Participants also completed the Number Comparison Test (Ekstrom et al., 1976) to measure their perceptual (processing) speed.

*Browsing Experience*—A questionnaire based on work by Ahuja and Webster (Ahuja & Webster, 2001) was used to gather information on users Perceived Disorientation and Reported Website Ease of Use. This questionnaire consisted of 10 questions, measured on a 7-point scale (Strongly Disagree, Disagree, Somewhat Disagree, Neither Disagree or Agree, Somewhat Agree, Agree, Strongly Agree).

**Table 7.1 Website Question Set used in this experiment**

| *Website Topic* | *Information Retrieval Question 1* | *Information Retrieval Question 2* |
|---|---|---|
| Maple Syrup | You are about to visit a website relating to Maple Syrup. Look around the website and find information on what early maple syrup makers would have done with a sugar shack. | How does buddy sap affect the flavour of maple syrup? |
| Jack the Ripper | You are about to visit a website relating to Jack the Ripper. Find a page on this website that talks about the Whitehall Mystery and how this relates to Jack the Ripper. | What was the name of the Police Surgeon that Robert Anderson asked about the murderers surgical skill and knowledge? |
| San Francisco | You are about to visit a website relating to San Francisco What type of transport hub would you find 13 miles south of downtown San Francisco? | How many visitors go to the San Francisco Museum of Modern Art annually? |
| The Titanic | You are about to visit a website relating to The Titanic. How many people were present at the launch of the Titanic and how many tons of soap were used on the slipway? | How many items did the post office on the Titanic sort per day? |
| Scotland | You are about to visit a website relating to Scotland. Find information about the Glasgow subway system and the reason for its refurbishment over the next few years. | In what century did trade with Colonial America blossom because of trade tariffs being abolished |
| Greek Mythology | You are about to visit a website relating to Greek Mythology. Look around the website and find information on who, along with Jason, was on the ship Argo to fetch the Golden Fleece. | Find a page with more information about the war that occurred between the Greeks and troy |

*Website Adaption Software*—The website adaption software described in section 3.2.2 was used during this study. This software was created so that individual changes could be made to the user interface while keeping the website content the same. Adaptions to the interface navigation position, drop down menu, inline subpages, breadcrumbs, advertisements, and menu highlighting were possible. Additionally, the topic of the website could also be changed.

*Website Question Set*—Questions were created that allowed participants to navigate through the website and were based on six topics. Questions are shown in Table 7.1 and correspond to their relevant topic. A total of 12 information retrieval questions were used, with two created for each topic.

*Experimental Equipment*—The experiment ran on an apple laptop computer[11] with the Google Chrome Browser being used. The laptop was placed in front of the researcher and the participant was given control through a 22" Widescreen Monitor, and a standard Microsoft Keyboard and Mouse.

### 7.2.4 Procedure

First, Participants were invited to take part in a group session in order to gather data on their *demographic information*, *Internet Ability* and *Cognitive Measures*. Separate sessions were used that allowed for participants to be split into smaller, more manageable groups.

Participants were then invited to take part in a one-to-one session where they were given a set of information retrieval tasks to complete. These tasks, taken from the *Website Question Set*, were used in conjunction with the *Website Adaption Software*. Each participant completed 12 questions in total (the complete website question set), resulting in them visiting a website about each of the six topics on two separate

[11] http://support.apple.com/kb/SP584

occasions. On each occasion of visiting a website, an adaption was made to the interface, allowing for both states of an individual adaption to be examined. The pairing of adaption (e.g. navigation position), website topic (e.g. Maple Syrup), and task order were randomised for each participant before the session occurred.

### 7.2.5 Data Analysis

Participants were placed into groups dependant on their scorings in the Internet confidence questionnaire, and also their scorings in the perceptual speed test. These two abilities were used as findings from Chapter 5 indicated that they are the best predictors to influence individuals' browsing experience. Three categories were created for both of these independent measures based on participant scorings. Participants scoring in the lowest third of each of these metrics were placed in group one, the middle third in group two, and the upper third in group three.

**Table 7.2 Participant perceptual speed and Internet confidence information.**

| | *Perceptual Speed* | | | | *Internet Confidence* | | | |
|---|---|---|---|---|---|---|---|---|
| | Min | Max | Mean | SD | Min | Max | Mean | SD |
| 1 | 19 | 37 | 30 | 7.1 | 21 | 36 | 28.8 | 5.16 |
| 2 | 39 | 49 | 43.5 | 3.9 | 39 | 49 | 43.8 | 3.65 |
| 3 | 49 | 72 | 57.8 | 7.9 | 51 | 60 | 55.6 | 3.2 |

The purpose of analysis is to examine any differences that exist in the browsing experience of these groups when the selected websites features are in both of their binary states, and also to examine if differences exist between the browsing experience of individuals between their Internet experience and perceptual speed groupings. This resulted in a factorial repeated measure ANOVA being used for analysis, with this being followed by Bonferonni corrected t-test for post-hoc analysis.

**Table 7.3 ANOVA Analysis Between Website Topics**

| | | DF | Sum of Squares | Mean Squares | F ratio | F probability |
|---|---|---|---|---|---|---|
| *Disorientation* | Between groups | 5 | 4.18 | .836 | .469 | .799 |
| | Within groups | 138 | 246.28 | 1.785 | | |
| | Total | 143 | 250.47 | | | |
| *Ease of Use* | Between groups | 5 | 10.08 | 2.016 | .817 | .540 |
| | Within groups | 138 | 340.58 | 2.468 | | |
| | Total | 143 | 350.66 | | | |
| *Time Taken* | Between groups | 5 | 8118.68 | 1623.7 | .262 | .933 |
| | Within groups | 138 | 855785.5 | 6201.35 | | |
| | Total | 143 | 863904.3 | | | |
| *Pages Visited* | Between groups | 5 | 60.06 | 12.01 | 1.451 | .210 |
| | Within groups | 138 | 1142.16 | 8.27 | | |
| | Total | 143 | 1202.22 | | | |

It must be noted that the six topics used in the study were selected only used as a stimulus to allow users to navigate through a website and not to influence their overall results. In order to validate this, a one way ANOVA was conducted to compare site topics based on user disorientation, reported website ease of use, time taken and pages visited. These all showed no significant effect to be present between the different topics.

## 7.3 Method

### 7.3.1 Experimental Variables

Participant browsing experience was used as a dependent measure and six different interface elements were selected and used as independent measures. Participant browsing experience was calculated using the same method used in the previous study, with Ahuja's (2001) browsing experience questionnaire being used. The website interface elements chosen for adaption were:

- Horizontal or Vertical Menu Navigation
- Drop Down Menus (On or Off)

- Inline Subpages (On or Off)
- Breadcrumbs (On or Off)
- Current Page Highlighting (On or Off)
- Advertisements (On or Off)

### 7.3.2 Participants

Twenty-four older adult participants were recruited ($M_{age} = 67.6$, $SD_{age} = 3.0$, $Range_{age} = 62\text{-}75$) from the SiDE user pool. All participants had previous experience of using the Internet to search for information and verified in pre-screening that they had not taken part in any HCI based studies in the last 12 months.

### 7.3.3 Materials and Equipment

*Demographic Information* —Demographic information including participant age, education and occupational status were collected from participants through a questionnaire.

*Internet Ability and Cognitive Measures*—Participants Internet confidence was measured through a liker scored questionnaire. This consisted of 16 questions examining how confident an individual was in various aspects of Internet usage, measured on a 5-point scale (Strongly Agree, Agree, Neither Agree nor Disagree, Disagree, Strongly Disagree). Participants also completed the Number Comparison Test (Ekstrom et al., 1976) to measure their perceptual (processing) speed.

*Browsing Experience*—A questionnaire based on work by Ahuja and Webster (Ahuja & Webster, 2001) was used to gather information on users Perceived Disorientation and Reported Website Ease of Use. This questionnaire consisted of 10 questions, measured on a 7-point scale (Strongly Disagree, Disagree, Somewhat Disagree, Neither Disagree or Agree, Somewhat Agree, Agree, Strongly Agree).

**Table 7.1 Website Question Set used in this experiment**

| *Website Topic* | *Information Retrieval Question 1* | *Information Retrieval Question 2* |
|---|---|---|
| Maple Syrup | You are about to visit a website relating to Maple Syrup. Look around the website and find information on what early maple syrup makers would have done with a sugar shack. | How does buddy sap affect the flavour of maple syrup? |
| Jack the Ripper | You are about to visit a website relating to Jack the Ripper. Find a page on this website that talks about the Whitehall Mystery and how this relates to Jack the Ripper. | What was the name of the Police Surgeon that Robert Anderson asked about the murderers surgical skill and knowledge? |
| San Francisco | You are about to visit a website relating to San Francisco What type of transport hub would you find 13 miles south of downtown San Francisco? | How many visitors go to the San Francisco Museum of Modern Art annually? |
| The Titanic | You are about to visit a website relating to The Titanic. How many people were present at the launch of the Titanic and how many tons of soap were used on the slipway? | How many items did the post office on the Titanic sort per day? |
| Scotland | You are about to visit a website relating to Scotland. Find information about the Glasgow subway system and the reason for its refurbishment over the next few years. | In what century did trade with Colonial America blossom because of trade tariffs being abolished |
| Greek Mythology | You are about to visit a website relating to Greek Mythology. Look around the website and find information on who, along with Jason, was on the ship Argo to fetch the Golden Fleece. | Find a page with more information about the war that occurred between the Greeks and troy |

*Website Adaption Software*—The website adaption software described in section 3.2.2 was used during this study. This software was created so that individual changes could be made to the user interface while keeping the website content the same. Adaptions to the interface navigation position, drop down menu, inline subpages, breadcrumbs, advertisements, and menu highlighting were possible. Additionally, the topic of the website could also be changed.

*Website Question Set*—Questions were created that allowed participants to navigate through the website and were based on six topics. Questions are shown in Table 7.1 and correspond to their relevant topic. A total of 12 information retrieval questions were used, with two created for each topic.

*Experimental Equipment*—The experiment ran on an apple laptop computer with the Google Chrome Browser being used. The laptop was placed in front of the researcher and the participant was given control through a 22" Widescreen Monitor, and a standard Microsoft Keyboard and Mouse.

### 7.3.4 Procedure

First, Participants were invited to take part in a group session in order to gather data on their *demographic information*, *Internet Ability* and *Cognitive Measures*. Separate sessions were used that allowed for participants to be split into smaller, more manageable groups.

Participants were then invited to take part in a one-to-one session where they were given a set of information retrieval tasks to complete. These tasks, taken from the *Website Question Set*, were used in conjunction with the *Website Adaption Software*. Each participant completed 12 questions in total (the complete website question set), resulting in them visiting a website about each of the six topics on two separate occasions. On each occasion of visiting a website, an adaption was made to the interface, allowing for both states of an individual adaption to be examined. The pairing of adaption (e.g. navigation position), website topic (e.g. Maple Syrup), and task order were randomised for each participant before the session occurred.

### 7.3.5 Data Analysis

Participants were placed into groups dependant on their scorings in the Internet confidence questionnaire, and also their scorings in the perceptual speed test. These two abilities were used as findings from Chapter 5 indicated that they are the best predictors to influence individuals' browsing experience. Three categories were created for both of these independent measures based on participant scorings. Participants scoring in the lowest third of each of these metrics were placed in group one, the middle third in group two, and the upper third in group three.

**Table 7.2 Participant perceptual speed and Internet confidence information.**

| | *Perceptual Speed* | | | | *Internet Confidence* | | | |
|---|---|---|---|---|---|---|---|---|
| | Min | Max | Mean | SD | Min | Max | Mean | SD |
| 1 | 19 | 37 | 30 | 7.1 | 21 | 36 | 28.8 | 5.16 |
| 2 | 39 | 49 | 43.5 | 3.9 | 39 | 49 | 43.8 | 3.65 |
| 3 | 49 | 72 | 57.8 | 7.9 | 51 | 60 | 55.6 | 3.2 |

The purpose of analysis is to examine any differences that exist in the browsing experience of these groups when the selected websites features are in both of their binary states, and also to examine if differences exist between the browsing experience of individuals between their Internet experience and perceptual speed groupings. This resulted in a factorial repeated measure ANOVA being used for analysis, with this being followed by Bonferonni corrected t-test for post-hoc analysis.

Table 7.3). Analysis therefore continues noting that there is no significant relationship between the individual site topics and that of the selected variables.

## 7.4 Results

### 7.4.1 Menu Highlighting

**Table 7.4 Menu Highlighting Descriptive Information**

| *Group Number* | *Internet Confidence* | | | | *Processing Speed* | | | |
|---|---|---|---|---|---|---|---|---|
| | Highlight On | | Highlight Off | | Highlight On | | Highlight Off | |
| | M | SD | M | SD | M | SD | M | SD |
| *1* | 1.93 | .473 | 1.84 | .529 | 1.86 | .428 | 1.84 | .352 |
| *2* | 1.88 | .573 | 1.97 | .551 | 1.96 | .571 | 2.07 | .488 |
| *3* | 1.93 | .544 | 1.77 | .461 | 1.92 | .579 | 1.67 | .604 |

A factorial dependent measure ANOVA was used to compare the effect of menu highlighting activation on participants with high, medium, and low levels of Internet confidence. This was accomplished through an examination of their browsing experience levels. No significant effect was found on menu highlighting being active or inactive [F(1,48) = .110, p = .742], the Internet confidence grouping of participants [F(2,48) = .085, p = .919], or in an interaction between these variables [F(2,48) = .249], p = .781]. As no significant effect was found, no post-hoc analysis occurred.

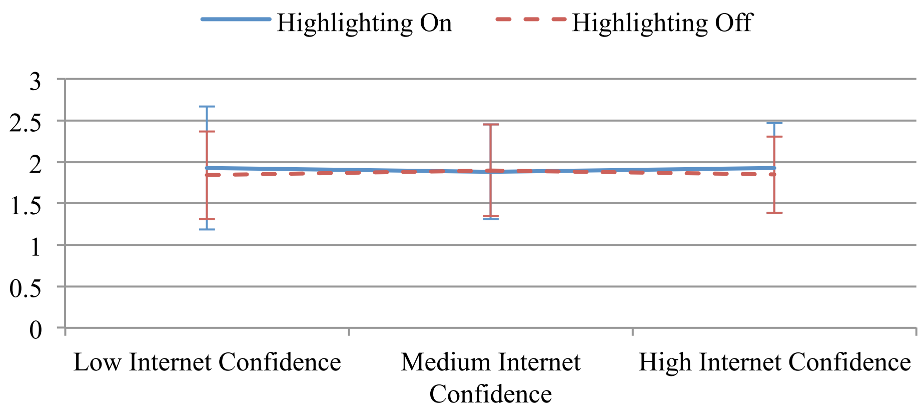


**Figure 7.1 A comparison of participant browsing experience in relation to menu highlighting and Internet confidence**

A second dependent measure ANOVA was used to compare the effect of menu highlighting activation on participants with high, medium, and low levels of perceptual (processing) speed, accomplished through an examination of participant browsing experience. As above, no significant effect was found on menu highlighting being active or inactive [F(1,48) = .115, p = .737], the perceptual (processing) speed grouping of participants [F(2,48) = .806, p = .453], or an interaction between these variables [F(2,48) = .513, p = .602]. As no significant effect was found, no post-hoc analysis occurred.

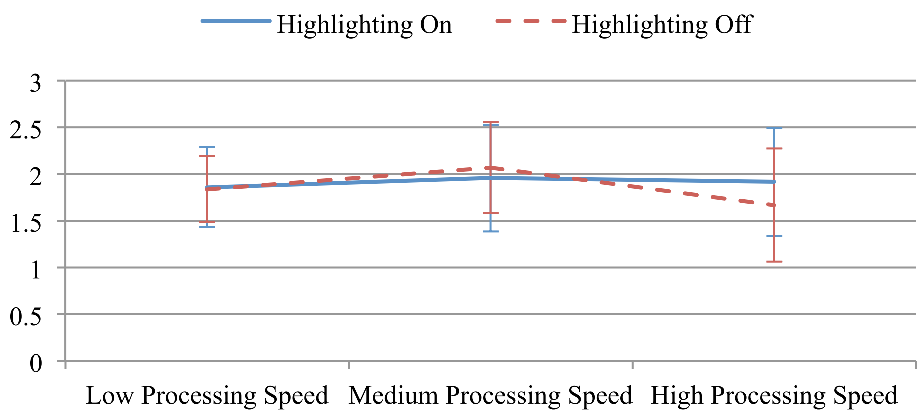


**Figure 7.2 A comparison of participant browsing experience in relation to menu highlighting and processing speed**

Combined, these results indicate that menu highlighting has no effect on the browsing experience of individuals when taking into account their Internet confidence or processing (perceptual) speed.

### 7.4.2 Breadcrumbs

**Table 7.5 Breadcrumb Descriptive Information**

| *Group Number* | *Internet Confidence* | | | | *Processing Speed* | | | |
|---|---|---|---|---|---|---|---|---|
| | Breadcrumb On | | Breadcrumb Off | | Breadcrumb On | | Breadcrumb Off | |
| | M | SD | M | SD | M | SD | M | SD |
| *1* | 1.65 | .422 | 1.39 | .483 | 1.93 | .478 | 1.82 | .410 |
| *2* | 1.89 | .515 | 1.88 | .583 | 1168 | .416 | 1.58 | .738 |
| *3* | 1.78 | .458 | 1.87 | .477 | 1.71 | .496 | 1.71 | .546 |

A factorial dependent measure ANOVA was used to compare the effect of breadcrumb usage on participants with high, medium, and low levels of Internet confidence. This was accomplished through an examination of their browsing experience levels. No significant effect was found on breadcrumbs being either active or inactive [F(1,48) = .174, p = .679], the Internet confidence grouping of participants [F(2,48) = 2.488, p = .095], or in an interaction between these variables [F(2,48) = .537], p = .589]. As no significant effect was found, no post-hoc analysis occurred.

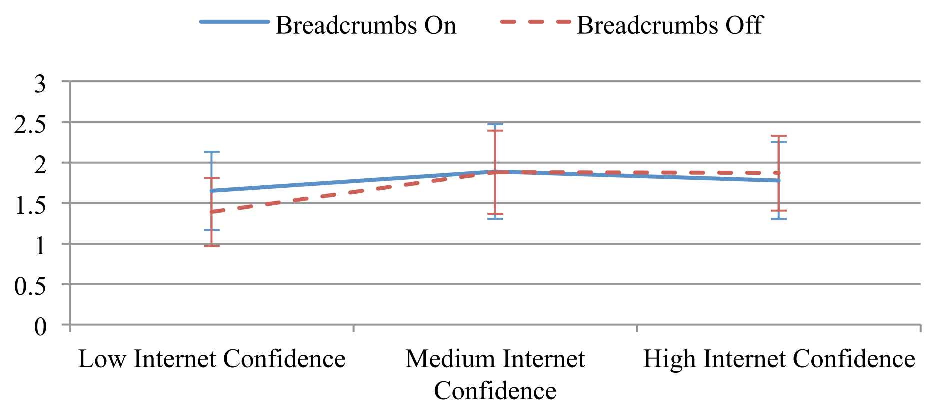


**Figure 7.3 A comparison of participant browsing experience in relation to breadcrumb usage and Internet confidence**

A second dependent measure ANOVA was used to compare the effect breadcrumb usage on participants with high, medium, and low levels of perceptual (processing) speed, again accomplished through examining participant browsing experience. As above, no significant effect was found on breadcrumbs being active or inactive [F(1,48) = .159, p = .692], the perceptual (processing) speed grouping of participants [F(2,48) = .901, p = .414], or an interaction between these variables [F(2,48) = .087, p = .917]. As no significant effect was found, no post-hoc analysis occurred.

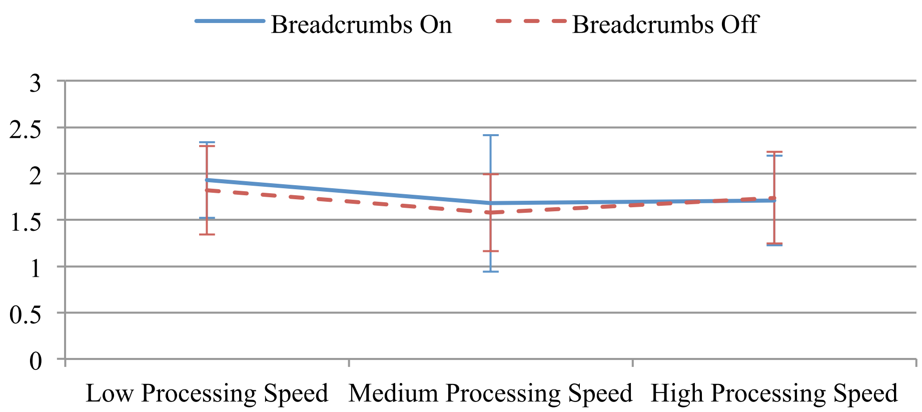


**Figure 7.4 A comparison of participant browsing experience in relation to breadcrumb usage and processing speed**

Combined, these results indicate that breadcrumb presence has no effect on the browsing experience of individuals when taking into account their Internet confidence or processing (perceptual) speed.

### 7.4.3 Subpage Menu Items

**Table 7.6 Subpage Descriptive Information**

| | *Internet Confidence* | | | | *Processing Speed* | | | |
|---|---|---|---|---|---|---|---|---|
| | Subpage On | | Subpage Off | | Subpage On | | Subpage Off | |
| *Group Number* | M | SD | M | SD | M | SD | M | SD |
| *1* | 1.71 | .593 | 1.83 | ,551 | 1.76 | .492 | 2.02 | .456 |
| *2* | 2.01 | .353 | 2.03 | .438 | 1.93 | .530 | 1.94 | .553 |
| *3* | 1.81 | .499 | 1.89 | .564 | 1.81 | .499 | 1.79 | .542 |

A factorial dependent measure ANOVA was used to compare the effect of vertical subpage menus being either enabled or disabled for participants with high, medium, and low levels of Internet confidence. This was accomplished through an examination of their browsing experience levels. No significant effect was found on subpage menus being either enabled or disabled [F(1,48) = .560, p = .458], the Internet confidence grouping of participants [F(2,48) = 1.212, p = .308], or in an interaction between these variables [F(2,48) = .105], p = .901]. As no significant effect was found, no post-hoc analysis occurred.

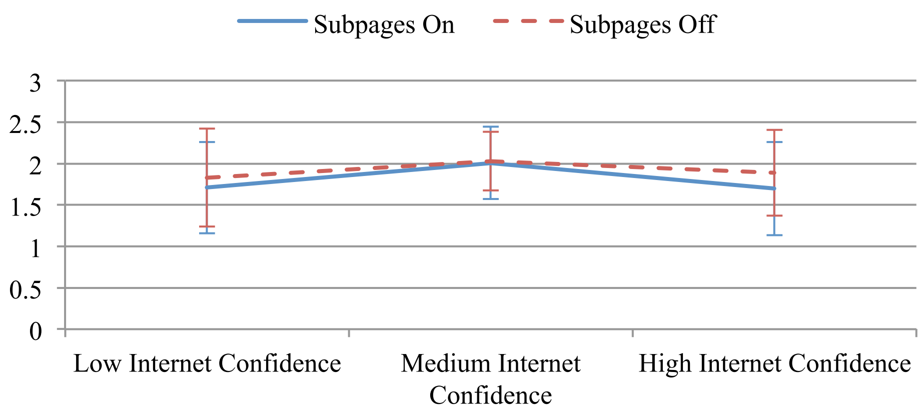


**Figure 7.5 A comparison of participant browsing experience in relation to subpage activation and Internet confidence**

A second dependent measure ANOVA was used to compare the effect vertical subpage menus had on participants with high, medium, and low levels of perceptual (processing) speed, again accomplished through examining participant browsing experience. As above, no significant effect was found on breadcrumbs being active or inactive [F(1,48) = .547, p = .464], the perceptual (processing) speed grouping of participants [F(2,48) = .490, p = .616], or an interaction between these variables [F(2,48) = .279, p = .758]. As no significant effect was found, no post-hoc analysis occurred.

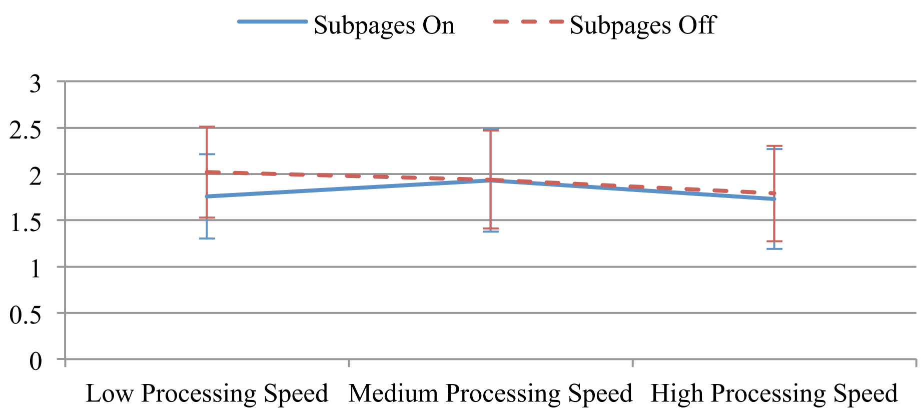


**Figure 7.6 A comparison of participant browsing experience in relation ti subpage activation and Processing Speed**

Combined, these results indicate that vertical subpage menus had no effect on the browsing experience of individuals when taking into account their Internet confidence or processing (perceptual) speed.

### 7.4.4 Menu Position

**Table 7.7 Menu Position Descriptive Information**

| | *Internet Confidence* | | | | *Processing Speed* | | | |
|---|---|---|---|---|---|---|---|---|
| | Vertical Menu | | Horizontal Menu | | Vertical Menu | | Horizontal Menu | |
| *Group Number* | M | SD | M | SD | M | SD | M | SD |
| *1* | 1.61 | .530 | 1.66 | .343 | 1.56 | .527 | 1.70 | .465 |
| *2* | 1.83 | .582 | 2.02 | .308 | 1.95 | .560 | 1.86 | .469 |
| *3* | 1.80 | .512 | 1.65 | .670 | 1.73 | .479 | 1.76 | .556 |

A factorial dependent measure ANOVA was used to compare either a horizontal or vertical menu being implemented for participants with high, medium, and low levels of Internet confidence. This was accomplished through an examination of their browsing experience levels. No significant effect was found on menu position being either vertical or horizontal [F(1,48) = ..046, p = .830], the Internet confidence grouping of participants [F(2,48) = 1.314, p = .279], or in an interaction between these variables [F(2,48) = .461], p = .634]. As no significant effect was found, no post-hoc analysis occurred.

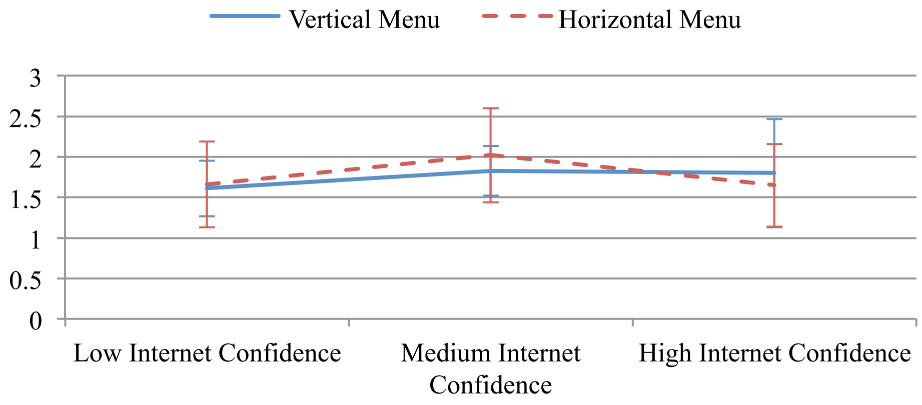


**Figure 7.7 A comparison of participant browsing information in relation to menu position and Internet confidence**

A second dependent measure ANOVA was used to compare either a horizontal or vertical menu being implemented for participants with high, medium, and low levels of perceptual (processing) speed, again accomplished through examining participant browsing experience. As above, no significant effect was found on menu position being horizontal or vertical [$F(1,48) = .046$, $p = .832$], the perceptual (processing) speed grouping of participants [$F(2,48) = 1.212$, $p = .308$], or an interaction between these variables [$F(2,48) = .221$, $p = .802$]. As no significant effect was found, no post-hoc analysis occurred.

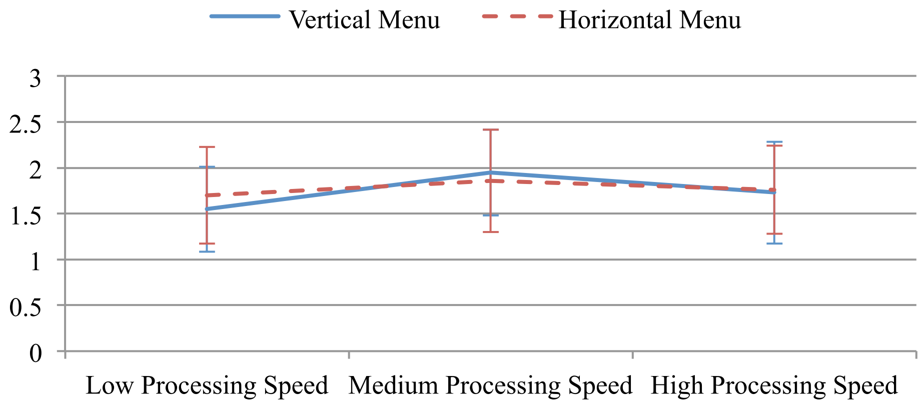


**Figure 7.8 A comparison of participant browsing experience in relation to menu position and processing speed**

Combined, these results indicate that the position of a menu had no effect on the browsing experience of individuals when taking into account their Internet confidence or processing (perceptual) speed.

### 7.4.5 Advertisements

**Table 7.8 Advertisement Descriptive Information**

| | *Internet Confidence* | | | | *Processing Speed* | | | |
|---|---|---|---|---|---|---|---|---|
| | Vertical Menu | | Horizontal Menu | | Vertical Menu | | Horizontal Menu | |
| *Group Number* | M | SD | M | SD | M | SD | M | SD |
| *1* | 2.05 | .516 | 1.88 | .520 | 2.23 | .342 | 1.98 | .465 |
| *2* | 2.06 | .572 | 2.07 | .439 | 1.99 | .538 | 2.03 | .548 |
| *3* | 2.19 | .476 | 1.94 | .570 | 2.07 | .628 | 1.87 | .526 |

A factorial dependent measure ANOVA was used to compare the implementation of website advertisements for participants with high, medium, and low levels of Internet confidence. This was accomplished through an examination of their browsing experience levels. No significant effect was found on advertisements implementation [$F(1,48) = .808$, $p = .374$], the Internet confidence grouping of participants [$F(2,48) = .197$, $p = .822$], or in an interaction between these variables [$F(2,48) = .268$], $p = .766$]. As no significant effect was found, no post-hoc analysis occurred.

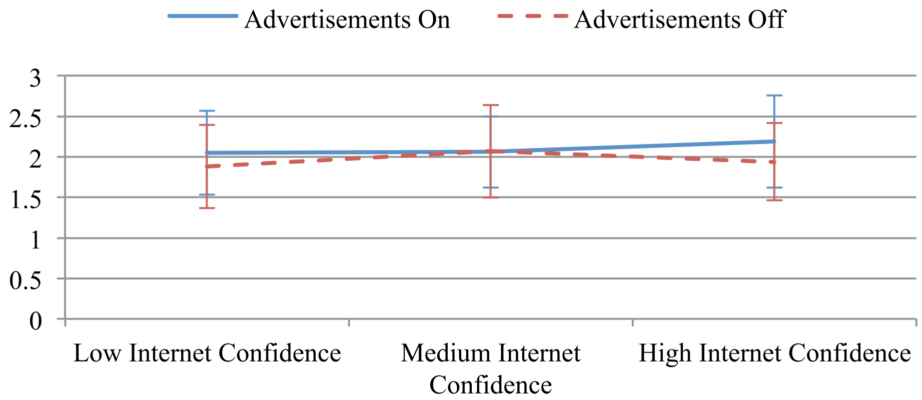


**Figure 7.9 A comparison of participant browsing experience in relation to advertisement activation and Internet confidence**

A second dependent measure ANOVA was used to compare advertisement implementation for participants with high, medium, and low levels of perceptual (processing) speed, again accomplished through examining participant browsing experience. As above, no significant effect was found advertisement implementation being on or off [$F(1,48) = .815$, $p = .372$], the perceptual (processing) speed grouping of participants [$F(2,48) = .302$, $p = .741$], or an interaction between these variables [$F(2,48) = .356$, $p = .703$]. As no significant effect was found, no post-hoc analysis occurred.

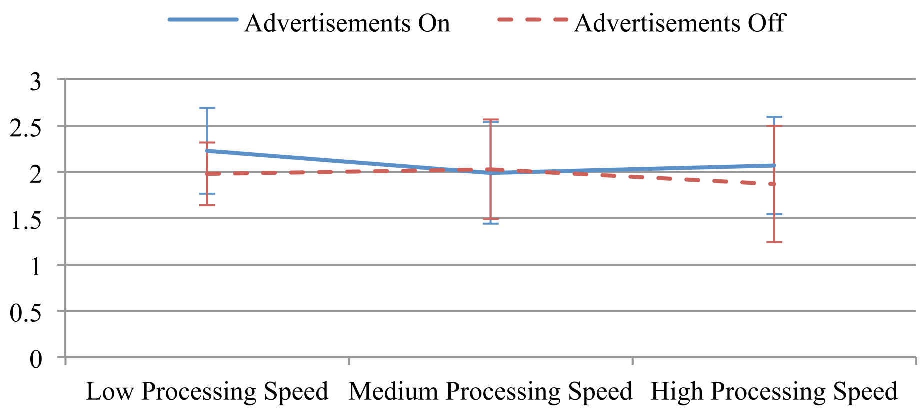


**Figure 7.10 A comparison of participant browsing experience in relation to advertisement activation and processing speed**

Combined, these results indicate that the implementation of advertisements had no effect on the browsing experience of individuals when taking into account their Internet confidence or processing (perceptual) speed.

### 7.4.6 Dropdown Menus

**Table 7.9 Dropdown Menu Descriptive Information**

| | *Internet Confidence* | | | | *Processing Speed* | | | |
|---|---|---|---|---|---|---|---|---|
| *Group* | Dropdown On | | Dropdown Off | | Dropdown On | | Dropdown Off | |
| *Number* | M | SD | M | SD | M | SD | M | SD |
| *1* | 1.72 | .695 | 1.67 | .494 | 20.0 | .370 | 1.87 | .541 |
| *2* | 2.06 | .364 | 1.98 | .518 | 2.11 | .421 | 1.84 | .535 |
| *3* | 1.98 | .512 | 2.06 | .439 | 1.98 | .512 | 2.01 | .455 |

A factorial dependent measure ANOVA was used to compare the implementation of dropdown menus for participants with high, medium, and low levels of Internet confidence. This was accomplished through an examination of their browsing experience levels. No significant effect was found on dropdown menu implementation [$F(1,48) = .249$, $p = .620$], the Internet confidence grouping of participants [$F(2,48) = 3.052$, $p = .058$], or in an interaction between these variables [$F(2,48) = .004$], $p = .996$]. As no significant effect was found, no post-hoc analysis occurred.

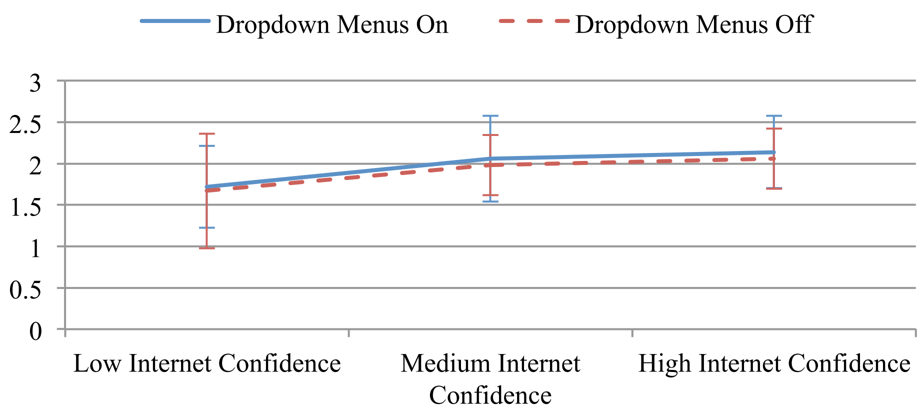


**Figure 7.11 A comparison of participant browsing experience in relation to dropdown menu activation and Internet confidence**

A second dependent measure ANOVA was used to compare dropdown menu implementation for participants with high, medium, and low levels of perceptual (processing) speed, again accomplished through examining participant browsing experience. As above, no significant effect was found advertisement implementation being on or off [F(1,48) = .228, p = .636], the perceptual (processing) speed grouping of participants [F(2,48) = .081, p = .923], or an interaction between these variables [F(2,48) = .945, p = .397]. As no significant effect was found, no post-hoc analysis occurred.

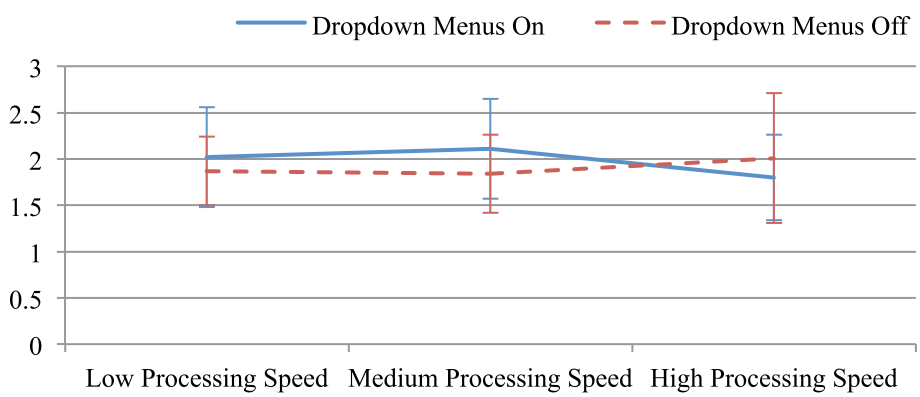


**Figure 7.12 A comparison of participant browsing experience in relationi to dropdown menu activation and processing speed**

Combined, these results indicate that the implementation of drop down menus had no effect on the browsing experience of individuals when taking into account their Internet confidence or processing (perceptual) speed.

## 7.5 Discussion

The purpose this chapter was to examine if adaptations to the user interface could be made for users based on their Internet confidence and perceptual (processing) speed in order to improve their overall browsing experience. Unfortunately, no significant findings were found during analysis. Discussion therefore focuses on possible reasons for this and suggests alternative approaches that may have produced alternative results.

*Adapting Multiple Interface Elements* – This work focused on an examination to very small changes in a website interface, with adaptions being examined individually in an attempt to create one-to-one mappings of interface elements to Internet confidence and perceptual speed. Perhaps a better approach would be to examine how a combination of interface elements could improve individuals browsing experience, rather than single factors. This approach may have more significant outcomes as any changes observed in browsing experience for individual interface elements was very small.

*Considering Multiple User Abilities* – A further limitation that may have affected the results concerns the view of participant Internet confidence and perceptual speed. These two abilities were considered separately, and not for examination combined. For example, examination occurred into participant low Internet confidence *or* low perceptual speed, perhaps an alternative approach would be to combine these into a model that examined both factor levels at the same time.

*User Created Changes* – A final alternative that may have improved the overall browsing experience of participants, would be to draw inspiration from Wobbrocks (2011) third principle of ability-based design. This would allow the users themselves to decide on what adaptions they believe would improve their overall browsing experience and could potentially provide information into what factors individuals view as necessary in decreasing the disorientation that could potentially be attached to information retrieval tasks.

## 7.6 Conclusion

This chapter set out to determine whether single adaptions made to user interface elements could affect the overall browsing experience of participants, when paying particular attention to user Internet confidence and perceptual (processing) speed. Six interface elements were chosen after a review of current governmental usability guidelines. These interface elements were:

- Menu Position (Horizontal or Vertical)
- Dropdown Menus (On or Off)
- Subpage Menus (On or Off)
- Advertisements (On or Off)
- Menu Highlighting (On or Off)
- Breadcrumbs (On or Off)

Analysis was accomplished though dependant measures ANOVA testing. The results obtained suggest that by analysing these individual interface elements, no significant differences exist in participant browsing experience when analysing both the implementation of these interface elements, or in the differences between participant Internet confidence and perceptual (processing) speed levels.

# Chapter 8. Discussion and Conclusions

This chapter begins by discussing an overall summary into the findings of this work and how these answer the questions asked at the beginning of the thesis. Second, it shows how these findings contribute to overall HCI knowledge and how they could potentially be implemented in a real world context. Third, it discuss the major strengths and limitations of each of the experiments presented in this thesis and then examine any extensions that could be made to this work and the direction that potential future research could take.

## 8.1 Summary of Findings

In order to reflect on the contribution that the work in this thesis has made, a return to the original research questions will be used. These questions will be answered, referring back to the research studies conducted and the contribution to knowledge that these have made.

Within Chapter 4, a preliminary research study was presented that examined how users' previous Internet usage and fluid intelligence can be used to understand the browsing habits of individuals. It was found that while an individuals' previous Internet usage could be used to find significant differences in objective measures such as task completion time, thematic analysis suggested that changes in subjective measures such participant feelings and search reasoning could be explained by examining their inductive reasoning. Key findings from this chapter were:

- **Users with high Internet usage are more efficient than those with low Internet usage.** High Internet usage participants would spend less time on a search result page before selecting a link than low Internet usage participants, and would also visit more pages overall. Additionally, it was observed that participants with high Internet usage would use a comparable number of mouse clicks to those with low Internet usage, suggesting that they are either making less 'misclicks' on a page, or are not using as many interactive page features than participants with low Internet usage.

- **Age based differences were apparent in objective performance between older and younger adults.** While no significant difference was found in the overall search engine usage between older and younger adults, it was found that younger adults visited more pages per minute than older adults, yet their average clicks per minute was comparable. This finding is very similar to that comparing high and low Internet usage older adults, and again suggests that these younger adult participants are either performing less mis-clicks during the study, using a combination of mouse and keyboard actions, or are using less interactive page elements during a study session.
- **Qualitative analysis showed differences in the problem solving ability of high and low inductive reasoning participants.** It was found that users with inductive reasoning would use a variety of problem solving techniques when searching within a site, where participants with low inductive reasoning would focus more on interface-prompts to move through a site. This suggests that individuals' cognitive abilities have an influence in the methods that use when completing information retrieval tasks.

This finding, combined by an interest in the experiences felt by users while completing online tasks created a move in all subsequent studies to examine participant browsing experience. Browsing experience, defined as the combination of participant reported disorientation and reported website ease of use, is a shift towards a more subjective measure of user performance. This term is therefore used in the first research question in this thesis, asking:

*1. What user-based metrics, apart from age, can be used to understand the browsing experience of individuals?*

The study presented in Chapter 5 examines this question, with age, Internet abilities, and cognitive characteristics used to examine the perceived disorientation, reported website ease of use, and overall browsing experience of users. Findings from this chapter to answer the above research question are:

- **User age has a very small effect when predicting users' browsing experience.** All regressions within this study reported that age could not account for a significant amount of variance that is attached to participant perceived disorientation, reported website ease of use, and overall browsing experience. As such, one of the key findings from this study, and a recommendation for future HCI work, is that age cannot be used as a grouping variable when examining the browsing experience of individuals.
- **Internet Confidence, rather than Usage, is important in predicting browsing experience.** While the amount of usage that individuals have in using a particular technology may increase their speed at completing tasks, the finding in this work suggests that it is their *confidence* in using technology that has an impact in their overall browsing experience. It is therefore suggested that a possible method of increasing the browsing experience for users is to attempt to invoke feelings of confidence an a particular service from an early stage, in order to make users feel more comfortable in using them.

- **Inductive Reasoning did not show to be a predictor of Browsing Experience**. A surprising outcome from this work surrounds inductive reasoning, and its inability to act as a predictor of browsing experience. A large amount of literature in the past has examined fluid intelligence as a predictor of user performance, and Inductive reasoning is one of the 3 sub-abilities in this measure. This work found that while while higher levels of inductive reasoning pointed towards less participant disorientation and a higher ease of use scoring, this was not at significant levels. A possible reason for this may be down to this work using a more subjective measure of performance, and that measures such as inductive reasoning are more key in objective performance metrics such as task completion time.
- **Perceptual Speed could be used as a predictor of determining participant Browsing Experience**. The processing speed sub-ability, perceptual speed, was successfully used as a predictor of user browsing experience. Higher levels of perceptual speed, resulted in lower levels or perceived disorientation, high levels of reported website ease of use, and higher levels of overall browsing experience. This findings suggests that the mental quickness that is associated with this ability, can be utilized in order to quickly understand links between information retrieval questions, and the possible routes through a website. However, caution must be applied as high levels of processing speed have been shown to correlate with high education levels in an individual, and this may in turn produce a secondary effect.

Overall, the findings from this study suggest that Internet confidence and perceptual speed can be used to more accurately understand an individuals browsing experience than by examining their age. Research then continued by using these two measures to attempt to answer the second research question:

2. *Can adaptations to website interface elements be made in order to improve the browsing experience for based on their cognitive and technical experience abilities?*

Chapter 7 presented a study examining if navigational elements on a website can effect the overall browsing experience of individuals while taking into account their Internet experience and perceptual speed. Unfortunately, no significant results were obtained in this work and we are unable to successfully answer this second research question.

### 8.1.1 Secondary Contributions

Complementing the contributions to knowledge, several secondary contributions have been made. These are a result of both the software created to aid in the execution of the studies presented and also in the methods used in the studies themselves.

#### *8.1.1.1 Created Software*

Three major pieces of software were created to aid in both the collection and analysis of date throughout this work. This software, while not a major contribution in this thesis, provides tools that can now be used in future work.

Software to aid in the gathering of information (top left in Figure 8.1) during the study presented in Chapter 4 provides a method of collecting data from lab based usability studies. This software aids the researcher both in organizing the studies and in the collection of research data in a format suitable for further analysis

Additional software was created as a result of the findings from Chapter 5 (top right in Figure 8.1). This software uses the created HTML and CSS parsing engine discussed in Section 3.2.1.1, displaying the usability 'scores' created for an individual page based on the usability guidelines collected for use in Chapter 6.

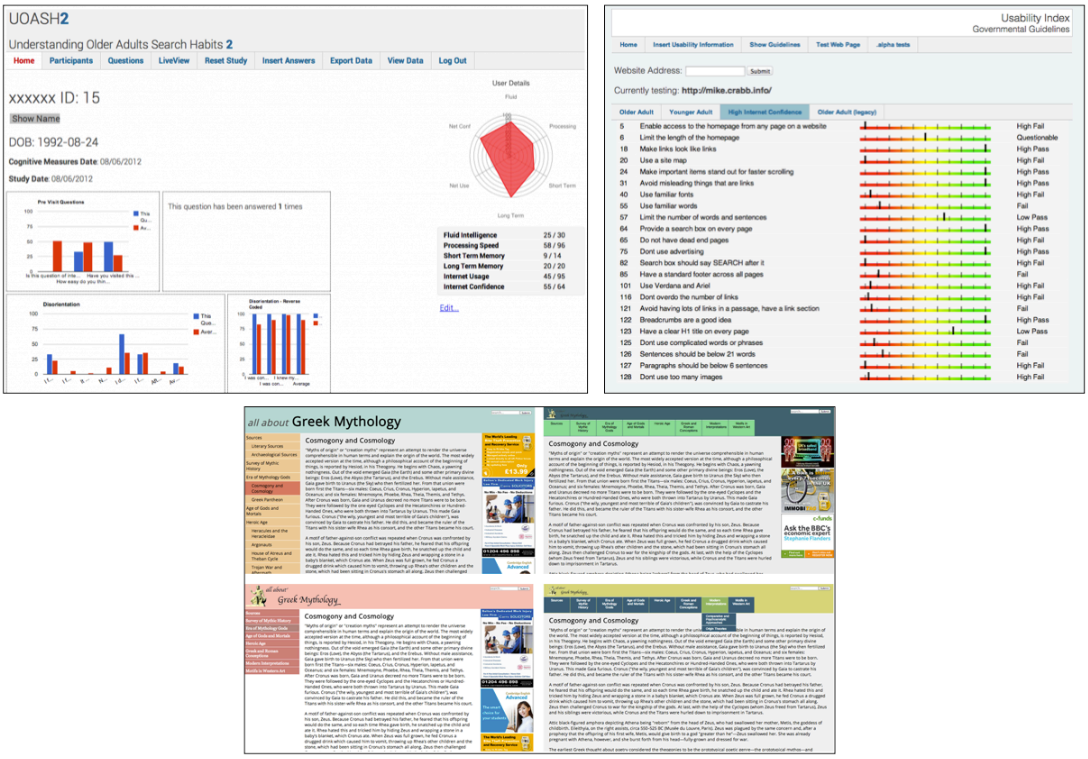


**Figure 8.1 Created Software Contributions**

Finally, adaptive navigational software was created (bottom in Figure 8.1) that was used to compare different usability elements in the study described in Chapter 7.. While this software was used to test user performance based on varying characteristics, it creates a simple method of adjusting interface elements with the principles used easily transferable for assisting in future A-B-testing methods. Additionally, this software has since been used as a training aid for students in order to teach basic principles in what makes websites usable. This was carried out during a university organized 'Easter School' to help high school level students in the local area.[12]

All of the software created for use in this thesis is available online through http://phd.crabb.info/thesis .

### 8.1.1.2 Study Design

The studies reported in this thesis all followed a very similar design. Participants were first invited to take part in a group session where information was gathered on their cognitive and Internet abilities, and were then invited to take part in a second individual session that focused on participants completing an information retrieval task. The repeated nature of experiment design in this manner provides a contribution surrounding the suitability of this methodology when performing multi-session studies of this type.

In addition, the varying methods of analysis used in each study have demonstrated the versatility of this research method. Chapter 4 used a mixed-method analysis, where a combination of qualitative and quantitative techniques was used to examine different characteristics of users' search experience. Chapter 5 presented a fully quantitative analysis technique where multiple regressions were used to demonstrate the increasing amount of variance accounted for. Finally the study presented in Chapter 7 uses a ANOVA testing to examine the difference between website interface element implementation and participant perceptual speed and Internet confidence levels in relation to user browsing experience. The differences between these experiments therefore demonstrate the versatility of this research method in

[12] http://easterschool.computing.dundee.ac.uk/

usability based research and also the wide variety of analysis techniques that are suitable to be used when examining any data collected.

## 8.2 Implications of Results

### 8.2.1 Implications for Research Practice

A key implication for research practice arising from this work surrounds the use of participant age as a grouping variable within future research studies. This work has shown that age cannot be used as a suitable metric to distinguish between individuals when examining their browsing experience, and as such, further questions must be asked regarding its usage as a suitable metric when distinguishing between individuals in both the HCI and User Experience fields. It is suggested that while age can be used to distinguish between different generational groups, and this may be beneficial in study design, analysis should consider alternative metrics such as participant confidence in using the technology or service being tested. This method may provide additional information into reasoning's surrounding the experiences of individuals before assuming that age based differences occur.

Additionally, and of importance when examining cognitive abilities, the work in this thesis has shown that subjective measures, such as perceived disorientation and browsing experience, can be used as alternative measures to understand user performance rather than relying on objective measures such as task completion time. This finding may have wider implications in the user experience domain as with a move to subjective based metrics, it is possible adapt methods to allow quantitative user experience experiments similar to those used in the HCI domain in general.

### 8.2.2 Implications for User Training

One of the key findings from the study presented in Chapter 5 suggested that Internet confidence is a key measure in accounting for the perceived disorientation, reported website ease of use, and overall browsing experience of an individual. This has implications for future user training, as it could be viewed that a focus on increasing the confidence that individuals have in using a particular service will increase their overall experience in using it. This approach, as opposed to providing users with information on how all aspects of a system works, may provide individuals with a higher level of satisfaction, improving their experience in using a service and in turn may also reduce the amount of assistance needed in the future and increase technology retention.

## 8.3 Limitations of Work

This is used to discuss the limitation of the work in this thesis, focusing on limitations apparent in the cognitive battery used, and also in the methods and analysis in the experiments.

### 8.3.1 Cognitive Testing Battery

One of the main limitations in this work lies in the cognitive abilities that were selected for inclusion. In total, four different cognitive tests were used, with these being related to four different cognitive abilities in the CHC model of human intelligence. These are detailed in Table 8.1.

**Table 8.1 Categorisation of Cognitive Abilities Used in This Work**

| *Test* | *Broad Measure* | *Narrow Measure* |
|---|---|---|
| Letter Sets Test | Fluid Intelligence | Induction |
| Number Comparison | Processing Speed | Perceptual Speed |
| Auditory Memory Span | Short-Term Memory | Memory Span & Working Memory |
| Meaningful Memory | Long-Term Memory | Meaningful Memory |

A number of problems occur when examining abilities using this very small amount of measures. With only four tests being used, this poses a problem in guaranteeing the accuracy of the results on a measure-by-measure basis. It would be beneficial to use a number of tests to measure each individual ability. Secondly, a very small number of broad factors were used in this work, a more detailed analysis would have been possible if an increased number of broad factors were considered. Of particular interest here is inclusion of testing that can measure an individuals crystallized intelligence and visual processing. Finally, this battery of tests was constructed as a shortened battery of the CREATE battery of testing (Czaja, Charness, Fisk, et al., 2006b) , with the result of this being that no reliability information on this newly created shortened battery was available.

A solution these limitations, would be to use a fully constructed ability battery, with a possible example being the Wechsler Adult Intelligence Scale (WAIS-IV). This battery of tests provides scorings of individuals Verbal Comprehension, Perceptual Reasoning, Working Memory, and Processing Speed. While the WAIS-IV battery measures abilities using its own four factors, it has also been shown that the measures in this can map to a number of the CHC abilities that are used in this thesis (Flanagan, Alfonso, & Reynolds, 2013). The abilities not being measured in this battery being Long-Term Memory (Glr), quantitative knowledge (Gq), Reading and

Writing (Grw), Auditory Processing (Ga), and Decision/Reaction Time (Gt). However, the abilities that are measured are done so over a variety of narrow factors, creating a vast improvement on the shorter battery used in this work.

In addition to the benefit of using an extended battery of testing, a second asset in using a pre made battery such as this is that reliability factors exist concerning all of the tests used. Concerning WAIS-IV, Flanagan (2009) p.338 discusses these to range from .71 (adequate) to .90 (reliable) for core tests and .74 to .90 for subtests, both of these being short term stability coefficients. It is noted that long-term stability coefficients are currently unavailable due of the young age of WAIS-IV, and that these will of course be influenced by the change in an individuals abilities over time. Table 8.1 details the tests, CHC broad measures, and associated narrow measures that this battery of testing covers, adapted from (Flanagan et al., 2013)

**Table 8.2 Tests in the WAIS-IV Battery and their associated CHC abilities**

| *Test* | *Broad Measure* | *Narrow Measure* |
|---|---|---|
| Matrix Reasoning | Fluid Intelligence | Induction |
| Figure Weights | Fluid Intelligence | Quantitative Reasoning |
| Vocabulary | Crystallised Intelligence | Lexical Knowledge |
| Information | Crystallised Intelligence | General Information |
| Similarities | Crystallised Intelligence | Lexical Knowledge and General Information |
| Comprehension | Crystallised Intelligence | General Information |
| Block Design | Visual Processing | Visualisation |
| Picture Completion | Visual Processing | Flexibility of Closure and General Information |
| Visual Puzzles | Visual Processing | Visualisation |
| Digit Span | Short-Term Memory | Memory Span and Working Memory |
| Letter-Number sequencing | Short-Term Memory | Working Memory |
| Arithmetic | Short Term Memory | Working Memory & Quantitative Reasoning |
| Symbol Search | Processing Speed | Perceptual Speed |
| Coding | Processing Speed | Rate of Test Taking |
| Cancelation | Processing Speed | Perceptual Speed |

It is therefore recommended that in order to overcome the limitations associated with the testing battery used in this work, a different, more comprehensive battery such as the one described above should be used in future research.

### 8.3.2 Study 1 – Preliminary Research

The experiment presented in Chapter 4 surrounded participants taking part in an information retrieval task, with this being used to develop an understanding into how participant Internet Usage and Inductive Reasoning can effect participants subjective and objective performance. Several limitations arise in this work, with this surrounding the sample size used in the experiment, the choice of users recruited, and the methods used during qualitative analysis.

In this experiment, a total of 18 users were recruited, with this being split into 12 older adults and 6 younger adults. Older adult participant were then further split into users with high and low Internet Usage, and fluid intelligence. While this number of participants if adequate for performing qualitative analysis, a larger number of participants would have been beneficial in performing the quantitative aspect of analysis. This low number of participants reduces the overall statistical power of the experiment and could be rectified in the future with an increase in the number of research participants.

Additionally a further limitation arises in the sample choice used in this study. The research was conducted with participants that could be described as 'extreme' values of independent metrics. Users were recruited based on high and low age levels, fluid intelligence, and Internet usage, with users that had 'average' levels being disregarded. Focusing on these dichotomous groupings was chosen to highlight the differences that were apparent in the browsing experience between these different population groups. An extension of this work would therefore be to include users that do not fall into these extreme categories, and instead examine the continuum of users in order to discover if any additional changes occur.

Finally, a limitation is apparent in the analysis of the qualitative data in this chapter. The validity of this data was not examined, and therefore the reliability of these results could not be guaranteed. In order to solve this limitation, an additional researcher would be needed to recode a subset of this data. This would allow for a cronbach score to be calculated, and would provide an indication into the reliability of the analysis conducted.

### 8.3.3 Study 2 – Human Factors in Relation to Browsing Experience

The experiment in Chapter 5 aimed to discover if participants perceived disorientation, reported website ease of use, and overall browsing experience could be accounted for by analyzing their age, Internet, and cognitive abilities.

During preliminary analysis, it became apparent that there was no significant difference in the processing speed, short-term memory, and long term memory measures between the older and younger adults in this work. This may be down to the sample recruited being very highly educated. 75% (9 participants) in this sample reported achieving a bachelor level degree or above. Compared Czaja et. al (2006b) where 33% of their sample reported post-college degree and 22% reported college level degree. This limitation is amplified by the low sample size used in this work. In total, 20 participants took part in this experiment with this consisting of 12 older adults and 8 younger adults.

Another limitation in this work surrounds the analysis technique used with these dichotomous age groupings. As these groups were included in the same regression analysis model, it was feared that any age-based variance accounted for would be amplified due to the large age difference between these two groups. However, as no age-based difference was found between groups, this far was unfounded.

A further limitation in this work lies in the number of independent metrics used in analysis when compared to the overall sample size of the population used. With a total of 20 participants and 7 independent measures in regression, caution must be applied to the findings. This imbalance in independent measures to participants severely hurts the power of any results obtained. Bonferroni adjusted significance values were however used through this (and all other) experiments to help compensate for Type-I error.

The issues of analysis between dichotomous age groupings and the lack of power due to the number of independent measures could be addressed by increasing the sample size used in this experiment. By recruiting a further 4 younger adults, and 12 middle aged participants, the overall sample size of the study would increase to 36. This would serve two purposes, first increasing the power of any results by an increase in sample size, and second to remove an analysis between dichotomous age groupings through in inclusion of a third 'middle-aged' participant group.

### 8.3.4 Study 3 – An Analysis of Website Interface Elements in Relation to User Browsing Experience

The final experiment set out in Chapter 7 aimed to analyze whether the presence of six individual website user interface elements could alter the browsing experience of participants, while additionally examining their Internet experience and perceptual speed. The obvious limitation in this experiment is that no significant findings were produced. Possible adaptions to this study were outlined in Chapter 7 itself and include:

- *Adapting Multiple Interface Elements* – While this experiment focused on adapting one interface element at a time, an alternative approach would be to adapt multiple interface elements in order to examine how browsing experience could be effected by their interactions as opposed to stand alone changes
- *Considering Multiple User Abilities* – A further limitation that may have affected the results concerns the view of participant Internet confidence and

perceptual speed. These two abilities were considered separately, and not for examination combined. For example, examination occurred into participant low Internet confidence *or* low perceptual speed, perhaps an alternative approach would be to combine these into a model that examined both factor levels at the same time.

- *User Created Changes* – As previously mentioned, the third principle of ability-based design suggests that by allowing users to create adaptions themselves to an interface, a more suitable mapping to their abilities may occur (Wobbrock et al., 2011). This implementation, may work in an experiment setting by allowing users to create their own interfaces that they believe is best suited to their abilities, and consequently identifying any features that are common between Internet and cognitive ability values.

## 8.4 Software Position in Ability Based Design

The software created in the final experiment was developed with the aim of constructing an interface that could be changed on a person-by-person basis in order to produce the best browsing experience for an individual. While the experiment in Chapter 7 failed to show any significance for individual user interface elements, this software does allow for the adaption of a large variety of user interface elements that can be used to cater for an individual's ability. All adaptions possible in this software (including some not tested in Chapter 7) are detailed in Table 8.2.

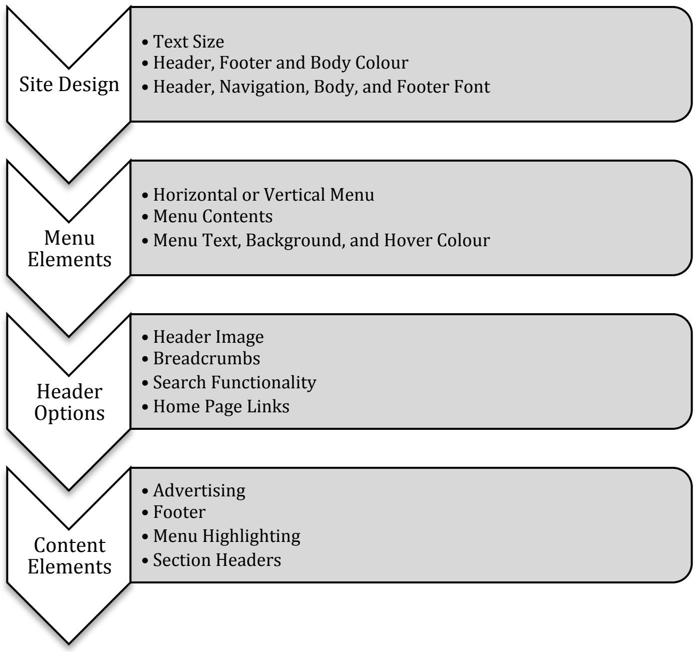


**Figure 8.2 Full list of adaptions possible in software created for final experiment**

What follows is a description of how this software fits into the seven principles of ability-based design, and some points in which it can be improved.

*Ability* – This software was designed from the outset to focus on focus on adapting to what an individual can do, rather than what they cannot do. For example, if an individual can easily access a menu along the top of a screen, then this can be implemented. The one difference apparent here, is that the software was designed with the principle to draw on individuals strengths in using a website, while *also* compensating for their weaknesses.

*Accountability* – One of the key strengths in this software is that is designed to be adaptable to the user, and that the user does not need to adapt to the software if there is an element that they dislike.

*Adaption* – The software created can be adapted to suit users needs, with a 'control panel' of options being used to select the current state of the interface elements, and colour schemes that can be used. Users may capable of making these adaptions themselves

*Transparency* – Users are aware of any adaptions made through the control panel for the software, with this being used to show the state of all current adaptions. An expansion to this, may be to provide graphical representation to the changes that would be made for each adaption, allowing users to preview any changes that may be made.

*Performance* – The software can track user objective performance metrics (time on page, website path) through log file information, but no predictions or modeling occurs

*Context* – The software is unable to sense context and anticipate its effect on user abilities. This is a very difficult area when examining the cognitive abilities, as although individuals cognitive abilities can be measured, these can be effected by a number of personal and environmental factors and constant measurement of this in not feasible.

*Commodity* – Not applicable as the software is created to be used in a standard web browser.

## 8.5 Recommendations for Future Work

This thesis has shown that the browsing experience on an individual can be partly predicted by examining a combination of their Internet and cognitive factors. This focus therefore opens up a number of areas for research potential. Areas which should receive attention in the future are detailed below

*Alternative Cognitive Testing*. The major constraint in using cognitive metrics as a method of tailoring systems is the amount of testing needed to obtain information about an individual. An area of particular interest is therefore in the development of methods that can quickly and accurately gather cognitive information about an individual to then be used to aid in customizing interfaces.

*Using Full Cognitive Models*. In this thesis, any suggestions regarding interface improvements have been made when looking at a single cognitive characteristic (for example, low fluid intelligence). While this is beneficial in creating adaptations to suit a particular user group, it does not take into account the full range of cognitive characteristics of an individual and only concentrates on one specific aspect. The use of a full cognitive model when analyzing user performance may be more beneficial in creating adaptations that could aid users on a more personal level. For example, instead of analyzing an individuals Internet experience and perceptual speed separately, an analysis of these factors concurrently may provide a larger insight into how these abilities interact to effect user performance.

*Contextually Aware Adaptions* – If a system was to exist that could adapt to an individuals cognitive needs, one of the next steps that would be required would be to create further adaptions based on the task that a user is performing. This area will be extremely difficult as there are a large number of unknowns surrounding developing an inference of user task intent, however a combination of gathering information from user search inquiries and an analysis of previous user behavior may provide information that could perform user adaptions that could aid both their individual cognitive profile's and also in creating a better browsing experience for the task being completed.

## 8.6 Final Remarks

This thesis has explored the use of individual's Internet and cognitive metrics as an alternative to age when carrying out website usability studies. The main finding to arise from this work is that when subjective metrics such as participant feelings, or browsing experience are being measured, age is not a suitable metric to distinguish between users. This work suggests that Internet confidence and perceptual speed are suitable alternatives to measure differences in user browsing experience, and that these measures should be used in future usability research as an alternative to participant age when grouping individuals.

## Further Acknowledgments

One of the most interesting parts of the PhD process over the last four years that I've loved the most is the ability to continuously ask 'why' when presented with a statement. I'm sure that this is something that I've been brought up to enjoy doing – *"why does the light turn on when I flick this switch, why does it go off when I flick it the other way, why do you look annoyed Dad?"* For this, two of the main people that I want to thank more than anything else is my parents; Margret and John Crabb. Without their continued help and support I would not be able to do half of the things that I could do today - Mum has always said that she taught me everything I know!

Secondly, a big thank you has to go to my amazing sister Jillian, she is one of the few people that finds it easy to put me in my place, continuously reminding me that even though she is younger than me, she had graduated two times before I even completed my undergraduate degree – and this is why her picture deserves to be higher on the wall! I have other opinions.

Finally, again I would like to say thank you to the supervision that I have received over the last 4 years from Vicki Hanson. Vicki is more than anyone could ever wish for in a supervisor, and this whole process would have been a million times more difficult without all of the guidance and support that she has provided. I am eternally grateful for all of the time that she has given over the last four years and also during my undergraduate degree.

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# Appendix A. Consent Forms and Ethical Approval

## Chapter 4 Ethical Information

**Ethical Approval - Supplemental Form**

This form has been created to give further information into the ethics being employed by Michael Crabb within research detailed in the '*University of Dundee-School of Computing Ethics Committee Approval Form*'.

### 1. Purpose of Project and Academic Rationale

The purpose of this research study is to look at the methods that people use in searching for information online and the different tools that are available for their use. Specifically, this study will look at comparing methods of aiding users in searching for information and how the combination of these tools can be used to supplement users searching activities

### 2. Methods and Measurements

**Methods and Measurement Description**

The research will be done through the form of individual interviews, asking users about how they search for information online. This will be followed by an interactive activity on a computer that has been previously prepared with all of the above tools. Users will be asked to search for different pieces of information and come up with sites that they deem to be relevant and non-relevant to the subject.

**Omitting Questions**

Participants are informed that if they do no wish to answer any questions they are free to do so. This is included in the consent form.

### 3. Participant Information

**Recruitment Methods**

Participants will be recruited from the SiDE user pool. Recruitment will be done by Ms Marianne Dee. This is detailed more within the attached 'SiDE Hub Researchers: Research Pool Request Form'

**Number**

3 for initial pilot study
17 for main study

**Age**

Users aged 60+

**Gender**

A mixture of 50/50 male/female participants ±10%

**Exclusion/inclusion Criteria**

**Exclusion**
Users must NOT be wearing bi-focal lenses for this study as it will adversely effect the eye tracking system
**Inclusion**
Users must have gone through the 'group measures' that are performed as part of an introduction to the work of the SiDE user pool

This work has been funded by the SiDE project as part of the RCUK Digital Economy Program (EP/G066019/1).

### 4. Participant Consent/information arrangements/debriefing

**Informed Consent**

Participants are informed that their participation is voluntary. This is included in the consent form.

**Participant Information Readability**

| | |
|---|---|
| **Consent Form**<br>Flesch Reading Ease: **61.5**<br>Flesch-Kincaid Grade Level: **8.4** | **Information Sheet**<br>Flesch Reading Ease: **59.1**<br>Flesch-Kincaid Grade Level: **10.9** |
| **Participant Requitment QRS**<br>Flesch Reading Ease: **59.5**<br>Flesch-Kincaid Grade Level: **10.4** | |

**Participant Withdrawal**

Participants are informed that they may withdraw from the research at any time without penalty and for any reason. This is included within the consent form.

**Data Confidentiality**

Data is treated with full confidentiality under DPA (1998) and if published, will not be identifiable by individual participants. This is included within the consent form.

**Participant Debriefing**

Participants will be debriefed at the end of their participation.

### 5. Physical or Psychological Distress

It is not expected that participants will be put through any physical or psychological distress or discomfort during this research study

### 6. Misleading of Participants

Participants will not be mislead any time during this study, they will be told at the beginning of their participation what the aim of the study is.

### 7. Disclosure Scotland Requirements

This research study does not require Disclosure Scotland as no work is being done with young people or vulnerable adults.

This work has been funded by the SiDE project as part of the RCUK Digital Economy Program (EP/G066019/1).

UNIVERSITY OF DUNDEE

School of Computing

*Dean*
Dr Janet Hughes

7 April 2011

Dear Mr Crabb,

Thank you for submitting your study for approval by the School of Computing Ethics Committee (SOCEC). Your application has been examined and any comments/concerns noted on the feedback form that accompanies this letter.

Please act on all feedback and do enlist the expertise of your supervisor (who has a copy of this information) when considering any/all modifications that you are required to make.

I trust that the feedback provided will enable you to maintain the ethical standards of the School of Computing and if you require further support then do get in touch.

I. W. R.

Professor Ian W. Ricketts FBCS FRSA FRSM
Chair of the SoC Ethics Committee
Email: ethics@computing.dundee.ac.uk

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## *Chapter 5 and 6 Ethical Information*

Form ECa- 2008v4

**UNIVERSITY OF DUNDEE**
**SCHOOL OF COMPUTING ETHICS COMMITTEE APPROVAL FORM**

Title of project: Understanding Older Adults Search Habits________________________

Name of Lead Investigator (Student in case of project work) Michael Crabb________________

Module Code if applicable n/a ___________ Module Name n/a ______________________

Research Supervisor / Other Academic Staff involved Prof. Vicki Hanson ________________

Email address michaelcrabb@computing.dundee.ac.uk
Funding Body (if applicable) SiDE ______________

Estimated start date 1/6/12__________________ Estimated end date 1/1/13____________________

Date submitted 1/5/12 _______________________ SoCEC Ref no. (LEAVE BLANK) ________________

**DECLARATION:**

I have read and understand the University of Dundee Guidelines for ethical practices in research and the School of Computing Code of Practice for Research involving Human Participants. I confirm that my research abides by these guidelines.

Print Name Michael Crabb............................................. Date 1/5/12 .............................................
(Lead Investigator)

## PART A

The declaration above confirms that you will:

- Provide an information sheet to participants which describes the main procedures to participants in advance so that they are informed about what to expect;
- Tell participants that their participation is voluntary (both in information sheets and consent forms);
- Obtain written informed consent for participation and provide participants with a copy;
- Ask participants for their consent to being observed, should the research be observational;
- Ensure that participants are able to read and understand the participant information sheet;
- Tell participants that they may withdraw from the research at any time without penalty and for any reason;
- Give participants the option of omitting questions they do not want to answer if a questionnaire is used;
- Tell participants that their data will be treated with full confidentiality and that, if published, it will not be identifiable as theirs;
- Tell participants that all recordings, e.g. audio/video/photographs, will not be identifiable unless prior written permission has been given by the participants;
- Debrief participants at the end of their participation (i.e. give them a brief explanation of the study).

## PART B

Please answer the following questions:

| | | | YES | NO |
|---|---|---|---|---|
| 1 | Will your project involved deliberately misleading participants in any way? | | | x |
| 2 | Is there any realistic risk of any participants experiencing either physical or psychological distress or discomfort? If Yes, give details on a separate sheet and state what you will tell them to do if they should experience any problems (e.g. who they can contact for help). | | | x |
| 3 | Do participants fall into any of the following special groups?<br><br>Note that you will also need to obtain satisfactory Disclosure Scotland (or equivalent) clearance when working with vulnerable people. | Children (under 18 years of age) | | x |
| | | People with Intellectual or communication difficulties | | x |
| | | People in custody | | x |
| | | People engaged in illegal activities (e.g. drug-taking) | | x |
| | | Non-human animals | | x |
| | | NHS Patients | | x |

If you have ticked YES to any of questions above, you must provide the information listed below as a separate attachment:

1. Title of project.
2. Purpose of project and its academic rationale.
3. Brief description of methods and measurements.
4. Participants: recruitment methods, number, age, gender, exclusion/inclusion criteria.
5. Consent and participant information arrangements, debriefing.
6. A clear but concise statement of the ethical considerations raised by the project and how you intend to deal with them.
7. Information and consent forms (See code of practice for examples).
8. If external ethical approval has been granted, please attach approval letter.

## PART C

If you have ticked NO to all the questions in part B above, you must attach to this application *copies of the information and consent forms which you will intend to give to participants* **(See code of practice for examples)**. You must also complete the box below.

| | |
|---|---|
| I consider that this project has **no** significant ethical implications to be brought before the Ethics Committee. | |

80 Participants will be recruited from the SiDE user pool and will either have carried out SiDE battery testing or will be tested as part of the study (ethical approval for battery testing has already been granted). Participant age will be split between three groups; younger adult, older adult, older old adult. Gender will be balanced 50/50 and no participants will have any disability.

Participants will be given a set of questions to answer by using a search engine to find information; any question that the participant does not wish to answer can be omitted.

Analysis information for the study will be drawn from previously determined SiDE battery scores, and also the created 'browser history file' made by the participant during the study.

Participants will be given a combined information sheet and consent form (attached) before the beginning of the study. All data will be treated anonymously. Participants will be debriefed at the end of the study.

**There is an obligation on the lead researcher to bring to the attention of the Ethics Committee any issues with ethical implications not clearly covered by the above checklist.**

Email this form and accompanying attachments as a zip file with your name and date submitted to ethics@computing.dundee.ac.uk

## Searching for Information on the Internet

There are many different reasons that someone would wish to use a search engine, one of the most common of these is to find out information online - or to answer a specific question that they may have. Today, you will be given a list of questions and asked to find the answer to these by searching for information online.

Questions will be given to you on a piece of paper and some of the questions might be a little bit difficult to answer, or may take more time to find the right information. The questions are given in a random difficulty order, so don't worry if they take different times to answer.

By signing this form, you consent to be a participant in the research project on the topic of search engine use. This research will be conducted by Mr. Mike Crabb.

Your responses will be kept strictly confidential. If at any time during the session you feel unable or unwilling to continue, you are free to leave. If you not wish to answer any particular question or questions, you are free to decline. Your name will not be linked with the research materials, and will not be made public in any report produced by the researcher.

If you have any questions about this research, these will be answered as best as possible. After todays study, if you require further information, please contact either

| | | |
|---|---|---|
| Michael Crabb | (PhD Student) | michaelcrabb@computing.dundee.ac.uk |
| Prof Vicki Hanson | (Primary Supervisor) | vlh@computing.dundee.ac.uk |

If you have any comments or concerns about the ethics procedures employed in this study, you can contact:

Dr Annalu Walker (Convener of Ethics Committee) ethics@computing.dundee.ac.uk

If you consent to participate in this study, please sign below. You will also be given a copy of this form to keep for your own records

____________________________ _____________________
Participant's Signature Date

I have explained the research procedure in which the participant has consented to participate. Furthermore, I will retain one copy of the informed consent form for my records.

____________________________ _____________________
Principal Investigator Date

This work has been funded by the SiDE project as part of the RCUK Digital Economy Program (EP/G066019/1).

UNIVERSITY OF DUNDEE

School of Computing

*Dean*
Dr Janet Hughes

Ethics Committee
*Convener*
Dr Annalu Waller
*Administrator*
Mrs Kathleen Cummins

Date: 18 May 2012

Michael Crabb
School of Computing
University of Dundee

Dear Michael

***Full title of study:*** Understanding Older Adults Search Habits

***SoCEC reference number: 12/013***

Thank you for submitting an ethics application on 2 May. Your application was reviewed by the committee.

**Ethical issues arising from the proposed study**

You have indicated that no significant ethical issues arise from this project. The Ethics Committee has approved this study.

However:

please confirm the upper and lower age limits of younger adults, older adults and older old participant groups;

please ensure the consent form explicitly states that participation is voluntary;

please discuss with your supervisor exactly what data you are storing and get her approval – the description in the form is very vague.

(An observation – the consent form includes space for signature of the Principal Investigator, but this term is not explained in the consent form, which mentions a PhD Student and Primary Supervisor. It's assumed the PhD student will be the researcher counter-signing the consent form, so may be worth ensuring consistency between terms used to describe the research team.)

Please discuss the above with your supervisor and have the changes agreed with her.

**Conditions of approval**

By submitting an application to the Ethics Committee you confirm that you have read and understand the University of Dundee Guidelines for Ethical Practices in Research and the School of Computing Code of Practice for Research involving Human Participants and undertake to abide by these guidelines. Permission is therefore granted for you to proceed with the study *on condition that you discuss the above with your supervisor.*

Administrator: Mrs Kathleen Cummins
*email* ethics@computing.dundee.ac.uk *telephone* 01382 386532

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*Dean*
Dr Janet Hughes



Please inform the committee of any change in project methodology which may have ethical implications.

Best wishes for your research,

Yours sincerely

Dr Annalu Waller MBCS MIPEM
Professor
Convener: School of Computing Ethics Committee

Administrator: Mrs Kathleen Cummins
*email* ethics@computing.dundee.ac.uk *telephone* 01382 386532

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## Chapter 7 Ethical Information

As the study detailed in Chapter 7 was very similar in methodology to that of previous studies, ethical approval was obtained as a *time extension to previous work.*

**From:** **Kathleencummins** kcummins@computing.dundee.ac.uk
**Subject:** RE: SoCEC Ref 12/013 - Time Extension
**Date:** 11 December 2012 15:31
**To:** **michaelcrabb** michaelcrabb@computing.dundee.ac.uk, **ethics** ethics@computing.dundee.ac.uk

Dear Mike
Thank you for the updated documents. Since the changes only pertain to a time extension there is no need for further ethical approval.
Many thanks
Kathleen

Kathleen Cummins
phone: +44 (0)1382 386532

---

**From:** michaelcrabb
**Sent:** 11 December 2012 15:19
**To:** ethics
**Subject:** SoCEC Ref 12/013 - Time Extension

Hi Kathleen,

Please see attached for forms regarding extending the time period on ethics submission *12/013*.

Attached is the approval PDF from the first time, along with updated consent form and ECa-2006 form. ECa-2006 and consent form have been updated to address issues arising from previous study.

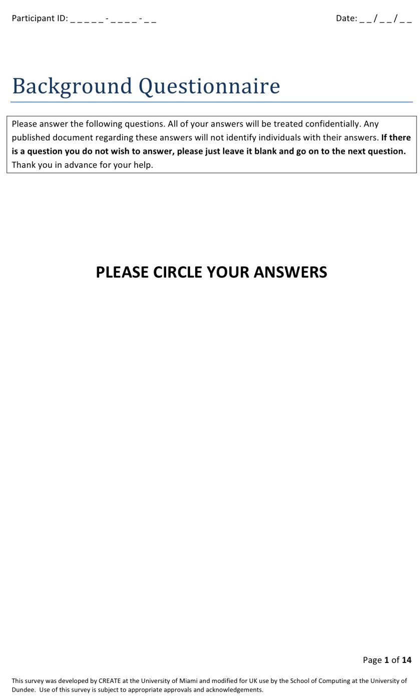
Let me know if there's anything else.

Thanks
Mike

# Appendix B. **Testing Battery**

## *Background Questionnaire*

The background questionnaire is used to gain demographic information and attitudes towards computer information from participants. Created by Professor Vicki Hanson and Dr. Lorna Gibson in collaboration with the CREATE project. Developed to be used in SiDE user testing.


Participant ID: _ _ _ _ _ - _ _ _ _ - _ _ Date: _ _ / _ _ / _ _

Background Questionnaire

Please answer the following questions. All of your answers will be treated confidentially. Any published document regarding these answers will not identify individuals with their answers. **If there is a question you do not wish to answer, please just leave it blank and go on to the next question.** Thank you in advance for your help.

**PLEASE CIRCLE YOUR ANSWERS**

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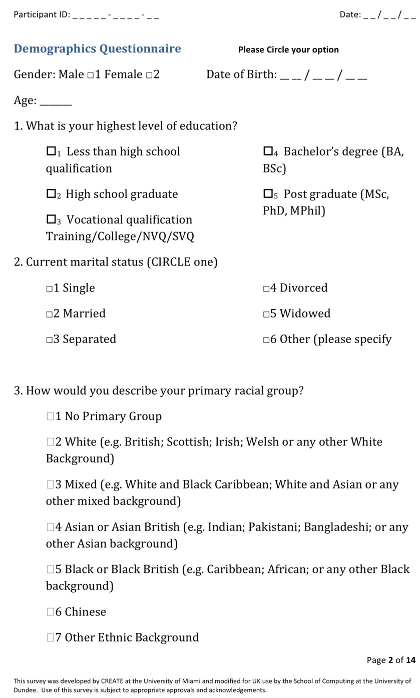
Participant ID: _ _ _ _ _ - _ _ _ _ - _ _ Date: _ _ / _ _ / _ _

**Demographics Questionnaire** **Please Circle your option**

Gender: Male □1 Female □2 Date of Birth: _ _ / _ _ / _ _

Age: ______

1. What is your highest level of education?

- □1 Less than high school qualification
- □2 High school graduate
- □3 Vocational qualification Training/College/NVQ/SVQ
- □4 Bachelor's degree (BA, BSc)
- □5 Post graduate (MSc, PhD, MPhil)

2. Current marital status (CIRCLE one)

- □1 Single
- □2 Married
- □3 Separated
- □4 Divorced
- □5 Widowed
- □6 Other (please specify

3. How would you describe your primary racial group?

- □1 No Primary Group
- □2 White (e.g. British; Scottish; Irish; Welsh or any other White Background)
- □3 Mixed (e.g. White and Black Caribbean; White and Asian or any other mixed background)
- □4 Asian or Asian British (e.g. Indian; Pakistani; Bangladeshi; or any other Asian background)
- □5 Black or Black British (e.g. Caribbean; African; or any other Black background)
- □6 Chinese
- □7 Other Ethnic Background

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Participant ID: _ _ _ _ _ - _ _ _ _ - _ _ Date: _ _ / _ _ / _ _

4. In which type of housing do you live?

☐ 1 Student Accommodation
2 House / Flat / Apartment
3 Senior housing (independent)
4 Sheltered Housing
☐5 Nursing home
☐6 Relative's home
☐7 Other (please specify) ________________

5. What is your primary mode of transportation? (**Circle one only**)

☐1 Drive my own vehicle
☐2 A friend or family member takes me to places I need to go
☐3 Transportation service provided by where I live
☐4 Use public transportation (e.g., bus, taxi)

### Occupational Status

6. What is your primary occupational status? (**Circle one only**)

☐1 Work full-time
☐2 Work part-time
☐3 Student
☐4 Homemaker
☐5 Retired
☐6 Volunteer worker
☐7 Seeking employment etc.
☐8 Other (please specify) ________________________

7. Do you currently work for pay?

☐1 Yes, Full-time
☐2 Yes, Part-time
☐3 No

7a. If "Yes", what is your primary occupation? ______________________

### If retired:

8. What was your primary occupation? ____________________

9. What year did you retire? ________________







### Health Information. Please CIRCLE your response.

1. In general, would you say your health is:

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Poor | Fair | Good | Very good | Excellent |

2. Compared to other people your own age, would you say your health is:

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Poor | Fair | Good | Very good | Excellent |

3. How satisfied are you with your present health?

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Not at all satisfied | Not very satisfied | Neither satisfied nor dissatisfied | Somewhat satisfied | Extremely satisfied |

4. How often do health problems stand in the way of your doing the things you want to do?

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Never | Seldom | Sometimes | Often | Always |







### Computer Questionnaire 1 Please CIRCLE your response.

1. I feel comfortable with computers.

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Strongly Agree | Agree | Neither agree nor disagree | Disagree | Strongly Disagree |

2. Learning about computers is a worthwhile and necessary subject.

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Strongly Agree | Agree | Neither agree nor disagree | Disagree | Strongly Disagree |

3. Reading or hearing about computers would be (is) boring.

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Strongly Agree | Agree | Neither agree nor disagree | Disagree | Strongly Disagree |

4. I know that if I worked hard to learn about computers, I could do well.

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Strongly Agree | Agree | Neither agree nor disagree | Disagree | Strongly Disagree |

5. Computers make me nervous.

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Strongly Agree | Agree | Neither agree nor disagree | Disagree | Strongly Disagree |







11. I think I am capable of learning to use a computer.

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Strongly Agree | Agree | Neither agree nor disagree | Disagree | Strongly Disagree |

12. Learning about computers is a waste of time.

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Strongly Agree | Agree | Neither agree nor disagree | Disagree | Strongly Disagree |

13. Computers are confusing.

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Strongly Agree | Agree | Neither agree nor disagree | Disagree | Strongly Disagree |

14. Computers make me feel stupid.

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Strongly Agree | Agree | Neither agree nor disagree | Disagree | Strongly Disagree |

15. Given a little time and training, I know I could learn to use a computer.

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Strongly Agree | Agree | Neither agree nor disagree | Disagree | Strongly Disagree |

Have you had any experience with computers? CIRCLE your response:

☐1 Yes ☐2 No

If NO, skip rest of questionnaire.

6. I don't care to know more about computers.

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Strongly Agree | Agree | Neither agree nor disagree | Disagree | Strongly Disagree |

7. Computers would be (are) fun to use.

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Strongly Agree | Agree | Neither agree nor disagree | Disagree | Strongly Disagree |

8. I don't feel confident about my ability to use a computer.

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Strongly Agree | Agree | Neither agree nor disagree | Disagree | Strongly Disagree |

9. Computers are not too complicated for me to understand.

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Strongly Agree | Agree | Neither agree nor disagree | Disagree | Strongly Disagree |

10. I think I am the kind of person who would learn to use a computer well.

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Strongly Agree | Agree | Neither agree nor disagree | Disagree | Strongly Disagree |







### Computer Questionnaire 2

Listed below are a series of statements that reflect the way that people feel about their experience(s) with computers. Please indicate whether you agree or disagree with each statement by CIRCLING the appropriate response.

1. When using a computer, I prefer to learn through trial and error.

| 1 | 2 | 3 | 4 | 5 | N/A |
|---|---|---|---|---|---|
| Strongly Disagree | Mostly Disagree | Uncertain | Mostly Agree | Strongly Agree | Not Applicable |

2. In the past, computers have made my task(s) far simpler.

| 1 | 2 | 3 | 4 | 5 | N/A |
|---|---|---|---|---|---|
| Strongly Disagree | Mostly Disagree | Uncertain | Mostly Agree | Strongly Agree | Not Applicable |

3. I have generally enjoyed learning how to use computer software.

| 1 | 2 | 3 | 4 | 5 | N/A |
|---|---|---|---|---|---|
| Strongly Disagree | Mostly Disagree | Uncertain | Mostly Agree | Strongly Agree | Not Applicable |

4. In situations where I have had to learn how to use a computer system, I have found the operating manuals difficult to understand.

| 1 | 2 | 3 | 4 | 5 | N/A |
|---|---|---|---|---|---|
| Strongly Disagree | Mostly Disagree | Uncertain | Mostly Agree | Strongly Agree | Not Applicable |







5. I feel inadequate when receiving training at the computer.

| 1 | 2 | 3 | 4 | 5 | N/A |
|---|---|---|---|---|---|
| Strongly Disagree | Mostly Disagree | Uncertain | Mostly Agree | Strongly Agree | Not Applicable |

6. I usually get frustrated when using a computer.

| 1 | 2 | 3 | 4 | 5 | N/A |
|---|---|---|---|---|---|
| Strongly Disagree | Mostly Disagree | Uncertain | Mostly Agree | Strongly Agree | Not Applicable |

7. In the past I have felt anxious when required to use certain software.

| 1 | 2 | 3 | 4 | 5 | N/A |
|---|---|---|---|---|---|
| Strongly Disagree | Mostly Disagree | Uncertain | Mostly Agree | Strongly Agree | Not Applicable |

8. I am reluctant to ask for help when using a computer.

| 1 | 2 | 3 | 4 | 5 | N/A |
|---|---|---|---|---|---|
| Strongly Disagree | Mostly Disagree | Uncertain | Mostly Agree | Strongly Agree | Not Applicable |

9. I enjoy exploring new applications/uses for the computer or software.

| 1 | 2 | 3 | 4 | 5 | N/A |
|---|---|---|---|---|---|
| Strongly Disagree | Mostly Disagree | Uncertain | Mostly Agree | Strongly Agree | Not Applicable |







10. Other people seem to be more skilful at using a computer than myself.

| 1 | 2 | 3 | 4 | 5 | N/A |
|---|---|---|---|---|---|
| Strongly Disagree | Mostly Disagree | Uncertain | Mostly Agree | Strongly Agree | Not Applicable |

11. I usually get frustrated when using certain software.

| 1 | 2 | 3 | 4 | 5 | N/A |
|---|---|---|---|---|---|
| Strongly Disagree | Mostly Disagree | Uncertain | Mostly Agree | Strongly Agree | Not Applicable |

12. From past experience, I would prefer to learn a new computer software package on my own.

| 1 | 2 | 3 | 4 | 5 | N/A |
|---|---|---|---|---|---|
| Strongly Disagree | Mostly Disagree | Uncertain | Mostly Agree | Strongly Agree | Not Applicable |

13. I am usually curious to use the latest version computer software.

| 1 | 2 | 3 | 4 | 5 | N/A |
|---|---|---|---|---|---|
| Strongly Disagree | Mostly Disagree | Uncertain | Mostly Agree | Strongly Agree | Not Applicable |

14. Computer support staff talk in computer jargon with which I am unfamiliar.

| 1 | 2 | 3 | 4 | 5 | N/A |
|---|---|---|---|---|---|
| Strongly Disagree | Mostly Disagree | Uncertain | Mostly Agree | Strongly Agree | Not Applicable |

Participant ID: _ _ _ _ _ - _ _ _ _ - _ _ Date: _ _ / _ _ / _ _

15. I have not received sufficient training at the computer.

| 1 | 2 | 3 | 4 | 5 | N/A |
|---|---|---|---|---|---|
| Strongly Disagree | Mostly Disagree | Uncertain | Mostly Agree | Strongly Agree | Not Applicable |

16. Instead of asking for assistance with a computer-related problem, I prefer to try and solve it myself.

| 1 | 2 | 3 | 4 | 5 | N/A |
|---|---|---|---|---|---|
| Strongly Disagree | Mostly Disagree | Uncertain | Mostly Agree | Strongly Agree | Not Applicable |

17. When seeking advice from computer support staff (technician), I am often unable to state clearly what my query or question is about.

| 1 | 2 | 3 | 4 | 5 | N/A |
|---|---|---|---|---|---|
| Strongly Disagree | Mostly Disagree | Uncertain | Mostly Agree | Strongly Agree | Not Applicable |

18. I often feel scared when using a computer.

| 1 | 2 | 3 | 4 | 5 | N/A |
|---|---|---|---|---|---|
| Strongly Disagree | Mostly Disagree | Uncertain | Mostly Agree | Strongly Agree | Not Applicable |

19. When I seek advice about a computer-related question, I feel stupid when I am told that the answer is simple.

| 1 | 2 | 3 | 4 | 5 | N/A |
|---|---|---|---|---|---|
| Strongly Disagree | Mostly Disagree | Uncertain | Mostly Agree | Strongly Agree | Not Applicable |

Page **11** of **14**



Participant ID: _ _ _ _ _ - _ _ _ _ - _ _ Date: _ _ / _ _ / _ _

20. I often feel concerned that I might do damage to the computer if I make a mistake.

| 1 | 2 | 3 | 4 | 5 | N/A |
|---|---|---|---|---|---|
| Strongly Disagree | Mostly Disagree | Uncertain | Mostly Agree | Strongly Agree | Not Applicable |

21. I feel incompetent when having to ask for computer assistance.

| 1 | 2 | 3 | 4 | 5 | N/A |
|---|---|---|---|---|---|
| Strongly Disagree | Mostly Disagree | Uncertain | Mostly Agree | Strongly Agree | Not Applicable |

22. The training I have received in computer usage has been very beneficial.

| 1 | 2 | 3 | 4 | 5 | N/A |
|---|---|---|---|---|---|
| Strongly Disagree | Mostly Disagree | Uncertain | Mostly Agree | Strongly Agree | Not Applicable |

23. When I cannot understand how to use computer software, I evaluate my own performance in a negative way.

| 1 | 2 | 3 | 4 | 5 | N/A |
|---|---|---|---|---|---|
| Strongly Disagree | Mostly Disagree | Uncertain | Mostly Agree | Strongly Agree | Not Applicable |

24. I feel quite powerless when I am being instructed to use a computer or computer software for the first time.

| 1 | 2 | 3 | 4 | 5 | N/A |
|---|---|---|---|---|---|
| Strongly Disagree | Mostly Disagree | Uncertain | Mostly Agree | Strongly Agree | Not Applicable |

Page **12** of **14**



Participant ID: _ _ _ _ _ - _ _ _ _ - _ _ Date: _ _ / _ _ / _ _

25. In the past, computer education has facilitated my understanding of computer software capabilities.

| 1 | 2 | 3 | 4 | 5 | N/A |
|---|---|---|---|---|---|
| Strongly Disagree | Mostly Disagree | Uncertain | Mostly Agree | Strongly Agree | Not Applicable |

26. In the past, I have had insufficient time at work to learn to use computer software.

| 1 | 2 | 3 | 4 | 5 | N/A |
|---|---|---|---|---|---|
| Strongly Disagree | Mostly Disagree | Uncertain | Mostly Agree | Strongly Agree | Not Applicable |

27. I often feel isolated from other people when using a computer.

| 1 | 2 | 3 | 4 | 5 | N/A |
|---|---|---|---|---|---|
| Strongly Disagree | Mostly Disagree | Uncertain | Mostly Agree | Strongly Agree | Not Applicable |

28. Most computer manuals need to be read from front to back to be understood.

| 1 | 2 | 3 | 4 | 5 | N/A |
|---|---|---|---|---|---|
| Strongly Disagree | Mostly Disagree | Uncertain | Mostly Agree | Strongly Agree | Not Applicable |

29. In the past, computer training has improved my ability to use computer software.

| 1 | 2 | 3 | 4 | 5 | N/A |
|---|---|---|---|---|---|
| Strongly Disagree | Mostly Disagree | Uncertain | Mostly Agree | Strongly Agree | Not Applicable |

Page **13** of **14**



Participant ID: _ _ _ _ _ - _ _ _ _ - _ _ Date: _ _ / _ _ / _ _

30. I feel more at ease using a computer when alone than with a group of people.

| 1 | 2 | 3 | 4 | 5 | N/A |
|---|---|---|---|---|---|
| Strongly Disagree | Mostly Disagree | Uncertain | Mostly Agree | Strongly Agree | Not Applicable |

31. When I encounter a computer-related problem that I cannot resolve myself, I feel comfortable about asking an expert.

| 1 | 2 | 3 | 4 | 5 | N/A |
|---|---|---|---|---|---|
| Strongly Disagree | Mostly Disagree | Uncertain | Mostly Agree | Strongly Agree | Not Applicable |

Page **14** of **14**

# Internet Usage and Experience Questionnaire

ID: __ __ __ __ __ - __ __ - __ __    Assessor: __ __ __ __    Date: __ __ / __ __ / __ __

**INTERNET QUESTIONNAIRE**

***Please indicate your agreement to the following statements by placing a CROSS in the appropriate box.***

1. **I feel confident getting on the Internet.**

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Strongly Agree | Agree | Neither Agree nor Disagree | Disagree | Strongly Disagree |

2. **I feel confident setting the home page on my web browser.**

| Strongly Agree | Agree | Neither Agree nor Disagree | Disagree | Strongly Disagree |
|---|---|---|---|---|

3. **I feel confident getting to desired web pages using links.**

| Strongly Agree | Agree | Neither Agree nor Disagree | Disagree | Strongly Disagree |
|---|---|---|---|---|

4. **I feel confident using the "Back" button to return to previous web pages.**

| Strongly Agree | Agree | Neither Agree nor Disagree | Disagree | Strongly Disagree |
|---|---|---|---|---|

5. **I feel confident scrolling around a web page.**

| Strongly Agree | Agree | Neither Agree nor Disagree | Disagree | Strongly Disagree |
|---|---|---|---|---|

6. **I feel confident using Internet search engines such as Yahoo, Google, and MSN.**

| Strongly Agree | Agree | Neither Agree nor Disagree | Disagree | Strongly Disagree |
|---|---|---|---|---|

7. **I feel confident using the Internet to find information about a topic.**

| Strongly Agree | Agree | Neither Agree nor Disagree | Disagree | Strongly Disagree |
|---|---|---|---|---|

8. **I feel confident selecting the right words for an Internet search.**

| Strongly Agree | Agree | Neither Agree nor Disagree | Disagree | Strongly Disagree |
|---|---|---|---|---|

Page 1 of 6



ID: __ __ __ __ __ - __ __ - __ __    Assessor: __ __ __ __    Date: __ __ / __ __ / __ __

9. **I feel confident accessing a web page by typing the URL address.**

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Strongly Agree | Agree | Neither Agree nor Disagree | Disagree | Strongly Disagree |

10. **I feel confident using email.**

| Strongly Agree | Agree | Neither Agree nor Disagree | Disagree | Strongly Disagree |
|---|---|---|---|---|

11. **I feel confident using attachments in email.**

| Strongly Agree | Agree | Neither Agree nor Disagree | Disagree | Strongly Disagree |
|---|---|---|---|---|

12. **I feel confident using an instant messenger such as Yahoo messenger or AOL messenger.**

| Strongly Agree | Agree | Neither Agree nor Disagree | Disagree | Strongly Disagree |
|---|---|---|---|---|

13. **I feel confident viewing videos online.**

| Strongly Agree | Agree | Neither Agree nor Disagree | Disagree | Strongly Disagree |
|---|---|---|---|---|

14. **I feel confident posting or sharing my videos online.**

| Strongly Agree | Agree | Neither Agree nor Disagree | Disagree | Strongly Disagree |
|---|---|---|---|---|

15. **I feel confident participating in online chats or discussions.**

| Strongly Agree | Agree | Neither Agree nor Disagree | Disagree | Strongly Disagree |
|---|---|---|---|---|

16. **I feel confident using social networking websites like Facebook, MySpace, and Twitter.**

| Strongly Agree | Agree | Neither Agree nor Disagree | Disagree | Strongly Disagree |
|---|---|---|---|---|

Page 2 of 6

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ID: __ __ __ __ __ - __ __ - __ __    Assessor: __ __ __ __    Date: __ __ / __ __ / __ __

***PART 2***

***Indicate your response by TICKING the box that best represents your answer.***

**1) About how often do you use the Internet?**

- ☐ 1. Several times a day
- ☐ 2. About once a day
- ☐ 3. 3-5 days a week
- ☐ 4. 1-2 days a week
- ☐ 5. Every few weeks
- ☐ 6. Less often
- ☐ 7. Never (Skip the rest of the questionnaire)

**2) How often do you use a search engine to find information?**

| 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|
| Everyday | Several times a week | Several times a month | Every few months | Less often | Never |

**3) How often do you use the Internet to look for advice or information about health or healthcare?**

| Everyday | Several times a week | Several times a month | Every few months | Less often | Never |
|---|---|---|---|---|---|

Page 3 of 6

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ID: __ __ __ __ __ - __ __ - __ __    Assessor: __ __ __ __    Date: __ __ / __ __ / __ __

**Type of Internet Use**

**How often do you do the following activities online?**

1) Pay bills or do your banking

| 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|
| Everyday | Several times a week | Several times a month | Every few months | Less often | Never |

2) Get financial info online, such as stock quotes or mortgage interest rates

| Everyday | Several times a week | Several times a month | Every few months | Less often | Never |
|---|---|---|---|---|---|

3) Communicate with friends or family

| Everyday | Several times a week | Several times a month | Every few months | Less often | Never |
|---|---|---|---|---|---|

4) Find information about community events or resources

| Everyday | Several times a week | Several times a month | Every few months | Less often | Never |
|---|---|---|---|---|---|

5) Learn something new (for example, a new language or on-line training)

| Everyday | Several times a week | Several times a month | Every few months | Less often | Never |
|---|---|---|---|---|---|

6) Search for information about employment or jobs

| Everyday | Several times a week | Several times a month | Every few months | Less often | Never |
|---|---|---|---|---|---|

7) Play games or pursue hobbies

| Everyday | Several times a week | Several times a month | Every few months | Less often | Never |
|---|---|---|---|---|---|

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ID: __ __ __ __ __ - __ __ - __ __ Assessor: __ __ __ __ Date: __ __ / __ __ / __ __

8) Find information about TV or radio shows, cultural or entertainment events, or information related to hobbies.

| 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|
| ☐ Everyday | ☐ Several times a week | ☐ Several times a month | ☐ Every few months | ☐ Less often | ☐ Never |

9) Visit a local council or government website

| ☐ Everyday | ☐ Several times a week | ☐ Several times a month | ☐ Every few months | ☐ Less often | ☐ Never |
|---|---|---|---|---|---|

10) Get news or weather information

| ☐ Everyday | ☐ Several times a week | ☐ Several times a month | ☐ Every few months | ☐ Less often | ☐ Never |
|---|---|---|---|---|---|

11) Shopping (for example, purchase products or buy tickets)

| ☐ Everyday | ☐ Several times a week | ☐ Several times a month | ☐ Every few months | ☐ Less often | ☐ Never |
|---|---|---|---|---|---|

12) Get travel info

| ☐ Everyday | ☐ Several times a week | ☐ Several times a month | ☐ Every few months | ☐ Less often | ☐ Never |
|---|---|---|---|---|---|

13) Buy or make a reservation for travel

| ☐ Everyday | ☐ Several times a week | ☐ Several times a month | ☐ Every few months | ☐ Less often | ☐ Never |
|---|---|---|---|---|---|

14) Look for new people to meet

| ☐ Everyday | ☐ Several times a week | ☐ Several times a month | ☐ Every few months | ☐ Less often | ☐ Never |
|---|---|---|---|---|---|

15) Use an online social networking site like MySpace, Facebook or LinkedIn.com

| ☐ Everyday | ☐ Several times a week | ☐ Several times a month | ☐ Every few months | ☐ Less often | ☐ Never |
|---|---|---|---|---|---|





ID: __ __ __ __ __ - __ __ - __ __ Assessor: __ __ __ __ Date: __ __ / __ __ / __ __

16) Look up phone numbers or addresses or get driving directions

| 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|
| ☐ Everyday | ☐ Several times a week | ☐ Several times a month | ☐ Every few months | ☐ Less often | ☐ Never |

17) Look for "how-to," "do-it-yourself" or repair information

| ☐ Everyday | ☐ Several times a week | ☐ Several times a month | ☐ Every few months | ☐ Less often | ☐ Never |
|---|---|---|---|---|---|

18) Look for religious/spiritual info

| ☐ Everyday | ☐ Several times a week | ☐ Several times a month | ☐ Every few months | ☐ Less often | ☐ Never |
|---|---|---|---|---|---|

19) Use online classified ads

| ☐ Everyday | ☐ Several times a week | ☐ Several times a month | ☐ Every few months | ☐ Less often | ☐ Never |
|---|---|---|---|---|---|



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# Cognitive Testing (Group Testing)



## Group Testing







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### Letter Sets Test

Each problem in this test has five sets of letters with four letters in each set. Four of the sets of letters are alike in some way. You are to find the rule that makes these four sets alike. The fifth letter set is different from them and will not fit this rule. Draw an X through the set of letters that is different.

NOTE: The rules will not be based on the sounds of sets of letters, the shapes of letters, or whether letter combinations form words or parts of words.

Examples:

A. NOPQ DEFL ABCD HIJK UVWX

B. NLIK PLIK QLIK THIK VLIK

In Example A, four of the sets have letters in alphabetical order. An X has therefore been drawn through DEFL. In Example B, four of the sets contain the letter L. Therefore, an X has been drawn through THIK.

Your score on this test will be the number of problems marked correctly minus a fraction of the number marked incorrectly. Therefore, it will not be to your advantage to guess unless you are able to eliminate one or more of the letter sets.

You will be allowed 7 minutes for each of the two parts of this test. Each part has 1 page. When you have finished Part 1, STOP. Please do not go on to Part 2 until you are asked to do so.

**DO NOT TURN THIS PAGE UNTIL ASKED TO DO SO.**







**THIS PAGE IS LEFT BLANK INTENTIONALLY**

Participant ID: _____-____-__ Date: __/__/__

## Part 1 (7 minutes)

1. QPPQ HGHH TTTU DDDE MLMM
2. BCDE FGHI JKLM PRST VWXY
3. BVZC FVZG JVZK PWXQ SVZT
4. BCEF FGIJ STWX CDFG PQST
5. BCCB GFFG LMML QRRQ WXXW
6. AAPP CCRR QQBB EETT DDSS
7. ABDC EGFH IJLK OPRQ UVXW
8. CERT KMTV FHXZ BODQ HJPR
9. PABQ SEFT VIJW COPD FUZG
10. CFCR JCVC CGCS CLXC KCWC
11. XDBK TNLL VEGV PFCC ZAGZ
12. CAEZ CEIZ CIOZ CGVZ CAUZ
13. VEBT XGDV ZIFX KXVH MZXJ
14. AFBG EJFK GKHM PSQT RWSX
15. KGDB DFIM KIFB HJMQ LHEC

**DO NOT TURN THIS PAGE UNTIL ASKED TO DO SO.**





Participant ID: _____-____-__ Date: __/__/__

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## Part 2 (7 minutes)

16. ABCX EFGX IJKX OPQX UVWZ
17. LNLV DTFL CLNL HRLL LLWS
18. ABCE EFGI IJKM OPQT UVWY
19. GFFG DCCD STTS RQQR MLLM
20. DCDD HGHH MMLM QQQR WWVW
21. FEDC MKJI DCBA HGFE JIHG
22. BDBB BFDB BHBB BBJB BBLB
23. BDCE FHGI JLKM PRQS TVWU
24. BDEF FHIJ HJKL NPQR SVWX
25. NABQ PEFS RIJV GOPK CUWG
26. DEGF KLHJ NOQP PQSR TURS
27. AOUI CTZR JHTN PBRL RTVH
28. BEPW HJTX KNRZ KOSV WRPM
29. RRBR QQAR FTEF JXIJ SSCS
30. QIFB CGIJ BCOR ZRED JIFC

**DO NOT GO BACK TO PART 1 AND**
**DO NOT GO ON TO ANY OTHER TEST UNTIL ASKED TO DO SO.**





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## Meaningful Memory

This test is a little different from the last test you did. You will first study a list of things, each followed by a word which describes that thing; for example, "coat – warm" or "eyes – blue", etc. After you have studied the list, you will be given an entirely different test, and then, without looking back, you will take a memory test of the list you studied.

There are 20 pairs of things and descriptions which you will study and memorize for 1 ¾ minutes. You will later be given a list of the same things but in a different order. Instead of having only one describing word next to each thing, there will be five. Of the five, you are to pick the word that *means the same or about the same* as the word that described the *thing* in the first list.

*EXAMPLE:* You will study a list like the one below. For practice, try to memorize the following three pairs.

### EXAMPLE STUDY LIST

| THING | DESCRIPTION |
|---|---|
| hammer | excellent |
| rock | rough |
| roof | flat |

Next, you will be given an altogether different task. When you have finished that task, you will be given questions like the following. Again, for practice, do EXAMPLES X, Y, and Z, without looking up at the list above. Mark your answers in the booklet by circling the correct description.

### EXAMPLE TEST

| THING | DESCRIPTION | | | | |
|---|---|---|---|---|---|
| X. rock | a. dirty | b. smooth | c. flat | d. jagged | e. large |
| Y. roof | a. level | b. rough | c. sloping | d. leaky | e. sturdy |
| Z. hammer | a. big | b. rough | c. good | d. small | e. heavy |

The correct answer to EXAMPLE X is *d. jagged*, because rock was described as "rough" in the list you studied, and "jagged" is closest in meaning to "rough." For EXAMPLE Y, the







correct answer is *a. level*, since roof was described first as "flat." and "level" is closest in meaning to "flat." For EXAMPLE Z, the answer is *c. good*.

Therefore, you should have filled in the *d* slot on your booklet for EXAMPLE X, the *a* slot for EXAMPLE Y, and the *c* slot for EXAMPLE Z.

When told to do so, turn the page and study the list of 20 pairs of things and their descriptions. You will be given 1¾ minutes for this.

**STOP**
**PLEASE DO NOT TURN THE PAGE UNTIL INSTRUCTED TO DO SO.**







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## Meaningful Memory Study List

*Study this list until time is called.*

| THING | DESCRIPTION |
|---|---|
| store | busy |
| hospital | nearby |
| street | empty |
| field | wide |
| lake | distant |
| door | hidden |
| bag | heavy |
| truck | dirty |
| house | small |
| table | sturdy |
| cup | full |
| box | flimsy |
| board | cracked |
| floor | moist |
| toy | shiny |
| car | expensive |
| package | fragile |
| chair | hard |
| barn | large |
| ball | clean |

**STOP**
**PLEASE DO NOT TURN THE PAGE UNTIL INSTRUCTED TO DO SO.**





Participant ID: _ _ _ _ _ - _ _ _ _ - _ _ Date: _ _ / _ _ / _ _

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## Number Comparison Test

This is a test to find out how quickly you can compare two numbers and decide whether or not they are the same. If the numbers are the same, go on to the next pair, making no mark on the page. If the numbers are not the same, put an X on the line between them. Several examples are given below with the first few marked correctly. Practice for speed on the others.

| | | | | | |
|---|---|---|---|---|---|
| 659 | _____ | 659 | 7343801 | _____ | 7343801 |
| 73845 | X | 73855 | 18824 | _____ | 18824 |
| 1624 | _____ | 1624 | 705216831 | _____ | 795216831 |
| 438 | X | 436 | 971 | _____ | 971 |
| 4821459 | _____ | 4814259 | 446014721 | _____ | 446014721 |
| 658331 | _____ | 656331 | 5173869 | _____ | 5172869 |
| 11653 | _____ | 11652 | 6430017 | _____ | 6430017 |
| 617439428 | _____ | 617439428 | 518198045 | _____ | 518168045 |
| 1860439 | _____ | 1860439 | 55179 | _____ | 55097 |
| 90776105 | _____ | 90716105 | 63216067 | _____ | 63216057 |

Your score will be the number marked correctly minus the number marked incorrectly. Therefore, it will not be to your advantage to guess unless you have some idea whether or not the numbers are the same.

You will have 1½ minutes for each of the two parts of this test. Each part has one page. When you have finished Part 1, STOP. Please do not go on to Part 2 until you are asked to do so.

**STOP**
**PLEASE DO NOT TURN THE PAGE UNTIL INSTRUCTED TO DO SO.**



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### Part 1 (1½ minutes)

Make an X on the line between the numbers that are not the same.

| | |
|---|---|
| 639 _____ 639 | 414982 _____ 415982 |
| 4714306 _____ 4715306 | 60971 _____ 60971 |
| 65382 _____ 65372 | 16253948 _____ 16253948 |
| 710 _____ 710 | 42018591760 _____ 43018591760 |
| 43210573 _____ 43210573 | 647107569 _____ 647107569 |
| 6182653905221 _____ 6182653905221 | 721532992531 _____ 721582992531 |
| 43270105338 _____ 43276105338 | 341798301 _____ 341798701 |
| 27109816843 _____ 27109816853 | 80537051248 _____ 80537051248 |
| 519605 _____ 519605 | 5911306581491 _____ 5911306581491 |
| 923452170687 _____ 923452170687 | 83614081 _____ 83614081 |
| 370543141 _____ 310543141 | 49471307 _____ 47471307 |
| 2570665292 _____ 2570665292 | 6082649875 _____ 6082647875 |
| 32018591670 _____ 32018691670 | 5930582136 _____ 5730582136 |
| 5471075693 _____ 5471075683 | 236031794137 _____ 236031294137 |
| 621532992531 _____ 621582992531 | 805731195 _____ 805131195 |
| 24179830 _____ 24179830 | 48210435512 _____ 48210435612 |
| 70537051248 _____ 70537057248 | 405176841309 _____ 405176841309 |
| 7361408 _____ 7361708 | 80145349786 _____ 80145349796 |
| 39471307 _____ 39471507 | 53210573 _____ 53210573 |
| 508264987503 _____ 508264987503 | 718265390521 _____ 718265390521 |
| 4930582136 _____ 4930582136 | 5327010538 _____ 5327010538 |
| 136031794137 _____ 136031794137 | 37109816843 _____ 37189816843 |
| 705731195 _____ 705736195 | 619605 _____ 619505 |
| 38210435512 _____ 38210535512 | 123452170687 _____ 123452190687 |

**STOP. PLEASE DO NOT TURN THE PAGE UNTIL INSTRUCTED TO DO SO.**







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### Part 2 (1½ minutes)

Make an X on the line between the numbers that are not the same.

| | |
|---|---|
| 7573 _____ 7573 | 289414 _____ 289414 |
| 347820 _____ 349820 | 17906 _____ 17906 |
| 4951 _____ 4951 | 16719581024 _____ 16719581024 |
| 4573043 _____ 4571043 | 16719581024 _____ 16719581024 |
| 37501243 _____ 37501243 | 3965701746 _____ 3665701746 |
| 125093562816 _____ 125093562816 | 135299235127 _____ 135299235127 |
| 8350107234 _____ 8350107234 | 13897143 _____ 13897145 |
| 34861890172 _____ 3486170172 | 84215073508 _____ 84216073508 |
| 506915 _____ 596915 | 941856031195 _____ 941856431195 |
| 786071254329 _____ 786071255329 | 8041638 _____ 8041438 |
| 41345073 _____ 41345073 | 70317494 _____ 70317494 |
| 925660752 _____ 925660752 | 35789462806 _____ 35789562806 |
| 16719581023 _____ 16717581023 | 6312850395 _____ 6312850795 |
| 3965701745 _____ 3965701745 | 731497130632 _____ 731497130632 |
| 135299235126 _____ 135299235136 | 591137508 _____ 591167508 |
| 13897142 _____ 13897142 | 21553401284 _____ 21553401284 |
| 84215073506 _____ 84215073507 | 1251373807 _____ 1251373307 |
| 941856031194 _____ 941846031194 | 903148671504 _____ 903148671504 |
| 8041637 _____ 8071637 | 68794353108 _____ 68754354108 |
| 70317493 _____ 70317493 | 37501235 _____ 37501235 |
| 35789462805 _____ 35789462805 | 125093562817 _____ 125093562817 |
| 6312850394 _____ 6312850394 | 8350107235 _____ 8350107235 |
| 731497130631 _____ 731497130681 | 34861890173 _____ 34861840173 |
| 591137507 _____ 591127507 | 506916 _____ 506616 |

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## Meaningful Memory

A while ago, you studied a list of 20 things and their descriptions.

Now, without looking back to the study list, try to remember what description went with each thing, and then, from the five words given, choose the one that means the same or nearly the same as the description used in the first list.

If you are not sure of the right answer for an item, mark the choice that is your best guess.

You will have 4 minutes for this test. If you finish before time is called, please STOP. Do not turn to other pages.

**PLEASE DO NOT TURN THE PAGE UNTIL INSTRUCTED TO DO SO.**





Participant ID: _ _ _ _ _ - _ _ _ _ - _ _ Date: _ _ / _ _ / _ _

## Meaningful Memory Test

THING DESCRIPTION

| | | | | | |
|---|---|---|---|---|---|
| 1. cup | a. cracked | b. strong | c. delicate | d. filled | e. tiny |
| 2. field | a. distant | b. broad | c. unoccupied | d. sheltered | e. narrow |
| 3. truck | a. heavy | b. filthy | c. powerful | d. little | e. high-priced |
| 4. chair | a. big | b. breakable | c. dirt-free | d. comfortable | e. firm |
| 5. store | a. vacant | b. bright | c. crowded | d. close | e. cramped |
| 6. floor | a. scratched | b. polished | c. dirty | d. damp | e. broken |
| 7. hospital | a. close | b. crowded | c. vacant | d. far-off | e. clean |
| 8. board | a. split | b. rickety | c. wet | d. smooth | e. narrow |
| 9. car | a. polished | b. broken-down | c. grimy | d. well-built | e. costly |
| 10. street | a. faraway | b. near | c. deserted | d. broad | e. bustling |
| 11. bag | a. hefty | b. covered | c. unclean | d. huge | e. empty |
| 12. ball | a. hollow | b. big | c. light | d. spotless | e. hard |
| 13. table | a. little | b. filled | c. creaky | d. untidy | e. strong |
| 14. barn | a. nearby | b. clean | c. small | d. big | e. well-built |
| 15. door | a. solid | b. concealed | c. distant | d. broad | e. heavy |
| 16. toy | a. bright | b. costly | c. wet | d. broken | e. breakable |
| 17. box | a. strong | b. full | c. weak | d. split | e. hefty |
| 18. lake | a. nearby | b. broad | c. concealed | d. narrow | e. faraway |



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| | | | | | |
|---|---|---|---|---|---|
| 19. house | a. uninhabited | b. tiny | c. untidy | d. well-built | e. roomy |
| 20. package | a. bright | b. large | c. breakable | d. costly | e. light |

**STOP**
**PLEASE DO NOT TURN THE PAGE UNTIL INSTRUCTED TO DO SO.**



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# Appendix C. **Chapter 6 Additional Material**

## *Usability Guidelines*

### Full List of Usability Guidelines

- Lists
- Page Layout
- Navigation
- Scrolling and Paging
- Headings and Titles
- Links
- Text Appearance
- Images
- Writing Content
- Search
- Content Organisation
- Forms

| **Guideline Text** | **a** | **b** | **c** | **d** | **e** | **f** | **g** | **h** | **i** | **j** | **k** | **l** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Use static menus | x | | x | | | | | | | | | |
| Links must be a different colour to non-link text | x | | x | | | | | | | | | |
| Horizontal navigation for getting through the site | x | | x | | | | | | | | | |
| Vertical navigation for going through sections | x | | x | | | | | | | | | |
| Links must be seen as links | x | | x | | | | | | | | | |
| Use breadcrumbs | x | | x | | | | | | | | | |
| Each page should link to the homepage | x | | x | | | | | | | | | |
| Capitalise first letters in lists | x | | | | | | x | | x | | | |
| Order elements in a list | x | | | | | | | | | | | |
| Place most important items at the top of a list | x | | | | | | | | | | | |
| Give each list a heading to introduce it | x | | | | | | | | | | | |
| Blue for non visited, purple for visited | x | | | | | | | | | | | |
| Always underline links | x | | | | | | | | | | | |
| Hover or Focus underline is ok, but always is better | x | | | | | | | | | | | |
| Don't put text in images | x | | | | | | | | | | | |
| Links should be underlined | x | | | | | | | | | | | |
| Different colours for visited and unvisited links | x | | | | | | | | | | | |
| Enable access to the homepage from any page on a website | | x | x | | | | | | | | | |
| Place important items consistently | | x | x | | | | | | | | | |
| Use clickable content on large pages | | x | x | | | | | | | | | |
| Keep navigation only pages short | | x | x | | | | | | | | | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Link to the home page on every page | | x | x | | | | | | | | | |
| Navigation along top of page after banner | | x | x | | | | | | | | | |
| Have a standard footer across all pages | | x | x | | | | | | | | | |
| Use more space for content rather than navigation | | x | x | | | | | | | | | |
| Limit the length of the homepage | | x | | x | | | | | | | | |
| Optimise density for easy scanning | | x | | x | | | | | | | | |
| Make important items stand out for faster scrolling | | x | | x | | | | | | | | |
| Use paging instead of scrolling | | x | | x | | | | | | | | |
| Use a fluid design that supports small screens without horizontal scrolling | | x | | x | | | | | | | | |
| Header at the top of page, 960px width | | x | | | x | | | | | | | |
| Don’t use ALL CAPS | | x | | | | | x | | | | | |
| Logo present in top left corner | | x | | | | | | x | | | | |
| Avoid cluttered displays | | x | | | | | | | | | | |
| Align items | | x | | | | | | | | | | |
| Have appropriate page lengths | | x | | | | | | | | | | |
| Don’t use advertising | | x | | | | | | | | | | |
| Place content consistently | | x | | | | | | | | | | |
| Put most of the content above the fold | | x | | | | | | | | | | |
| Use a single column for text | | x | | | | | | | | | | |
| Use a page index for long pages | | | x | x | | | | | | | | |
| Label click-able images | | | x | | | x | | x | | | | |
| Don’t create pages that have no navigation options | | | x | | | x | | | | | | |
| Make a difference between primary and secondary navigation | | | x | | | x | | | | | | |
| Primary navigation should be in a left panel | | | x | | | x | | | | | | |
| Use descriptive link titles | | | x | | | x | | | | | | |
| Use a site map | | | x | | | x | | | | | | ` |
| Highlight current page in menus | | | x | | | x | | | | | | |
| Use meaningful link titles | | | x | | | x | | | | | | |
| Match link names to their destination pages | | | x | | | x | | | | | | |
| Only underline links | | | x | | | x | | | | | | |
| Include a link to the home page on every page | | | x | | | x | | | | | | |
| Make the site logo link to the home page | | | x | | | x | | | | | | |
| Highlight the current page on the navigation bar | | | x | | | x | | | | | | |
| Make links stand out from standard text | | | x | | | x | | | | | | |
| Make links descriptive when read out by themselves | | | x | | | x | | | | | | |
| Make visited links appear differently | | | x | | | x | | | | | | |
| Don’t use images for navigation | | | x | | | | | x | | | | |
| Limit prose on navigation pages | | | x | | | | | | x | | | |
| Have a search box on every page | | | x | | | | | | | x | | |
| Use breadcrumbs | | | x | | | | | | | | x | |
| Tell users where they are in a website | | | x | | | | | | | | | |
| Make links look like links | | | x | | | | | | | | | |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Don’t use breadcrumbs - they are ineffective | | | x | | | | | | | | |
| Do not have dead end pages | | | x | | | | | | | | |
| Make navigation levels clear | | | x | | | | | | | | |
| Make the navigation bar stand out | | | x | | | | | | | | |
| Avoid drop down menus | | | x | | | | | | | | |
| Don’t use horizontal scrolling | | | | x | | | | | | | |
| Use clear category labels | | | | | x | | x | | | | |
| Have a clear H1 title on every page | | | | | x | | | | x | | |
| Use descriptive headings | | | | | x | | | | | | |
| Use unique headings | | | | | x | | | | | | |
| Clarify if images are clickable | | | | | | x | | x | | | |
| Images that are links should look like buttons | | | | | | x | | x | | | |
| Link text should relate to the page it is going to | | | | | | x | | | x | | |
| Avoid misleading things that are links | | | | | | x | | | | | |
| Use text for links rather than images | | | | | | x | | | | | |
| Make used links a different colour | | | | | | x | | | | | |
| Make links long enough to understand but short enough to minimise wrapping | | | | | x | | | | | | |
| Don’t overdo the number of links | | | | | | | x | | | | |
| Only use one type of link style | | | | | | x | | | | | |
| Breadcrumbs are a good idea | | | | | | x | | | | | |
| Don’t rely on colour for information | | | | | | | x | | x | | |
| Search box present on every page - 27 characters long and white | | | | | | | x | | | x | |
| Use black text on high contrast backgrounds | | | | | | | x | | | | |
| Don’t use ALL CAPS | | | | | | | x | | | | |
| Use bold text sparingly | | | | | | | x | | | | |
| Use familiar fonts | | | | | | | x | | | | |
| Use at least size 12 for reading | | | | | | | x | | | | |
| Verdana as default font | | | | | | | x | | | | |
| Verdana > Helvetica >Arial >San Serif | | | | | | | x | | | | |
| Don’t convey meaning through colour | | | | | | | x | | | | |
| Use Verdana and Arial | | | | | | | x | | | | |
| Align text to the left | | | | | | | x | | | | |
| Use icons to show errors | | | | | | | | x | | | x |
| Use background images sparingly | | | | | | | | x | | | |
| Include logos | | | | | | | | x | | | |
| Images should not look like banner ads | | | | | | | | x | | | |
| Don’t use too many images | | | | | | | | x | | | |
| Avoid using jargon words | | | | | | | | | x | | |
| Use familiar words | | | | | | | | | x | | |
| Define acronyms and abbreviations | | | | | | | | | x | | |
| Limit the number of words and sentences | | | | | | | | | x | | |
| Use an active voice | | | | | | | | | x | | |
| Make first sentences very descriptive | | | | | | | | | x | | |
| Have good readability | | | | | | | | | x | | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Avoid having lots of links in a passage, have a link section | | | | | | | | | x | | | |
| Use lists as opposed to comma separations | | | | | | | | | x | | | |
| Don't use complicated words or phrases | | | | | | | | | x | | | |
| Sentences should be below 21 words | | | | | | | | | x | | | |
| Paragraphs should be below 6 sentences | | | | | | | | | x | | | |
| Provide a search box on every page | | | | | | | | | | x | | |
| Search box should say SEARCH after it | | | | | | | | | | x | | |
| Have a submit button for any search box | | | | | | | | | | x | | |
| Use a logical structure | | | | | | | | | | | x | |
| Group related elements | | | | | | | | | | | x | |
| Minimise the number of pages that are needed to be visited | | | | | | | | | | | x | |
| Distinguish between required and optional controls | | | | | | | | | | | | x |
| Display push buttons clearly | | | | | | | | | | | | x |
| Allow users to see all of their entered data | | | | | | | | | | | | x |
| Label mandatory fields | | | | | | | | | | | | x |
| Server side form validation | | | | | | | | | | | | x |
| Opt in rather than opt out | | | | | | | | | | | | x |
| Avoid multi-column forms | | | | | | | | | | | | x |
| Don't use free text when possible in forms | | | | | | | | | | | | x |
| Put labels to the RIGHT of radio boxes | | | | | | | | | | | | x |
| Use radio buttons and checkboxes | | | | | | | | | | | | x |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |