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Interactive Visualisation for Low Literacy Users

Neesha Kodagoda

A thesis submitted to Middlesex University in partial fulfilment of the requirements for the degree of Doctor of Philosophy

School of Engineering and Information Sciences

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CANDIDATE'S DECLARATION FORM

Name of candidate: **Neesha Kodagoda**

Student number: **M00082863**

Thesis Title: **Interactive Visualisation for Low Literacy Users**

Degree for which thesis is submitted: Doctor of Philosophy (Engineering and Information Sciences)

Statement of associated studies undertaken in connection with the programme of research (Regulation G3.1 refers) While a registered student of the University, I attended the following courses /workshops / conferences:

- 3rd UK Visual Analytics Consortium workshop, (UKVAC 2011), September 7-8, London, UK
- 29th annual CHI conference on Computer-Human Interaction (CHI 2011), May 7-12, Vancouver, Canada
- Visual Analytics Community Consortium meeting, May 3-4, University of Maryland, Washington, USA
- 1st UK Visual analytics summer school (UKVAC 2010), September 16-24, London, UK
- 28th annual conference of the European Association of Cognitive Ergonomics (ECCE 2010), August 24-26, Delft, The Netherlands
- 1st UK Visual Analytics Workshop (VAW 2009), September, London, UK
- 24th BCS Conference on Human Computer Interaction (BCS HCI 2010), September 6-10, Dundee, UK
- 10th Annual Conference of the NZ ACM Special Interest Group on Human-Computer Interaction, (CHINZ 2009). 6-7 July 2009 — Auckland, New Zealand
- 9th bi-annual International Conference on Naturalistic Decision Making (NDM9) – June 23-26, London, UK.
- 53rd Annual Meeting in Human Factors and Ergonomics Society (HFES 2009) - October 19-23, San Antonio, Texas, USA
- 12th IFIP TC13 International Conference on Human-Computer Interaction (INTERACT 2009), August 24-28, Uppsala, Sweden
- European Conference on Cognitive Ergonomics (ECCE 2009) - November 30 – October 2, Helsinki, Finland
- 22nd British HCI Group Annual Conference on (BCS HCI 2008) – September 1-5, Liverpool, UK
- 26th CHI Conference (CHI 2008) – April 5–10, Florence, Italy
- 10th Human-Centred Technology Postgraduate Workshop (2007) - December 6, Brighton, UK

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ABSTRACT

Sixteen percent (5.2 million) of the UK population possess low levels of literacy. The Government and other non-profit organisations, due to funding reforms, are forced to reduce the provision of face-to-face advice, and therefore, are pushing advice services via telephone or internet. As a consequence, low literacy users are experiencing difficulties finding the information they need to solve their day to day problems online. This thesis evaluates how walk in clients of a local Citizens Advice Bureau (CAB) who come to get social service information, obtain information online using the Adviceguide website.

The thesis presents two challenges: (i) knowing the users in a way that can help consider design solutions that are probably not in a typical designer's standard repertoire of design patterns, and (ii) knowing what is the problem that needs to be addressed. It is not simply an issue of usability or the need for simpler language, but understanding that these low literacy users are very different from the high literacy users. These low literacy users need this information to solve their day-to-day problems and are likely to be less successful in doing so. By providing an information architecture that permits them of a reasoning space and context, while supporting less abstract skills by visualized information in an unconventional way. The above challenges leave us with these research questions to address: what is the basis of such a design, how can these designs be incorporated into existing non-traditional interface proof of concept and finally how can these designs be evaluated.

This thesis is dedicated to my grandfather

M K Thomas Perera

who was a senior lecturer

in motor mechanical engineering

at

Royal Army Service Corps & Ceylon Technical College.

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Finally yet importantly, I would like to dedicate this thesis to my grandfather Thomas Perera who unfortunately I never meet face to face. However, his letters to my mother conveyed his expectations that he would like me to grow up and become a doctor. I may have not been able fulfil his exact dreams, but one cannot say I have not tried.

Thank you.

Neesha Kodagoda

Middlesex University

PUBLICATIONS RELATED TO THIS PHD

2012

Kodagoda, N., Wong, W., Roony, C., & Khan, N. (2012). Interactive Visualization for Low Literacy Users: From Lessons Learnt to Design. CHI 2012: 1159-1168.

2011

Wong, W., Chen, R., Kodagoda, N., Rooney, C., & Xu, K. (2011). INVISQUE: intuitive information exploration through interactive visualization. Proceedings of the 2011 annual conference extended abstracts on Human factors in computing systems - CHI EA '11 p. 311.

Wong, W. & Kodagoda, N. (2011). Designing UI for Low Literacy Users: Knowing Your User. Workshop position paper IUI4DR - Intelligent User Interfaces for Developing Regions.

2010

Kodagoda, N., Wong, W., & Khan, N. (2010). Information seeking behaviour model as a theoretical lens: High and low literate users behaviour process analysed as way of informing interface design, ECCE 2010.

Kodagoda, N., Wong, W. & Khan, N. (2010). Open-Card Sort to Explain Why Do Low-Literate Users Abandon their Web Searches Early?, BCS HCI 2010.

2009

Kodagoda, N., Wong, W. & Khan, N. (2009). Identifying Information Seeking Behaviours of Low and High Literacy Users: Combined Cognitive Task Analysis, in the proceedings of the 9th bi-annual international conference on Naturalistic Decision Making, London 2009 (pp 347-354).

Kodagoda, N., Wong, W. & Khan, N. (2009). Behaviour Characteristics: Low and High Literacy Users Information Seeking on Social Service Websites, CHINZ 2009.

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EQUATION

LIST OF ABBREVIATIONS

CAB	Citizens Advice Bureau
CTA	Cognitive task Analysis method
ETA	Emergent Themes Analysis
GT	Grounded Theory
HL	High literacy
LL	Low Literacy

LIST OF DEFINITIONS

Homogeneous	Refer to similar
Heterogeneous	Refer to dissimilar

CHAPTER 1

INTRODUCTION

BACKGROUND

This thesis evaluates an interactive visualisation as a possible support mechanism to assist low literacy (LL) users during online information seeking on e-social websites. The rapid growth of online information over the last few decades presents new challenges. Users are now required to use these online information sources to solve their day-to-day problems.

For the purpose of this thesis, *literacy* is one's ability to read, write and speak depending on the expectations of the social-economic environment the person lives in (Lonsdale & McCurry, 2004)[1].United Nations estimates indicate that over 770 million adults in the world have LL skills and a higher chance of being digitally excluded (UNESCOPRESS, 2005). In the United Kingdom alone, 16% (5.2 million) of the population have low levels of literacy (Williams, Clemens, Oleinikova, & Tarvin, 2003). LL users' reading and comprehension skills are below the UK adult literacy entry level 3 (reading age of eleven years) and below the secondary school level (Kemp & Eagle, 2008).

[1] *Please refer to Appendix A for an in-depth definition and analysis of Literacy. Appendix B for literacy assessment methods; and Appendix C for measurements of readability levels of text.*

Due to the expectation of the environment, these LL users experience anxiety as they try to navigate a world that confounds and intimidates them (Whitaker, 2009). Parsons and Bynner (1998) showed that adults with poor literacy levels compared to high literacy (HL) people were more likely to be unskilled or semi-skilled, had a high chance of being dismissed from work, made redundant and experienced long-term unemployment. LL users have a higher chance of being socially and financially disadvantaged and associated with poor health and low motivation. Consequently, the imbalance between the skills required to find online information and the resources available for the LL users has created a digital divide, hindering the effective participation of the LL users in the digital community. Sir Claus Moser stated that *"[roughly] 20% of adults – that is perhaps as many as 7 million people – have more or less severe problems with basic skills, in particular with what is generally called 'functional literacy' and 'functional numeracy'"* (Metcalf et al., 2009).

The Citizen Advice Bureau (CAB) agreed to collaborate with the research, and consequently this thesis refers to their e-social website *Adviceguide* www.adviceguide.co.uk. The CAB provides free, impartial, confidential, face-to-face advice and information to people who live, work or study in the area regardless of their race, gender or ability level. Information they provide is also available online via the *Adviceguide* website. The CAB provides information about rights, welfare benefits, council housing information, tax credits, debt, education, and employment. The CAB, as many other none profit organisations (NGO), is reducing face-to-face advice, thus, the importance of this research to evaluate LL users' online information seeking behaviour.

IMPLICATIONS OF BEING LOW LITERATE

Government departments and other non-profit organisations place important information on the web whilst reducing face-to-face advice. This becomes a challenge and a disadvantage for the LL users who find using online resources less intuitive (Summers & Summers, 2003). These LL users are likely to require social service information to solve their everyday needs. Those who manage to overcome these initial barriers are challenged by information requiring higher reading skills, navigating hierarchical menu structures and interacting with challenging interfaces presented by different websites (Summers & Summers, 2003). The problem is further complicated as information needed is likely to be scattered across several sources (silos). For example, websites of various government departments such as the Department of Health, Council Services, Work and Pension etc. (Wong, Keith, & Springett, 2005).

> *"In a fair society, all individuals would have equal opportunity to participate in, or benefit from, the use of computer resources regardless of race, sex, religion, age, disability, national origin, or other such similar factors"* (Shneiderman, 2000).

Previous research suggests that LL users were less successful in finding the required information from online searches (Jensen, King, Davis, & Guntzviller, 2010; Summers & Summers, 2003). They exhibited different patterns of behaviour compared to HL users such as reading word-for-word when confronted with long and dense pages, having a narrow field of view, skipping chunks of text, being satisfied with information quickly, and avoiding further searching as it requires spelling skills (Summers & Summers, 2005). A previous study by Kodagoda and Wong (2008), not part of this thesis, identified that LL users spent eight times longer to complete a task when searching for social service information, visited eight times more web pages, back tracked thirteen times more, were four times more likely to revisit a web page, spent one third more time on a web page, and were thirteen times more likely to be lost or deviated from the optimal navigating path than HL users.

Because HL users were more likely to succeed during online information seeking tasks, it was important to identify the behaviour and strategies that support their success. By doing so, these strategies and behaviours could be implemented in a system to support LL users during online information seeking. Previous research showed that LL users were overwhelmed by information and challenged with higher cognitive load during information seeking (Nielsen, 2005; Summers & Summers, 2005). Visualisation techniques help amplify human cognitive capability through visual perception, while interactive animation assists users to manipulate the visualisation in real time (Card, Mackinlay, & Shneiderman, 1999). These techniques have been predominantly applied and tested with larger datasets and mainly for the HL users. By using interactive visualisations, we might be able to reduce the cognitive load that overwhelms LL users. However, these techniques should not only be considered but also tested as a support tool. Therefore, there is a need to compare behaviour of HL and LL users during online information seeking.

RESEARCH QUESTION AND OBJECTIVES

The thesis addresses the following research question:

Does the use of interactive visualisations support low literacy users?

Given that there is evidence suggesting that LL users are less successful than HL users during online information seeking, the following steps needs to be investigated:

1. Determine LL users' online information seeking difficulties by defining the following characteristics in a way that allows for new designs:
    a. Online information seeking behaviour strategies (Chapter 4)
    b. Information seeking behaviour models (Chapter 5)
    c. Differences between users' metal models though the classification of information (Chapter 6)
2. Based on the characteristics found above, the researcher aimed to:
    a. Determine design principles to support LL users by incorporating these principles in a working prototype or adapting an existing system (Chapter 7)
    b. Evaluate this new interactive visualisation against the current *Adviceguide* website (Chapter 8)

METHODOLOGY ADOPTED

This research uses both qualitative and quantitative research methods to address these issues. Exploring the differences between HL and LL users was crucial to determine LL users' online information seeking difficulties. The literature provided certain strategies used by HL and LL users when seeking information. It also defined behaviour models but mainly for HL users. Hence, observations, in-depth interviews, think-aloud techniques and card-sorting methodologies were used to identify HL and LL user strategies, behaviour models (see Table 1-1 for Study1) and mental models (see Table 1-2 for Study2).

STUDY	**AIM**	**METHODS**	**PARTICIPANTS**
STUDY 1 Investigate the strategies used by HL and LL users during information seeking	Determine strategies used (Chapter 4). Determine behaviour models (Chapter 5).	Qualitative (Think-aloud - video recorded, Observations - video recorded, field notes, In-depth interviews modelled after Critical Decision Method - video play-back, and use of field notes)	10 5 HL & 5 LL 4 Males & 6 Females Mean age 40 years (ranging 36 to 55)

Publications related to Chapter 4

Kodagoda, N., Wong, W. & Khan, N. (2009). Identifying Information Seeking Behaviours of Low and High Literacy Users: Combined Cognitive Task Analysis, in the proceedings of the 9th bi-annual international conference on Naturalistic Decision Making, London 2009 (pp 347-354).

Kodagoda, N., Wong, W. & Khan, N. (2009). Behaviour Characteristics: Low and High Literacy Users Information Seeking on Social Service Websites, CHINZ 2009.

Kodagoda, N., Wong, W. & Khan, N. (2009).Overview of Behaviour Characteristics of High and Low Literacy users: Information Seeking of an Online Social Service System, INTERACT 2009.

Kodagoda, N., Wong, W. & Khan, N. (2009). Cognitive Task Analysis of Low and High Literacy Users: Experiences in Using Grounded Theory and Emergent Themes Analysis, HFES 2009.

Publications related to Chapter 5

Kodagoda, N., Wong, W., & Khan, N. (2010). Information seeking behaviour model as a theoretical lens: High and low literate users behaviour process analysed as way of informing interface design, ECCE 2010.

Table 1- 1. Aims, methods and publications incorporated to identify HL and LL users strategies and behaviour models adopted.

STUDY	AIM	METHODS	PARTICIPANTS
STUDY 2 Investigate HL and LL users understanding of information structures	Determine differences between metal models though the classification of information (CHAPTER 6).	Qualitative (Think-aloud - video recorded, Observations - video recorded, field notes, In-depth interviews modelled after Critical Decision Method - video play-back, and use of field notes), Quantitative (investigate clusters - hierarchical cluster analysis, find the strength of a card been placed in a category –agreement weight)	17 9 HL & 8 LL 6 Males & 11 Females Mean age 38 years (ranging 34 to 48)
Publications related to Chapter 6 Kodagoda, N., Wong, W. & Khan, N. (2010). Open-Card Sort to Explain Why Do Low-Literate Users Abandon their Web Searches Early?, BCSHCI 2010.			

Table 1- 2.Aims, methods and publications incorporated to identify HL and LL users' mental models.

The results of this exploration contributed with arguments to support the design rationale for an interactive visualisation. Based on the design principles proposed, a prototype was introduced to evaluate information seeking performance of LL users. Quantitative methods were used for this evaluation. Several statistical tools were used to analyse user information seeking responses. Users search outcomes were analysed using Friedman's analysis of ranks test, while users performance such as total time on task, number of pages visited, unique number of pages visited and number of page revisits were analysed using Repeated measures ANOVA to find the equality of means. Finally, the subjective feedback was analysed using Wilcoxon signed-ranked test (see Table 1-3 for Study 3).

STUDY	AIM	METHODS	PARTICIPANTS
STUDY 3 Evaluate and compare these visualisations for information seeking performance between HL and LL users	Evaluate this new interactive visualisation against the current *Adviceguide* website (CHAPTER 8).	Qualitative (Card-sort, Think-aloud - video recorded, Observations - video recorded, field notes, In-depth interviews - video play-back, and use of field notes, Post-task Questionnaires for tasks and system) Quantitative (for parametric data – ANOVA, and for non-parametric data – Friedman's test and Wilcoxon signed test)	24 12 HL &12 LL 12 Males & 12 Females Mean age 39 years (ranging 35 to 50)

Publication related to Chapter 8

Wong, W., Chen, R., Kodagoda, N., Rooney, C., &Xu, K. (2011). INVISQUE: intuitive information exploration through interactive visualization. Proceedings of the 2011 annual conference extended abstracts on Human factors in computing systems - CHI EA '11 p. 311.

Wong, W. &Kodagoda, N. (2011).Designing UI for Low Literacy Users: Knowing Your User. Workshop position paper IUI4DR - Intelligent User Interfaces for Developing Regions.

Kodagoda, N., Wong, W., Roony, C., & Khan, N. (2012). Interactive Visualization for Low Literacy Users: From Lessons Learnt to Design. CHI 2012: 1159-1168.

Table 1- 3. Aims, methods and publications incorporated to evaluate the new interactive visualisation against the *Adviceguide*.

THE STRUCTURE OF THE THESIS

Chapter 2 determines difficulties LL users face during online information seeking and review the state of the art techniques to support interactive visualisations. Chapter 3 identifies information seeking strategies, behaviour models and users' mental models that can inform interface design principles.

The aim of Chapter 4 is to explore and compare information seeking strategies adopted by HL and LL users as they navigate through online information. This chapter describes a study, which identified information seeking strategies used by HL and LL users and reasons for LL users to perform poorly. This chapter also reports experiences using multiple cognitive task analysis methods that were used to capture users' behaviour.

Chapter 5 investigates whether an information seeking behaviour model can be used as a theoretical lens to map HL and LL users' strategies, decisions and search outcomes made. The findings from this evaluation show two variations of Ellis' information seeking behaviour model for the HL and LL users. The models are likely to help identify what support mechanisms are required to assist LL users during their information seeking.

While Chapter 6 describes a card-sorting study, using the information items of the *Adviceguide* website. The principal finding from this study was that LL users did not make use of prominent keywords and made flawed semantic relationships between information items. The results suggested that this is due to the mismatch between the system's conceptual model and the LL users' mental model.

Chapter 7 determines the design principles required to support LL users. It introduces a proof-of-concept prototype known as *Invisque* (Interactive VIsual Search and Query Environment). *Invisque* is an interactive visualisation for searching and querying that evaluates the design principles without changing the readability of the Adviceguide.

Chapter 8 describes the final study that compared HL and LL users' performance using *Adviceguide* and *Invisque*. The study suggests that affordances built into *Invisque* allowed the users to employ visual cues that enabled them to use the system effectively. The chapter discusses the study rationale, the methodology adopted and its findings.

Finally, Chapter 9 concludes that a system like *Invisque* with a flat structure menu supports LL users by reducing the time they spent on a search, reducing the number of pages visited and increasing their success rate. The chapter discusses the limitations of this thesis and proposes possible future research.

SUMMARY

This chapter has introduced the difficulties that LL users face in the online realm. In order to identify ways to present the information online, it is important to determine the strategies, behaviour models and mental models of LL users. Once these characteristics are defined, the thesis will evaluate an interactive visualisation that contains the design principles required to support LL users seeking online information.

CHAPTER 2

STATE OF THE ART TECHNIQUES TO SUPPORT INTERACTIVE VISUALISATIONS

The thesis focuses on the analysis of interactive visualisations to support low literacy (LL) users. This chapter will survey the related design principles and guidelines, and discuss schemes of interactive visualisations that offer efficient solutions for the LL user.

Visualisation can be defined as "*the use of computer supported, interactive, visual representations of data to amplify cognition*" (Card et al., 1999). In interactive visualisation, the visual representation aids or amplifies the users cognitive capability while interactivity assist the manipulation of the visual representation. Interactive visualisation plays an important role to draw the users' attention and retain context while making obscure information visible (Hearst, 2009); while interactive animation has shown to shift users' cognitive load into the human perceptual system (G. G. Robertson, Mackinlay, & Card, 1991).

This chapter describes research related to the field of information seeking and LL users, focusing on interactive visualisation techniques. Firstly, it draws attention to the current problems that LL users face during information seeking, followed by techniques currently used to support LL users. Secondly, interactive visualisation techniques are reviewed (visualisation is often used to analyse very large amounts of data taking advantage of human cognitive capabilities). Finally, gaps in the literature are reviewed using lessons learnt from the first and second sections.

Increasingly, information technology is being based on interactive visual media, and visualisation techniques are emerging as one of the primary factors underpinning decision-making tasks. Allied to this trend is the growing capacity of computers to process and render intensive graphics in real time. Visual user interfaces constitute a crucial aspect of modern applications (Tarantino, 2001).

Several approaches of information visualisation have been developed throughout the years. Most of them have focused on representing large datasets in visual displays. Only a very few have evaluated interactive visualisation techniques to support the needs of LL users.

PROBLEMS FACED BY LOW LITERATE USERS SEEKING INFORMATION

Previous research showed that LL users are more likely to be socially disadvantaged, unemployed, to have poor mental and physical health, to be less motivated, and to be less empowered (Canadian Council on Social Development, 1996; Shalla & Schellenberg, 1998). Low levels of Literacy affects both developed and developing countries as it is a break down in society and development as it costs businesses and taxpayers billions in lost wages profits and productivity annually, suggesting that it is a global challenge (Smith, 2008; Wickens & Sandlin, 2007). There is recent research in both developed and developing countries in domains such as health (Birru et al., 2004; Houts, Doak, Doak, & Loscalzo, 2006; Norman & Skinner, 2011; Ratzan & Parker, 2000; Selden, Zorn, Ratzan, & Parker, 2000a, 2000b; Summers & Summers, 2003), education (Carothers, 1959; Farrell, 1977), agriculture (Agarwal, Kumar, Nanavati, & Rajput, 2011; Ajmera et al., 2011; Patel et al., 2008), e-governance (Chesi & Pallotti, 2005; Commission, 2006; Dada, 2006; Dwivedi & Sahu, 2008; Froud, 2002), mobile-banking (I Medhi, Cultrell, & Toyama, 2010; Indrani Medhi et al., 2011; Indrani Medhi, Gautama, & Toyama, 2009) and retail commerce (Adkins & Ozanne, 2005; Jae & Delvecchio, 2004). As the result of the increasing use of information technology, self-help information is on the rise due to funding reforms in the Government and Social Service Sector. Therefore, it becomes increasingly important to recognise that interfaces designed primarily for high literacy (HL) users are not similarly effective for LL users. Following the European e-government Action Plan 2010, one criterion has been that all citizens must benefit from the online information. The roadmap for inclusion e-Government includes user groups at a disadvantage, including adults with LL and other disabilities.

The current research in the medical area that provide health information online observed that LL participants have significant differences in their reading strategies and online navigational behaviour compared to HL users (Summers & Summers, 2005). LL users most often lack skim-reading (scanning) skills and consequently tend to exert considerably more effort and mental concentration when searching information. The researchers further found that LL users have a higher tendency to skip sections of text when faced with long and dense pages, especially if it requires scrolling, contains numbers, or unfamiliar words, parenthetical text etc. LL users had problems navigating deep hierarchical information structures where paying attention to detail was crucial and consequently had trouble anticipating the next action to be carried out. The researchers found that LL users had a narrow field of view. LL users tend not to notice content above, below, or on the sides to their focus of attention. Researchers also found that LL users assume to have enough information and prematurely abandon reading before they acquire full comprehension of the context. They had difficulty searching information, especially when correct spelling and typing capabilities are required. These users "*are less able to pay attention to cues about what might be coming up or remember where they came from because processing the text itself takes so much cognitive attention*" (Summers & Summers, 2003). The 1992 National Adult Literacy Survey (Kirsch, Jungeblut, Jenkins, & Kolstad, 1993) report that even though LL users are usually successful at performing simple browsing tasks such as locating a single piece of information, they often find it difficult to integrate such activities into fulfilling their overall objectives of information seeking and comprehension.

Medhi and her colleagues (Medhi et al 2010) suggested that there are two potential problems during abstract thinking at two levels. Firstly, LL users comprehend linear navigation better compared to hierarchical structures; secondly, LL users communicate relevant information, particular ideas and concepts using long stories that are only remotely related to the main point of focus. The researchers refer to the former problem as hierarchical abstraction and later as conceptual abstraction.

Challenges of hierarchical abstraction have been identified in culture specific domains during interpretation of these structures or isolation of people of both graphical and ideological levels due to representation of information according to western traditions (Kress & Leeuwen, 1999; Walton, Vukovic, & Marsden, 1996). The authors found that LL users explain ideas and concepts using situational stories, which suggest that they struggle with abstract concepts.

Katre (2006) suggests that literacy is not simply about being able to read and write, but it also refers to a set of cognitive skills crucial for acquiring knowledge using a language, and the related process of structuring, reasoning and comprehension of abstract information. He presents a case study that reveals cognitive habits of illiterate people, and characteristics and limitations from the perspectives of rural e-learning. The results suggested that, unlike their literate counterparts, the illiterate subjects were unable to summarise the overall cognitive structures. He further stated that knowledge structures take a shape of a pyramid, with very specific and concrete topics at the bottom of the hierarchy, and becoming more abstract as one moves up the pyramid.

A previous study by Kodagoda and Wong (Kodagoda & Wong, 2008) identified that LL users spent eight times longer to complete a task when searching for social services information, visited eight times more web pages, back tracked thirteen times more, were four times more likely to revisit a web page, spent one third more time on a web page, and were thirteen times more likely to get lost or deviated from the optimal path.

Howless and Howless (2001) identified that HL web users employ a scanning strategy, where they looked for headings, skipped sections that were not relevant or did not grab their attention and selectively narrowed down the search until they found the required information. Nielsen (2005) also identified that experienced HL readers developed a scanning strategy. In contrast, the LL users did not employ a scanning strategy; instead, they read line by line, which required concentration and higher cognitive effort (Nielsen, 2005; Summers & Summers, 2005). Perfetti (1985) also identified that the lack of reading fluency leads to higher cognitive resources being devoted for low levels of reading process (word-for-word), leaving less room for comprehension of the overall message. LL users tend to “satisfice – accept something as good enough – based on very little information because digging deeper requires too much reading, which is both challenging and time consuming” (Nielsen, 2005a). These findings were consistent with the ones reported by Summers & Summers (2003, 2005).

Carothers (1959) and Farrell (1977) observed that total oral[2] people do not develop beyond pre-concrete (2-7 years) operational (7-12 years) stages. Orality (2002) is when ancestors and certain cultures rely on the living human memory to store and retrieve knowledge. Carothers compared rural African children, a culture not exposed to any reading and writing, against European children. He speculated that by learning to read and write, people develop thinking and cognitive skills discussed in Piagets' concrete operational stage (please refer to Appendix D).

Warschauer (2002) explains that there are fundamental cognitive differences between those who are literate versus illiterate, resulting in a significant division at an individual and social level. Literacy at an individual level allows mastering the logical functions of a language while facilitating abstract thinking.

Luria (1976) and Manly et al (1999) found that literate people acquire skills to organize and process information in less idiosyncratic and more efficient ways compared to illiterate people. Richard et al (1971) notes that good readers develop effective skills of comparing, distinguishing, and relating meaning when compared with poor readers.

Research in retail consumer domain found that LL users faced particular challenges: choosing the wrong product, misunderstanding pricing information (Adkins & Ozanne, 2005); trading in making decisions (effort vs. accuracy) (Bertrand, Mullainathan, & Shafir, 2006); being over dependent on peripheral cues in product advertising and packaging (Jae & Delvecchio, 2004).

Narasimhan (2004) discussed how characterising literacy takes into account the literate behaviour instead of the capability of reading and writing. Firstly, he looked at

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[2] *Please refer to Appendix D for an in-depth definition and analysis of Literacy and orality.*

the reflective behaviours, enabling how to deal with the world and the self/agent[3] when moving from oral to the literate behaviour. He further discussed the cognitive implications when learning occurs through observation, apprenticeship and formal education. He stated that '*currently computer technology is opening up entirely new possibilities. By structuring feedback through computer supported visual-graphic representations, qualitatively new levels of articulations should become available to serve as literate props to narrow the gap between orality and literacy*'.

As mentioned above, previous research had already approached the issue of providing information systems and services to LL users. The section below briefly lists some of the efforts by other authors directed at this group of users highlighting the possible solutions using different visualisation techniques to support LL users.

VISUALISATION TECHNIQUES CURRENTLY USED TO SUPPORT LL USERS

Shneiderman (2000) advocates the concept of *universal usability* which refers to the design of information and communications products and services that are usable for every citizen regardless of their level of literacy. Universal usability is closely related to concepts of *universal accessibility* (accessible for all) and *universal design* (design for all). Universal usability aims to support a broad range of hardware, software and network access as well as to accommodate individual differences among users (such as age, gender, literacy, culture, and disabilities). The key to universal usability is recognizing the diversity of user population and user needs (Shneiderman, 2000). Previous research has focused on several visualisation design techniques based on such demographics, and in the following section, some of these techniques such as the use of menu structures, multimodal interface, visual cues and patterns, and use of audio will be described in detail.

[3] *Self/ agent - Self is objectified by dealing with an agent, on the one hand, as autonous and capable of intentional actions, and on the other hand, as a member of a social group determined in various ways by its rules and norms. The intentionality aspects of an agent are characterized by a variety of agentive states such as knowing, believing, wanting, planning etc., and affects of various kinds (Narasimhan, 2004) pg52.*

Flat and shallow menu structures

Summers and Summers (Summers & Summers, 2005) in their work on online medical content, discussed a number of guidelines for website redesign and make them similarly accessible to both HL and LL users. Some of their key findings were that less experienced or older or LL web users had difficulties navigating complex information structures. Keeping the site hierarchies relatively flat and shallow was shown to improve their navigation strategy; for example, starting with content that is more generic and progressively obtaining specific and relevant content. Medhi et al. (2010; 2009, 2011) evaluated LL user experience of transferring money using a menu-driven mobile phone application (see Figure 2-1). When users were presented with non-textual user interfaces that combined voice, graphics and video, evaluations showed that LL users strongly preferred the new designs over the traditional text based interfaces and were able to meaningfully navigate through the menus. The redesigning process minimized the deep hierarchical structures.

a) Main menu **b) Enter phone number of receiver**

Figure 2- 1. Navigating screens of the rich client prototype.

Source :(Medhi et al., 2009)

Multimodal interfaces

Medhi et al (2007) looked at text-free user interfaces for novice, illiterate and LL users. They avoided text where possible, used semi-abstract or hand-drawn graphics, used voice feedback for all functions and provided help for all functions. These techniques were used to develop text-free applications such as job search for domestic labourers, map application to navigate through cities, health information and money transfer. The results suggested that users preferred the text-free design to the standard text-based interfaces, and were able to carry out tasks better using text-free interfaces (see Figure 2-2).

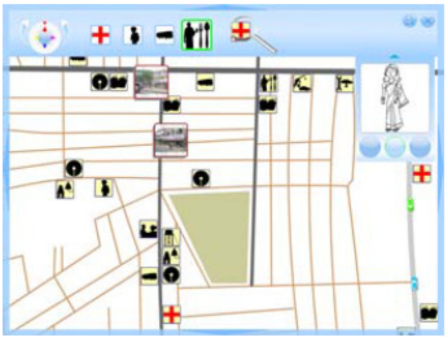


Figure 2- 2. Design of the final prototype of the map application.
Source: (Medhi et al., 2007)

Findlater et al (2009) compared semi-literate and illiterate users' ability to transition from audio and text to text-only interaction (see figure 2-3). The findings suggest that LL users reduced their audio support after the first hour of using the system, and there was a further decrease after several hours of use. Low literacy users gaining visual word recognition accompanied the decrease. However, this was not evident with the illiterate users. The authors concluded that when designing interfaces, semi-literate users should be considered differently from illiterate users.

Figure 2- 3. Screenshot of experimental system showing text and audio pairs. Control buttons allow the participant to continue to the next trial upon completion of the current one, and to replay the audio prompt for the current trial. English text labels are for illustration only, and were not shown on original screen. Source: (Findlater et al., 2009)

Visual cues and patterns

Joshi et al (2008) proposed a phonebook that organised contacts associated with colour and icons. This 'visual phonebook' would allow accessing a contact using two buttons on a number pad. The results suggested that some participants have assigned a colour to represent the type of contact (family, relative, friend and work), while others used location and distance (same village, nearby villages, far off places). The prototype was limited to hold nine contacts only. They compared speed of entering and retrieving a contact in the visual phonebook versus an alphabetical phonebook. The semi-literate users preferred the alphabetical phonebook to the visual one although they were significantly faster when using the visual phonebook (see Figure 2-4).

Figure 2- 4. Screenshot from the phonebook prototype.
Source: (Joshi et al., 2008)

Goetze and Strothotte (2001) developed a web browser (IGAR-Browser) tailored to the needs of illiterate people in Germany. Interviews with teachers were carried out to investigate the needs of illiterate people. The researchers proposed interface design principles focused on connecting images and text. The graphical reading aid used three techniques: (a) picture as text overlay, (b) text visualisation within a sentence, and (c) text as picture overlay (see Figure 2-5). The findings showed that users who were unable to read a word, pointed on the word to obtain pictorial reading aids. In general, the system received positive feedback from illiterate participants. However, participants misinterpreted some of the pictograms used.

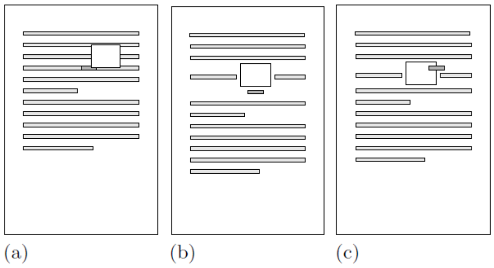


Figure 2- 5. Graphical reading aids.
a) Dynamically shown picture as text overlay. b) Picture and text visualisation within a sentence.
c) Dynamically shown text as picture overlay. Source: (Goetze & Strothotte, 2001)

Birru et al (2004) investigated how LL adults used internet to search health related information. The finding suggests that on average their information browsing competence was that of 10th grade level. These LL users had difficulty generating search terms and were reluctant to use hyperlinks. However, LL users were able to use cues from the sentence structure to locate an answer.

Houts et al (2006) assessed the effect of images when providing health related information. They found that when images are associated with simple text compared to text alone, that it increased all types of users to recall information, and those LL users exhibited the largest improvement in their activities. The researchers further suggested that combining spoken words with pictures or simple printed words with pictures could be used to further support illiterate or LL users (see Figure 2-6).

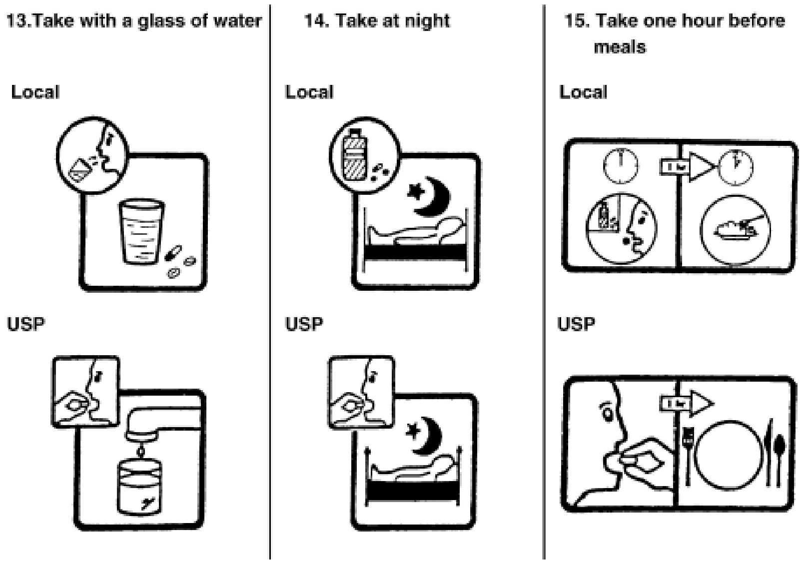


Figure 2- 6. Examples of drawing made locally and from the US Pharmacopeia.
Source: (Dowse & Ehlers, 2001)

Audio interfaces

Agarwal et al (2011), Ajmera et al (2011) and Patel et al (2008) from IBM research India developed a voice-driven web framework comparable to the WWW. This system is known as the "Spoken Web" or the "WWW Telecom Web". It contains voice driven applications created by users themselves and hosted in the network (see Figure 2-7). The main advantage is that it can be accessed via a mobile phone. The Spoken Web can deliver locality-relevant content to the masses. The Spoken Web was affordable with no hardware other than a telephone and supported illiterate and LL users very well also given its voice-based interface supporting local dialects. The site can be navigated using a voice-based interface via an ordinary phone. The end user was able to create a site using his/her voice within approximately four minutes. There were many local services such as grain prices, electricity outage times, train schedules, and schedule of mobile hospitals and advertisements, which can be uploaded into the site over the phone. The phone number acts like a URL. By simply dialling the phone number, users gained access to the information. Yet, the Spoken Web has its limitations. It becomes more difficult to use as the content grows; it is error prone; and navigation is sequential and tend to be slow.

Figure 2- 7. Urban micro-business through voice site and voilinks.
Source: (Rajput, 2009)

Meade et al (1989) found participants who received reading material (on the effects of smoking) written at fifth-grade standard showed 13% better level of comprehension over the participants who received the same material written for tenth-grade standard. Moreover, lowering the reading comprehension level of the text to suit the needs of LL users also improved the satisfaction and comprehension for both HL and LL users (Eppler, 2006; Frank-Stromborg & Olsen, 2004; Leavitt & Shneiderman, 2004; Meade et al., 1989; Summers & Summers, 2005; Weis, 2007; Young, Hooker, & Freeberg, 1990).

Cecilia et al (1996) and Summers and Summers (Summers & Summers, 2005) have recommended reducing page complexity (clutter), for example by visually limiting the number of concepts per page by breaking down into more manageable segments, using more meaningful headings and use of large text sizes to improve readability for LL users. Clutter can draw the users' attention away from important text, making it harder to find required content, and consequently increasing the cognitive burden for LL users.

Frank-Stomborg and Olsen (2004) in their work for medically underserved LL populations suggested reducing the reading comprehension level of text, increasing font sizes and using graphics that matched the topic should increase the overall comprehension and reduce the level of abstraction of the message being communicated, removal of page clutter from the screen, avoiding long lists by boxing information separately to provide further focus, and the use of white space and colour to draw attention which should consequently help LL users with their overall objectives.

In summary, to support LL user information seeking, visual techniques (such as colour, white space, and graphical pictures), multimodal interfaces and audio, flat or shallow menu structures to support with navigation are introduced. However, the problems and the solutions above reviewed address smaller datasets for very specific tasks and not tested for larger datasets. This suggests a need to review how interactive visualisations are addressed with larger datasets.

INTERACTIVE VISUALISATION TECHNIQUES THAT SUPPORT HL USERS

This section reviews research conducted on interactive visualisations that primarily investigate visualising large datasets amplifying human cognition through visual perception. This allows exploration and enables use of pattern recognition techniques. The theoretical accounts discussed focus on the importance of facilitating insight and sound judgement in time-pressure environments. Some interactive visualisation techniques that have been tested for the HL users and large datasets might be useful to support LL users. The following section discusses some of the acknowledged interactive visualisations theories such as keyhole problem, cognitive load theory, principles of visual affordances, visual cues, gestalt principles, among other information visualisation techniques.

Keyhole effect

When the size of the virtual information space is larger than the available viewport of the information display, the user is limited to see only a small section of the information space at a given time (see Figure 2-8). Consequently, the analogy of peering into a vast room through a tiny keyhole is known as the keyhole effect (Woods, 1994). When working with large displays users are effected by getting lost or disorientation effects. One of those problems is the 'art museum effect'. For instance, users who examine many items one or only a few at a time though the computer keyhole become overwhelmed and lose any larger coherent understanding of the individual pieces they have examined (Smith & Wilson, 1993). Another instance is when users lose track of what portions of the space they have explored already because they can see only a small portion of the display behind the keyhole (Shneiderman & Plaisant, 2004).

Designing ways to navigate through these large datasets has posed several challenges. Watts-Perotti and Woods (1999) suggested that navigation support is not about helping users navigate from one place to another in a virtual data space, but is about building transparent interfaces to help users find relevant information without having to switch their attention away from the original tasks and goals. Their research focused on office workers who used Excel spread sheets.

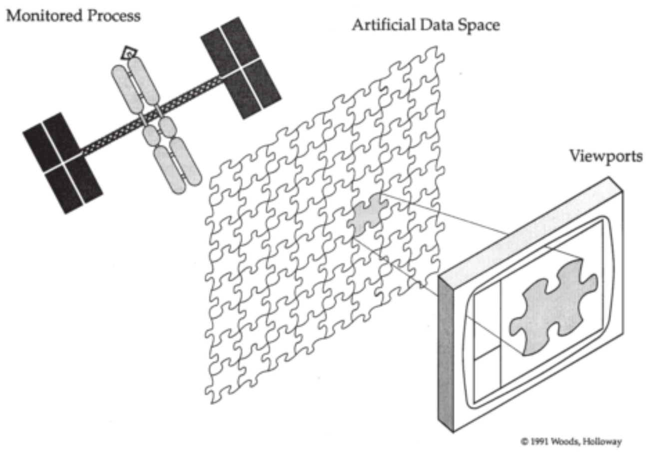


Figure 2- 8. The keyhole effect.
This arises when the size of the virtual information space is larger than the available viewport of the display, allowing users to see only a small piece of the information space at one time. Source: (D. D. Woods, 1995)

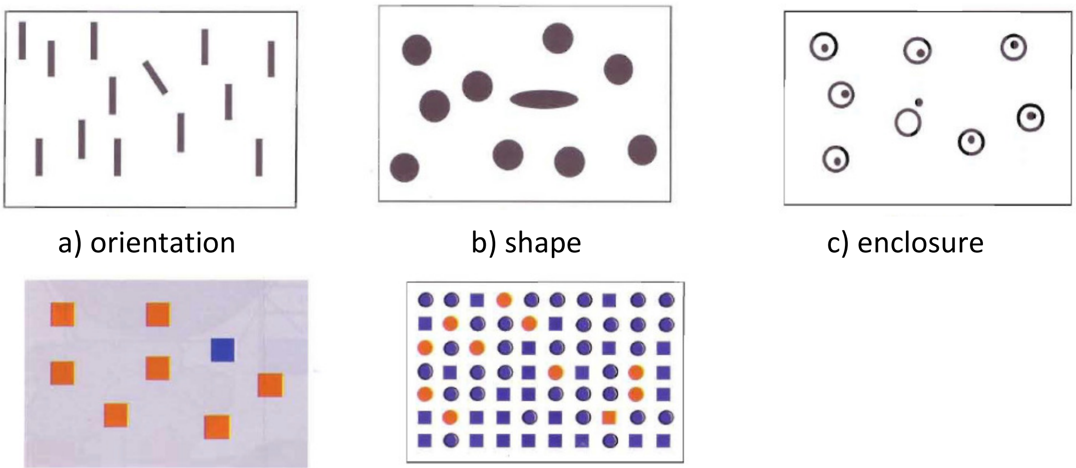
Cognitive load theory

Cognitive load refers to the total amount of mental activity that the working memory has to attend to at an instance in time. This was proposed by Sweller and colleagues (Chandler & Sweller, 1991; Sweller, Chandler, Tierney, & Cooper, 1990; Sweller, 1994). The main focus here is on the role of working memory during the learning process. Here the major contributor to cognitive load is the number of elements that is imposed on working memory. This theory is built upon the research of Miller (1956) that stated the capacity of working memory is limited to seven (plus or minus two) chunks of information at a given time. This is widely accepted by instructional designers and acts as a design guideline to enhance development of learning material.

Working memory becomes an important factor as it organise and process information when learning occurs (Global, 2000). Here information is sorted and organised into relevant schema. Schemas can be referred to as models or hypothetical structures that organises once knowledge of the world.

Visual cues

Pre-attentive vision refers to cognitive operations that can be performed prior to focusing attention on any particular region of an image, taking advantage of the human visual system (Treisman, 1985). This has shown to be an important perceptual property as a user is able to perceive information without the need to serially scan the visual interface that may also obviate the movements of the eye that can take about 250 milliseconds to initiate. Certain features such as colour, shape and orientation are pre-attentively detected and later joined with focused attention, which is required to conjoin the separate features into a coherent object. Pre-attentive processing are independent of attention and are fast and effortless, capable of execution while the subject is engaged in another task (Logan, 2007).



a) orientation b) shape c) enclosure

d) colour e) conjunction

Figure 2- 9. The "odd one out"
this can be identified very quickly due to pre-attentive processing with some forms of patterns –[a] to [d]. However, with some other patterns, identification may take considerably more time as they are not identified and processed pre-attentively) Orientation - The odd one out can quickly be identified b) Shape - Different shapes can often pop out. c) Enclose - A single lack of enclosure. d) Colour - A different coloured square. e) Conjunction - With conjunction encoding the red square is not pre-attentively identified. Source:(Spence, 2006)

Any perception that is possible within this time frame involves only the information available in a single glimpse. Random placement of the elements in the displays ensures that attention cannot be pre-focused on any particular location. Observers report that these tasks can be completed with very little effort (Healey, Booth, & Enns, 1996).

Wittenburg et al (2001) introduced a multidimensional visualisation and interaction techniques in a system known as EZChooser. The system is used for dynamic querying. It provides instantaneous visual feedback, continuous reformulation of goals and tight coupling of query parameters. The interactive attribute selection corresponds to the instantaneous visual feedback using visual cues highlighting information of interest. The visual cues help draw users attention to user-configurable system property (for example, aspect of the search results) as shown in Figure 2-10.

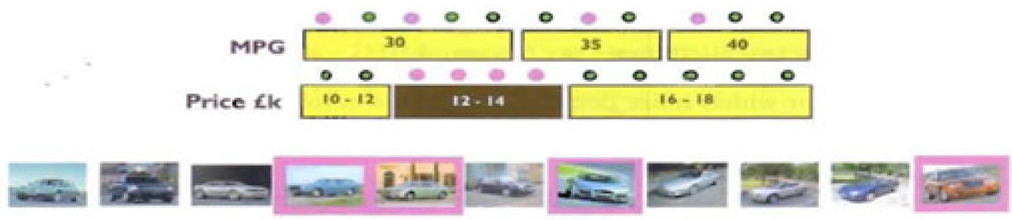


Figure 2- 10. The interactive selection of a bargram rage (here price £12 - £14) identifies four cars whose price falls within that range. Source:(Spence, 2006)

Gestalt principles

Most notably Max Wertheimer (1880 - 1943), Wolfgang Koher (1887 - 1967) and Kurt Koffka (1886 - 1941) applied Gestalt psychology developed by German psychologist in the 1920s, during the 30s and 40s to visual perception. Here Gestalt principles of perception attempt to describe how the brain automatically organises objects it perceives and their mutual arrangements into groups that are governed by relationships. For example, when a user is presented with a painting for the first time, the user sees the whole painting prior to seeing the individual parts that make up the whole (Few, 2006; Hearst, 2009). The principle explains how users perceive visual objects and their arrangement. A designer is able to take greater control once he/she understand how users perceive visual objects and communicate designs across to users that makes sense in a holistic manner. Although there are several gestalt principles, we will only focus on the proximity compatibility principle and the similarity principle for the purpose of this thesis.

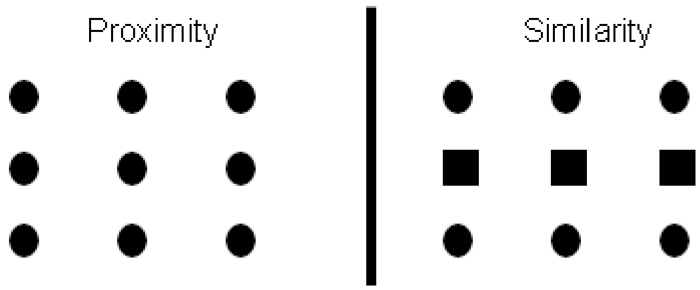


Figure 2- 11. (a) Proximity and (b) Similarity
a) Proximity [Things that are close to one another are perceived to be more related than things that are spaced farther apart] – eg. by organising nearby object together, the user should see columns because the dots in columns are closer than the dots in rows. b) Similarity [When object look similar to one another] – eg. by organising together objects that are similar in shape, the user should see rows instead of columns.

The proximity compatibility principle proposes that related information and instruments that interact with information should be close together to reduce scanning, processing time and cognitive burden (Hearst, 2009; Wickens & Carswell, 1995). Control display compatibility principle stipulates that the spatial arrangement and manipulation of controls should be consistent with the operation of the display (Wickens & Carswell, 1995) (see Figure 2-11 a).

The principle of similarity states that artefacts that share visual characteristics such as shape, size, colour, texture, value or orientation will be seen as belonging together (see Figure 2-11 b). The brain tends to group objects that are similar in colour, size, shape and orientation.

Spatial arrangement and representation

ZOOMING

Zoomable user interfaces organize information in space and scale, and use panning and zooming as the main interaction techniques (Perlin & Fox, 1993). Zooming is a popular technique used in visualising large data sets: Zooming-out allows the user to see more of the overall perspective but in less details, whereas zooming-in is used to inspect a specific portion in greater detail while seeing less of the overall perspective. Zooming has been used successfully with maps, image collections, and large document sets.

SLIDER

Sliders have been used as a means of direct manipulation. Sliders make visualizations more interactive by providing users with immediate response and the ability to dynamically query data (Shneiderman, 1994), as well as vary the parameterisation of various combinations of visualisation characteristics (see Figure 2-12). Items are placed on the axis, allowing users to query results and zoom into items of interest. Some of the early dynamic query systems that use sliders were HomeFinder, FilmFinder, chemical table and dynamic browser (Ahlberg & Shneidennan, 1994).

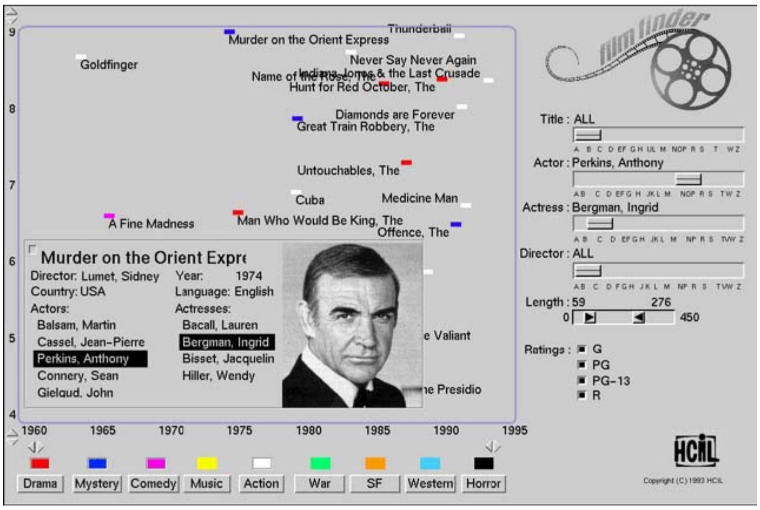


Figure 2- 12. The film finder.
Source: (Ahlberg & Shneidennan, 1994)

AXIS

Axis refers to the use of mapping information into meaningful dimensions by selecting attributes in the data set that represent those dimensions (Ahlberg & Shneidennan, 1994; Fox et al., 1983; Newell, France, & Heath, 1994; Shneiderman, Feldman, Rose, & Grau, 2000). Axes are important building blocks for developing visual structures.

Spatial visualization ability

McGee (1979) described spatial visualization as "the ability to mentally manipulate, rotate, twist, or invert a pictorially presented stimulus object". Previous research conducted on information extraction across successive displays showed that maintaining the continuity between display transitions improved performance when integrating and extracting information (Woods, 1984). Early work investigated sequence of view obtained by the viewers which were given by a filmmaker where this was call visual momentum by Hochberg (Hochberg, 1978). Woods defined the presenting of information across displays as visual momentum. Visual momentum refers to the mechanisms that support the identification of relevant data in human perception so that display system design can maintain an effective level of user attention.

Some of the visual momentum methods proposed by Woods (1984) consist of placing perceptual landmarks across displays, overlapping consecutive representations, or spatially separating the relationship among the displays. Visual momentum has been also used to explain the getting-lost phenomenon (Billingsley, 1982; Elm & Woods, 1985; Woods, 1984). Woods (1984) explained that discontinuity in the display transitions is similar to assembling a puzzle without the final picture, which creates no relationship among puzzle pieces. The findings from Vicente and Williges (1988) on people with low and high spatial abilities on an historical textual interface against a new graphical interface suggested that people with high spatial abilities are unlikely to get lost when using a hierarchical file system. Users with low spatial abilities presented difficulties keeping track of position, and to be lost due to higher cognitive effort required. Moreover, users with low spatial abilities tended to use commands that caused continuous transition between views even when such commands increased the time to find all required information (Vicente, 1997). This suggested that use of visual momentum improved the efficiency of searching for information by the people with low spatial abilities.

PERCEPTUAL LANDMARKS

Hochberg and Gellman (1977) describe landmarks as features that are visible at a distance and provide information about the locality and the orientation across the display. A study by Allen, Siegel and Rosinski found that landmarks assisted users to make judgments that required integrating data across successive views. Woods (1984) suggests the use of landmarks increase visual momentum (by providing data about the locality of one view with respect to the another.

INFORMATION LAYERING

Denenberg (1989) information layering approach refers to the ability to present large amounts of information in the same display. The information is presented in different layers where the primary layer is the focus of attention and the secondary layers are blurred behind the primary layer. He suggests that using a single information display, the various layers and their underlying meanings can be interpreted simultaneously, which in return reduces the cognitive load of the users.

Focus-plus-context

Focus-plus-context has been used to overcome certain challenges of visualising large amounts of information on screen, such as helping users to maintain focus and avoiding disorientation. Card et al (1999) argued that focus-plus-context was based on three premises: "*First, the user needs both overview (context) and detail information (focus) simultaneously. Second, information needed in the overview may be different from that needed in detail. Third, these two types of information can be combined within a single (dynamic) display, much as in human vision*".

Focus-plus-context has been introduced into visualisations using methods such as filtering, selective aggregation, micro-macro readings, highlighting and distortion. These techniques have been implemented in the perspective wall (Mackinlay, Robertson, & Card, 1991), hyperbolic browser (Lamping, Rao, & Pirolli, 1995), document lens (Robertson & Mackinlay, 1993), and data mountain (Robertson et al., 1998) as discussed below.

<u>PERSPECTIVE WALL</u>

Mackinlay et al (1991) proposed the perspective wall to visualise large volumes of linear data (eg. Chronological or alphabetical data). It was able to handle wide aspect ratios (see Figure 2-13), also with better utilisation of space, for example, the details on the centre panel showing at least three times of space compared to the details on a flat wall that fits in the same field of view. This effectively allowed perspective wall show three times more information compared to a flat wall of the same size. The perspective wall also offered other advantages such as perceiving object consistency with animation and transition views, highlighting object relationships with the context, adjusting aspect ratio, and in overall, offering the users with intuitive control.

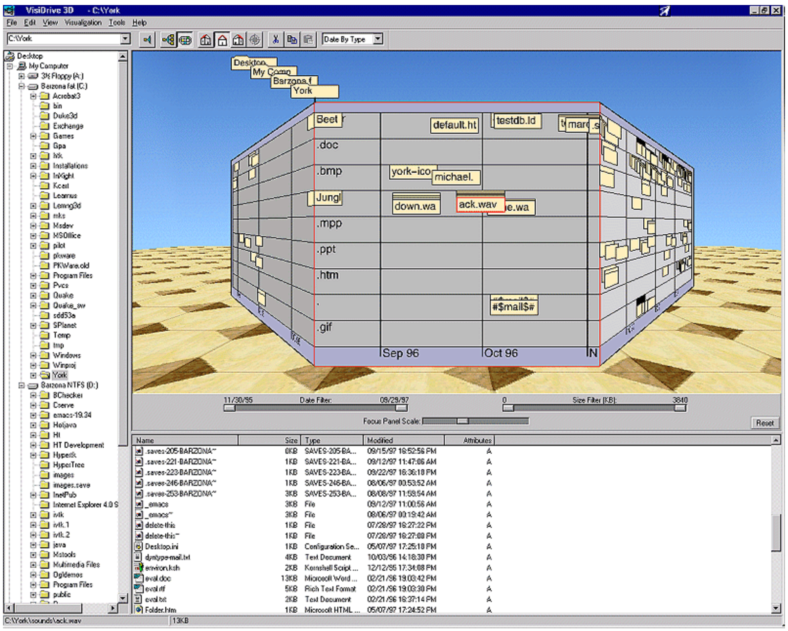


Figure 2- 13. The perspective wall.
Source: (Mackinlay et al., 1991)

HYPERBOLIC BROWSER

The Hyperbolic browser (Lamping et al., 1995) replaced the conventional approach of laying large hierarchical tree structure on a Euclidean plan; the information structures were first projected onto a hyperbolic plane, and then the plane is mapped to the visual display (see Figure 2-14).

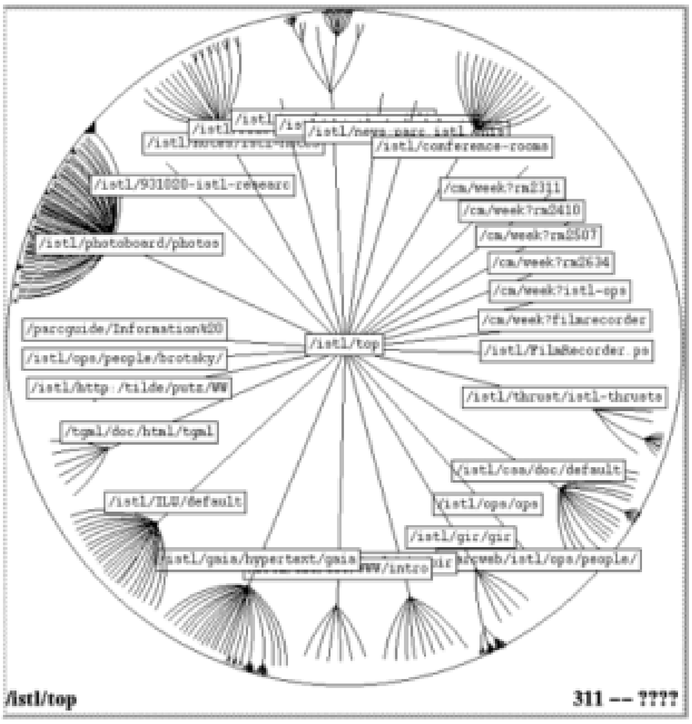


Figure 2- 14. The hyperbolic browser in long text mode in World Wide Web hierarchy utilised in a laboratory experiment.
Source: (Lamping et al., 1995)

DOCUMENT LENS

Robertson and Mackinley (1993) proposed a visualization technique to suitable for paper documents with unknown structures (see Figure 2-15). Here the documents were arranged in a rectangular array on a large table where the overall structure and distinguishing features can be identified. Visualisation of the large table structure was subsequently mapped to visual display using a fisheye view or the magnifying glass perspective. However, this approach failed to show global context adequately. The finding suggested that the document lens has broader applicability than simply viewing text documents, for example, for viewing 2D graphs and providing a 3D perspective.

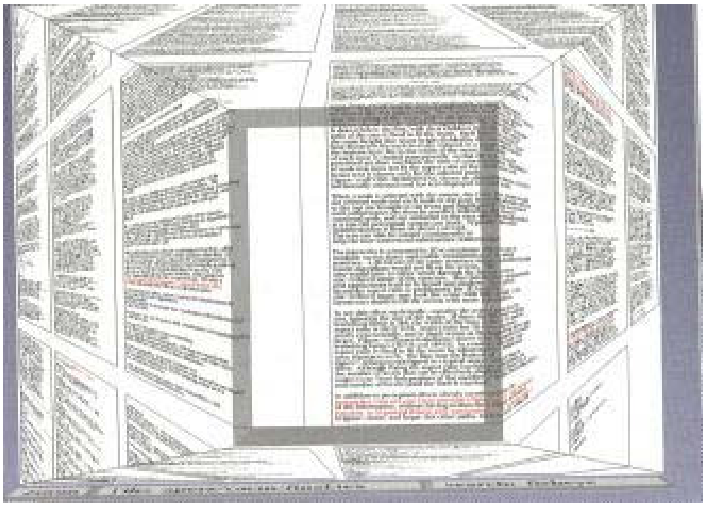


Figure 2- 15. The document lens with lens pulled towards the user.
The resulting truncated pyramid makes text near the lens' edges readable.
Source: (Robertson & Mackinlay, 1993)

DATA MOUNTAIN

Robertson et al (1998) introduced an interface known as data mountain to manage documents in computers taking advantage of human spatial memory (see Figure 2-16). The system allowed users to arbitrary place documents by creating their own organizational schemes and applying mental mapping of the physical space in to a virtual layout manager.

The virtual space uses *depth cues* to display more information without incurring additional cognitive load. The most widely used spatial cognition techniques were pre-attentive processing of perspective views and occlusion, particularly when documents were being moved. Other visual cues (for example, shadows) were used to help users to identify web pages. A minimum distance between pages was set to avoid occlusion. The system provided audio cues to reinforce the visual cues as well as page titles similar to tool-tips when hovering over the documents and consistently coloured halos around thumbnails thus creating visual links with the title. Finally, *landmarks* were used where the surface had coloured areas to facilitate conceptual organisation, which assisted in spatial navigation and added visual cues to improve the memory of recall.

The study required users to organize 100 pre-selected pages and then retrieve them with either title, summary, thumbnail or all three of the above. This was compared against the Microsoft Internet Explorer 4 (IE4) favourites and the Data Mountain for the same storage and retrieval task. The results suggested that data mountain was an effective alternative to IE4, even with the preliminary prototype. The data mountain allowed users to informally arrange their space in a very personal way. This feature appeared to have great power and enabled the user to view the whole information space and the spatial relationships between the documents as well as to arbitrarily control those relationships in information space. Furthermore, results of this study suggested that spatial memory of the users was able to reduce information storage and retrieval times as well as retrieval failure rate.

Figure 2- 16. Data mountain.
The figure shows that as one of the pages is dragged, other pages move out of the way so the page being moved is not occluded. Source: (Robertson et al., 1998)

Other information visualisation techniques

Several interface design guidelines have been proposed over the past decade, Schneiderman (eight golden rules), Norman (design principles) and Nielsen's (ten usability heuristics) have been some of the most well-known. All of these guidelines state that the interface should be consistent, offer feedback to help the user recognize, diagnose, and recover from errors, ease of use while providing system status at all times. In addition, the interface should permit easy reversal of actions and reduce cognitive load (See Table 2-1 for a list of all design guidelines).

Schneiderman (2009)	Norman (1998)	Nielsen (2007)
Strive for consistency	Consistency	Consistency and standards
Permit easy reversal of actions	Affordances	Match between system and the real world
Offer informative feedback	Feedback	Help users recognize, diagnose, and recover from errors
Design dialogs to yield closure	Visibility	Visibility of system status
Reduce short-term memory load	Constraints	Recognition rather than recall
Enable frequent users to use shortcuts	Mapping	User control and freedom
Offer error prevention and simple error handling		Error prevention
Support internal locus of control		Flexibility and efficiency of use
		Aesthetic and minimalist design
		Help and documentation

Table 2- 1. Summary of interface design guidelines proposed by Schneiderman (eight golden rules), Norman (design principles) and Nielsen's (ten usability heuristics).

<u>AFFORDANCES</u>

Affordances were originally proposed by Gibson (1977) who was a perceptual psychologist, who used the term to refer to all actionable properties between the world and living things. Norman (1988) introduced affordances to the domain of Human Computer Interaction first with his book "The Psychology of Everyday Things". He stated that affordance refers to "the perceived and actual properties of the thing, primarily those fundamental properties that determine just how the things could possibly be used".

Affordances provide strong clues to how things could be operated just by looking (e.g. knobs are for turning, door plates for pushing). Although complex things might require further explanation. However, it should not be the case with simple things (door knobs, for example); otherwise, their design should be considered failed.

To summarise, interactive visualisations discussed in this sections has shown to most effectively take advantage of humans cognitive and visual perceptual capabilities to help attain and gain knowledge. However, these techniques have been only tested with HL users and for large datasets.

GAPS IN THE LITERATURE

This chapter has identified that LL face challenges during information seeking; however, visualisations, multimodal and audio techniques have been introduced to fill this gap. Nevertheless, this gap has only been addressed for very specific domains or domains with smaller data sets. Over the last two decades theories and subsequent interactive visualisation techniques that take advantage of the human cognitive and perceptual capabilities have been tested for large datasets that have been well established. To the knowledge of the researcher, these theories and subsequent interactive visualisation techniques have not been tested for LL users in order to evaluate their response. The researcher finds this as a gap in the literature.

The internet would appear to provide an ideal medium for the provision of information on government information including benefits, health, policies and education. This potential is restricted by the relative absence of studies, particularly on the efficacy of the use of the web by people with different ranges of literacy and disability.

The evidence from literature suggests that LL users are less successful in finding information compared with HL users. These LL users' who are more likely to be socially disadvantaged, unemployed, have poor mental and physical health, and be less motivated, have problems with reading, navigating hierarchical deep menu structures, abstract thinking and are likely to be cognitively challenged.

There is a general lack of research focusing on ways to support LL users with interactive visualisations for large information spaces. Some of the studies mentioned above were successful in supporting LL users to carry out very specific tasks such as job search for domestic labourers, navigate through a city using a map application, search for health information, transfer money through a mobile phone, adding contacts in a mobile phone book and creating and navigating items through audio sites. However, when it came to larger websites, prior research suggests that the cognitive effort required by people with LL is so great that they usually failed to find the information required. Previous research suggests that changing the reading levels of the text, reducing clutter, adding white space and boxing important information facilitates online information seeking.

Additionally, most of the studies that evaluated the use of interactive visualisations for large datasets have not been explored for their potential to support LL users. Interactive visualisations have normally been evaluated to support critical thinking and analysis in areas that require high levels of literacy and abstract thinking, such as financial markets, counter terrorism or safety critical systems. However, the methods used in those visualisations that take advantage of the human perceptual capabilities might support people who have not developed abstract thinking or reached acceptable readability levels, possibly due to lack of formal education.

Some researchers argue, however, that observed features developed for one user group are less likely to work for another (Rich, 1983). To address this problem, when designing interfaces for multiple user groups, it is recommendable to take advantage of adaptive interfaces. Examples of adaptive interfaces include how systems filter and recommend products, news or emails. Any adaptive interface has, at some level of detail, a model of the user behaviour that is refined, and provides an interaction that fits the behaviour as best as it can. This allows the users to take advantage of the capabilities of additional features incorporated in the interface depending on the users. As users have diverse needs and abilities, it becomes a challenge to design interfaces that fits all users. A system adapting adaptive user interfaces is able to enhance users interaction, thereby contributing to successfully achieve their goals.

Previous studies that have focused on literacy presented some limitations. For instance, Roberson's interface known as the data mountain showed that the retrieval tests should be based on information need, not simple visual cues. Previous research by Jones and Dumais (1986) has suggested that little significant value is provided by adding spatial location information for storage and retrieval over simply providing semantic labels for the same purpose.

To summarise, most of the interactive visualisation techniques evaluated and improved over the years for large data sets have been conducted with literate users compensating the human cognitive limitations. However, interactive visualisation techniques enhancing cognitive limitations have not been explored for the LL group of users. Thus, there is a clear need to examine whether interactive visualisations support online information seeking of LL users. Chapter 7 will investigate interactive visualisation techniques that will help compensate identified cognitive limitations of LL users (information seeking strategies (Chapter 4), behaviour models (Chapter 5) and mental models (Chapter 6)) to propose design principles.

CHAPTER 3

INFORMATION SEEKING BEHAVIOUR AND USERS' MENTAL MODELS

People have been seeking and making sense of information for thousands of years to solve problems, to conduct their work, and to gain knowledge or used simply for survival. However, the rapid growth of information over the last few decades, especially the on-line presence of information, poses new challenges. Most users are now required to use these online information sources to carry out with their day-to-day activities. Information seeking behaviour can be defined as "the purposive seeking for information as a consequence of a need to satisfy some goal" (Wilson, 1997).

This chapter describes research related to the field of information seeking behaviour and mental models in a way that allows new designs to be investigated. Firstly, it draws attention to a review of information seeking behaviour models as a way to understand user behaviour and to broaden the understanding of effective interface design. Secondly, it briefly reviews user satisficing and optimising solutions taken during information seeking. Thirdly, reviews of mental models are discussed. Finally, gaps in the literature are reviewed using the three sections discussed.

Over the last few decades, researchers have been investigating information seeking behaviour of the users, especially in the use of libraries and in readership studies (Wilson, 2000). An important objective is to understand how users perceive information by exploring their mental models and to incorporate that knowledge in to the interface design of a visualisation system so that the system is able to optimally respond.

INFORMATION SEEKING BEHAVIOUR MODELS

Acquiring an accurate understanding of information requirements of users and their information seeking behaviour are fundamental to facilitate successful information systems. Wilson (2000) points out that the research scope of information-seeking behaviour is vast, with many new concepts and research methodologies being developed. It is clear that the study of human information-seeking behaviour has become a well-established area of research. Information seeking is more focused on a specific problem where a search originates from (Belkin, 1980). Information seeking begins with the recognition and acceptance of the problem and continues until the problem is resolved or abandoned (Marchionini, 1997).

Especially over the past few decades information behaviour, has evolved into a succession of related models and theories, such as Wilson's (1981, 1997) model of information seeking behaviour, Dervin's (1983) sense-making theory, Ellis' (1989, 1993) behavioural model of information seeking strategies, Bates (1989) berry-picking model, Kuhlthau's (1991, 1993) model of the stages of information seeking behaviour, Catledge and Pitkow's (1995) search behaviour, Byrne et al's (1999) search behaviour, Choo et al's (1999) search activities and Pirolli's (1999) information foraging theory, which have gained strength as they have been adopted as the basis for further research by other investigators (Wilson, 1999). The following sections review some of the seminal behaviour models and delineate their respective contributions addressing specific challenges related to information seeking.

Spoerri (2004) outlined problems related to information search on the World Wide Web, and describes the following factors that affect the quality of searching. Firstly, users do not frame their search objective. Secondly, users sometimes tend to lack sufficient domain knowledge to interpret the matching results, and finally users develop anxiety if the results do not fulfil their search requirements immediately. Due to these problems, users with limited knowledge or vocabulary tend to formulate and refine queries to find more search results (Albertoni, Bertone, & De Martino, 2004). Behavioural studies related to information searching found that users are likely to create shorter queries and rarely adopt Boolean expressions to optimize search criteria (Belkin & Croft, 1992; Spink, Wolfram, Jansen, & Saracevic, 2001). Marchionini's (1989) exploratory study of elementary school children searching a full-text electronic encyclopaedia on CD-ROM investigated whether novice users are able to use a system successfully with little formal training. He also investigated the features of full-text retrieval applied by novices, the relationships among user objective and their search patterns, and how search patterns were related to information seeking strategies. The results showed that young novice users were successfully able to use full-text electronic encyclopaedia with minimal training. The sixth grade users were more successful than the third and the fourth grade students. Novice users preferred to use system defaults and avoided using more advanced search features. Novice users were less likely to try advanced features if they feel intimidated by the system. Thus, this study attempted to find ways to facilitate advanced search features for novice users and provide default configurations in a way that does not clutter user interfaces or intimidate end-users.

Catledge and Pitkow (1995) have studied search behaviour in a natural setting where they analysed search logs of users under natural settings to understand their intrinsic browsing patterns. Pattern detection algorithms investigated the number of occurrences of the users' search trajectories to determine the frequency of repeated accesses to a particular web site or a web document. They were able to categorise browsing into three types; serendipitous browsing, general purpose browsing and long-narrative browsing. The main limitation observed during this study was that the keystrokes users made during the search were examined in isolation to the main context of the search.

Byrne et al (1999) studied the search behaviours of the users in a natural setting. He focused on user's daily web usage, instead of using a pre-determined control task. Think-aloud protocols and video logs were used as data collection means. Some of his research conclusions (for example, suggestions to improve the browsers ergonomics) are out of date since the study was conducted twelve years ago. However, results showed that if users found articles that are of interest to them, they took time to read the information. The authors suggested that verbose and textual web pages are not necessarily a bad design, but they should be designed with a focus on improving readability.

Information seeking behaviour model by Ellis (1989) represented an empirically driven framework. The study conducted in collaboration with various academic social scientists and identified six stages of information seeking stages: starting, chaining, browsing, differentiating, monitoring and extracting. The work was extended to users who are physicists and chemists in subsequent studies, which confirmed the original six stages along with two additional ones, verifying and ending characteristics (Ellis, 1993; Ellis et al., 1993). These characteristics could happen in any order and a sequence is not required.

Ellis characteristics can be elaborated as below:

Starting	"Activities characterising the initial search for information." (Ellis & Haugan, 1997)
Chaining	"Following chains of citations or other forms of referential connections between material." (Ellis, 1989)
Browsing	"Semi-directed searching in an area of potential interest." (Ellis, 1989)
Differentiating	"An activity which uses differences between sources as a filter on the nature and quality of the material examined."(Ellis et al., 1993)
Monitoring	"Maintaining awareness of the developments of technologies in a field through regularly following particular sources."(Ellis & Haugan, 1997)
Extracting	"Systematically working though a particular source to identify material of interest."(Ellis, 1993)
Verifying	"Checking the information and sources found for accuracy and errors." (Ellis et al., 1993)
Ending	"The assembly and dissemination of information or the drawing together of material for publication." (Ellis et al., 1993)

The Ellis model has been used to investigate information seeking in several domains. A study by Meho and Tibbo (2003) conducted with social science faculty researchers confirms validity of the six characteristics of Ellis model, while identifying further new features: accessing, networking, verifying and information managing. The new model groups all these features into four interrelated stages: searching, accessing, processing, and ending.

Choo et al (1999) studied the web searching activities in natural settings. Interviews carried out to investigate on user critical experiences on the web searching helped identifying information requirements and information seeking preferences. They proposed a new behaviour model for information seeking on the web using the theories proposed by Francis Aguilar and David Ellis Aguilar (1967) proposed four main modes of organisational scanning: (a) undirected viewing, (b) conditioned viewing, (c) informal search and (d) formal search, were combined with Ellis' information seeking activities (Ellis, 1997). Table 3-1 shows how both these models were combined. The finding from the study suggested that a behaviour framework that is able to relate motivations (the strategies and reasons for viewing and searching) and moves (the tactics used to find and use information) might be helpful for analysing web-based information seeking. The study also suggests that multiple and complementary methods of collecting qualitative and quantitative data may be used within a single study to compose a richer portrayal of how individuals seek and use web-based information in their natural working environment.

Aguilar model/ Ellis model	Starting	Chaining	Browsing	Differentiating	Monitoring	Extracting
Undirected Viewing	identifying selecting starting pages, sites	following links on initial pages				
Conditioned Viewing			browsing entry pages headings, site maps	bookmarking printing, copying, going directly to known site	revisiting 'favourite' or bookmarke d sites for new information	
Informal Search				√	√	using (local) search engines to extract informatio n
Formal Search					√	√

Table 3-1. Behavioural model and moves of information seeking on the web.
Source: (Choo et al., 1999)

Dervin's (1992) sense-making theory focuses on how individuals use the observations made by others as well as of their own to construct a picture of the reality and use these pictures to guide behaviour. Dervin's sense making triangle has situation, gap and uses (see Figure 3-1). Situation refers to the when an individual moves through time and space, gap refers to the information need that arises due to having difficulty due to the need or lack of ideas formed or lack of resource to bridge cognitive gap, and finally refers to how the cognitive gaps are set to work. The triangle is where the situation provides the context in which the individual needs to make sense of information needed (gap), which, in its turn, drives him/her to seek information.

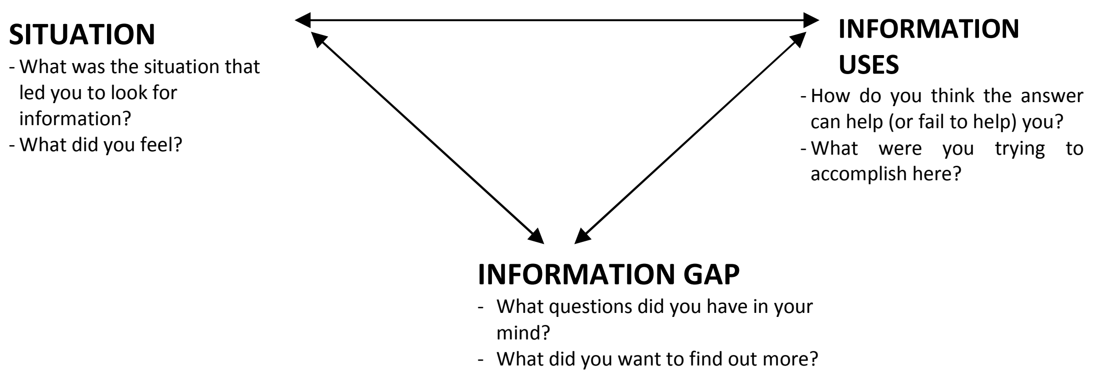


Figure 3-1. The sense-making triangle: situation-gap-uses. With questions posed at each selected time space moment. **Source: (Cheuk & Dervin, 1999)**

Kuhlthau (1993) carried out a series of studies and proposed an uncertainty principle for information seeking. The principle of uncertainty is associated with emotional and cognitive state of the user, and represents anxiety and lack of confidence. Kuhlthau's (1991) study focuses on the feelings, thoughts and actions associated with information seeking stages of initiation, selection, exploration, formulation, collection, presentation and assessment. The model does not come across as a high-level model. A high-level model refers to a one that analyses users search data at a higher level of abstraction, while a low-level model refers to a one that analyses users search data at a low level of abstraction. The model described when the searcher starts with a state of uncertainty and eventually becomes more relieved and satisfied (Kuhlthau, 1991; Wilson, 2000). A research study investigated the information seeking process by a team of lawyers and students. The students showed intolerance to uncertainty as they felt that they were not achieving the objective, while lawyers look upon the uncertainty positively, taking up the challenge with interest and enthusiasm. This might be due to the fact that novice users seek for right information, whereas the objective of expert users tend to be to add marginal value to the knowledge they already possess (Kuhlthau, 2008).

Bates' (1989) model of berry-picking is considered to be a user-centred searching model that is closer to the behaviour of information searches than the process of information retrieval (see Figure 3-2). She describes that the berry-picking model differs from other information seeking models by the nature of the query, overall search process, search techniques used and which domain the search is conducted. The berry-picking model is based on the premise that search queries of the users are not static, but are refined in an incremental fashion as the users gather further information in an evolutionary fashion. It is difficult to generalize user search techniques and users are not limited to a single data resource. As berry-picking is similar to browsing, Bates points out that sophisticated browsing techniques such as in contrast to directed searching don't-know-what-I-want behaviour should be incorporated into interfaces to enhance capabilities. The model puts into context the types of searching capabilities that users might apply in a system. The designers can incorporate user search capability during system design. An advantage of this model is in the sense that it is malleable and can conform to different types of search methods in a variety of settings (internet, physical, electronic) and disadvantage is that it is a very difficult concept to apply systematically as its very nature is inconsistent.

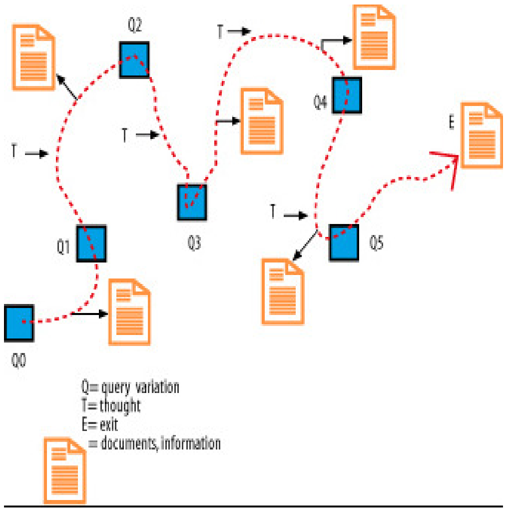


Figure 3-2. A berry-picking, evolving search.
(Q=query variation, T=thought, E=exit, =documents, information).
Source: (Bates, 1989) http://www.flickr.com/photos/morville/84894767/lightbox/

Finding relevant information can be associated with a cost and time factors (Card, Robertson, & Mackinlay, 1991). A reduction in cost or time means optimising the gain, allowing other options to be invested in the sense making process (Russell, Stefik, Pirolli, & Card, 1993). Anthropologists and ecologists developed the optimal foraging theory to explain how animals hunt their pray. This concept was later adopted by Pirolli and Card (1999) in elaborating information foraging theory by identifying similar characteristics among users searching information and the manner animals search for food. The theory is an approach to understanding how strategies of information seeking, gathering, and consumption may be restructured to maximise their rate of gaining valuable information. Pirolli and Card further discussed information scent models, which identified value of information using cues. Animals tend to follow clues to track their prey, follow their prey and change their attack strategies according to changing circumstances. Similarly, when people look for information, they often tend to navigate through virtual spaces to find high-yield patches, and follow strong "scent" of information. A study investigated browsing behaviour of users and how information scent was used to navigate through interfaces (Pirolli & Card, 1999).

A study by Makri et al (2008) revisited Ellis model which investigated lawyers and their information seeking. The refined Ellis model identifies subtypes of behaviour: resources, source, document, content and search query/ result levels. The authors suggest that the findings based on Ellis' model due to the low-level nature could inform designs supporting behaviour stages identified. The insights of information seeking behaviour from specific user groups can be useful to improve design of systems. Makri et al showed that information seeking behaviour models that are of high-level abstraction are only likely to yield broad-scope design insights. However, a low-level abstraction model such as Ellis' is able to provide details design insights based on user behaviour.

To summarise this section Wilson's (1981) model of information seeking behaviour is described as a high-level model. The focus of his behaviour model is prompted by the individual's physiological, cognitive, and effective needs. It explains that the need for information arises from external factors such as the users work environment or socio-cultural surroundings. The need will depend on the person's social role and his/her personal needs (Wilson, 1981, 2000). While Wilson's (1981) model of information seeking behaviour looks at the users' interaction with the system at a higher level, the two models by Kuhlthau and Ellis focuses on detailed low-level behaviours. The Ellis' model attempts to understand a users' quest for exploring information from a systems point of view, while Kuhlthau's model focus on the feelings of the information searcher. Because of its low-level orientation to detail, the Ellis model has been used to elaborate the design of interfaces. Currently the Ellis model has been used to identify information seeking behaviours of HL users who are academic social scientists, physicists, chemists or lawyers.

Satisficing and Optimising During Information Seeking

This section is introduced to this chapter to investigate satisficing and optimising solutions made during information seeking by users. Previous research found that LL users are less effective during information seeking and were satisfied with relatively little information compared to the HL users (Nielsen, 2005; Summers & Summers, 2003, 2005). LL users tended to read word-for-word, which imposes higher cognitive load. Therefore, LL users may not necessarily see a benefit of exploring further information due to the additional cognitive load. Russell et al (1993) discussed how to maximize the expected gain by reducing the cost of operations of an information processing task by quantifying the cost structure of sense-making. They identified the main costs as finding the relevant documents, contacting the information and then transforming the information into canonical forms. They showed how the technology can affect sense-making by reducing the cost (or increase in gain) associated with time to invest on other information processing steps.

In order to explain satisficing and optimising solutions, Herbert Simon (1965) presented a behavioural theory of decision-making. The concept of satisficing denotes problem solving and decision-making aspiration levels (Simon 1965). Satisficing means that people "stop searching as soon as [one has] found an alternative that meets [one's] aspiration level". In the field of analytical reasoning, Heuer (1999) explained satisficing as "people settle for a good enough answer, sometimes stopping their analytical process before they identify critical information that would have lead them to a different conclusion". Whereas optimizing refers to "… finding optimum solutions for a simplified world or by finding satisfactory solutions for a more realistic world" (Simon, 1955).

CONCEPTUAL MODELS AND USER MENTAL MODELS

Usability of a system is strongly correlated with the extent to which user's mental model is able to predict the responsiveness of the system. Consequently it is important for the system designers to analyse and capture the user requirements and incorporate these into system's design (Norman, 1988). Norman suggests that the best way for an interface designer to guide a novice user to gain expert status would be to conceal the system model and indulge the user's mental models to bridge the gap. A mental model that does not accurately represent the system responsiveness would leads to errors (Reason, 1990). Many systems place higher cognitive load on the humans that use them. Software interfaces should be designed to help the users to build productive mental models of the system. The field of Human Computer Interaction strives to understand and explain the users mental model in respect to a system. Moreover, there is growing need to investigate the mental models for the LL users as it is a category of users who have been less successful seeking information.

Note that there is a tendency for researchers to use the terms conceptual and mental model interchangeably; in addition, various authors describe the similar notions using the terms mental models, conceptual models and cognitive models (Straggers & Norcio, 1993).

Kenneth Craik (1943) is usually credited with bringing the concept of mental models into the realm of psychology when he described "thought models, or parallels realities" in 1943 (Rogers, Rutherford, & Bibby, 1992). He described the models as having predictive power whereby the user would try an event or action by executing the models in their minds, before or instead of in the real life. This model is informed through prior experiences that the human has during his or her life. Thus, they can be considered to be mutable internal representations of the aspects of the external world, from which predictions and inferences can be drawn (Rogers et al., 1992).

Norman (1983) distinguished between the mental models and the conceptual models. "Conceptual models are devised as tools for the understanding or teaching the physical systems. Mental models are what people have in their minds and what guides their use of things" (Norman, 1983). Norman's (2002) *conceptual model* and *system model* are different. He refers to the system model to be the actual manner the system works from the programmer's perspective. The conceptual model is the manner the designer represents the program to the user, including presentation, interaction, and object relationships. A mental model of a user allows to understand the problem statement and to predict the consequences of actions intended for solving problems (Marchionini 1989).

The literature identifies card-sorting as a popular technique to elicit the knowledge that is otherwise implicit, which also helps understanding the mental models employed by users (Chaparro, Hinkle, & Riley, 2008; Kaufman, 2006; Nielsen & Sano, 1994; Olmsted-Hawala, 2006). An open card sort provides the users with the freedom to classify information according to their level of understanding, available domain knowledge and their intrinsic experience (that is, without any external influences). This enables researchers to investigate the implicit knowledge of the participants and reasons for the classification (card sorting) using think-aloud protocols. Card-sorts can be carried out either electronically or on paper.

It is usually assumed that taxonomies are stable in people's minds. In contrast, the concept of goal-derived categories offers a perspective in which the individual actively constructs cognitive representations to achieve salient goals (Barsalou, 1983; Ratneshwar, Barsalou, Pechmann, & Moore, 2001; Ratneshwar, Pechmann, & Shocker, 1996). The literature in the field of retail consumer research suggests that personal and situational goals can exert a systematic impact on category representations. Consequently, people with different goals may classify the same domain in different ways.

Card sorting has been used by information architects (Coxon, 1999; Fincher & Tenenberg, 2005; Nielsen & Sano, 1994; Nielsen, 2009; Spencer, 2009; Spencer & Warfel, 2004), cognitive psychologists (Upchurch, Thrapston, Rugg, & Kitchenham, 2001) and social scientists (Ameel, Storms, Malt, & Sloman, 2005) in order to capture mental models of how participants would organise information.

As a way to improve user experience, information architects carry out card sorting studies to understand how users perceive the information presented, and to organise content accordingly.

Olmsted-Hawala (2006) carried out a card sort study related to reorganising the information content in a Census Bureau web site. The focuses was on creating the information architecture in order to accurately and efficiently find demographic and economic information user's need when searching for information on the Census Bureau website. The first round of findings identified ten high-level categories, while the second round identified terms that can be double-linked from various pages. They further identified confusing or uncommon terms the users were unaware of. The study provided an insight into what users were expecting and where in the website that users were expecting to find the respective information.

Kurniawan and Zaphiris (2003) carried out a card sort study to investigate experience of older users in a health information website during an effort to redesign and improve its information architecture. The results suggested that the older participants grouped the items conceptually at higher levels of the information hierarchy (e.g., by putting items related to Organizations or Diabetes in one group) however, they were based on similar words found in the titles at the lower level of the hierarchy. The classification was heterogeneous with respect to the original information architecture. The category labels suggested by the users preferred less formal terms compared to the terms on the existing website.

Schoenfield and Herrmann (1980) conducted card sort study to investigate knowledge structure and problem representation of the expert and novice users in the domain of mathematics. There were 32 mathematical problems with deep and surface structures. Deep structures referred to the mathematical principles necessary for solving a given problem, while surface structures referred to the items described within the problems. The results showed clear differences in the way expert and novice users resolved the mathematical problems. The results indicated that experts and novices used different criteria for evaluation. The experts resolved the problems more consistently compared to the novices. The similarity matrix showed a strong agreement among the experts compared to the novices.

A study was carried out by Liu and Camp (Liu & Camp, 2007) to explore mental models of security experts and non-experts in a closed card sort study. They were asked to categorise given words into six groups. The findings suggested that experts and non-experts have two different mental models, which strongly correlates with their level of expertise.

Ziefle and Bay (2004) investigated the interrelationship between user mental model of a cellular phone menu using novice young and older users (see Figure 3-3). The participants were given four tasks using two phone simulations that used a touch screen. On completion of the tasks, users' mental representation of the phone menu was assessed though a card sort technique. The findings showed that the users' mental model about a mobile phone menu structured significantly influenced their navigation performance. The novice younger and older adults' mental models differed substantially. The mental model of the menu in older adults was linear and functions were arranged in clusters without any interconnectivity. The specific attributes of older users' mental representation resulted in inferior navigation performance compared to the younger group.

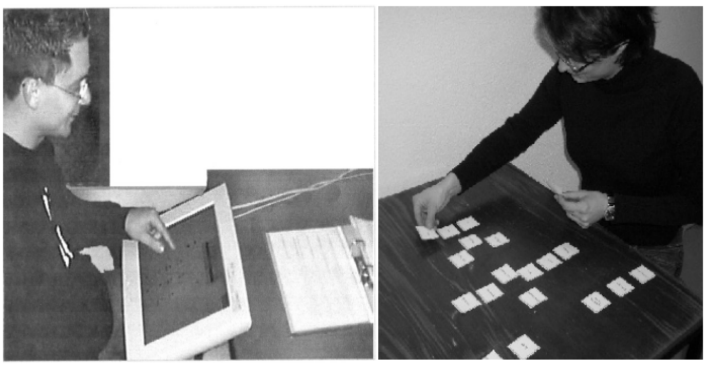


Figure 3-3. Card sorting study.
Left: participant solving the phone task on a computer-simulated cellular phone; right: participant arranging the menu functions in the card-sorting task.
Source: (Ziefle & Bay, 2004)

Joshi et al (2008) created a phonebook based on how LL users use colours and icons to identify a contact (see Figure 3-4). To evaluate this idea, a card sort study was carried out. The participants' phone book contacts were written on post-it notes and were asked to sort those using categories and subcategories (relationships, age, colours, tastes and icons). The users sorted the number into categories. The icons category was most linked to an individual (friends, close relatives etc.). The abstract shapes were used to represent their relationship to the person. Some used the colour category to help them differentiate their contacts.

Figure 3-4. Initial ideas of the phonebook for semi-literate users.
Source: (Joshi et al., 2008)

GAPS IN THE LITERATURE

Information seeking is a conscious activity to acquire information in response to fill a gap in the user's knowledge or to provide a solution to an existing problem. There have been studies carried out over the last two decades that examined the information seeking behaviour in different users groups, such as librarians, lawyers, scientists, students, and researchers who were considered of high literacy. However, an evident gap in the literature has been investigating LL user behaviour in relation to the existing information seeking behaviour models. The existing information seeking behaviour models have been investigating HL users' behaviour as a way of informing useful design. This gap in the literature can be addressed by mapping both HL and LL user information seeking behaviour strategies, actions and outcomes to a low level model such as Ellis model. By using existing information seeking behaviour models, it might be possible to inform design and to investigate whether there are variations between information seeking behaviour of different groups of users.

There is evidence suggesting that during information seeking, LL users employ satisficing solutions while HL users usually tend to optimise. It is necessary to identify the strategies HL users adopt to optimise their solution. By identifying the methods they use, we could potentially incorporate those methods and strategies (or adopted variations thereof) into designing systems to support LL users.

Previous research showed that LL users are less successful during their information seeking and showed a higher chance of abandoning a search task, unlike HL users. Most systems are designed keeping HL users in mind. When designing a system, the designer needs to fully understand what the user intends to do (Young, 2008a). By understanding how users perceive the current system, one could devise a strategy for improving the system. There is some literature that has endeavoured to understand LL users mental models prior to designing new interfaces or to improve existing interfaces (Joshi et al., 2008).

In order to propose an interactive visualisation for LL users, it is important to appreciate differences between information seeking behaviour of HL and LL users and their respective mental models. The following chapters will compare the information seeking strategies (Chapter 4), behaviour models (Chapter 5) and mental models (Chapter 6) that are adopted by HL and LL users.

CHAPTER 4

IDENTIFYING BEHAVIOUR STRATEGIES

This chapter reports the investigation into the reasons for low success in information seeking experienced by low literacy (LL) users compared to high literacy (HL) users during online information seeking on a social service website called the *Adviceguide.*

Previous studies on LL users suggests that, when confronted with long and dense pages, they tend to read word-for-word, have a narrow field of view, skip chunks of text, are satisfied with information quickly, and avoid searching (Summers & Summers, 2005). A study by Kodagoda & Wong (2008) looked at the user performance of 6 LL and 6 HL users when searching for, and retrieving information from the *Adviceguide* site. The findings showed that LL users performed this task less successfully compared to HL users.

As more government and other organisations place information online and reduce face-to-face advice, the importance of understanding the data exploration strategies of LL users becomes more apparent.

There is thus a need to investigate if there is a difference in behaviour strategies employed by HL and LL users. This chapter describes the methods and results of the investigation into information seeking behaviour strategies. Additionally, information seeking behaviour strategies are explored to investigate the less successful strategies employed by LL users.

IDENTIFYING OF INFORMATION SEEKING BEHAVIOUR STRATEGIES

The study aimed to identify strategies used when searching for information on the *Adviceguide* website, where the effects of literacy levels (high vs. low) were assessed against level of task difficulty (easy, medium and difficult). Data was collected using multiple Cognitive Task Analysis (CTA) methods including, think-aloud and semi-structured interviews and observations, which were then analysed using principles inspired from Grounded Theory (GT) (Glaser & Strauss, 1967) and Emergent Themes Analysis (ETA) (Wong & Blandford, 2002). Ethics approval for the study was obtained from the School of Engineering and Information Sciences at Middlesex University Ethics Committee.

METHODOLOGY

Participant Selection Criteria

Past research has suggested that people who were literate in their first language were able to transfer those skills to learn a second language (Strucker & Davidson, 2003). From the 5 HL and 5 LL participants who participated in this study3 participants were immigrants who had settled in the UK for over ten years, of which one were LL and the remaining two were HL. None of the volunteers had prior experience using the *Adviceguide*, even though they were walk-in clients of the local CAB. None of the volunteers according to them had any known learning disabilities (such as dyslexia).

Participants

An advertisement was placed in a local CAB, and staff were informed of the aim of attracting clients to participate in the study. Participants had to be 18 years old and above and have computer and internet literacy (weekly computer and internet usage between four – ten hours), but have no prior experience using the *Adviceguide* website. In total, ten participants took part in the study. Five were HL while the remaining five were LL. There were six females and four males with a mean age of 40 years (ranging from 36 to 55). From the ten volunteers, three were cleaners, three were security officers, and the remaining four were not working at the time of the study.

Participants' literacy was only evaluated on completion of the study using the UK National Skills for Life Literacy Survey[4]. The total score determined the level of literacy (Williams, Clemens, Oleinikova, & Tarvin, 2003). The survey is on a scale of 40: scores ranging from 5 to 28 defines LL while scores ranging from 29 to 40 defines HL. The Literacy survey tested users on eight listening, 16 writing, and 16 grammar questions (Williams et al., 2003). The HL participants of this study scored an average of 32 out of 40 (ranging from 31 to 39) while the LL participants scored an average of 12 out of 40 (ranging from 6 to 17).

Design of the Information Search Tasks

For the purpose of this study a social service website in the United Kingdom was selected (*Adviceguide* - http://www.adviceguide.org.uk – see Figure 4-1). Four information search tasks were developed based on advice types frequently requested by walk-in clients to the local CAB (between April 2005 and May 2007). Each information search task required a participant to find a specific piece of information such as eligibility for benefits, money advice, debt, council housing, or advice on council tax arrears, etc. Each search task also varied in difficulty (easy, medium, or difficult).

[4] *Please refer to Appendix E for UK National Skills for Life Literacy Survey*

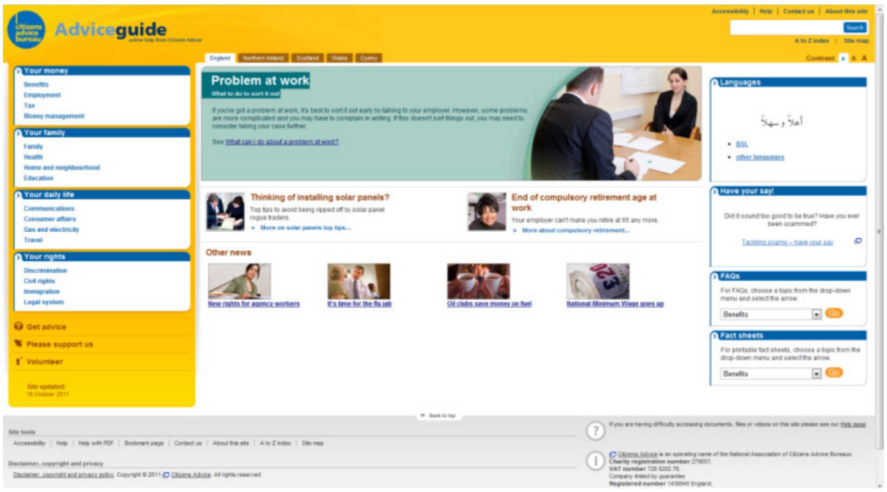


Figure 4-1. *Adviceguide* website home screen.

The difficulty of the task was defined by:

1. Number of steps and paths available to find the information within the *Adviceguide* website. A step refers to the number of links required to get to the answer, while a path refers to the number of trajectories available to get to the answer. For instance, if the correct answer is under *benefits,* the participant will have to go from the *home page* to *benefits.* This means the answer is one-step away and there is only one path.
2. Number of concepts per page.
3. Readability of the text[5] (e.g. corresponding to UK National Skills Literacy Levels - Entry Level 2 = EL2, Entry Level 3 = EL3 and Level 1 = L1).

Easy tasks (E1 and E2) were two steps away from the home page, and had one concept in the target information page with a reading level of EL2. The medium difficulty tasks (M) had multiple paths to arrive at the same answer from the home page, a minimum of four steps away, two concepts in the target information page with a reading level of EL3. Finally, the difficult task (D) had multiple paths leading to similar answers from the home page, a minimum of five steps away, more than three concepts in a target page and with a reading level of L1.

[5] *Please refer to Appendix C for measurements of readability levels of text*

Methods Used for Investigation

Cognitive task analysis (CTA) methods are used to study human cognition in real-world settings (Militello & Hoffman, 2008). CTA is an extension of traditional task analysis techniques to yield information about the knowledge, thought processes and goal structures that underlie observable task performance. The approach emerged in the early 1980s in response to demands of the workplace. As introduction of smart machines crated unanticipated complexities for human operators and led to high-visibility incidents.

CTA methods are used to analyse work systems and inform the design of systems, taking into account human operators, technologies, and the work environment. Cognitive task analysis (CTA) methods are used to discover expertise that domain practitioners utilise to perform tasks so that better support, such as automation or training, for these cognitive activities can be developed (Militello et al., 1997). Specifically, CTA's identify ineffective strategies that lead to poor performance (i.e., a model of mistakes that "novices" make), as well as adaptive strategies that have been developed by highly skilled practitioners to cope with task demands (i.e., a model of "expert" skill). The complexity of understanding the environment and the tasks, combined with the fact that experts performing cognitive tasks have difficulty reliably articulating about the task when asked, contribute to making discovering expertise hard. There is a myriad of other challenges, which is why a variety of cognitive task analysis methodologies exist (Schaafstal, Schraagen, & van Berlo, 2000). These improved designs would reduce the likelihood of error and allow workers to better leverage the strengths of increasingly powerful technologies (Militello & Hoffman, 2008).

Multiple CTA methods were used to extract and understand the human decision process during the participants' cognitive work (Crandall, Klein, & Hoffman, 2006; Klein & Militello, 2001; Militello & Hutton, 1998). CTA methods used were process tracing and interview methods. CTA is defined as "*the extension of traditional task analysis techniques to yield information about the knowledge, thought processes, and goal structures that underline observable task performance*" (Schraagen, Chipman, Shalin, & Shalin, 2000). These three techniques were used to triangulate and identify participants search behaviour strategies. Process tracing captures what participants were doing, decisions they were making, and experiences encountered during the search task via the think-aloud protocol (Ericsson & Simon, 1993). User Observations (Stanton, 2005) assists the interviewer to identify participants' physical aspects.

The Critical Decision Method (CDM) is a case-specific multi-trial retrospection, structured by probe questions, designed to elicit information about the important cues, choice points, options, and action plans (Klein, Calderwood, & MacGregor, 1989). The method is a variant of a Flanagan's (1954) critical incident technique extended to include probes that elicit aspects of expertise such as the basis for making perceptual discriminations, conceptual discriminations, typicality judgments, and critical cues. The method has been used to elicit domain knowledge from experienced personnel such as urban and wild land fire ground commanders, tank platoon leaders, structural engineers, design engineers, paramedics, and computer programmers.

The in-depth interviews used for this study was modelled after CDM (Klein, Calderwood, & MacGregor, 1989). In order to elicit users' experiences and information search strategies the CDM probes were modified to extract what the users were seeing, doing, reasoning and what decisions were made during the search in order to arrive at the answer.

PROBE TYPE	PROBE CONTENT
Cues	What were you seeing, noticing, etc?
Options	How was this option chosen or were others rejected?
Mental models	Why did you decide early in the search the information was not available, what was the reasons behind this? So where did you expect to find the information? Did you expect the information to be available somewhere in the site?
Decision making	What let you know that this was the right answer at this point in the task?

Table 4-1. Modified CDM probes.

The limitations of individual methods can be overcome by triangulating and orchestrating multiple methods such as think-aloud, semi-structured interviews and observations. The information not identified during think-aloud sessions, can be compensated, and identified during observations, and during semi-structured interview sessions. During semi-structured interviews, selected sections of the video can be played back to help reduce any assumptions, misinterpretations and assist participants to recall and discuss what they were doing, thinking, and what actions they were taking during that specific time. Further to this, participants could take advantage of the video to show and discuss anything they felt was interesting or important.

For the purpose of this research, it was felt important to follow the methods such as CTA and CDM, as they are able to capture users' cognitive activities during a search task. These methods help discover effective and ineffective strategies used, which lead to optimal (i.e., a practitioner utilise) or poor performance (i.e., a model of mistakes that "novices" make). Due to the above discussed methods, ethnography, action research and participatory design was disregard.

Procedure

A pilot study conducted prior to the main study. Four participants (2 high and 2 LL) from the local CAB volunteered. The pilot study examined whether the instructions given were clear, the study design was complete and the data collected was correct.

The main study conducted in the Interaction Design Centre Usability Lab at Middlesex University. Participants were informed of the study procedure and all participants gave consent for video and audio recording. In order to prepare participants with the think-aloud, a sample practice problem was given to familiarise them with the verbalisation process while solving the task.

Four tasks based on social service information each having different levels of difficulty were used for this study. The four tasks were randomised using Latin-squares to counter balance the order of tasks. Participants were given time to familiarise themselves with the *Adviceguide* website. Participants dealt with only one task at a time. Each search task started from the home page, the cache on the system was reset prior to each session to minimise any confounding variable efforts. The participants controlled the start and the end of each search task. The outcome (the specific information found by the participant) of the search task was written on the answer sheet provided.

Participants were informed of the study procedure, and gave consent for video and audio recording (For study setup, see Figure 4-2). Multiple CTA methods were used to extract and understand the participants' decision process during their tasks. Methods used were (a) think-aloud (video capture), (b) semi-structured interviews (video play-back and field notes taken) and (c) user observation (video capture and field notes taken) were used as data collection methods. The participants used the think-aloud protocol, the observations made by the interviewer were noted for further clarifications during interview. Participants' interface interactions with the *Adviceguide* were recording using BB FlashBack software. BB FlashBack is screen recording software. During the interview selected sections of the recorded video were played back to help participants recall and reflect on the interviewer questions. This helped clarify observations made during the search or the queries noted by the interviewer during the participants think-aloud sessions. These insights help understand the participants' actions and their decisions before they arrive to the final solution. Participants level of literacy[6] were evaluated once all tasks and interviews were completed (Williams et al., 2003).

[6] *Please see Appendix E for UK National Skills for Life survey*

Figure 4-2. The study setup in the usability lab.
Participants gave permission to be recorded and photographed.

METHOD USED FOR DATA ANALYSIS

The study, excluding the literacy test and breaks, on average took two hours for the HL user and four hours for the LL user. The qualitative data from the think-aloud, observations, video recordings along with the in-depth interviews were transcribed. There were 24 hours of LL user video data and ten hours of HL users' video data, which were also transcribed.

The data analysis method was inspired by principles of GT and ETA approaches. During the data analysis process the literacy status of the participant were blinded, to avoid any bias. The two methods required coding the data at different levels. One used coding data at a bottom up approach while the other used a top down approach. Server log files were used to determine users search trajectories.

Data Analysis Inspired By the Principles of Grounded Theory

The GT attempts to investigate and discover concepts that are grounded in the data, which can be used to build theory (Glaser & Strauss, 1967). Glaser & Strauss insist the data needs to be analysed systematically in a rigorous manner while not forcing pre-conceived ideas or hypotheses. Strauss and Corbin (1998) recommend the use of the *microanalysis* method where the data is analysed word by word. The analyst should be able to see how concepts emerge from the coded data, and how those discovered concepts subsequently lead to broader categories (Allan, 2003). A rift in the analysis method is identified, where Straus & Corbin (1998) recommend "microanalysis which consists of analysing data word by word" and "coding the meaning found in words or groups of words" while Glaser recommends identifying key points rather than selecting individual words (Glaser, 1992). The next section shows how microanalysis was applied to the qualitative data.

Guided by the micro-analysis procedure, the transcripts were analysed inspired by the principles of grounded theory. The theory attempts to investigate and discover concepts that are grounded in the data, which can be used to build theories.

Post-it notes were used to write down the identified phenomenon. In order to validate the results a small sample (two out of the ten participants) of data was analysed by two independent researchers. The double blinding of coding showed a match of 85% between the researches and to the existing analysis. This gave a firm starting point to continue coding with the remaining transcripts. The post-it note labels got unmanageable, due to increasing numbers. The data then was imported to HyperResearch, which is a qualitative data analysis software tool. The software allows tagging of codes to text (transcripts) and captured video. As the code list increased, even HyperResearch software became difficult and unmanageable. The transcripts needed to be revisited three to four times to minimise data being over looked and to avoid duplication of codes. The HyperResearch software tool enabled the query of coded data. Lists of codes or code maps were generated to identify relationships between categories. Then the categories were classified into themes.

The GT method consists of identifying incidents, events, activities, and coding them into their respective categories by constantly comparing them to the properties of the emerging category to develop and saturate the category.

Data Analysis Using Emergent Themes Analysis

The ETA, which is based on Grounded Theory, intends to help filter vast amount of rich qualitative data in a structured manner (Wong & Blandford, 2002). It is a top-down approach, where broad concepts, called themes are identified across the transcripts. These themes are then indexed and collated. In this study, the themes were associated with broad aspects of the behaviour strategies identified by HL and LL users during their information seeking. Sub-themes that are more specific were identified using a similar procedure by further categorising them using a framework for describing each behaviour strategy in finer detail show the systematic and rigorous process taken.

The framework consists of four categories, which describes: (a) the *activities* carried out by users during information seeking, (b) the *cues* users attended to during the information seeking and what resources and strategies they considered based on their identified cues, (c) the *knowledge* and experience the users gained by carrying out the search task, and (d) the *difficulties* the HL and LL users encountered such as problems and mistakes and what the consequences were, including likely mistakes of the search process. Supporting evidence of the specific sub-themes was summarised into the framework, which provided finer understanding to the decision process. The framework assisted to produce summary tables required for data reduction, this is an essential step for making sense of large data sets. The narratives helped make sense of the heavily reduced data tables.

RESULTS

This section discusses outcomes, which analysed the qualitative data of the HL and LL users during their information seeking. The analysis identified user strategies employed in detail later. For the purpose of this thesis homogeneous will refer to similar and heterogeneous will refer to as dissimilar.

The Strategies Identified are Discussed below with Evidence

<u>READING STRATEGY (scanning vs. word-for-word)</u>: LL users read word-for-word. R*eading* takes place when users try to read word-for-word, to make sense of the information they read. S*canning* takes place when users take a glance through headings and subheadings or start, middle of a paragraph until they find the relevant content.

The observations made for the five HL users during their information seeking showed that they (a) scrolled through the page and stopped when they found relevant content (headings, new paragraphs, keywords), (b) two out of the five users' observations suggested that they hovered the cursor over the word or heading being read, or pointed at the line or paragraph they were reading, (c) all users spent less time on the web pages. The three observations were verified during the in-depth interviews, where captured videos were played back to the participants while they were asked to explain what they were doing at that point of the search. The explanations suggested that the five HL users, during their information seeking, employed a scanning strategy at an early stage of their search and then moved towards a reading strategy when they found something more relevant or specific to what they were looking for. The reading strategy however, was observed to increase as the task difficulty increased. In the easy and medium tasks, all HL users first scanned and then moved to reading. However, for the difficult task only four out of the five participants scanned the text before reading (see Table 4-2).

The observations made for the five LL users during their information seeking showed they (a) pointed the mouse at words being read, lines they were reading, and at paragraphs they were reading, (b) taking a considerable amount of time, on a line, paragraph or page before they moved the mouse to another part of the same page or another new page. The LL users during the in-depth interviews explained that they were reading the content of the webpage in these instances. The explanations suggested that the five LL users during their information seeking employed a reading strategy where they were reading word-for-word trying to make sense of what they were reading. This suggests that these participants do not employ a scanning strategy on all task difficulties.

The following quotes were extracted to demonstrate and justify the conclusion made.

> Participant LL3, Information task M. One remark from a LL user demonstrated that the user read word-for-word. *"… I am just reading though the list of basic rights at work now, I am reading through to see if there is anything about rights at work …"*
>
> Participant HL3, Information task M. One remark from a HL user demonstrated that the user browsed through the content until the person came across a relevant or an interesting information clue, then only the user employed the reading strategy. *"… I was just scanning though this list, and at this point I found something related what I was looking for. I selected it and then started reading."*

For a summary of the scanning and reading strategy carried out by the HL and LL users during their information search tasks observed at least once see *Tables 4-2 and 4-3*respectively.

HL USERS	**INFORMATION SEARCH TASKS**			
	E1	**E2**	**M**	**D**
HL1	SR	SR	SR	SR
HL2	SR	SR	SR	SR
HL3	SR	SR	SR	SR
HL4	SR	SR	SR	R
HL5	SR	SR	SR	SR

Table 4-2.Scan and reading done by HL users.

LL USERS	**INFORMATION SEARCH TASKS**			
	E1	**E2**	**M**	**D**
LL1	R	R	R	R
LL2	R	R	R	R
LL3	R	R	R	R
LL4	R	R	R	R
LL5	R	R	R	R

Table 4-3.Reading done by LL users.

S = scan, and R = read

<u>FOCUS (wide vs. narrow field of view)</u>: Narrow field of view. *Focus* refers to when LL users were confronted with dense pages of information, where they did not notice content above, below, or to the side of their focus creating a narrow field of view.

The observations made for the five LL users suggests, when confronted with dense web pages they either started reading the first few paragraphs or later scrolled skipping the actual information that they needed and moved to another section, and continued with their reading. This was observed during the medium and difficult tasks. The LL users during the in-depth interviews explained that they were reading the content of the webpage in these instances, they skipped content due to the amount of text, and were unable to find the correct information from the sections they were in, deciding to move to a new area and continued with reading.

The following quote from a LL participant were extracted to demonstrate and justify the conclusion made.

> Participant LL1, Information task M. This LL user skipped over large amounts of information, missing out on the actual information the user was looking for, and moved into a new section. When we showed the video and ask what the participants were doing."*… Oh here...., there is a lot of text in this page, I found a couple of like this before too, I was reading this* [points at the paragraph the user had been reading]*, I could not find anything related to what I was looking for so I moved here* [scrolled] *to see if I can find any information here* [shows where the user finally scrolled and started to read again, scrolling over the actual information the user was looking for.] *I read this bit too but the information was not available."*

This was not observed with the HL users. For a summary of the focus strategy identified for the LL users observed at least once see *Tables 4-4 and 4-5*respectively.

HL USERS	**INFORMATION SEARCH TASKS**			
	E1	**E2**	**M**	**D**
HL1	-	-	-	-
HL2	-	-	-	-
HL3	-	-	-	-
HL4	-	-	-	-
HL5	-	-	-	-

Table 4-4. HL users focus.

LL USERS	**INFORMATION SEARCH TASKS**			
	E1	**E2**	**M**	**D**
LL1	-	-	F	F
LL2	-	-	F	F
LL3	-	-	-	F
LL4	-	-	-	-
LL5	-	-	F	F

Table 4-5. LL users focus.

F = focus, '-' = focus strategy not identified

<u>VERIFICATION (optimizing)</u>: LL users do not verify the information found for correctness. *Verification* refers to when users found information they need and yet examined other related links differentiating the information and validating the information found for correctness to optimize their findings. The observations made with the five HL users during their information seeking suggested, when HL users found the information they were looking for, yet continued with their search for the medium and difficult tasks. In some instances, they informed that they had found the information and continued the search. In some instances, they arrived at the information pages and some of them highlighted the correct information for a while and continued their searching, later these users went back to the very same pages and informed they found the information or again highlighted the correct information and informed they completed the search. The explanations suggested that the five HL users employed a verifying strategy to verify the information found for correctness. In the medium and difficulty tasks, 100% of the HL users verified the information found for correctness. However, for the easy tasks, verification decreased to 60% of the users (see Table 3-7).

The following quotes from HL users were extracted to demonstrate and justify the conclusion made.

> Participant HL1, Information task E1. This HL user found the answer to the task, but still checked another link to verify the answer. *"… then I went to paid holidays just to double check and confirm and I found the same thing …".*
> Participant HL2, Information task E1. These HL users found the answer to the task, but still scrolled down *"… how much paid holiday can you take …"* to verify the answer found. *"… Hmm I am just trying to see if there is any other information regards to the paid holidays …".*
> Participant HL5, Information task E1. The HL user found the answer but still wanted to verify the answer with other available links. *"… I have already identified the information that is useful to me, which is holiday and holiday pay; there is a list now, with various information that I would like to find more on …".*

This strategy was not observed with the five LL users for any of the tasks. The verification strategy identified for the HL users during their information search tasks observed at least once are shown in *Tables 4-6 and 4-7*respectively.

HL USERS	**INFORMATION SEARCH TASKS**			
	E1	**E2**	**M**	**D**
HL1	V	V	V	V
HL2	V	V	V	V
HL3	-	V	V	V
HL4	-	V	V	V
HL5	V	V	V	V

Table 4-6.HL users verified the found information for correctness.

LL USERS	**INFORMATION SEARCH TASKS**			
	E1	**E2**	**M**	**D**
LL1	-	-	-	-
LL2	-	-	-	-
LL3	-	-	-	-
LL4	-	-	-	-
LL5	-	-	-	-

Table 4-7.LL users did not verify information found for correctness.

V= verify, '-' = not verified

VERIFICATION (satisficing): The LL users employed a *satisficing* strategy. As soon as LL users assumed they had found the relevant information they were looking for, they stopped the search (early closure). However, the information found was incorrect. *Satisficing* refers to when participant stopped the search as soon as they assumed the information found were relevant information or when the information meets with their aspiration levels.

The observation made for the LL users suggests they stopped the search as soon they assumed they found the relevant information they were looking for. During the think-aloud session, LL users were stating "… *Yes this is what I was looking for …*" or "…*I have found the answer to this question …*" before ending the searches. Although, HL users, made similar statements during medium and difficult tasks, they continued their search further than just ending the search. The in-depth interviews suggested that these LL users might have employed a satisficing strategy by ending the search assuming the information they found was correct. This strategy was not observed with the HL users especially in the medium and difficult tasks as they employed a verification strategy to optimize their finding for correctness. For a summary of the satisficing strategy employed by LL users during their information search tasks observed at least once are shown see *Tables 4-8 and 4-9*respectively.

The following quote from a LL participant is extracted to demonstrate and justify the conclusion made.

Participant LL4, Information task E1. This LL user assumed they found the answer to the task and stopped searching. During the think-aloud the user is in the holiday and holiday pay page at first reads the links and then moved to who has the right to paid holiday and read the paragraph underneath the title and scrolled down to can you choose when to take holiday and started reading the content underneath the title and then stated "… *Yes you can decide when to take your holiday and inform your employer …*" and then stopped the search by saying that the user has found the information. During the in-depth interviews the user was shown the video starting from where the user scrolls down to *can you choose when to take a holiday*, here the participant was asked to explain what he/she was doing?*"… Hmmm ah yes the first part I was reading did not have what I was looking for so I scrolled down in the page and found the answer …".*When asked how did you know it was the correct answer? Pointed to the video and showed"… *if you just go to where I highlighted the text that is where I found the answer from …*". Do you think it is the right answer to the question? "… *Yes it is as the question is how much of holiday pay am I entitled to. So when I decide to take a holiday I should find out how much of days I am going to be off on holiday and let my employer know and then I will get paid for those days …*".

HL USERS	**INFORMATION SEARCH TASKS**			
	E1	**E2**	**M**	**D**
HL1	-	-	-	-
HL2	-	-	-	-
HL3	-	-	-	-
HL4	-	-	-	-
HL5	-	-	-	-

Table 4-8.HL users satisfied strategy.

LL USERS	**INFORMATION SEARCH TASKS**			
	E1	**E2**	**M**	**D**
LL1	-	S	-	-
LL2	-	-	-	-
LL3	-	-	-	S
LL4	S	-	S	S
LL5	S	S	-	-

Table 4-9.LL users satisfied strategy.

S = satisfied, '-' = satisfied strategy not identified

RECOVERY (good vs. bad): LL users were unable to recover from a mistake. R*ecovery* refers to recuperate from a wrong or irrelevant information search to a more focused and relevant search, enabling them to find information.

The results show that HL users recognised wrong and irrelevant information or paths they were at from seven out of the twenty search tasks. Adjustments were made to the current search by going back to the home page, main section page, or clicking on the back button and choosing different links until they found the information they were looking for. The results indicate that only in seven out of twenty tasks, that HL users identified wrong or irrelevant information at early stages in their search. From this, only six out of seven were able to make successful recoveries. This strategy was not evident during the easy search tasks for the HL users.

The results indicated that all LL users during their information seeking showed poor system recovery. During the think-aloud sessions, it was observed that four out of the twenty search tasks carried out by the LL users, recognised wrong irrelevant information. Even though they made changes to the current search by, either going back to the home page, main section page, clicking on the back button or choosing different links, they were unable to make successful recovery. From this two out of these four tasks the LL users assumed they found the answer they were looking for, which were incorrect. Finally, in the other two out of four tasks, they abandoned their searches assuming the information they were looking for was unavailable in the sections expected. See *Tables 4-10 and 4-11*respectively for a summary of HL and LL users identified recovery strategies, correct answers, wrong answers and search abandonments during the information seeking.

The following quotes from HL and LL users were extracted to demonstrate and justify the conclusion made for recovery.

> Participant HL4, Information task M. This HL user at the start followed links that were wrong and irrelevant but was aware, gained focus and found the necessary information. Appropriate keywords enabling to back track and choose correct links. *"… I am going to go to Frequently asked questions ….A list have come up with questions and err so far this link has not been very useful to*

me. Now I am going to try the link on your money and employment there is a list of the employment stuff there…. I think this will give me the answer does my employer need to give me a certain period of notice before he dismisses me, hmm here one week, if you've worked for your employer for one month but less than two years."

Participant HL5, Information task M. The participant identified irrelevant content but was able to recover. *"… hmm I am just going to go back and see if there is something more relevant… I think this will give me the answer does my employer need to give me a certain period of notice before he dismisses me, hmm here one week, if you've worked for your employer for one month but less than two years."*

Participant LL3, Information task E2. The participant identified irrelevant content, was unable to recover, and gave up. *"… does not have any information on the holiday pay, I went to the employment and from there to government employment schemes and there is no holiday pay or any information on pay …"*

Participant LL4, Information task M. The participant identified irrelevant content but was unable to recover assuming the information found was correct. *"Ok that's what …. I found it…. very it, dismissed, unfair dismissed or actual dismissed* [and again reads through the links]*, ha ha ok what is wrongful dismissal ok that's the one I found it …"*

HL USERS	**INFORMATION SEARCH TASKS**			
	E1	**E2**	**M**	**D**
HL1	C	C	C	IC
HL2	C	C	W	IW
HL3	C	C	IC	IC
HL4	C	C	IC	W
HL5	C	C	IC	IC

Table 4-10. HL users selecting or identifying correct, wrong information, and abandoning a task.

LL USERS	**INFORMATION SEARCH TASKS**			
	E1	**E2**	**M**	**D**
LL1	C	W	A	A
LL2	IA	A	A	A
LL3	C	IA	A	W
LL4	IW	C	IW	W
LL5	W	W	A	A

Table 4-11. LL users selecting or identifying correct, wrong information, and abandoning a task.

C = correct answer, W = wrong answer, I = identify information (wrong or irrelevant), A = user abandoning an information search

TRAJECTORIES (homogeneous vs. heterogeneous): The trajectories by LL users were heterogonous (different) to the optimal path (refers to the shortest trajectory to find the information), however, the HL users trajectories were homogeneous (similar) to the optimal path.

The *trajectories* are information search paths taken to solve a search task. Seventy five percent of the paths or trajectories employed during search tasks by HL users' were homogeneous to the optimal path. A 100% homogeneity on trajectories were observed for all the ten easy tasks for the HL users, however, as the tasks difficulty increased from medium to difficult the similarities in the task trajectories decreased to 40%.

The following quotes were extracted to demonstrate and justify the conclusion made. One of the most interesting tasks showing the different behaviours between LL and HL users is E2. While HL participants presented the same trajectories in all the trials, LL presented completely different trajectories.

> The trajectory used in E2 for all HL users was: *Employment* **->***Basic rights at work->holiday and holiday pay* (users found required information). *More information link…(*Users went to this link to further verify the information found)
>
> As shown below a) presents LL user LL1, b) presents LL user LL2 and c) presents LL user LL4 trajectories, respectively. a) *employment ->basic rights at work ->holiday and holiday pay*(users found required information).*b) employment ->government employment schemes ->other help*(user gave up the information search by this point).c)*employment ->dismissal ->steps to work through to identify an unfair dismissal ->*scrolls down *step two: have you actually been dismissed->*scroll up *dismissal ->*scrolls down *step two: have you actually been dismissed* **- >**scroll down *what is wrongful dismissal ->*scrolls up *dismissed*(user assumed the information extracted was correct)

Only 10% of the trajectories for LL users were similar or homogeneous for the easy tasks. For a summary of the trajectories identified for the HL and LL users during their information seeking, see *Tables 4-12 and 4-13*respectively.

HL USERS	**INFORMATION SEARCH TASKS**			
	E1	**E2**	**M**	**D**
HL1	T	T	T	D
HL2	T	T	D	D
HL3	T	T	D	T
HL4	T	T	T	D
HL5	T	T	T	T

Table 4-12. Comparison of similar and different trajectories carried out by the HL users.

LL USERS	**INFORMATION SEARCH TASKS**			
	E1	**E2**	**M**	**D**
LL1	T	D	D	D
LL2	D	D	D	D
LL3	T	D	D	D
LL4	D	D	D	D
LL5	D	D	D	D

Table 4-13. Comparison of similar and different trajectories carried out by the LL users

T= similar trajectories, D=different trajectories

ABANDON (tolerance vs. intolerance of uncertainty): LL users showed a higher tendency to abandon their searches prematurely assuming the information is not available to them.

The observations showed that LL users abandoned ten out of their twenty tasks. During the think-aloud or interviews they stated that there were insufficient information available to them or the information was not available in the sections they expected them to be. This suggests they were intolerant to uncertainty causing the LL users to abandon their search. However, this behaviour was not evident with the HL users showing they were tolerant to uncertainty. For a summary of search abandonments identified for the HL and LL users, see *Tables 4-14 and 4-15*respectively.

HL USERS	**INFORMATION SEARCH TASKS**			
	E1	**E2**	**M**	**D**
HL1	-	-	-	-
HL2	-	-	-	-
HL3	-	-	-	-
HL4	-	-	-	-
HL5	-	-	-	-

Table 4-14. HL users selecting or identifying correct, wrong information, and abandoning a task

LL USERS	**INFORMATION SEARCH TASKS**			
	E1	**E2**	**M**	**D**
LL1	-	-	A	A
LL2	A	A	A	A
LL3	-	A	A	-
LL4	-	-	-	-
LL5	-	-	A	A

Table 4-15. LL users selecting or identifying correct, wrong information, and abandoning a task.

A = user abandoning an information search, '-' =user did not abandon the search task

<u>REPRESENTATION (good vs. poor system model)</u>: LL users mental representation of the information menu structures on where information should be available on the website was a mismatch to their perception and to other LL users.

LL users were likely to prematurely abandon their searches stating that the information was unavailable in the places expected. They explained during the semi-structured interviews that they expected the information to reside in certain parts of the website. Since they were not available in the expected sections, they abandon the search. This strategy increased as the difficulty of the search task increased. This suggests that they had a mismatch between their mental representation of information and the system information structure.

The following quotes of LL participants were extracted to demonstrate and justify the conclusion made.

> Participant LL1, Information task E1. The user did not want to back track and find another solution expecting the answer should be available within the selected links. *"… This is why I go for now for the employment, and it should be there whatever the government law, how long your entitle for holiday, the information* [does] *not coming up … there should be one in here* [section] *holiday rules and regulations, so you can click on holiday and find straight away how much you're entitled for …".*
>
> Participant LL2, Information task E2. The user was scrolling up and down in one page, clicking on anchor links, did not check other options available, and finally abandoned the search. *"… hmmm same* [information] *comes up help finding work …". S*crolls up and down again and says, *"… same* [information] *comes up again… there is nothing on holiday in the employment***,** *I cannot find the information …"*

Summary of the results

READING STRATEGY (scanning vs. word-for-word): LL users read word-for-word trying to make sense of the information they read at an early stage in the search. While HL users scanned through headings and paragraphs, skipped sections that did not grab their attention, selectively searched until they found relevant or interesting information and then move to reading strategy.

FOCUS (wide vs. narrow field of view): LL users when confronted with dense pages of information did not notice content above, below, or to the side of their focus creating narrow field of view, unlike the HL users.

VERIFICATION (optimizing vs. satisficing): LL users did not examine other related links to verify the information found for correctness, while HL users as the search task increased in difficulty employed a verification strategy to reconfirm answers they found for correctness. LL users as soon as they found something they assumed was relevant to what they were looking for terminated the search early assuming they have enough information to solve the problem.

RECOVERY (good vs. poor): LL users were unable to recover from a wrong or irrelevant information search to a more focused and relevant search suggesting the course corrections made resulted to a bad system recovery. The HL users showed a higher chance of recovery suggesting the course corrections made resulted to a good system recovery.

TRAJECTORIES (homogeneous vs. heterogeneous): The HL users' trajectories were homogeneous to the optimal path. However, the LL users' trajectories were heterogeneous to the optimal path and within other LL users.

ABANDON (tolerance vs. intolerance of uncertainty): LL users unlike the HL users had a tendency to abandon the search assuming the information they were looking for was not available in the sections expected or assuming the information is simply not available in the system; LL users were unable to tolerate uncertainty. It was also noted that this behaviour was not evident with the HL users.

REPRESENTATION (good vs. poor system model): The LL users' mental representation of the information structure was a mismatch to the system. This resulted as a disadvantage to the LL users as they were unable to find relevant information they were looking for, suggesting their mental model of the system did not map across to the information structure or poor system model. However, there was no evidence from the think-aloud or interview data suggesting that the HL users mental representation of the information structure was a mismatch to the system suggesting that they had a good system model.

The strategies identified for the HL and LL users are summarised see Table 4-16.

HL USERS	**LL USERS**
Reading strategy (scanning)	Reading strategy (word-for-word)
Focus (wide field of view)	Focus (narrow field of view)
Verification (optimising)	Verification (satisficing)
Recovery (good)	Recovery (poor)
Trajectory (homogeneous to optimal path)	Trajectory (heterogeneous to optimal path)
Abandonment of searches (tolerance of uncertainty)	Abandonment of searches (intolerance of uncertainty)
Representation (good system model)	Representation (poor system model)

Table 4-16. Summary of HL and LL users' information seeking behaviour strategies.

Successful search outcome

The five HL users' completed the ten easy tasks successfully, while the success decreased to four out of five for the medium difficult tasks and three out of five for the difficult tasks (see Table 4-10 and Table 4-17). However, for the five LL users' only three out of the ten easy tasks were completed successfully, while none of the participants managed to successfully complete the medium and difficult tasks (see Table 4-11 and Table 4-17).

	HL USERS			**LL USERS**		
	E	**M**	**D**	**E**	**M**	**D**
Successful completion	100%	80%	60%	30%	0%	0%

Table 4-17. HL and LL user successful search outcome.

The Use of Combined Cognitive Task Analysis Methods

The study discussed in this chapter, uses multiple CTA methods, such as process tracing and interviews. The combination of CTA methods, enabled to capture interesting insights of both HL and LL users. Some interesting insights include (a) LL users were unable to articulate themselves fully during the think-aloud sessions, (b) while some HL users omitted some of the interesting reasoning. In both cases, the observations made during their search tasks, assisted to probe the participants during the semi-structured interview sessions. Related sections of the captured video were played back to help participants recall and explain what they were thinking and doing at that point in the search. Sections of the captured video were showed during the interviews to prevent any assumptions that could have been made by the interviewee or the interviewer.

To highlight insights gained by the use of multiple CTA methods few quotes from both HL and LL users have been taken: Observations made for the LL users' showed they stopped searching and indicated that they could not find the relevant information. During the interview sessions, selected parts of the video were played to the participants, and were asked to explain why they said *they were unable to find the information.* Participants, explained that they abandoned the search due to insufficient information three out of the ten tasks abandoned, while the remaining six out of the ten tasks they expected the information to reside in certain sections of the *Adviceguide* website and they were not. This suggests that LL users had a clear expectation of where the information should be represented and if this information was not available in these sections, they chose to abandon without further investigation. However, LL users did not seem to show similarities where they expected the information.

> Participant - LL1 information search task - E1 "… *there should be one in here holiday rules and regulations, so you can click on holiday and find straight away how much you're entitled for whatever …*".

Observations made for the HL users showed that they opted to make no comment during the think-aloud sessions. This was intriguing when observations were made, where these participants come across the information they were to look for and yet continued with the search. During the interview, selections of the video were played back and were asked to explain what they were doing. These observations were made for the medium and difficult tasks only. The interviews suggested that, these HL participants adopted a differentiating and verification strategy to authenticate the information found for correctness.

> Participant - HL1 information search task - E1 "... *then I went to paid holidays just to double check and confirm and I found the same thing ...*".

The limitations of individual CTA methods were overcome by triangulating and orchestrating. The information that was not found during the think-aloud sessions, was identified during the observations and were helpful during the semi-structured interview session to probe the participants. During the interview as selected sections of the video was played back to the participants this helped reduce any assumptions, misinterpretations and helped participants to recall and discuss what they were doing, thinking, and what actions they were taking during that specific time. Further to this, participants took advantage of the video to show and discuss anything they felt was interesting to them.

DISCUSSION

The main purpose of this study was to determine what information seeking behaviour strategies were employed by HL and LL users.

The findings suggest that LL users had a tendency to read word-for-word at an early stage in their search resulting in the following scenarios: (a) when faced with dense pages, skip chunks of text and employ a narrow field of view, (b) be satisfied early with information they obtain, or (c) abandon the searches.

Long dense pages cause LL users to skip chunks of text and employ a narrow field of view, which results in LL users to miss the actual information they needed. This narrow field of view and skipping chunks of text might be a strategy LL users employ to reduce being overwhelmed with dense information. As the LL users are not experienced readers like the HL users, they employed a reading strategy instead of a scanning strategy (Nielsen, 1994; Summers & Summers, 2005). Perfetti (1985) suggests that due to the lack of reading fluency, users employ low-level reading strategies, which leads to high cognitive demand and users therefore are unable to comprehend overall messages. Summers and Summers (Summers & Summers, 2005) aimed to understand the differences between the reading and navigational strategies of HL and LL users. They observed that LL users read word-for-word so they will not miss what they were looking for, as they were unable to grasp the content the same way HL users do. This strategy was not observed with the HL users. This might be due to HL users employ a scanning strategy that requires less cognitive demand than reading. Previous research confirms that LL users are successful in performing simple comprehension tasks such as finding a piece of information, however, when required to combine and integrate the information LL users find this challenging and show lower success (Kirsch, Jungeblut, & Campbell, 1992). This was evident with the current study, as LL users had some success during the easy search tasks (three out of ten tasks), unlike the medium and difficult ones (were not successful at all).

LL users may have used a satisficing solution to end their searches (early closure) suggesting they have identified a good enough solution, or worse still, thought they found the answer when in reality they had not. Nielsen (2005) observed similar findings in another study where he discussed that LL users are likely to be satisfied with little information as digging deeper required more reading which is cognitively challenging. Simons' (1956) theory on satisficing explains that users stop searching when they meet their aspiration level. He further explains satisficing and optimising using cost and benefit analysis. Satisficing occurs when a user invests minimal time and effort (less investment) for a good enough solution, whereas optimizing occurs when a user investigates all possible solutions (higher investment) for a higher return.

This finding suggests that HL users employ an optimising strategy. Optimising strategy refers to filtering information by *differentiating* and *verifying* it for correctness as the task difficulty increases. HL users employ a scanning strategy at an early stage and then moving towards a reading strategy allows them to explore optimizing solutions. The skills HL users are equipped with, such as higher education, better reading strategies, critical and analytical skills are likely to assist when searching for optimizing solutions. As LL users have not developed good reading skills this is likely to have an effect on comparing, distinguishing, and relating meaning (Richards, Baker, & Barzun, 1971). This suggests the strategies employed by the LL users are likely to be higher in cognitive demand, resulting in them not moving to an optimising strategy.

The results from this study indicate that LL users abandoned ten out of twenty tasks. They assumed that the information they were looking for was not available. They stated that the information should be in a specific section and failing to find it there caused search abandonment. In other cases, they looked for the information in different sections and failed to find the right answer.

Possible reasons for LL users to abandon searches are

1. Having higher threshold of intolerance of uncertainty (Russell, Stefik, Pirolli, & Card, 1993). LL users assumed that the higher the degree of uncertainty, the higher the cognitive demand and the lower return on investment will be.
2. Presenting a mental representation that is different from the *Adviceguide* website structure.
3. Not perceiving visual cues that HL users take into account to determine whether they had visited a page or not.

LL are not very good at recovering from their mistakes to resume their search task, they get lost and they appeared to do it very often (Kodagoda & Wong, 2008). The search paths or trajectories employed by LL users were observed to be more haphazard by trial and error, resembling patterns of use by one who has little understanding of how things work or are stored. In contrast, the HL users, in that short time were able to quickly develop a reasonable mental model of the information menu structure and therefore able to direct their search to a more successful one. Similar findings on users getting lost were found with users with low spatial abilities who, were getting lost in the hierarchical file structure (Vicente & Williges, 1988). For example, low spatial users become disoriented quickly. This raises a question on whether there is a relationship between people with LL and low spatial abilities.

There might be many factors that contribute towards LL users being less successful in finding the relevant information than HL users (successful search outcome). Our results suggest that the density of the pages, their readability level and the satisficing strategy combined contribute to LL users failure find the correct information.

SUMMARY

This chapter identified differences in behaviour strategies employed by HL and LL users. Even if the identified behaviour strategies for the HL and LL users are not entirely new, the way the strategies have been complied, compared and presented itself is a contribution.

This chapter raises two challenges: First, as strategies employed by LL users seem to be less successful during information seeking when compared with HL users, one approach is to focus on the user's search strategies in the context of information seeking behaviour models. As information seeking models help capture a searcher's activities, which in return increases the usefulness to determine what support mechanisms are likely to be required and at what stages (Meho & Tibbo, 2003). Chapter 5 discusses how information seeking behaviour models were evaluated, in addition to providing justification towards choosing David Ellis's model by using it as a theoretical lens to map data from this chapter. Second, the findings show that LL users abandon their searches unlike the HL users, expecting the information to reside in sections they expected with no similarity among the users. Chapter 6 investigates if differences in literacy have an effect on a users' mental model of the information menu structure.

LIMITATIONS OF THE STUDY

One caveat to the present study is the small sample size that could influence the results observed. Reasons behind the current sample size were, due to the in-depth nature of the study and due to following limitations such as; time constraints, difficulty in encouraging participants to volunteer at the time of the study, and limitations in funding to pay participants. It will be important to validate and analyse a larger sample size in further studies. However, the outcomes of the current study confirmed findings to previous findings.

The think-aloud protocol used in this study was ineffective by itself, as participants had to be prompted. None of the participants consistently articulated their step-by-step process at all points during the study. The investigator was required to prompt users. To avoid being intrusive and avoid loss of participants trail of thought during the search process, the investigator only prompted a few times during a search task reminding the participant to verbalise their thought process. This meant the participants were unable to continue freethinking. One possible explanation might be due to participants being cognitively challenged and overwhelmed to concurrently verbalise and carry out the search task. During the data analysis, process the double blinding only gave an 85% agreement to the analysis already in place; however, it would have been better to have a higher agreement during the initial coding for GT and ETA coding. Overall, however, the participants were very enthusiastic and felt their participation would help empower social service information systems in the future. None of the participants were aware that literacy was a considered factor in the study.

CHAPTER 5

MAPPING IDENTIFIED STRATEGIES TO AN INFORMATION SEEKING BEHAVIOUR MODEL

The findings in the previous chapter showed that the strategies employed by LL users were different to the HL group, and LL users were less successful than HL users during online information seeking. The conclusion was that it's important to investigate if a difference existed between HL and LL users' information seeking activities (as classified in behaviour models). In this Chapter, Ellis's information seeking behaviour model is used as a theoretical lens to map HL and LL users' information seeking on the *Adviceguide* website (strategies, search decisions users made, and search outcomes) by revisiting Chapter 4 study data. The chapter investigates if differences exist between the HL and LL users' information seeking behaviour models and how these differences contribute to task completion.

Hearst (2009) points out that gaining a deeper understanding of human information seeking behaviour strategies during a search activity will provide opportunities to improve user interface designs. As information seeking models capture the activities a searcher carries out, it is useful to determine what support mechanisms are required at what stages (of the search) (Meho & Tibbo, 2003).

According to Meho & Tibbo (2003), some information seeking behaviour models capture a users' search process at either an abstract (high level) or detailed (low level). Ellis' model is considered a *low-level model*, and has been applied in various HL user domains (lawyers, social scientists, physicists and chemists). It has subsequently provided meaningful design insights for interactive interfaces (Makri, Blandford, & Cox, 2008) and has captured a users' search process such as starting a search, chaining, browsing, differentiating, extracting, verifying and ending (see Chapter 3).

METHOD USED FOR DATA ANALYSIS

Four methods were used and are described in the following section. First, the semi-structured interview, think-aloud, and recorded video data, in addition to the researcher's observations and field notes discussed in Chapter 4, were revisited to investigate HL and LL users' information seeking behaviour. The data were analysed without taking levels of literacy into consideration.

Data Analysis Using Ellis' Information Seeking Behaviour Model

This study does not plan to validate the correctness of Ellis' information seeking behaviour model or its features. Ellis discovered these features during empirical studies with academic social scientists, physics, and chemists.

The focus instead is to outline and compare the users' strategies, decisions and search outcomes made during information seeking using Ellis' model as a theoretical lens. First, the think-aloud, semi-structured interviews modelled after CDM, and observations made (field notes taken) were visited taking Ellis' model as a theoretical lens to identify stages such as (Chaining, Browsing, Differentiating, Extracting and Verifying, End) were evident among the participants. This is discussed in detail in the results section *Ellis' information seeking behaviour model stages* (on the following page). The findings of each participant's search behaviour was mapped using Ellis' model as a theoretical lens which identified Ellis' stages. Second, the above data (videos which captured the think-aloud and semi-structured interviews modelled after CDM which used video play-back) was revisited again taking each identified associated strategies and decisions made by participants during Ellis' stages. These were then added to Ellis' model. This is discussed in detail under the heading *Strategies/ decisions adopted by participants which were associated with Ellis' stages* in the following results section. Third, the models identified for each user were grouped based on similarities of the new emerged model. Finally, the level of literacy was taken into consideration. The emerged models were compared to identify differences in a way that supported design.

In order to reduce the researchers bias, a small sample of data (three out of the ten participants) was analysed by two independent researchers. Their analysis was 82% similar to the analysis already in place.

STARTING	*"Activities characteristic of the initial search for information."*(Ellis and Haugan 1997).
CHAINING	Scanning or Reading menus or links.
BROWSING	Scanning or Reading content of a web page.
DIFFERENTIATING	Scanning or reading and differentiating between currently and previously looked links as a filter to find the relevant information.
MONITORING	Not applicable to our study.
EXTRACTING	Systematically working though a particular web page content to identify material of interest.
VERIFYING	"*Checking the information and sources found for accuracy and errors.*" (Ellis, Cox et al. 1993).
ENDING	Ending the search.

Table 5-1.Ellis' information seeking behaviour model (1989) features were slightly modified to reflect online information seeking.

For the purpose of the thesis the terms (in the table 5-1 above) *links* refers to the *Adviceguide* menus and hyperlinks, content refers to *Adviceguide* webpage information.

RESULTS

This section reports the findings of HL and LL users by adopting Ellis's information seeking behaviour model. The analysis identified strategies, decisions, and search outcomes made by both users groups associated to Ellis' stages. These findings are mapped to Ellis' information seeking behaviour model.

Ellis' Information Seeking Behaviour Model Stages

<u>CHAINING</u>: Both HL and LL users navigated the *Adviceguide* using menus or hyperlinks.

The researcher observed that the five HL participants clicked on the menus or hyperlinks links from the home page and subpages, and spent considerably less time during the chaining stage. The analysis of the interviews showed that 95% of the HL participants used a scanning strategy to go over the menus and hyperlinks, while only 5% of the HL participants used a reading strategy during the chaining stage (please refer to Chapter 4 for more information on scanning and reading strategies). One remark from a HL user demonstrated the scanning strategy during the chaining stage

"... I just quickly scanned the menu, and found benefits..., ...I clicked a menu from the main page and then came to this page which has links to other pages...., I just browed it and selected this link..." (Participant HL4, Information task D).

It was observed that during information seeking the LL users pointed the mouse at the menus or hyperlinks they were reading and took considerably more time than the HL users during the chaining stage. The analysis of the interviews showed that all the LL users carried out a word-for-word reading strategy during this stage. For instance a remark from a LL user demonstrated the word-for-word reading strategy was used during the chaining stage*"... oh here ..... I was moving the mouse under the menus ..... I was trying to read the menus before clicked..." (Participant LL2, Information task D*).

For a summary of the chaining stage where HL uses scanned, while LL users read word-for-word, observed at least once during their information seeking, see *Tables 5-2 and 5-3* respectively.

HL USERS	**INFORMATION SEARCH TASKS**			
	E1	**E2**	**M**	**D**
HL1	CS	CS	CS	CS
HL2	CS	CS	CS	CS
HL3	CS	CS	CS	CS
HL4	CS	CS	CS	CR
HL5	CS	CS	CS	CS

Table 5-2. Chaining stage observed for HL users.

LL USERS	**INFORMATION SEARCH TASKS**			
	E1	**E2**	**M**	**D**
LL1	CR	CR	CR	CR
LL2	CR	CR	CR	CR
LL3	CR	CR	CR	CR
LL4	CR	CR	CR	CR
LL5	CR	CR	CR	CR

Table 5-3. Chaining stage observed for LL users.

C = chaining, S = scanning, and R = reading

<u>BROWSING</u>: Both HL and LL browsed the *Adviceguide* website, navigating and visiting web pages (content pages) during their information seeking.

The researcher observed that two out of five HL participants hovered the cursor over headings, new paragraph or prominent keywords, that were relevant to what they were looking for, and spent considerably more time than on the chaining stage, the remaining participants were not observed to hover the cursor. The researchers observations were verified during the interview sessions, which suggested that for 95% of the tasks, HL users employed the scanning strategy and the remaining 5% of the task only employed the reading strategy during the browsing stage (please refer to Chapter 4 for more information on scanning and reading strategies). One remark from a HL participant has been taken to demonstrate that the user used a scanning strategy during the browsing stage. *"... at this point I was just quickly scrolling to find if there is any information about rights at work in this page..., ..."* (Participant HL1, Information task M).

The researcher observed that all five LL participants hovered the cursor over the words being read, or lines they were reading or the paragraph they were reading, and spent a considerably longer time than the HL users during the browsing stage. The observations were verified during the interview sessions, which suggested that on all tasks LL users employed a word-for-word reading strategy during the browsing stage. One remark from a LL participant has been taken to demonstrate a word-for-word reading strategy during the browsing stage. *"...pointing under the text helps me know which part i am reading..., ...trying to find some relevant information from this page, there was a lot of text..."* *(*Participant LL3, Information task D*).*

For a summary of the browsing stage where HL uses scanned, while LL users read word-for-word (observed at least once during their information seeking), see *Tables 5-4 and 5-5* respectively.

HL USERS	**INFORMATION SEARCH TASKS**			
	E1	**E2**	**M**	**D**
HL1	BS	BS	BS	BS
HL2	BS	BS	BS	BS
HL3	BS	BS	BS	BS
HL4	BS	BS	BS	BR
HL5	BS	BS	BS	BS

Table 5-4. Browsing stage observed for HL users.

LL USERS	**INFORMATION SEARCH TASKS**			
	E1	**E2**	**M**	**D**
LL1	BR	BR	BR	BR
LL2	BR	BR	BR	BR
LL3	BR	BR	BR	BR
LL4	BR	BR	BR	BR
LL5	BR	BR	BR	BR

Table 5-5. Browsing stage observed for LL users.

B = browsing, S = scanning, and R = reading

<u>DIFFERENTIATING</u>: HL users showed that they recognised the difference between current web page content and previously visited web page content and used it as a way to filter out information.

The researcher observed that HL users during five out of the 20 information-seeking tasks switched between currently and previously visited web pages using hyperlinks or menus or simply clicking on the back or forward buttons. They were observed to scroll up or down a web page that was dense, revisiting sections on the same page that were relevant to what they were looking for. However, this was only evident in some medium and difficult tasks. Two out of the five participants during the difficult task were observed to hover the cursor over the headings, new paragraph or prominent keywords in relation to the task. Finally, HL users were observed to spend considerably more time than when on the chaining or browsing stage.

The researchers observations were verified during the interview sessions, which suggested during 25% of the tasks HL users employed the differentiating strategy. However, this was only during the medium and difficult tasks. For the remaining 75% of the tasks HL users trajectories were similar to the optimal path (please refer to Chapter 4), which reconfirms there was no differentiating. This strategy was not evident with the LL users. One remark from a HL participant has been taken to demonstrate that the user differentiated information they found by scanning and reading. *"... the page I was in before had some information about rights at work and some links [points to the hyperlinks on that page]..., ...clicked on one of the links..., ...that page did not have the information I was looking for..., ...went back to the previous page..., ...did a quick scan..., ...found what I was looking for.., ...ah! you mean here, I was trying to read..." (*Participant HL2, Information task M*)*.

For a summary of the differentiating stage where HL uses scanned and read, while LL users were not observed differentiating information, observed at least once during their information seeking, see *Tables 5-6 and 5-7* respectively.

HL USERS	**INFORMATION SEARCH TASKS**			
	E1	**E2**	**M**	**D**
HL1	-	-	-	DSR
HL2	-	-	DSR	DSR
HL3	-	-	DSR	-
HL4	-	-	-	DR
HL5	-	-	-	-

Table 5-6. Differentiating stage observed for HL users.

LL USERS	**INFORMATION SEARCH TASKS**			
	E1	**E2**	**M**	**D**
LL1	-	-	-	-
LL2	-	-	-	-
LL3	-	-	-	-
LL4	-	-	-	-
LL5	-	-	-	-

Table 5-7. Differentiating stage observed for LL users.

D = differentiating, S = scanning, R = reading and "-"=none

EXTRACTING: Both HL and LL users systematically worked through a particular web page content to identify material of interests.

The researcher observed that the five HL users during their information seeking in some instances stated they have found the information, in some other tasks the users were observed to be in the page, that contained the information, however, they continued their searching. The HL users spent more time in the extracting stage than in chaining, browsing or differentiating stages. The researchers' observations were verified during the interview sessions, which suggested that all HL users extracted information by using the reading strategy. One remark from a HL user demonstrated that the user used a reading strategy during the extracting stage. *"... I have found what I was looking for..., I was reading so I can answer to the question ...(*Participant HL1, Information task E*)*

It was observed that during information seeking that the five LL users on 50% of the tasks stated they had found information. They pointed the mouse at the words being read or lines they were reading, or the paragraphs they were reading, and spent a considerable amount of time on a line of text, paragraph or page before they moved the mouse to another part of the same page or another new page. *"*. . One remark from a LL user demonstrated that the user used a word-for-word reading strategy during the extracting stage. *"... there is not much to read in this page..., however, I had to read it twice to find the answer..." (*Participant LL5, Information task E*).*

For a summary of the extracting stage where HL uses and LL users read the information, observed at least once during their information seeking, see *Tables 5-8 and 5-9*respectively.

HL USERS	**INFORMATION SEARCH TASKS**			
	E1	**E2**	**M**	**D**
HL1	ER	ER	ER	ER
HL2	ER	ER	ER	ER
HL3	ER	ER	ER	ER
HL4	ER	ER	ER	ER
HL5	ER	ER	ER	ER

Table 5-8. Extracting stage observed for HL users.

LL USERS	**INFORMATION SEARCH TASKS**			
	E1	**E2**	**M**	**D**
LL1	ER	ER	-	-
LL2	-	-	-	-
LL3	ER	-	-	ER
LL4	ER	ER	ER	ER
LL5	ER	ER	-	-

Table 5-9. Extracting stage observed for LL users.

E = extracting, R = reading, and "-" = none

VERIFYING (optimising vs. satisficing): In Chapter 4, it was identified that none of the LL users verified information for correctness, however, 35% of the LL users simply moved to a satisficing stage and stopped the search (early closure). The HL users optimised their search by verifying information found for correctness 90% of the time.

END (search outcomes): The HL users on 85% of the tasks provided the correct answer and only on 15% of the tasks provided the answer wrong. However, on 20% of the task they were not sure if the answer obtained was correct or wrong even though in some task the answer was correct

The LL users had a task success rate of 15%, while 35% the answers provided were wrong and the remaining 50% of the task were abandoned. However, on 10% of the task they were not sure if the answer obtained was correct or wrong and on 30% of the tasks they gave situational justifications to the answers they found without being asked.

For a summary of the search out comes for HL and LL uses, where correct answer, wrong answer, user abandoning an information search, uncertain about answer and where a user provides a situational justification, observed at least once during their information seeking, see *Tables 5-18 and 5-19* respectively.

HL USERS	**INFORMATION SEARCH TASKS**			
	E1	**E2**	**M**	**D**
HL1	C	C	C	C
HL2	C	C	IW	IW
HL3	C	C	C	IC
HL4	C	C	C	IW
HL5	C	C	C	C

Table 5-10. Search outcome observed for HL users.

LL USERS	**INFORMATION SEARCH TASKS**			
	E1	**E2**	**M**	**D**
LL1	IC	JW	A	A
LL2	A	A	A	A
LL3	C	A	A	JW
LL4	IW	JC	JW	JW
LL5	W	JW	A	A

Table 5-11. Search outcome observed for LL users.

C = correct answer, W = wrong answer, A = user abandoning an information search, I = uncertain about answer (correct or wrong), and J = situational justification

Strategies adopted by participants which were associated with Ellis' stages

READING: please refer to Chapter 4 for more information on reading strategies.

SCANNING: please refer to Chapter 4 for more information on scanning strategies.

MEMORY NOTES: HL users were observed making memory notes with relevant information.

The researcher observed that the five HL users during their information seeking were observed either differentiate or verify information found for correctness (see Chapter 4). The researcher's observations verified during the interview sessions, showed on 85% of the tasks HL users made memory notes during browsing, differentiating or extracting stages. This was not evident with the LL users, LL users were seen less likely to remember pages they were at previously. One remark from a HL user demonstrated that the user made memory notes during the browsing/ differentiating or extracting stages. *"... I opened up this other tab, so I don't have to remember where I found this bit of information [differentiating stage]..., ... I can come back to it if I think it is important later ..." (*Participant HL1, Information task M*).*

For a summary of the memory notes made by HL users' during the differentiating and verifying stages, observed at least once during their information seeking, see *Tables 5-10 and 5-11* respectively.

HL USERS	**INFORMATION SEARCH TASKS**			
	E1	**E2**	**M**	**D**
HL1	M	M	M	M
HL2	M	M	M	M
HL3	-	M	M	M
HL4	-	M	M	M
HL5	-	M	M	M

Table 5-12. Memory notes made by HL users.

LL USERS	**INFORMATION SEARCH TASKS**			
	E1	**E2**	**M**	**D**
LL1	-	-	-	-
LL2	-	-	-	-
LL3	-	-	-	-
LL4	-	-	-	-
LL5	-	-	-	-

Table 5-13. Memory notes made by LL users.

M = memory notes, and "-" =none

Decisions adopted by participants which were associated with Ellis' stages

LINK OF (interest-i, no relevance-n and unable to identify link of relevance): Both HL and LL users were observed making decision from the *chaining*.

The researcher observed that the five HL users during the chaining stage showed they scanned for information (discussed above). The HL users were observed making the following decisions, and were verified during the think-aloud and observations. They were observed making decisions such as *identification of link of interest* or *link of no relevance* followed this. The HL users on 25% of the tasks *identified link of no relevance* to what they were looking for. During this time, HL users were observed at least once to click on the back button, click on menu links presented on the home page or click on the home page icon and go back to the chaining stage. However, all HL users were able find a *link of interest* at some point during their information seeking tasks. Following this decision, HL users were seen to move to *browsing* or *differentiating* stages (discussed above).

It was observed that during information seeking of the five LL users during the *chaining* stage showed they read information word-for-word (discussed above). LL users were observed making the following decisions, which were verified during the think-aloud and observations. They were observed making decisions such as to identify a *link of interest*, *link of no relevance* or *unable to identify link of relevance* at least once. The LL users on 20% of the tasks identified *link of no relevance* to what they were looking for. They were observed to click on the back button, click on menu links presented on the home page or click on the home page icon and go back to the chaining stage. LL users on 90% of the tasks *identified link of interest* at some point during their information seeking tasks. Following this decision, LL users were observed moving to *browsing* or *differentiating* stages (discussed above). However, 30% of the tasks LL users were unable to *identify link of relevance* and decisions were made to *abandon* the task at this early *chaining* stage.

For a summary during the chaining stage where HL and LL users *identified link of interest*, *link of no interest* and being *unable to identify link of relevance*, observed at least once during their information seeking, see *Tables 5-12 and 5-13* respectively.

HL USERS	**INFORMATION SEARCH TASKS**			
	E1	**E2**	**M**	**D**
HL1	I	I	I	IN
HL2	I	I	IN	IN
HL3	I	I	IN	I
HL4	I	I	I	IN
HL5	I	I	I	I

Table 5-14.Link of interest, no relevance and unable to identify link of relevance by HL users.

LL USERS	**INFORMATION SEARCH TASKS**			
	E1	**E2**	**M**	**D**
LL1	I	I	I	R
LL2	I	I	R	IR
LL3	I	IR	I	IN
LL4	I	IN	IN	I
LL5	I	IN	IR	R

Table 5-15.Link of interest, no relevance and unable to identify link of relevance by LL users.

I = link of interest, N=link of no interest, and R = unable to identify link of relevance

<u>CONTENT OF (interest, no relevance and unable to identify content of relevance)</u>: Both HL and LL users were observed making decision from the *browsing stage*.

The researcher observed that the five HL users during the browsing or differentiating stage showed they scanned or read the information (discussed above). The HL users were observed making the following decisions, which were verified during think-aloud and observations. They were observed making decisions such as to identify *content of no relevance*, *content of interest* or *make memory notes*. The HL users on 15% of the tasks identified *content of no relevance* to what they were looking for. During this time, HL users were observed at least once to click on the back button, click on menu links presented on the home page, click on links available on the current page they are on or click on the home page icon and go back to the chaining or browsing stage. However, all HL users were observed finding *content of interest* at some point of their information seeking. Following this decision, HL users were seen to move to making *memory notes*, *extracting* or moving back to the *browsing*, *differentiating* or *chaining* stages (discussed above).

It was observed that during information seeking of the five LL users during the *browsing* stage showed they read information word-for-word (discussed above). The LL users were observed making the following decisions, which were verified during think-aloud and observations. They were observed making decisions such as to identify *content of no relevance*, *content of interest* or *unable to identify content of relevance* at least once. The LL users on 20% of the tasks identified *link of no relevance* to what they were looking for. They were observed to click on the back button, click on menu links presented on the home page, links on the page they are on or click on the home page icon and go back to the chaining or browsing stage. LL users on 70% of the tasks identified *content of interest* at some point of their information seeking. Following this decision, LL users were observed moving to the *extracting* stage (discussed above). However, on 20% of the tasks LL users were unable to identify *content of relevance* and decisions were made to *abandon* the task at the browsing stage.

For a summary during the browsing and differentiating stage where HL and LL uses made decisions by identified, *content of no interest*, *content of no interest*, *unable to identify content of relevance* and being *unable to identify link of rel*evance, observed at least once during their information seeking, see *Tables 5-12 and 5-13* respectively.

HL USERS	**INFORMATION SEARCH TASKS**			
	E1	**E2**	**M**	**D**
HL1	I	I	I	IN
HL2	I	I	I	IN
HL3	I	I	IN	I
HL4	I	I	I	I
HL5	I	I	I	I

Table 5-16.Content of interest, no relevance and unable to identify link of relevance by HL users.

LL USERS	**INFORMATION SEARCH TASKS**			
	E1	**E2**	**M**	**D**
LL1	I	I	IR	-
LL2	IR	IR	-	-
LL3	I	-	IR	IN
LL4	I	IN	IN	I
LL5	I	IN	-	-

Table 5-17.Content of interest, no relevance and unable to identify link of relevance by LL users.

I = content of interest, N = content of no interest, R = unable to identify content of relevance. "-" = had abandoned the search at the chaining stage

ANSWER (solution identified): All HL users arrived at an answer and used the answer sheet provided to write down the solution they arrived too, however, only 50% of the tasks were answered by the LL users and remaining 50% of the tasks were abandoned either at the *chaining*(abandoned 30% of the tasks) or *browsing* (abandoned 20% of the tasks) stages.

For a summary of the search outcomes (successful or unsuccessful) were identified by HL and LL uses during their information seeking, see *Tables 5-16 and 5-17* respectively.

HL USERS	**INFORMATION SEARCH TASKS**			
	E1	**E2**	**M**	**D**
HL1	S	S	S	S
HL2	S	S	S	S
HL3	S	S	S	S
HL4	S	S	S	S
HL5	S	S	S	S

Table 5-18. Solution identified by HL users.

LL USERS	**INFORMATION SEARCH TASKS**			
	E1	**E2**	**M**	**D**
LL1	S	S	-	-
LL2	-	-	-	-
LL3	S	-	-	S
LL4	S	S	S	S
LL5	S	S	-	-

Table 5-19. Solution identified by LL users.

S = solution identified, and "-" = had abandoned the search at the chaining or browsing stage

Summary of the Users' Information Seeking Strategies, Decisions and Search Outcomes

The following strategies, decisions, and search outcomes observed for participants during their information seeking were added to Ellis' information seeking behaviour models' associated stages (see Table 5-20).

STRATEGIES	
READING	Reading headings, links or content word-for-word
SCANNING	Glancing through headings, links or start, middle of a paragraph
MEMORY NOTES	Temporally storing information in memory
DECISIONS	
LINK OF INTEREST	Following associated link of interest and narrowing the search
LINK OF NO RELEVANCE	Using the back button to move up the links or clicking on a main menu link or clicks on home
UNABLE TO IDENTIFY LINK OF RELEVANCE	Abandoning the search assuming information not available
CONTENT OF INTEREST	Identifying the search answer
CONTENT OF NO RELEVANCE	Scrolling up or down on the page, using back button, or clicking on home to return to initial stage
UNABLE TO IDENTIFY CONTENT OF RELEVANCE	Abandoning the search as related content is not found
ANSWER	Identifying answer
SEARCH OUTCOMES	
CORRECT ANSWER FOUND	Confident answer is correct
WRONG ANSWER FOUND	Confident answer is wrong
ABANDON SEARCH	Convinced the answer is not available in the website
CORRECT/ WRONG ANSWER FOUND	Subjective - Not very confident if the answer is correct or wrong
SITUATIONAL JUSTIFICATION	Subjective - User assumes answer found is correct and gives situational evidence to support the wrong answer without being prompted

Table 5-20. Summary of identified strategies, decisions and search outcomes for Ellis' information seeking behaviour models' associated stages.

Ellis Behavioural Model Refined By Level of Literacy

The refined models, which emerged from the analysis, showed that HL and LL users had different information seeking behaviour models to each other. HL users had similar features to those found by Ellis' when searching for social service information using the *Adviceguide*. However, LL users' features were different to those identified by Ellis and different to the HL users. Some of the features identified by Ellis such as *differentiating* and *verifying* were not observable for the LL users.

Neither HL nor LL users identified Ellis' monitoring feature during this study. This is possibly due to the study not being empirical and that updates of the web page content were not required to solve a task.

Refinement of Ellis Model for Online Social Service Information Seeking

Ellis' model makes no claim that the features occur in a particular sequence. He notes that an individual's information seeking pattern will depend on their search strategy during that period. The current analysis discovered two different adaptations of Ellis' information seeking behaviour model that formed relationships between the features in particular order. The adaptation of Ellis' model were different for the HL and LL users. The features identified from Ellis' information seeking behaviour models stages are shown in solid lines, while strategies, decisions, and search outcomes observed in this study which were associated with the models stages are marked using dotted lines in Figures 5-1 and 5-2.

HL USERS INFORMATION SEEKING BEHAVIOUR MODEL

The HL users moved from *starting* to *chaining* stage. While in the *chaining* stage, the only strategy carried out by these users was to scan information links, which led to the following identifications *link of no relevance* and *link of interest*. If *link of no relevance* was identified, a decision was made to move back to the *chaining* stage by using back buttons, clicking on links on the menu or clicking on the home page icon. If *link of interest* was identified, a decision was made to move to the *browsing* or *differentiating* stages. The decision to move to the *browsing* stage was made if they were in their first round of search or during cycle of the search, and decision to move to *differentiating* was if the search tasks level of difficulty was medium or difficult.

In the *browsing* stage, they carried out the *scanning* strategy, in the *differentiating* stage they carried out *scanning* and *reading* strategy. Both stages led to the following identifications *content of no relevance*, *content of interest* while the *differentiating* stage had this additional strategy *memory note*. If *content of no relevance* was identified a decision was made to move to the *chaining* stage by using back buttons, clicking on links on the menu, clicking on links on the current page or clicking on the home page icon. If *content of interest* was identified by the browsing stage a decision was made to move to the *extracting* stage, while if *content of interest* was identified by the *differentiating* stage they were more likely to first move to the *memory note* strategy and then move back to the *chaining* stage by using back buttons, clicking on links on the menu, clicking on links on the current page or clicking on the home page icon.

During the *extracting* stage, HL users identified the *answer* they moved to the *end* stage, if the confidence level was low and for the medium and difficult search task, the user during the first round of the search followed the strategy *memory note* and moved to the *verifying* stage. In the *verifying* stage, they moved back to the *Browsing*, *differentiating* or *chaining* stages by using back buttons, clicking on links on the menu, clicking on links on the current page or clicking on the home page icon.

In the *end* stage, HL users outcomes were *correct answer found*, *wrong answer found* or *not certain if answer correct or wrong*. HL users showed similar behavioural features to those found by Ellis' model. HL users spent less time and low cognitive effort as they scanned through content and only read information when they found something interesting or relevant to what they were searching for.

They were able to browse through the content and if any irrelevant data was identified, they *backtracked* or selected *another link* and recover by finding the information. HL users tend to *verify* the information found for correctness, which was not present with the LL users. This might have been possible due to the less cognitive load and higher capacity of working memory available to make better selections and decisions discussed in Chapter 4. The mapped information seeking behaviour for the HL users see Figure 5-1.

<u>LL USERS INFORMATION SEEKING BEHAVIOUR MODEL</u>

The LL users were observed to move from a *starting* to a *chaining* stage. While in the *chaining* stage the only strategy carried out by these users were reading information links. The following decisions were made during this stage like *link of no relevance*, *link of interest,* and *no link of relevance*. If they could not find relevant information (link of no relevance), they clicked the back button or go to the homepage (chaining stage) until they found *a link of interest*. They either wanted to see more related content and moved back to chaining or moved back to *Browsing* to get more information on the page. Finally, in the *no link of relevance* the users assumed the information was not available on the site and decided to abandon the search early on. In *browsing,* the only strategy they carried out was reading which led to the following decision making by them *content of no relevance*, *content of interest* and *no content of relevance*. Here if the decision was *content of no relevance* the actions and outcomes were moving back to stages such as chaining or *browsing* as they were unable to find related content. In the content of interest decision, the actions and outcomes made were to move to the *extracting* stage or moving back to stages such as *chaining* or *browsing* as the user was interested in finding more related resources. Finally, if the user decided that there was no content of relevance then they *abandoned* the search assuming the information was not available.

In the *extracting* stage, LL users continued with their reading the content word-for-word and *extracting* the answer, which they presumed suitable for the question and moved to the *end* stage. Finally, in the *end* stage users outcomes of the search which varied from *correct answer found*, *wrong answer found*, *not certain if answer correct or wrong*, *abandon search* and finally *situational justification*. The action reading took place at a very early stage of the search. Ellis's features *verifying* and *differentiating* were not identified for the LL users. LL users put high cognitive effort on reading. They missed out, on finding interesting or relevant information and even when they did find the correct web page containing the information, they were unable to comprehend the information. They were also unable to recover from a mistake even if they were able to identify it.

LL users were either likely to be satisfied with information or abandon at the *chaining* or *browsing* stages. If they found something relevant during the *browsing* stage they moved to the *extracting* feature and *end* the search assuming, (a) information found is relevant, or (b) information was not available. Chapter 4 explains possible reasons on why LL users are likely not to *verify* or *differentiate* information found for correctness. The mapped information seeking behaviour for the LL users is shown in Figure 5-2.

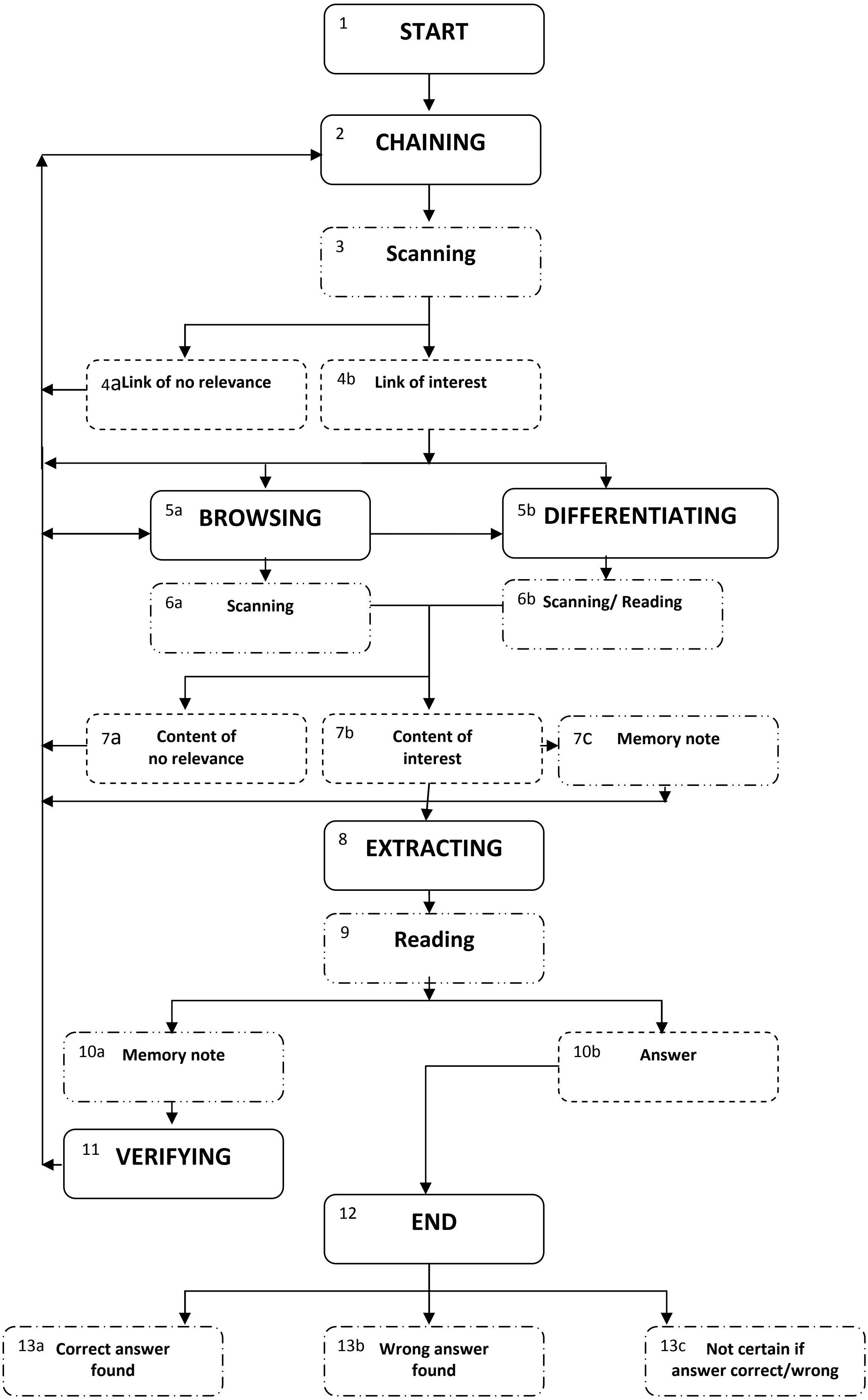


Figure 5-1. Adoptation identified from Ellis' Information seeking behaviour model for HL user.
a) Observed strategies which were similar to Ellis' behaviour model strategies [__], b) observed strategies [-..-], c) user decisions [--], e. search outcomes [-.-]

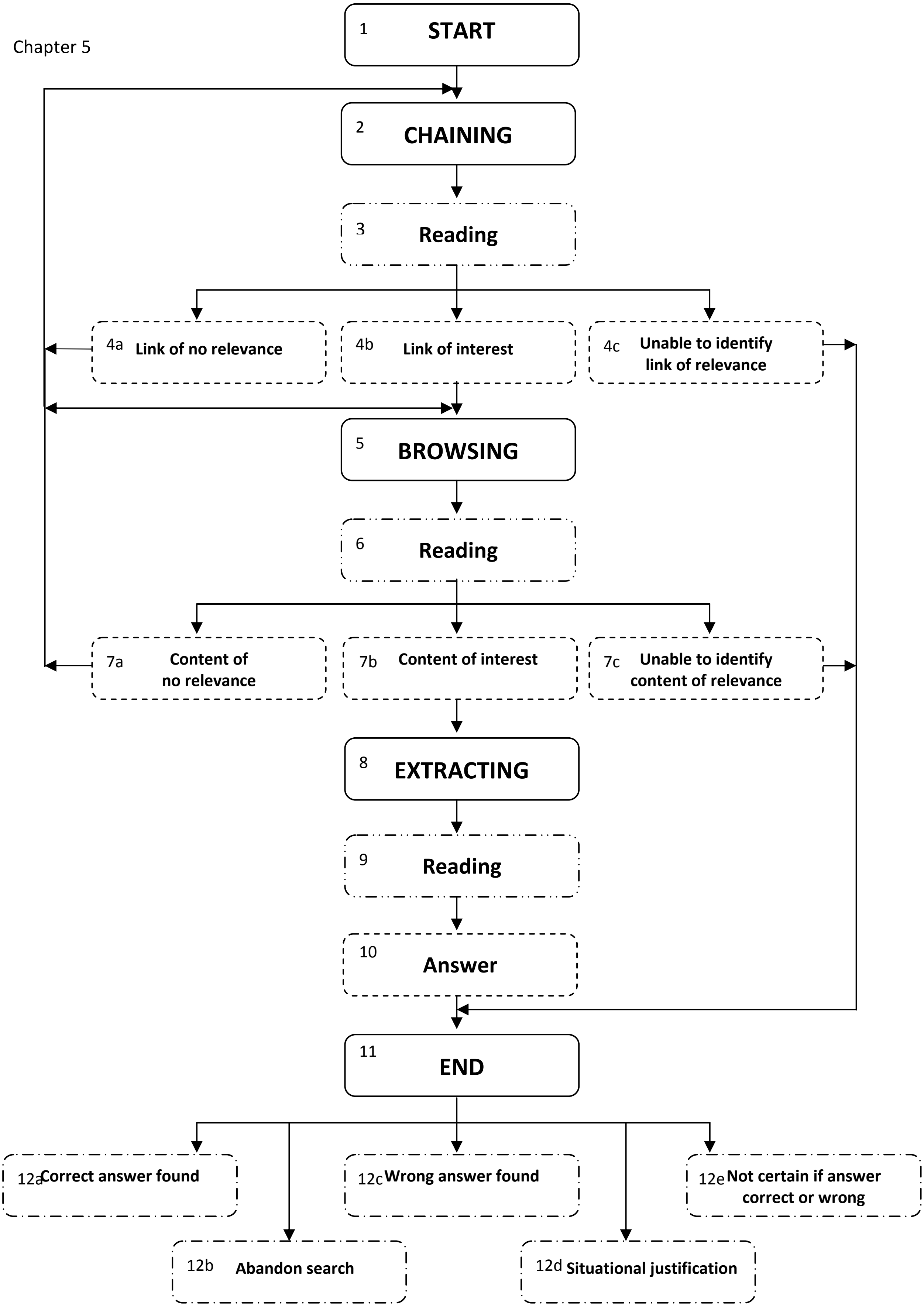


Figure 5-2. Adaptation identified from Ellis' Information seeking behaviour model for LL user.
a) Observed strategies which were similar to Ellis' behaviour model strategies [__],
b) observed strategies [-..-], c) user decisions [--], e. search outcomes [-.-]

DISCUSSION

The study identified differences between HL and LL users information seeking behaviour. While, Chapter 4 identified differences in the strategies between HL and LL users, this chapter suggests that literacy has an effect on users' information seeking behaviour activities (i.e. behaviour model) thus creating two refined models inspired by Ellis's information seeking behaviour.

LL users started reading at early stages during the search (see Figure 5-2 boxes 3, 6 and 9), while HL users started reading later, (see Figure 5-1 boxes 6b and 9). Literature suggests that LL users low level reading results in a higher cognitive load (Perfetti, 1985), making it difficult for them to find interesting or relevant information. While the HL users seem to employ a scanning strategy at early stages (see Figure 5-1 boxes 3, 6a, 6b), this was not evident with the LL users. Furthermore LL users were likely to abandon the search (see Figure 5-2 boxes 4c and 7c), which was not evident with the HL users. This is likely due to LL users intolerance of uncertainty discussed in Chapter 4. Unlike the LL users, HL users used differentiating and verifying information for correctness, suggesting that the former employed a satisficing solution while the latter users employed an optimising strategy. This is discussed in detail in Chapter 4. A study carried out with LL consumers found that LL users have difficulty making comparisons (Jae & Delvecchio, 2004). Richards et al (1971) found good readers have developed skills such as comparing, distinguishing and relating meaning compared with poor readers, explaining why HL users were likely to differentiate and verify information. HL users seem to take memory notes (see Figure 5-1 boxes 7c and 10a), which was not evident with the LL users. Another interesting finding is that LL users gave supporting evidence to justify their answer without being prompted (see Figure 5-2 box 12d). This behaviour was not evident with the HL users (see Figure 5-1).

SUMMARY

This chapter identified two adaptations of the Ellis' information seeking behaviour model, one for HL (Figure 5-1) and the other for the LL (Figure 5-2) users. The adaptation identified for the LL users mainly lacked Ellis' differentiating and verification stages, along with reading over scanning and abandoning searches at early or mid-stage making them less successful during online information seeking. Also the adaptation identified for the HL users which captured Ellis' stages and showed that they scan for information over reading was shown to make them successful. The chapter compared HL users with LL users' adaptation of Ellis' information seeking behaviour model to investigate which type of support mechanisms should be considered when designing interfaces for LL users (Ellis, 1989; Kuhlthau, 1993; Marchionini, 1995; Meho & Tibbo, 2003). This is discussed in Chapter 7. This chapter contributes to the body of literature in the way Ellis' information seeking behaviour model has been adopted as a theoretical lens in order to analyse HL and LL users' information seeking behaviours to provide meaningful interface design insights.

LIMITATIONS

The data analysed in Chapter 4, which identified behaviour strategies for HL and LL users were reused, taking advantage of Ellis's information seeking behaviour model as a theoretical lens. Even though the data was analysed prior to selecting an information-seeking model, no preconceived ideas were enforced during the data analysis of the module. In order to reduce the possible bias, two independent researchers analysed the data of (three out of ten participants) and obtained an 82% match to the analysis already in place. Although, it would have been better to have higher than 82% agreement on the analysis, it indicated a good consensus.

CHAPTER 6

INVESTIGATING HL AND LL USERS' UNDERSTANDING OF INFORMATION STRUCTURES

This chapter investigates differences between high literacy (HL) and low literacy (LL) users' mental models when classifying *Adviceguide* website information following a card-sort method. A good design depends on the mapping between users expectation or mental representations and the designer's model of the system (Norman, 1988).

Chapters 4 and 5 examined the online information seeking behaviour strategies and models used by HL and LL users on the *Adviceguide*. The results showed that LL users' abandoned 50% of the tasks, compared to HL users who did not. Out of the search tasks abandoned by LL users, 60% of them were due to LL users not being able to find the relevant information in the sections they were expected to be. This suggests that there is a disparity between LL users' mental model of the *Adviceguide* website, and the website design. This resulted with a mismatch between LL users search trajectories and optimal path. As a consequence, LL users showed behaviours became intolerant because of the uncertainty generated by their experience, compared to the HL users discussed in Chapter 4.

It is important to determine why these differences occur in order to inform the design of a system. If LL and HL mental models are delineated then the design of the system can adopt a similar conceptual model and highlight the areas where LL users have difficulties when searching online.

In order to investigate these differences, three structures need to be compared, which is the focus of the following study.

1. HL users' mental model of the *Adviceguide*
2. LL users' mental model of the *Adviceguide*
3. *Adviceguide* menu structure

STUDY DESIGN RATIONAL

Marchionini (1995) describes that the *"process of information seeking is a cognitive activity that involves long and short term memory, background knowledge, spatial cognition and mental models, to name a few critical factors"*. He further observes that *"information seekers develop and use mental models for a variety of mental and physical objects, including information objects and different domains of knowledge"* (Marchionini, 1995). Marchionini (1989) stated that *"Mental models serve the dual purposes of representing entities and relationships which are refreshed and extended by experience, and simulating the possible effects of acting on these entities and relationships."* .Young (2008) explained that once the beliefs and assumptions users make in their heads are understood, the mistakes and misunderstandings, and oversights with respect to the system will become clearer. Vicente et al (1987) in their studies identified users with low spatial abilities were more likely to get lost in hierarchical menu structures than people with high spatial abilities. Carey (1986) describes mental models as follows: *"a mental model represents a person's thought process for how something works (i.e., a person's understanding of the surrounding world). Mental models are based on incomplete facts, past experiences, and even intuitive perceptions. They help shape actions and behaviour, influence what people pay attention to in complicated situations, and define how people approach and solve problems"*.

For the purpose of this study, a mental model refers to the participants' mental representation of the *Adviceguide* menu structure. In order to be able to compare the users' mental models against the *Adviceguide* menu structure a card sorting study was carried out. Card sorting is a popular method used by many different research domains such as information architects (Coxon, 1999; Fincher & Tenenberg, 2005; Hannah, 2005; Nielsen & Sano, 1994; Rugg, 2005; Spencer, 2009; Spencer & Warfel, 2004), social scientists (Ameel et al., 2005) and psychotherapists (Upchurch, Rugg, & Kitchenham, 2001), to elicit the implicit knowledge of the users. An open card sort gives users the freedom to classify information according to their understanding, available domain knowledge, and experience without external influences. This enables the investigating of participants' implicit knowledge and reasons for the classification using the think-aloud protocol. Card-sorts can be carried out either electronically or manually using paper. A manual card-sorting technique was preferred for this study. This was to minimize learning, computer literacy and other external factors that might influence the findings.

The card-sort focused on identifying how HL and LL users classify information freely in a non-goal driven situation. The focus was to identify users' perceived understanding of the menu items, how they classified the information and what influenced their thought processes. Ethics approval for the study was obtained from the School of Engineering and Information Sciences Ethics Committee at Middlesex University.

Pilot Study

A pilot study was conducted prior to the main study. Four volunteers (2 HL and 2 LL users) of the local CAB participated in this study. The pilot study examined whether the instructions given were clear, the study design was complete, the data collected was correct and whether the number of information cards overwhelmed participants.

The study was conducted at the Middlesex University, Interaction Design Centre Usability Lab. Participants were informed of the study procedure and given time to familiarise them with the think-aloud protocol. To get the participants familiarised with the card-sort study, a practice session with 10 cards with names of cities (2), birds (2), mammals (4), and reptiles (2) were handed. The cards were shuffled and placed in a pile for each participant. All participants gave consent for video and audio recording. Figure 6-1 shows how the study was setup.

Figure 6- 1.Card-sort study setup.
(a) Left – shows how the room was setup for the study, (b) right – shows what the downward faced camera captured. Participants gave permission to be recorded and photographed.

Main Study Hypothesis

Based on the results of the study shown in Chapter 4 and the pilot study mentioned above, two hypotheses were developed:

- The mental model of the LL users is different from the *Adviceguide* menu structure
- The mental model of the HL users is similar to the *Adviceguide* menu structure

METHOD

Participants

An advertisement was placed in a local Citizens Advice Bureau (CAB) and staff were informed or the aim of attracting clients to participate in the study. Participants had to be 18 years old and above and have no prior experience using the *Adviceguide website*. Assumptions were made that the participants had basic domain knowledge of the social service information to carry out the card-sort activity. Of the participants who participated in this study five were immigrants (settled in the UK for more than ten years). Two of the five volunteers were LL and the remaining 3 were HL. Past research has suggested that people who were literate in their first language were able to transfer those skills to learn a second language (Strucker & Davidson, 2003). None of the volunteers had prior experience using the *Adviceguide*, even though they were walk-in clients of the local CAB. None of the volunteers according to them had any known learning disabilities (such as dyslexia).

In total, 17 clients of the local CAB volunteered for the study. Nine participants were classified as HL, and the remaining eight were classified as LL. They comprised 11 females and six males with a mean age of 38 years, ranging from 34 to 48. From these participants, 60% were currently claiming some benefit from the Government at the time the study was conducted. Participants' literacy was evaluated on completion of the study using UK National Skills for Life Literacy Survey[7] (as in the previous chapter). The HL participants for this study scored an average of 34 out of 40 (ranging from 31

[7] *Please refer to Appendix E for UK National Skills for Life Literacy Survey*

to 36) while the LL participants scored an average of 15 out of 40 (ranging from 8 to 16).

Design of the Card-Sort Study

For the purpose of this study, the same social service website as in the previous study was used (*Adviceguide* -http://www.adviceguide.org.uk). From the *Adviceguide* menu, structure thirty-seven menu information items were selected. These menu items were selected because walk-in clients of the local CAB between April 2007 and May 2009 frequently requested them. The CAB provided the data and a frequency count was conducted. The items selected covered benefit types such as employment, tax, debt, family, and housing.

Thirty-seven menu items were selected to enable participants to place them on a table without overlapping them and leaving room for grouping. All menu items were assigned a unique identifier and were printed on a 13 x 8cm cardboard (see Figure 6-2).

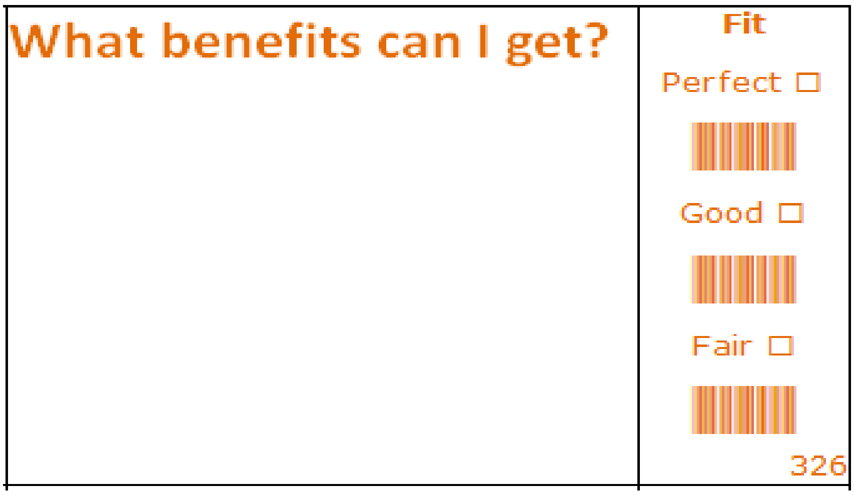


Figure 6-2.A menu item.

The local CAB provided detail descriptions for each of the selected menu items. The descriptions were printed and made available to the participants to prevent any inconsistencies. Table 6-1 shows all 37 menu items selected and the *Adviceguide* menu structure.

ADVICEGUIDE MENU STRUCTURE	MENU ITEM	CARD NO ASSIGNED
Benefits	Benefits and bereavement	2
	Benefits and tax credits for people in work	3
	Benefits fact sheets	4
	Benefits for families and children	5
	Benefits for people looking for work	6
	Benefits for people over sixty	7
	Benefits for people who are sick or disabled	8
	Frequently asked questions about benefits	15
	Help for people on a low income - Income Support	18
	Help for people on a low income - the Social Fund	19
	Help with health, education and legal costs	21
	Help with your Council Tax – Council Tax Benefit	23
	Help with your rent – Housing Benefit	24
	National insurance – contributions and benefits	28
	Payment of benefits and tax credits	30
	Problems with benefits and tax credits	31
	What benefits can I get?	34
	Young people and benefits	36
Your Money	Credit	10
	Credit and debt fact sheets	11
	Debt test	12
	Financial health check	14
	Frequently asked questions about debt	16
	Help with debt	20
	Mortgage arrears	27
	What happens when your mortgage lender takes you to court	35
	Your mortgage lender takes you to court – how to prepare for the court hearing	37
Tax	Benefits in kind	9
	Help with tax problems	22
	Income tax and pensioners	26
	Pay As You Earn: common problems	29
Employment	Bank and public holidays	1
	Dismissal and benefits	13
	Frequently asked questions about employment	17
	Holidays and holiday pay	25
	Redundancy	32
	Self-employment: checklist	33

Table 6- 1. Adviceguide menu structure showing the 37 menu items.

Procedure

Following a practice session (10 cards with names of cities, birds, mammals and reptiles), participants were given the 37 menu items randomised and placed on top of each other along with the menu item description sheet. Participants were asked to classify the cards according to what they felt was best. To make sure that they understood the meaning of each card, they were told to ask the interviewer or to look-up the meaning of the term in the menu item description sheet that they were provided.

The participants were informed that there was no right or wrong way to classify information, and there was no limit to the number of classifications. The participants grouped the cards and gave a name to each group. Once this was completed a semi-structured interview took place. Think-aloud sessions which captured users' verbalized aspects of what they were doing, decisions made and experiences during the information search task were video recorded. The interviewer took notes of observations made such as users physical and verbal aspects and some were captured on video.

The semi-structured interview took place at the end of the card-sort study taking advantage of participants think-aloud and observations made. During the interview selected sections of the recorded video was played back to help participants recall and reflect on the interviewer questions. This helped clarify observations made during the card sort or questions identified from the think-aloud. These insights help understand participants actions, decisions, justifications and cues they used to arrive at their final solution. During the interview process, the participants were allowed to reclassify the cards.

Once the interviews were completed, participants were asked to complete The UK National Skills for Life Literacy Survey (Williams et al., 2003) to determine their level of literacy.

Data Analysis Techniques

Data analysis was divided into two parts. First, the classification process used by HL and LL users was identified. Second, the differences between mental models of the *Adviceguide* were explored.

To determine the classification process multiple Cognitive Task Analysis (CTA) methods were used to extract and understand the participant's decision process during card-sorting. Methods such as think-aloud (video capture), and semi-structured interviews (video play-back and field notes taken), and user observation (video capture and field notes taken) were used for data collection.

Once the participant had left, the facilitator wrote down the card numbers, the labels assigned to each group and the hierarchy created. The qualitative data from the think aloud, observations, video recordings along with the semi structured interviews were transcribed. In total 33 hours of audio data was transcribed: 20 hours of LL users data and 13 hours of HL users data.

During the qualitative data analysis process, information about the participants' literacy status was not provided to avoid any bias. Additionally, in order to validate the results data were analysed by two independent researchers, whose results showed 87% match to the original analysis.

In order to define the mental models of the HL and LL users, four main steps were taken.

- Definition of collective classifications
- Calculation of agreement weight
- Construction of dendograms
- Visual comparison of mental models and *Adviceguide* menu structure

DEFINITION OF COLLECTIVE CLASSIFICATIONS

There were a total of 120 label names created during classification of the 37 menu items by the HL and LL participants. Of which, 76 were created by HL participants and 44 created by LL participants. Participants during the creation of the 120 label names gave their reasons during the think-aloud and semi-structured interview sessions. These were revisited to find if similarities existed across the creation of the label names, without considering the participants literacy. Label names that had similar meanings were grouped together. This process identified 19 classifications (categories) across both HL and LL users. As described above, two independent researchers were given a sample of the label names, with the transcribed think-aloud and semi-structured interview data to identify similar groups to avoid facilitators' bias. The 19 classifications will be referred as high-level categories and are listed as follows:

The 19 high-level category list

1. Accident related information
2. Benefits related information
3. Debt and Credit information
4. Employment related information
5. FAQ
6. Finances
7. General information
8. Health related information
9. Help
10. Holiday related information
11. Income related information
12. Job centre
13. Legal related information
14. Mortgage or Housing related information
15. National insurance related information
16. Problems
17. Retirement related information
18. Tax related information
19. Unknown

Table 6-2 shows the label names created between the HL and LL participants with regard to *Benefits related information*. The table below show the following HL (HL1, HL2, HL3, HL5, HL6, HL8 and HL9) users used label names to represent multi-level classifications. The think-aloud session and interview data point out the remaining HL (HL4 and HL7) or LL (LL1, LL2, LL3, LL4, LL5, LL8) participants created single-level classifications. However, LL6 and 7 did not create any classifications for *benefit related information*. Some of these single-level classifications fell into broader high-level classifications, but the participants did not make the necessary connections.

PARTICIPANTS	MENU ITEMS

HL1	**Benefits**
	    Benefit problems
	    Tax problems
	    Tax returns
	    Tax payment

HL2	**Benefit Information**
	    Benefit questions and facts
	    Benefits and tax
	    Daily life benefits
	    Other benefits

HL3	**Benefits Main**
	    Benefits fact sheets information
	    What benefits can I get
	    Who can get benefits

HL4	Benefits Income help

HL5	**Benefit Information**
	    Benefits for Sick or disable people
	    Family

HL6	Benefits
	    Benefits Information
	    Available support from the council

HL7	Benefit Helps

HL8	**Benefits Main**
	    Benefits and support
	    Benefits General Information

HL9	**Benefit Information**
	    Benefit A-Z
	    Help section

LL1	Benefits for people sick or disabled Benefits in kind
LL2	Benefit credit Benefit for people Benefits of tax
LL3	Child benefits
LL4	Benefit Department Help and Advice on Benefits
LL5	Benefits and Tax
LL8	Second on Tax Papers on Benefits

Table 6-2.Label names created by HL and LL participants for "Benefits related information".

Calculation of agreement weight

The spread sheet template created by Lamantia (2003) was used to calculate the agreement weight (see Formula 6-1). This takes a count of how many individual cards were placed in a category.

$$Agreement\ weight = \frac{number\ of\ cards\ in\ category}{total\ number\ of\ cards}$$

Equation 6- 1. Calculating agreement weight.

The agreement weight is a way to describe the strength of a card in a single high-level taxonomy (Paul, 2008). Multi-level classifications were converted into single-level classifications when creating the collective set for all participants. The results of the agreement weight could vary from 0 – 1 (Lamantia, 2003). High percentages indicate that more participants consistently placed that card in that category. The highest percentage being 100 (or agreement weight = 1). These percentages are referred to as the level of participant *agreement* on the placement of the cards. Different studies have grouped the agreement weights into high, medium and low (Lamantia, 2003; Paul, 2008). For the purpose of this study, a *high agreement* weight within participants refers to a score equal or greater than 0.66. A *medium agreement* refers to a score between 0.33 and 0.65. A *low agreement* refers to a score equal to or less than 0.32.

Construction of dendrograms

A hierarchical cluster analysis was used to summarize the card-sort data into a dendrogram. A dendrogram allows visualisation of the correlation of the groups which is represented as a tree structure (Olmsted-Hawala, 2006). Items, which were very similar, were grouped together, while items, which were dissimilar, were grouped separately.

A dendrogram that branches towards the far left indicates high agreement on the card placement group, whereas low agreement is indicated by branching towards the right. A 'cut-off' point is marked from the right of the dendrogram depending on how items have been grouped. The 'cut-off' point helps determine whether the classification is general or specific (Romesburg, 2004). It is important to cut the dendrogram at some point within a wide range of resemblance coefficient for which the number of clusters remains constant, because a wide range indicates that the clusters are well separated in the attribute space.

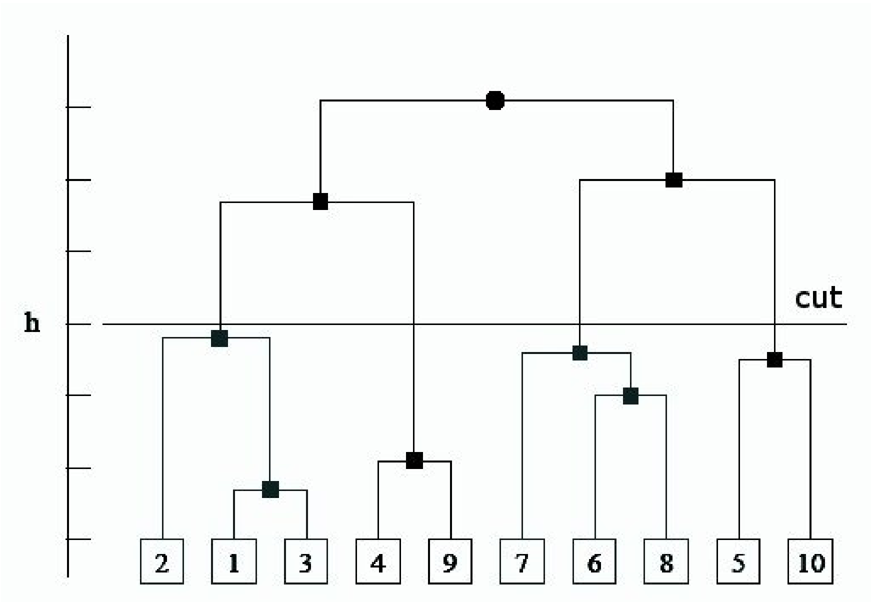


Figure 6-3. Example of a dendogram showing 10 items, and the selected cut out point showing 4 (clusters) classifications.

The raw data collected were combined and entered into a data matrix. A single variable with two different values used to represent group membership (HL vs. LL e.g. 1, 2). Then 37 variables used to represent one for each card (eg card1 to card37). A variable was assigned to each pile a participant created (eg. 1 – x). Each card was given a value based on the pile the card was sorted into. For example, a participant created two piles of cards, then the cards in pile one would have a value of 1, and the cards in pile two will have a value of 2. Similarly, if a participant creates six piles, you would enter the values 1 to 6 for each card variable to indicate the group to which it belonged. The matrix used to run the hierarchical cluster analysis and draw dendrograms.

VISUAL COMPARISON

Finally, the analysis, the menu structure of the *Adviceguide* was compared to the collective classifications. There were four classifications in the *Adviceguide* menu (see Table 6-1) structure while there were 19 collective classifications.

RESULTS

The study took on average 1.5 hours for HL users and 2.5 hours for LL users excluding the literacy assessment and breaks. The results will be reported in two main sections. The first section will report on the participants' classification process. The second section discusses the agreement weight and dendograms.

Results from the Analysis of the Classification Process

An analysis of the transcribed data helps define the process that participants followed to classify the cards. This process is defined in table 6-3.

CLASSIFICATION PROCESS		**HL**	**LL**
When did participants initiate the classification process?	Initiated the classification as soon as the cards were read	67%	100%
	After they laid cards on the table	33%	0%
	Keep cards aside for later classification	78%	38%
Methods participants used to classify cards	By keywords only	11%	0%
	By keywords & semantic meaning	67%	0%
	By semantic meaning only	22%	100%
Classification tools	Multi-level taxonomy (Main and subgroups)	78%	0%
	Ranking (Total ranking % for Vertical and Horizontal)	100%	50%
	Vertical Ranking (Cards had importance over the following)	44%	25%
	Horizontal Ranking (Classification had importance over the next)	56%	25%
	Personal or hypothetical concepts or experiences		
	Own experience	33%	63%
	Friends and families experience, news	11%	25%
	Someone else's shoes	22%	0%
	Concepts	33%	12%
Overall results	Completion (once the participant stated they finished grouping others continue to group over the interview session)	100%	25%
	Time for completion on average (in minutes)	15	75

Table 6-3.Classification process during the card sorting.

When did participants initiate the classification process?

Participants initiated the classification process either as soon as the cards were read or after they laid the cards on the table. Regardless of how they initiated the classification process, some tended to keep cards aside for later classification. Observations were made that only 67% of the HL participants initiated their classification process, as the cards were being read compared to a 100% of the LL participants. For instance, a HL participant while reading the *benefit fact sheets* card stated, "… *hmm I will put the benefit fact list separate from the mortgage because that Mortgage is not benefits. Even though both are connected to financial problems. But they are different*." While a LL participant said "… *credit, this* [the card labelled credit] *can go* [with] *this one* [referring to finance]*, because it is about financial.*"

Thirty three percent of the HL participants set aside the cards before grouping, while this behaviour was not observed with the LL participants. For instance, participant HL7 asked "… *Can I just place the cards on the table first?.*"

Additionally, 78% of the HL participants and 38% of the LL participants kept cards aside for later classification as they were uncertain where the cards would fit. However, the majority (62%) of the LL participants do not set aside cards for later classification. For instance, participant HL1 reasoned "*Benefits for families and children the other one is benefits for people over sixty they are different because families and children are normally younger people and over 60 are elderly people. Can I skip one and go back as I don't know about these right now...*". Participant LL5 came across the card *benefit for people who are sick or disabled* while stating "… *Benefit for people sick or disabled, I am not sure what group it's going to right now, can I leave it and come back? …*".

How participants classified the cards?

The analysis identified that participants used three methods to classify the information: by keywords only, by keyword and semantic meaning and by semantic meaning only. Here reference is made to keyword classification if they grouped the cards by use of a prominent word. Keyword and semantic meaning refers to grouping the cards by keyword, they then further grouped them by justifying the cards meaning based on their personal or hypothetical experiences. Finally, reference to semantic meaning only, is when the participant justified a cards meaning based on their personal or hypothetical experiences and did not use keywords only.

Eleven per cent of the HL participants used keywords, 67% of the HL participants classify cards using keywords and semantic meaning, and the remaining 22% of the HL participants use semantic meaning only to group the cards. LL participants only used semantic meaning only to classify the cards.

Those who grouped the cards by keywords only found, for instance, all cards that contained the word *tax* and grouped them together. *Participant HL3 said* "*… I think I am going to put 'tax' together and let's see and put the 'debt' one together, ok, I think I see a few 'frequently asked questions' about different subjects, I am going to try to group them together and see if it works.*"

Participants who used keywords and semantic meaning tended to classify the cards in two stages. For example, participant HL6 classified some of the cards using keywords and explained that is unable to carry out the same process with the remaining cards "*… I am not making any assumptions I am looking for straight associations. Ok, now I am trying to understand this because I grouped these for the basic grammatical associations. This* [by keyword] *is the group criteria I am using here, but here, since this* [looking at another card] *is different I cannot use this trick. I am trying to look behind the word. I am trying to understand what this heading is telling me …*".

Some participants used personal or hypothetical experiences to justify their groupings. Observations were made that not all LL participants interpretations of the semantic meanings were flawed at some point of the classification process, while this was observe with the HL ones. For example, participant LL3 came across *national* *insurance contribution and benefits, which refers to the amount of tax that you can claim,* back towards contribution-based allowances such as Jobseeker's Allowance, and Incapacity Benefit. The participant said, "*National insurance is for tax that means when you earn you pay tax and not enough pay*". Although this participant was claiming benefits from the government and was aware of the fact that one pays a tax on national insurance, the person failed to understand that the benefit refer to the possibility of claiming it back.

Factors that influenced participants' thought process?

Participants' thinking was influenced by: (a) number of levels for each classification, (b) ranking within these levels, and (c) personal or hypothetical experiences.

NUMBER OF LEVELS FOR EACH CLASSIFICATION: Observations show that HL participants tend to create subgroups within the main groups; this is referred to as multi-level taxonomy. LL participants did not create subgroups within their classification; this is referred to as single-level taxonomy. These participants tend to rank their groups. Observations further shows that HL participants ranked the main classifications and the subgroups, i.e. they performed a horizontal and vertical ranking. LL participants were observed to only rank their groups horizontally.

HL participants classified for 78% of the time in a multi-level fashion. When participant HL1 placed the cards, the participant had a multi-level taxonomy: benefits -> tax problem -> tax credits. The person stated "*Problems with benefits and tax credits, … hmmm as it is to do with benefits and tax credit problems. It should go under this big category benefits and hmmm then under tax problems and finally under tax credits …*".

Figure 6-3 shows how the HL participant organised the cards in a multi-level taxonomy. Under the *Benefit* taxonomy, the participants placed cards "… *What benefits can I get?, Benefits fact sheets, and Benefit in kind …",* followed by two sub-level classifications *Benefit problems* and *tax problems*. Cards placed respectively under the above were "*Frequently asked questions about benefits, Benefits for people over sixty, Young people and benefits, benefits for families and children, Benefits for people who are sick or disabled, Benefits for people looking for work, National* *insurance contributions and benefits and Dismissal and benefits*" and "*Help with tax problems*". The *tax problems* taxonomy followed by two sub-level classifications*tax payment* and *tax returns* which contained the following cards respectively "*Help with your council tax-council tax benefit and Payment of benefits and tax credits*" and "*Problems with benefits and tax credits and Benefits and tax credits for people in work*".

Observations show participants placed cards, which were very general about benefit under the *Benefit* taxonomy, followed by information about benefit for different people under *Benefit problems* sub taxonomy. The sub taxonomy *Tax problems* had general information about help with tax problems, and the two-sub classifications*tax payment* contained cards related to payment of tax and *tax return* contained cards, which were related to tax returns.

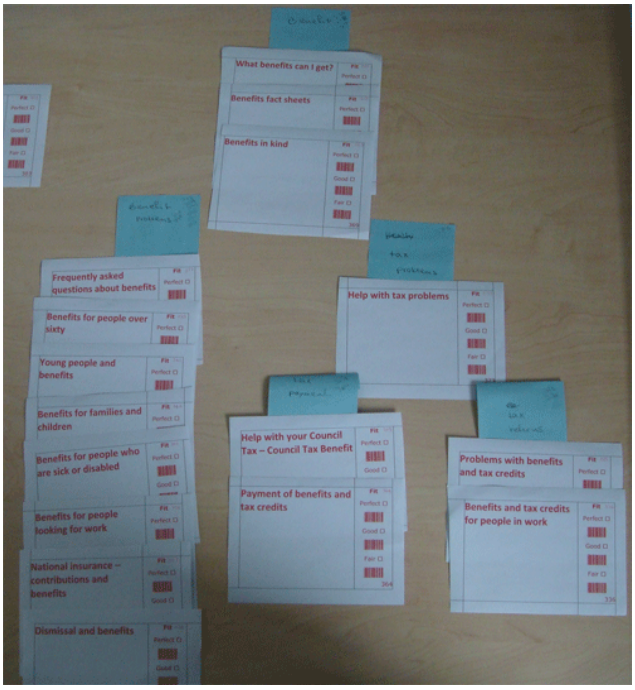


Figure 6-4. Participant HL1 – Shows a multi-level taxonomy

<u>RANKING WITHIN THESE LEVELS</u>: All HL users ranked their groups either horizontally or vertically; while 50% of the LL participants ranked the groups horizontally. Participant HL3 observed the classification carried out and made changes to make the group smaller, ranking it vertically according to age starting from families and children, young people, over 60 going to disabled. *"… I think ideally this group should not be this big, if you look here the top once are like benefits for different people like young people, families, people over 60 and sick people …".Another example of ranking is given by participant LL8 who affirms "… in the number one [referring to the tax group], the most frequently used one, I think this one [participant's most important group] … I think more priority on this one, Yes first is tax and benefit, then mortgage, number 3 for holiday and the last one is....".*

<u>PERSONAL OR HYPOTHETICAL EXPERIENCES</u>: It is important to note that some participants justified their actions based on personal or hypothetical concepts or experiences. Observations show that 67% of the HL participants and 88% of the LL participants used their personal or hypothetical experiences to influence their thought process. These participants referred to their own experience; friends and family experiences, news, or placed themselves in someone else's shoes. While all LL participants used a personal or hypothetical experience that was flawed or incorrect. HL participants did not present incorrect or flawed interpretations even when using personal experiences. Participant LL1 recalled a personal experience and said, "… *My husband passed away few years ago, so I am on the benefits and bereavement. I kind of know how most of the tax things work.*" Participant HL4 tried to recall friends or family experiences when grouping the cards "… *hmm have not taken benefits in my life, but I tried to remember what others have discussed about benefits and stuff like that and I used that knowledge.*" Participant HL6 tried to imagine himself in the specific situation "… *I am trying to understand what this heading is telling me, and I have to wear the shoes of someone else to look for this information …".*

Nevertheless, participant LL4 justified the creation of a new group that was labelled "accidents' with a flawed interpretation of the cards dubbed *benefits fact sheets and young people and benefits*. The participant stated "*Benefits fact sheets and young people and benefits name is 'accident', sometimes, an accident in a car or fell on a* *street, like walking and sometimes get dizzy, or slippery, children like sometimes sitting on a car and don't wear a seat belt, and sometimes, slippery like us. It's called 'accident'.*"

Besides the several classification initiation processes and the different methods participants used, there were differences in completion times. This refers to completion as the instant in which participants stated they finished grouping. However, 75% of LL participants made major changes to their groupings during the interview process. None of the HL participants made any changes after completion. The time for completion, differ greatly between the two groups. On average LL participants took 75 minutes for completion while HL participants took about 15 minutes. Thus, LL users took 5 times longer for completion, and yet continued to make changes to the classifications during the interview process as seen in Figure 6-4.

COMPLETION | DURING THE INTERVIEW PROCESS (4TH MODIFICATION) | AFTER INTERVIEW

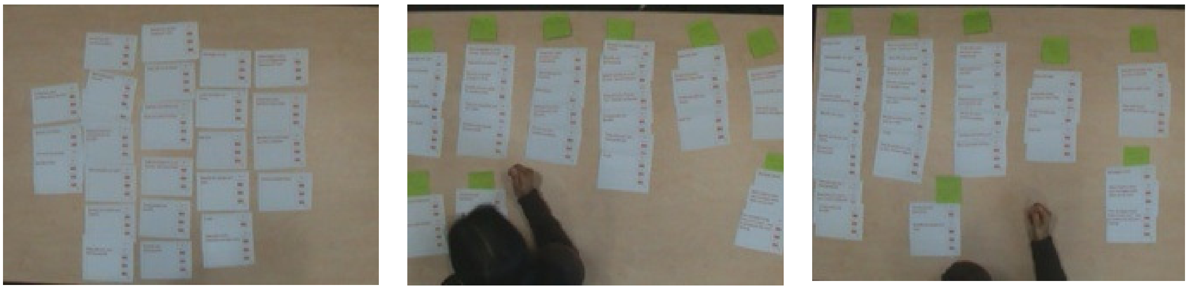


Figure 6-5. Participant LL1 – changes made to the classification after completion.

Results from the Calculation of the Agreement Weight

An agreement weight (see Equation 6-1) was calculated per card and per taxonomy for each participant. The summary (see Table 6-4) below shows the different agreement weights high (green), medium (white) and low (yellow). These are represented in Figure 6-5 and 6-6 respectively for the HL and LL participants; a column visually shows the relationship between cards, categories and participants. Reading across a row, you can see how often a card was put into a category.

Only HL participants presented a high agreement: 39% of HL participants scored 0.66 or more, only 9% scored between 0.33 – 0.65, and 52% scored less than 0.32. While 22% of LL users scored between 0.33 and 0.65 and 78% of them scored less than 0.32 (see table 6-4).

AGREEMENT WEIGHT	HL	LL
High agreement (=>0.66)	39%	0%
Medium agreement (.33 => x =<0.65)	9%	22%
Low agreement (=>0.32)	52%	78%

Table 6-4. Summary of agreement weights for HL and LL participants

It is important to note the visual differences observed from Figure 6-5 and 6-6 indicate: (a) high agreements by HL participants only, (b) HL participant's items are less dispersed than LL participants, (c) LL participants use many high-level classifications. This shows that HL users had a higher agreement among them self, while LL users agreement was heterogeneous among them.

Card Name	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Bank and public holidays				67%						22%	11%								
Benefits and bereavement		89%																	11%
Benefits and tax credits for people in work		56%		11%														33%	
Benefits fact sheets		89%		11%															
Benefits for families and children		100%																	
Benefits for people looking for work		89%		11%															
Benefits for people over sixty		100%																	
Benefits for people who are sick or disabled		100%																	
Benefits in kind		67%		33%															
Credit		11%	78%															11%	
Credit and debt fact sheets		11%	89%																
Debt test		11%	89%																
Dismissal and benefits		67%		22%							11%								
Financial healthcheck		22%	67%	11%															
Frequently asked questions about benefits		100%																	
Frequently asked questions about debt		11%	89%																
Frequently asked questions about employment				89%	11%														
Help for people on a low income - Income Support		67%		11%							22%								
Help for people on a low income - the Social Fund		67%		11%							22%								
Help with debt		22%	78%																
Help with health, education and legal costs		67%		11%			11%	11%											
Help with tax problems		33%																67%	
Help with your Council Tax – Council Tax Benefit		67%																33%	
Help with your rent – Housing Benefit		78%												22%					
Holidays and holiday pay				67%						22%	11%								
Income tax and pensioners		22%	11%															56%	11%
Mortgage arrears		11%												89%					
National insurance – contributions and benefits		56%		11%											11%			22%	
Pay As You Earn: common problems				33%														56%	11%
Payment of benefits and tax credits		56%																44%	
Problems with benefits and tax credits		67%																33%	
Redundancy				##															
Self-employment: checklist				89%														11%	
What benefits can I get?		100%																	
What happens when your mortgage lender takes you to court		11%												89%					
Young people and benefits		100%																	
Your mortgage lender takes you to court – how to prepare for the court hearing		11%												89%					

Figure 6-6. HL participants agreement on card is homogenous and less dispersed across the 19 classifications compared to LL users. The cells marked in green show higher agreement weight, white show medium agreement and yellow show low agreement.

Card Name	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Benefits for people who are sick or disabled		50%							13%			13%					13%	13%	
Benefits in kind		50%							13%	13%		13%						13%	
Credit			50%			13%					13%			25%					
Credit and debt fact sheets			63%			13%								25%					
Debt test			63%			25%								13%					
Dismissal and benefits		50%	13%			13%						13%						13%	
Financial healthcheck		13%	13%	13%		13%		13%	13%					13%		13%			
Frequently asked questions about benefits		50%				13%						13%				13%		13%	
Frequently asked questions about debt			63%			25%								13%					
Frequently asked questions about employment				50%		13%										25%		13%	
Help for people on a low income - Income Support		50%							13%		13%	13%						13%	
Help for people on a low income - the Social Fund		13%		13%		13%			13%		13%	13%				13%		13%	
Help with debt			50%	13%		13%								25%					
Help with health, education and legal costs		38%		25%				13%	13%					13%					
Help with tax problems		63%							13%		13%	13%							
Help with your Council Tax – Council Tax Benefit		63%							13%			13%		13%					
Help with your rent – Housing Benefit		38%							13%			13%		38%					
Holidays and holiday pay		13%		38%					13%	38%									
Income tax and pensioners		25%		13%								13%				13%	25%	13%	
Mortgage arrears			25%			13%								63%					
National insurance – contributions and benefits		25%		25%								13%				13%	13%	13%	
Pay As You Earn: common problems				50%		13%										25%		13%	
Payment of benefits and tax credits		50%							13%		13%			13%				13%	
Problems with benefits and tax credits		50%									13%	13%		13%		13%			
Redundancy		13%	13%	50%		13%										13%			
Self-employment: checklist			25%	63%														13%	
What benefits can I get?		63%	13%									13%						13%	
What happens when your mortgage lender takes you to court			13%										13%	63%		13%			
Young people and benefits	13%	63%							13%									13%	
Your mortgage lender takes you to court – how to prepare for the court hearing			25%										13%	63%					

Figure 6-7. LL participant agreement on a card is heterogeneous and dispersed across the 19 classifications. The cells marked in green show higher agreement weight, white show medium agreement and yellow show low agreement.

Results from the Construction of the Dendograms

The cluster analysis was conducted separately for the 9 HL and 8 LL users resulting in two dendrograms as seen in Figures 6-7 and 6-8. The “cut-off” point chosen for the HL users dendrogram at d_{jk}= 20 and low-literacy users dendrogram at d_{jk}= 18.

Dendrogram for low-literacy users

Three distinct clusters were identified at d_{jk}= 18 as seen in figure 6-7. Among these clusters, there were two groups of menu items with the shortest branches, which means they have the highest perceived similarity. The first pair located in cluster 1 was *Credit* and *frequently asked question about benefits.* The second pair located in cluster 2 was Benefits *for families and children* and *Benefits for people who are sick or disabled*. These two pairs were tightly coupled while the rest of the items were loosely coupled.

Cluster 1: (financial, mortgage related, benefit related) Tax, debit, credit, young people and court related information (10, 15, 20, 35, 36, 23, 31, 26, and 4). The first cluster is loosely correlated apart from *credit* and *frequently asked questions about benefits, which* is related to debt. The cluster shows items, which are related with debt with relation to financial, mortgage and benefit, related areas.

*Cluster 2: Housing, family and holiday related information. (12, 24, 5, 8, 25, and 28).*The second cluster is further classified into several groups. Apart from *Benefits for families and children* and *Benefits for people who are sick or disabled*, which have very high similarity, all remaining items are loosely coupled.

*Cluster 3: Finances, mortgage, tax, income support, employment and redundancy related information. (14, 18, 2, 21, 32, 34, 1, 17, 19, 29, 30, 9, 22, 11, 16, 27, 6, 33, 37, 13, 3, and 7).*The third or final cluster is further classified into several groups. All clusters seen in the dendrogram are loosely correlated and cover a wide range of areas such as finances, mortgage, tax, income support, employment and redundancy related information.

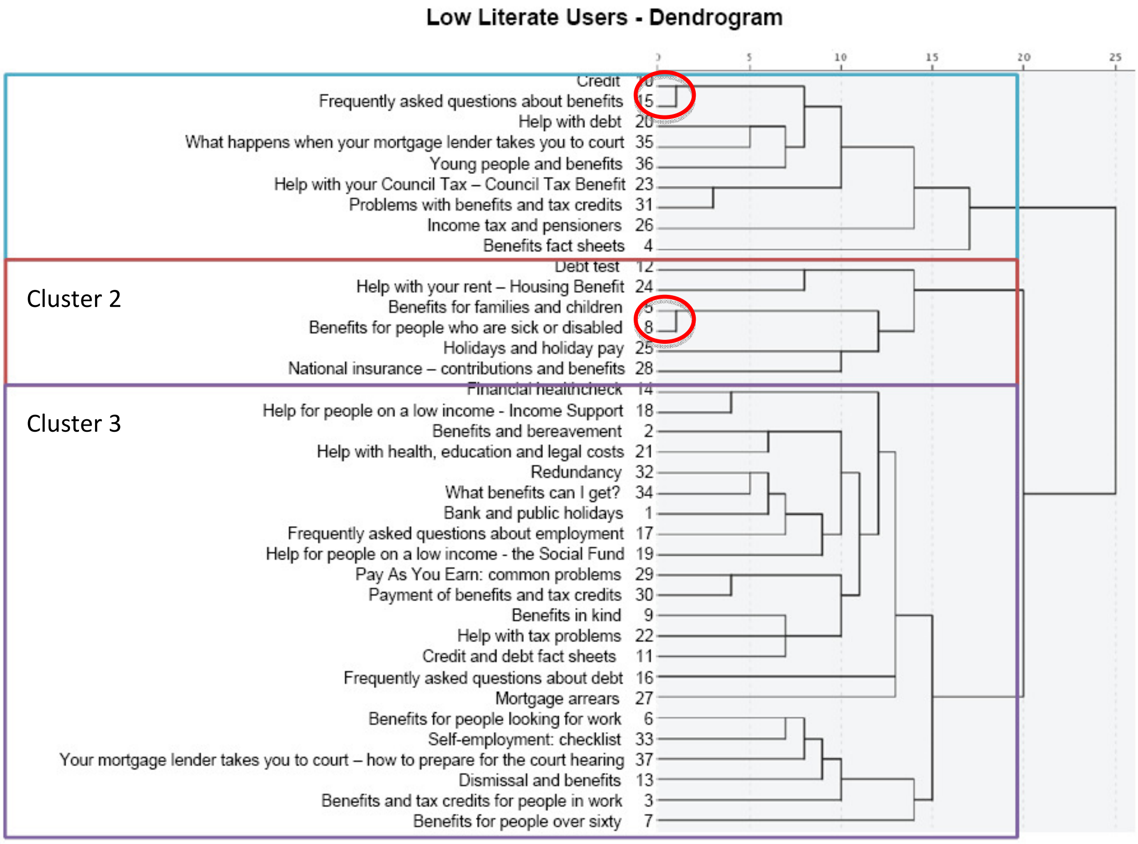


Figure 6-8.LL users dendogram showing 37 menu items of the *Adviceguide* website.

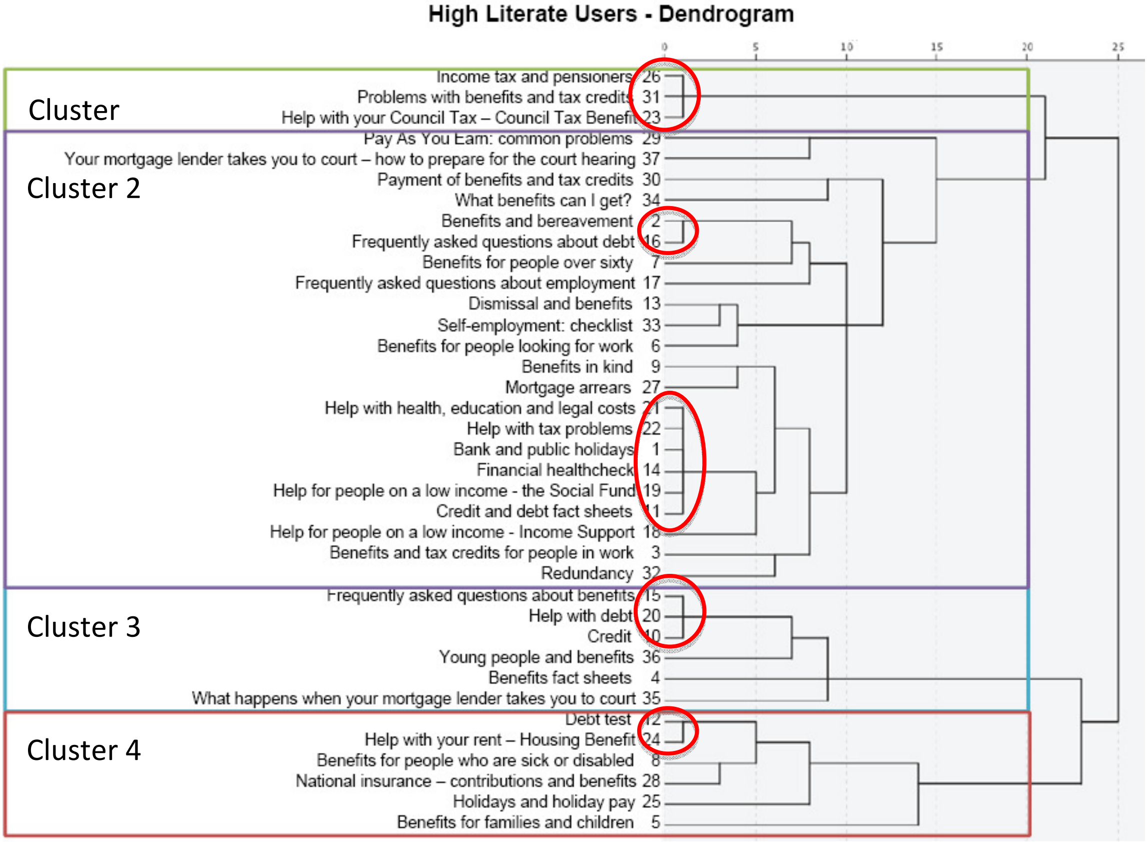


Figure 6-9. HL users dendogram showing the 37 menu items of the *Adviceguide* website.

The dendrogram for high-literacy user

Four distinct clusters were identified at d_{jk}= 20 (see Figure 6-8). There were five groups with the highest perceived similarity:

1. *Income tax and pensioners*, *Problems with benefits and tax credits* and *Help with your council tax – council tax benefits*,
2. *Benefits and bereavement* and *Frequently asked question about debt*
3. *Help with health, education and legal costs*; *Help with tax problems*; *Bank and public holidays*; *Financial health check*; *Help for people on a low income – the social fund;* and *Credit and debt fact sheet*
4. *Frequently asked question about benefits*; *Help with debt; and Credit*
5. *Debt test;* and *Help with your rent – housing benefits*

The rest of the menu items were loosely coupled.

*Cluster 1: Council and income tax related information. (26, 31, and 23).*The first cluster shows a very high similarity between its items which are closely related to tax related information such as Income tax and pensioners, Problems with benefits and tax credits and Help with your council tax – council tax benefits.

*Cluster 2: Finances, mortgage, tax, income support, employment and redundancy related information. (29, 37, 30, 34, 2, 16, 7, 17, 13, 33, 6, 9, 27, 21, 22, 1, 14, 19, 11, 18, 3, and 32).*The second cluster is further classified into several groups. One group shows a very high similarity between six items, which are finance related. The remaining groups relate to employment and other finance related benefits. These items show a high co-relation between the items.

*Cluster 3: Housing, family and holiday related information. (15, 20, 10, 36, 4, and 35).*The third cluster is further classified into three groups. The first group shows a very high similarity between *frequently asked questions about benefits*, *help with debt* and *credit*. The group is more specific towards matters relating to debt and credit related benefits.

*Cluster4: Tax, debit, credit, young people and court related information. (12, 24, 8, 28, 25, and 5).*The final or fourth cluster is further classified into four groups. The first group shows a very high similarity between *Debt test* and *Help with your rent – housing benefit*. The second group shows a high similarity between *Benefits for people who are sick or disabled* and *National insurance – contribution and benefits* that are related to types of benefits you can be entitled for when sick. The remaining two items are loosely co-related.

DISCUSSION

The study explored the possibilities of finding differences within the mental models of HL and LL users against the *Adviceguide* menu structure.

The first hypothesis was that LL user's mental model is different from the *Adviceguide* menu structure. The results from the agreement weight showed that 78% of the LL users scored less than 0.32. This showed that the mental models within LL users were different. Additionally the dendrogram only 3 cluster with only two groups which were tightly coupled.

The second hypothesis stated that HL users' mental model was similar to the *Adviceguide* menu structure. The results from the agreement weight showed that 39% of the HL users scored more than 0.66. A high agreement only obtained by HL users. The dendograms showed 4 distinct clusters with 5 groups that have the highest perceived similarity.

By comparing four classifications of the *Adviceguide* menu structure against the 19 collective classifications, mismatches between both were found. When comparing the *Adviceguide* menu structure to each of the dendograms:

1. A mismatch between HL users and LL users' mental models
2. A mismatch between HL users' mental models and *Adviceguide* menu structure
3. A mismatch between LL users' mental models and *Adviceguide* menu structure
4. A mismatch within LL users' mental models
5. A match within HL users' mental models

The dendrograms illustrate a mismatch between HL (see Figure 6-7) and LL (see Figure 6-8) user's classification. It was also a mismatch with the *Adviceguide* website menu structure (see Table 6-1). The agreement weight of the card placement shows that HL users had 30% high agreement, 9% medium agreement and a 52% low agreement. The results also confirmed the second hypothesis tested, partly. However, HL user's classification and the interfaces information menu structure showed differences.

The findings from this study show differences between users' classification reasoning, agreement weight and emerged clusters from the hierarchical cluster analysis. The results suggest that there are differences between HL and LL participants' card-sorting outcomes. For the LL users, the understanding of the information hierarchy showed differences to HL users.

Results from the classification process analysis suggest that HL user's classifications were based on keywords, semantic meaning or a combination of the two, while LL user's classifications were based on semantic meanings of the cards only.

LL users are less likely to take advantage of prominent keywords and only base their classifications on semantic meaning. This reconfirms previous findings that LL users are less likely to scan for information and instead they employ a reading strategy (Kodagoda & Wong, 2008; Nielsen, 2005; Summers & Summers, 2003).

Furthermore, the LL users' interpretation of the meaning of the cards probably affected their classification. Previous studies have suggested that flawed interpretations from LL users are due to the low-level reading. The latter leads to high cognitive demand that reduces comprehension of the overall message (Perfetti, 1985). Similar results were found with oral cultures as they put a higher cognitive effort on memorisation, were unable to understand the overall meaning of the message communicated (Sherwani et al., 2009), and were likely to be less successful in combining and integrating information (Kirsch et al., 1993).

Another factor that could have influenced the LL users classification is likely to be their personal goals as explained by the theory of orality[8](Ong, 2002). Unlike HL users, LL

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[8] *Please refer to Appendix D for Literacy and orality*

users do not have well developed understand abstract skills (Havelock, 1982) and they are more prone to express themselves through a situation. This may have influenced how LL users sorted the information using their personal situations resulting differences in individual classifications.

The level of literacy seemed to have an influence on the classification hierarchy (main and subcategories) that was created (Kodagoda & Wong, 2008; Nielsen, 2005; Summers & Summers, 2003). A large percentage (78%) of the HL users created a multi-level taxonomy, while the LL users created single-level classifications. All participants tended to rank their groups, depending on the levels of classifications created. Reports in the literature suggest that LL users were better at understanding linear navigation over hierarchy (Medhi, Menon, Cutrell, & Toyama, 2010; Summers & Summers, 2003). A study by Luria and colleagues identified that illiterate users were likely to classify information based on practical rather than by a categorical manner. The researchers further identified that these illiterate users had problems with syllogistic and inferential reasoning (Luria's study in Uzbekistan and Kirghizia in 1931-2). Problems in understanding hierarchy were identified in cultural specific domains (Kress & Leeuwen, 1999; Walton et al., 1996), oral users (Sherwani et al., 2009) and with users with low spatial abilities (Vicente & Williges, 1988). Havelock (1982) argues it is only once literacy is developed that abstract categories are added into language. Therefore, inferences can be made that since LL users are not fully literate they do not understand abstract categories.

The literature also suggests users develop a basic cognitive process by constructing a mental model of a system (Marchionini & Shneiderman, 1988). If the mapping between the users and the system shows similarities, they can be successful with the system (Norman, 1988). There was no evidence suggesting HL users finding the *Adviceguide* menu structure a mismatch to their mental model. While LL users abandon their searches most of the time stating the information was unavailable in the sections they expected them to be.

The paths taken by HL users during information seeking tasks were similar to the optimal path and among themselves, whereas LL users' paths taken were a mismatch to the optimal path and among other LL users. Very early research indicated that by learning to read and write, people develop thinking and cognitive skills (Carothers, 1959; Farrell, 1977). This suggests that HL users' critical and analytical skills allowed them to make use of keywords and linking of semantic concepts by taking advantage of the ability to comprehend text and use abstract categorical skills. It also suggests that HL users are capable of changing their mental model to fit the conceptual model of a system depending on the task demand, as mental models are subject to change (Davidson, Dove, & Weltz, 1999).

In the field of consumer research, a variety of issues in product categorisation has been examined, such as consumer's mental representation of product categories and how categorisation affects choice (Ratneshwar et al., 2001). Prior research in categorisation has already found considerable evidence that goals can alter category representations. It can be argued that HL users are more successful unlike the LL ones during information seeking as they were expected to classify information similar to both models (interfaces conceptual model and users' mental model). It was an unexpected finding to observe that HL user's classification showed differences to the interfaces conceptual model similar to the LL users. However, unlike the LL users, the HL users' classification was generally similar within this group. As the card sort study carried out in this chapter did not have a specific goal, the results may have been influenced by the lack of them and participant's unknown personal situational goals.

The findings from this study confirm that there are differences between the mental models of HL and LL users. The HL users seemed to show similar mental models, while LL users showed dissimilar mental models within each other. However, both user groups' mental models were a mismatch to the *Adviceguide*.

SUMMARY

This study identified mismatches between HL and LL users' mental models, where both user groups' mental models were a mismatch with the Adviceguide menu structure, and also a mismatch with the LL users' mental model. However, there were similarities within HL users' mental models. The HL user groups showed a higher agreement weight on the card placement (39% HL participants scored 0.66 or more), while the LL users had a lower agreement weight on the card placement (78% LL participants scored less than 0.32).

The findings show that LL users were less likely to take advantage of prominent keywords as they based their classification only on semantic meaning. The interpretations were flawed, as they were likely to take advantage of situational justifications. The findings additionally revealed that the level of literacy influenced the classification due to LL users' lack of understanding of abstract categories and cognitive skills such as critical thinking and analytical skills.

These results, that the current Adviceguide menu structure is a mismatch to both HL and LL mental models, raise an important question: How can interactive visualisations be designed to support LL users? These design principles are discussed in Chapter 7. This chapter contributes to research by using the card-sort method to investigate differences between HL and LL users' mental models, and further identifying variations that exist within the LL user group.

LIMITATIONS

Two main limitations could have affected the results in this study. The first one is the small sample size that might have affected the dendrogram results: the more participants, the higher the accuracy of the hierarchical cluster analysis. However, the results were triangulated using agreement weights and CTA methods that confirmed the results obtained with the hierarchical cluster analysis.

The second limitation lies on the personal interpretation of the collective classifications. In order to reduce the possible bias, two independent researchers categorised the participants' classification and obtained an 87% match with the collective classifications. Given that is noticeably higher than 50%, it is safe to assume that the researcher did not bias the collective classifications.

CHAPTER 7

INCORPORATING DESIGN RATIONALE INTO AN EXISTING PROOF OF CONCEPT

This chapter investigates the design principles used to equalise LL users towards HL users by revisiting lessons learned in previous chapters. For example, the identified variations in behaviour strategies (Chapter 4), behaviour models (Chapter 5) and mental models (Chapter 6). Previous research has shown that low literacy (LL) users are less successful when searching for information online (Jensen, King, Davis, & Guntzviller, 2010; Summers & Summers, 2003). They exhibit different behaviours compared to high literacy (HL) users such as reading word-for-word when confronted with long and dense pages, having a narrow field of vision, skipping chunks of text, being satisfied with quickly retrieving information, and avoiding searching as it requires spelling skills (Summers & Summers, 2005). It therefore is increasingly important to recognise that interfaces designed primarily for HL users are less useful for LL users.

This chapter presents two challenges: First, define LL users' information seeking characteristics in a way that allows for new designs not typically found in a designer's repertoire. Second, understanding the problem that needs addressing. The first part of this chapter summarises the problems LL users face, and establishes a set of design principles for interfaces suitable for them. The findings suggest it is not simply an issue of usability or the need for simpler language; LL users also have a different way of thinking. This is followed by a description of how these design principles are mapped to the design concepts of a novel interactive visualisation (Stelmaszewska, Wong, Attfield, & Chen, 2010). For the purposes of this thesis, the above interface was realised into a working system and later an overview of the prototype is discussed with a system walkthrough.

PROBLEMS WITH LOW LITERACY

Research carried out to identify whether differences exist between HL and LL users when seeking information online identified clear differences in user performance (Kodagoda & Wong, 2008). A study investigated what causes these performance differences and identified variations in information seeking behaviour strategies for HL and LL users (Chapter 4). The findings identified differences in information seeking behaviour strategies, which includes: reading strategy (scanning vs. word-for-word), focus (wide vs. narrow field of view), verification (optimizing vs. satisficing), recovery (good vs. poor), trajectories (homogeneous vs. heterogeneous), abandonment (tolerance vs. intolerance of uncertainty), and representation (good vs. poor system model). LL users had a tendency to read word-for-word and tended to focus narrowly on parts of the screen due to skipping chunks of text, whereas the HL users often scanned the page for relevant information. LL users tended to go for early closure instead of *differentiating* and *verifying* the information found for correctness. Then when they got lost (which they appeared to do very often), the LL users struggled to recover from their mistakes and resume the search task. The search paths or trajectories employed by LL users were observed to be more haphazard by trial and error, resembling patterns of use by one who has little understanding of how things are stored. In contrast, the HL users in that short time were able to quickly develop a reasonable mental model of the information architecture and therefore able to direct their search to a more successful one.

To investigate what support mechanisms need to be in place for LL users' information seeking, the identified behaviour strategies of HL and LL users were mapped to David Ellis's (1997) information seeking behaviour model, using it as a theoretical lens (Chapter 5). The findings identified two refined information seeking behaviour models for the HL and LL users, which showed clear differences. The comparison of the two models revealed that the strategies, actions, identifications employed by HL users were not evident with the LL users, contributing possible reasons to why LL users are less successful.

Users will develop a mental model of information provided to them (Marchionini, 1995), and an ideal system will have a strong mapping between the users' mental model and the system's conceptual model (Norman, 1988). A follow up study tried to determine if differences in literacy has an effect on users' mental model of the information menu structure of a traditional website (Chapter 6). The results showed a difference in mental models between HL and LL users. However, while there was a consistency in the mental models of HL users, LL users' mental models were dissimilar to each other. This suggests difficulties if developing a hierarchical menu structure for traditional websites to suit all LL users.

While low literacy is assessed using reading levels, it is clear that the cognitive processes (i.e. users' strategies, behaviour and mental model) are also different, contributing to why LL users are less successful during information seeking (Chapter 4, 5 and 6). Sherwani et al (2009) suggest that when designing for oral or LL users it is not only the reading levels that need to be taken into account but also their different way of thinking. Medhi et al (2010) and colleagues reconfirm content designed for HL users is less likely to be appropriate for oral or LL users.

A body of research focuses on LL users reading difficulties, which includes (a) lower reading levels, (b) using multimodal interfaces with little or no text , (c) audio facilities with voice feedback and voice input, (d) the use of colour and semi-abstract graphics, (e) using white space by minimizing clutter, (f) increasing font size, and (g) the use of flat menu structures (Findlater, Balakrishnan, & Toyama, 2009; Frank-Stromborg & Olsen, 2004; Medhi, Prasad, & Toyama, 2007; Narasimhan, 2004; Jakob Nielsen, 2005;

Summers & Summers, 2003). These studies, however, do not take advantage of unconventional, interactive visualization as a support mechanism to amplify the users abilities (Vicente & Williges, 1988), including their ability to reason (Wong & Kodagoda, 2011).

Shneiderman (2000) states that by trying to dumb down interfaces, it prevents innovation and exploring a broader spectrum of design considerations. This is also confirmed by Nielsen (1993), who argues that rather than just refining an existing design, completely redesigning allows conception of novel and useful interfaces. Rich (1983) observed that adapted design techniques should be used when designing systems that are aimed at more than one group of users. Hearst (2009) claims "Unfortunately, in most cases, usability studies incorporating these visualizations find that they in the best case do not improve peoples' performance, and in the worst case they slow people down or cause them to make errors". This suggests careful consideration needs to be made when drawing from literature and lessons learnt to create design principles and visualisations.

DESIGN RECOMMENDATIONS

Based on the identified differences in LL users' reading strategy, verification, recovery, and mental model, this section proposes a number of recommendations for designing user interfaces for LL users.

Reading Strategy

A problem for LL users is that they start word-for-word reading at a very early stage in their search (Chapter 4 and 5). Perfetti (1985) explains that LL users devote a higher cognitive effort to low-level reading processes (word level), leaving less room for comprehension of the overall message. This makes it difficult to extract information from the text from simple inferences (Cheung, Grypma, & Zhong, 1979). A likely coping mechanism they adopt is to follow a narrow field of view. As LL users are likely to have lower educational levels they are challenged with less critical and abstract thinking skills.

To improve LL users' reading strategies on the internet, Frank-Stromborg and Olsen (Frank-Stromborg & Olsen, 2004) suggested the removal of page clutter from the screen, avoiding long lists by boxing information separately to provide further focus, and the use of white space and colour to draw attention. As LL are likely to have low spatial abilities, the use of visual momentum (animation) to assist with integrating and extracting information is also expected to improve their performance (Vicente & Williges, 1988; Woods, 1984).

Verification

LL users during their information seeking walked away with an adequate solution, suggesting that they employed a satisficing solution (Kodagoda, Wong, & Khan, 2009; Jakob Nielsen, 2005; Pirolli, 2010; Simon, 1957). The satisficing theory suggests that individuals are most likely to find information that is most convenient, compromising accuracy, quality or efficiency.

HL users are able to revisit previously visited information without visual memory cues (Chapter 5). This allows them to investigate new information and verify it against previously visited information. Since word-by-word reading already places a high cognitive load on LL users, they find it difficult to remember where they have been and, therefore, are satisfied easily. The steps discussed above on reducing the amount of word-for-word reading are likely to reduce LL users' cognitive load, enabling them to move from a satisficing strategy to a verifying strategy.

Visual cues such as colour change draw users' attention and focus. Healy et al (1995) identified that users are able to pre-attentively (Treisman, 1985) recognize differences in colour however, unable to recognize simultaneous variation of colour plus shape. While traditional websites change the colour of previously visited hyperlinks, the subtle change is not evident to LL users (Kodagoda & Wong, 2008). A more obvious cue is required.

The Google lists of lists design, that users are familiar with, is not a suitable representational form for users who reason in a less abstract fashion (Frank-Stromborg & Olsen, 2004; Warschauer, 2002). Also, users have been known to benefit from the ability to spatially arrange data (Maglio, Matlock, Raphaely, Chernicky, &Kirsh, 1999). The capability to spatially collate previously visited documents provides another cue for LL users.

Recovery

Recovery occurs when HL or LL users identify irrelevant or wrong link or content and then adjust the search to a more focused and successful one. However, LL users were less successful in recovering from identified irrelevant or wrong links to a successful search outcome. The design principles that are used for reading and verification are to lower LL users' cognitive load, which is likely to help them recover. By adopting functionality such as use of visual memory cues, spatially collate previously visited documents discussed in verification, and giving the ability to remove unwanted documents. By adapting multiple search abilities, is likely to provide the user with an overview (context) of the searches while providing the ability to narrow down to the information try require (focus) (Card et al., 1999).

Reduce Abandonment

LL users were seen to abandon searches assuming the information was unavailable in the places expected. Traditional websites contain hierarchical information structures and links that require LL users to make early decisions, which is a problem because LL users have less of an understanding of hierarchical menu structures than HL users (Medhi et al., 2010; Sherwani et al., 2009; Summers & Summers, 2003). By adopting commands such as SEARCH, the user is presented with a discontinuous transition into new sections (Hochberg, 1978). However, search is unable to give an overview of a conceptual model of the information menu system when compared with the hierarchical menu system. As LL users struggle to conceptualise the spatial layout of the data, providing a display with visual momentum has shown to improve their accepted level of performance (Woods, 1984), while making use of visual patterns (Joshi et al., 2008). These are likely to lower the cognitive load, early decisions making on what menu to search on, which results in search abandonment due to differences in mental model.

INVISQUE

This section describes a system called *Invisque* (Interactive VIsual Search and Query Environment), which was developed as a proof-of-concept mock-up for creating queries and searching for information in an interactive and visual way (Stelmaszewska et al., 2010) (see Figure 7-2). The non-conventional interactive visualization is based on a metaphor of index cards laid out on a tabletop. As an electronic representation, it has been embedded with a variety of functions not easily carried out in the physical world. The design itself is guided by principles such as visual cues and affordances, cognitive load theory, focus + context, and Gestalt principles of perception. These techniques can be incorporated yet keeping the system simple and learnable by empowering good interface design principles and heuristics (Nielsen, 2007; Norman, 1988).

The proof-of-concept mock-up was originally designed for use in electronic library systems for searching and retrieving scholarly and scientific publications (Stelmaszewska et al., 2010). Since the mock-up contained concepts that it was felt were relevant to LL users, it was adopted into a working prototype for the purpose of this thesis. The working prototype was developed to meet the design requirements described above in the context of *Adviceguide*.

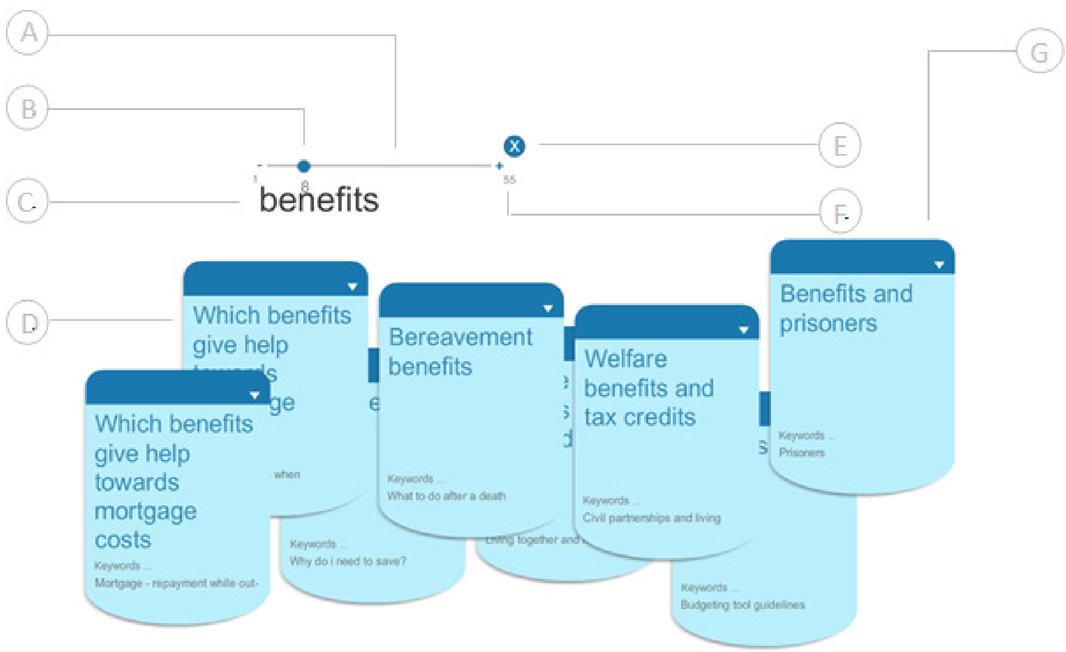

Figure 7- 1. Search canvas with two search results.

A) data slider bar, B) data interval window, C) search term, D) search results displayed by index cards , the index cards are organized in the X-axis by subject matter and Y-axis by demand, E) cluster close button , F) total number of results, G) information drill down icon.

When a user commences their search they are presented with a simple search box. Rather than a hierarchical menu a search box will minimize LL users' mental model differences and prevent early word-for-word reading. The results are presented as a cluster of index cards, with each index card representing a search result (see Figure 7-1). By placing each search item in an index card the amount of text is reduced and the information is boxed (the user is able to drill down to view more information if required, (see Figure 7-1G). This addresses the early reading strategy by reducing LL users' cognitive over load (see Figure 5-1 box 3). Clustering the index cards together on the white space draws attention and reduces screen clutter (Frank-Stromborg & Olsen, 2004).

To prevent LL users being overwhelmed, and prevent overlap, only the top eight results are displayed by default, which is the results mostly likely to be viewed (Kummamuru, Lotlikar, Roy, Singal, & Krishnapuram, 2004). The user is able to increase or decrease the number of index cards that they want to view by adjusting a slider (see Figure 7-1A). The index cards are ordered in both x and y axes depending on the metadata available (e.g., relevance on the x-axis and frequency of information request on the y-axis). Literature suggests visualizing information using meaningful dimensions have been shown to be useful (Ahlberg & Shneidennan, 1994; Fox et al., 1983; Newell, France, & Heath, 1994; Shneiderman, Feldman, Rose, & Grau, 2000).

Visual cues are used to help LL users verify their search. The index cards, which have already been viewed (drilled down) are coloured purple (see Figure 7-2A). This is in line with traditional websites, however, changing the colour of the index card is expected to be more noticeable than only changing the colour of the text (hyperlink).

Users are able to create multiple searches in the same search canvas; this provides the user with an overview of multiple result sets. Transparency is used to clearly distinguish between the current (foreground see Figure 7-2G) and previous searches (background see Figure 7-2F). The current search is brought to the foreground of the canvas while the remaining searches will remain in the background. Users are able to navigate through the multiple searches select the cluster they are interested in, automatically making it active, which brings that cluster to the foreground, while the remaining searches move to the background.

Zooming can be used to either draw focus on an area of interest, or give an overall view of the complete search space. With hierarchical menu systems, if LL users proceed down an incorrect path then they face the problem of “what was I looking for?”. In this situation LL users can become lost in the data and unable to recover. By presenting the complete search space, LL users are able to see where they came from and proceed down a new path, thus addressing the problem of recovery.

Each index card can be dragged and placed anywhere on the canvas, giving the user the flexibility to arrange and order information as they see fit. This allows the user to group relevant index cards that come from different searches, supporting the verification process by reducing the need to memorize the location of relevant index cards (i.e. reducing their cognitive load).

Invisque also has a feature which is referred to as ‘wizard’ allows users to delete or save index cards (Figure 7-2D shows the save area, and Figure 7-2C shows the delete area). The Wizard can also be toggled on or off by clicking a button on the task bar (see Figure 7-2F). If a user feels an index card is of a particular importance, then they can drag it into the save area. The results of which is that the index card is coloured green, providing an obvious visual cue to the user (see Figure 7-2B).

Index cards can be deleted by dragging them to the bin icon (see Figure 7-2C), which is representative of dragging icons to the recycle bin on a Windows desktop. This reduces clutter, helping reduce cognitive load. In addition, the ability for LL users to discard data support the verification and recovery processes.

Drawing from Wood's conclusions, we could argue that visualisations designed to support LL users must provide a high visual momentum. To increase the visual momentum, the visualisation must show the relationship between sets of information, allow the user to identify viewed index cards, allow the user to increase or decrease the amount of information displayed, maintain layers of information in view with the current search on the foreground and provide perceptual landmarks to support verification. While the focus has been bridging the gap between HL and LL users, the hope is that the designs will also support both literacy groups for performing search and query tasks.

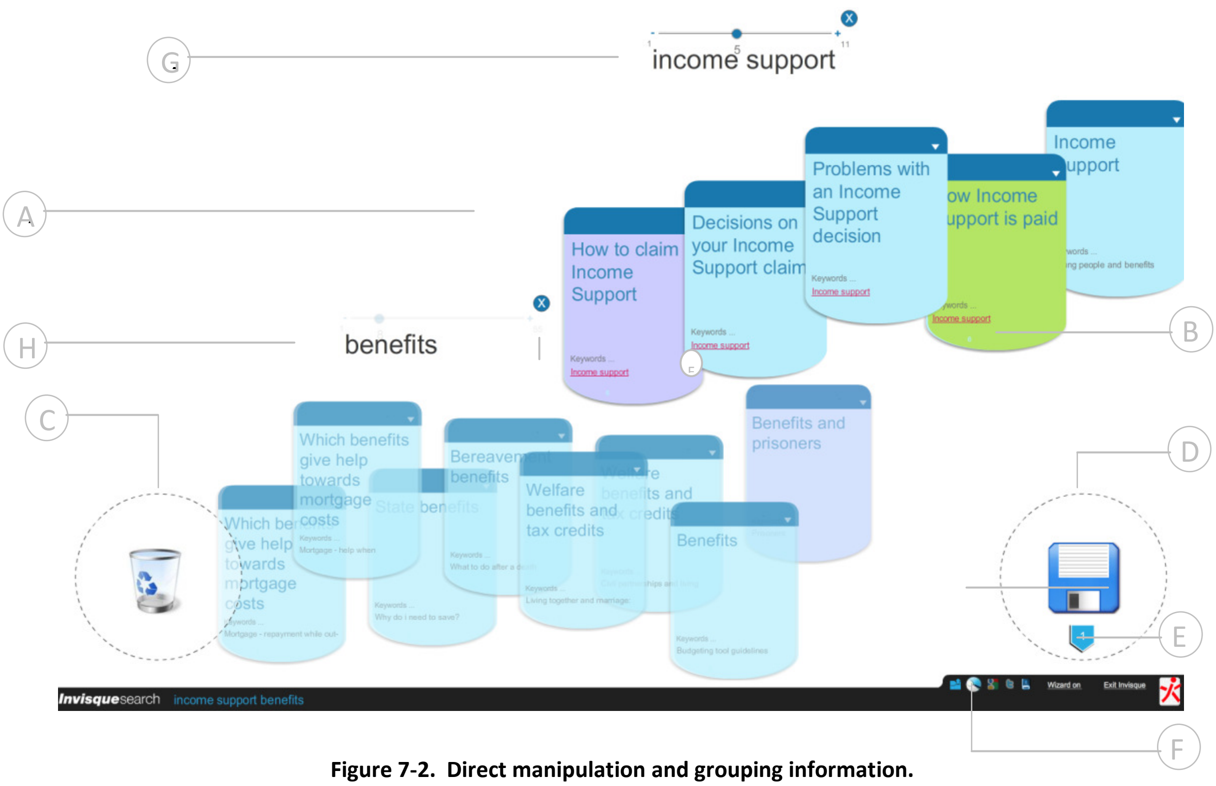

Figure 7-2. Direct manipulation and grouping information.

A) Index cards viewed or drilled down are marked in purple, B) Index cards saved marked in Green, C) to delete an index card it needs to be dragged into the delete area, D) total count of the Index cards saved, E) in order to save an index card it needs to be dragged into this area and F) Wizard icon, which switches on or off the delete and safe areas, G) current or active search 'income support' which is displayed in the foreground, H) previous search 'benefits' which is displayed in the background.

Invisque: a 'user's journey'

This section takes the reader though the proposed prototype step by step to conceptualise the functionality through a journey a user is likely to take while trying to solve a search task which is referred to as a 'User's Journey'.

<u>START-UP SCREEN</u>:

Upon launching the *Invisque*, the users start their search by clicking on the Google-like search box stating what they want to search for. See Figure 7-3.

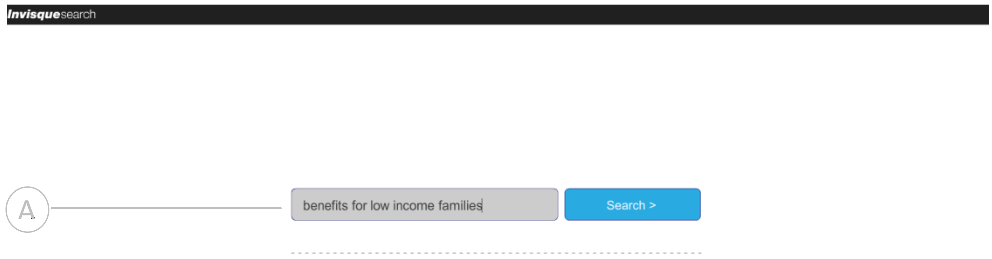

Figure 7-3. *Invisque* start-up screen is blank canvas showing only the search box.
A) Invisque search box

INITIAL DISPLAY: Visual integration of multi-dimensional information

The system presents a visualisation that corresponds to the search term. Each result is represented by an index card, containing essential information such as social service matter, type of information e.g. benefit, tax, etc. The index cards are presented in a cluster, and organised by subject matter along the x-axis, and by the demand of the information matter on the y-axis.

Such information is usually not available together, and in the current CAB website information often resides in different hierarchical menu structures. The visualisations has helped to combine two dimensions that might be important to the users and transform the task from an effortful cognitive task to a relatively easier visual comparison perceptual task. The index cards that appear higher up on the y-axis represent the more frequently asked information from walk in clients of the local CAB, and those along the x-axis represent similar subject matter. Such a visualisation helps answer questions such as, “I am currently on income support what other benefits am I entitled to?” see Figure 7-4.

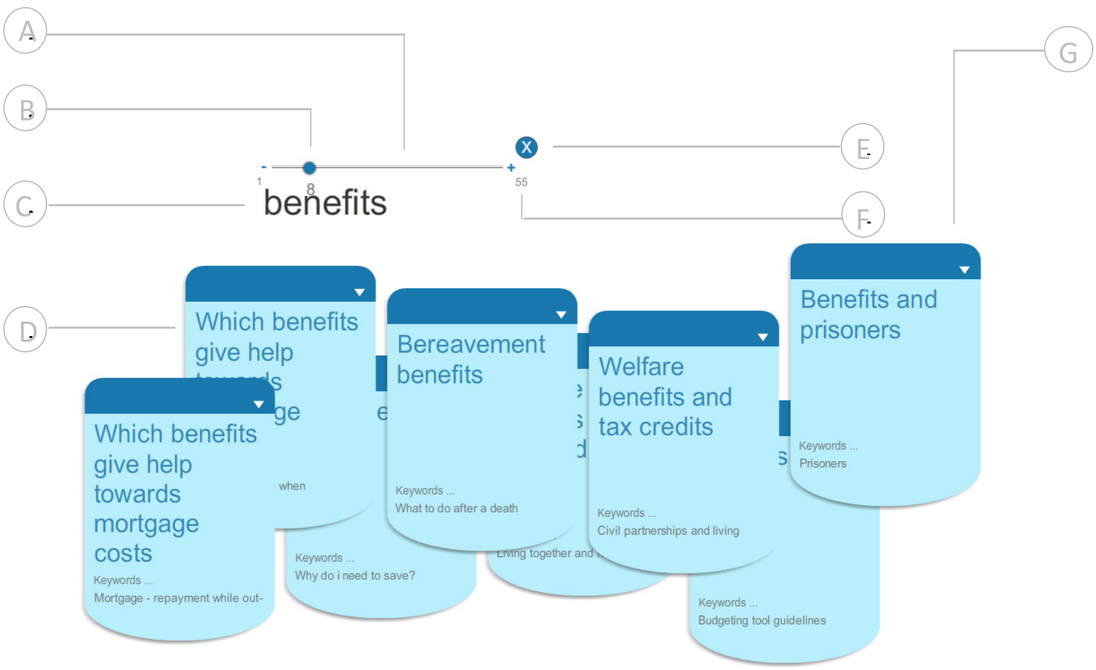

Figure 7-4. Search result screen.

A) data slider bar, B) data interval window, C) search term, D) search results displayed by index cards , the index cards are organised in the X-axis by subject matter and Y-axis by demand, E) cluster close button , F) total number of results, G) information drill down icon

<u>NEW SEARCH: Information layers to differentiate groups</u>

The users may want to change their search and look for other possibilities. The system allows the user to click anywhere in the white canvas and start a new search. Here the system is able to present the second cluster of results using index cards in the same white canvas. The new cluster is presented in the primary layer appearing in the foreground, whilst the older cluster appears to recede into the background in the secondary layer. By using techniques to fade and slightly reduce size, here Gestalt principle of figure and ground draws attention to the objects that appear in the foreground, while still showing one's previous searches faded into the background. See Figure 7-5.

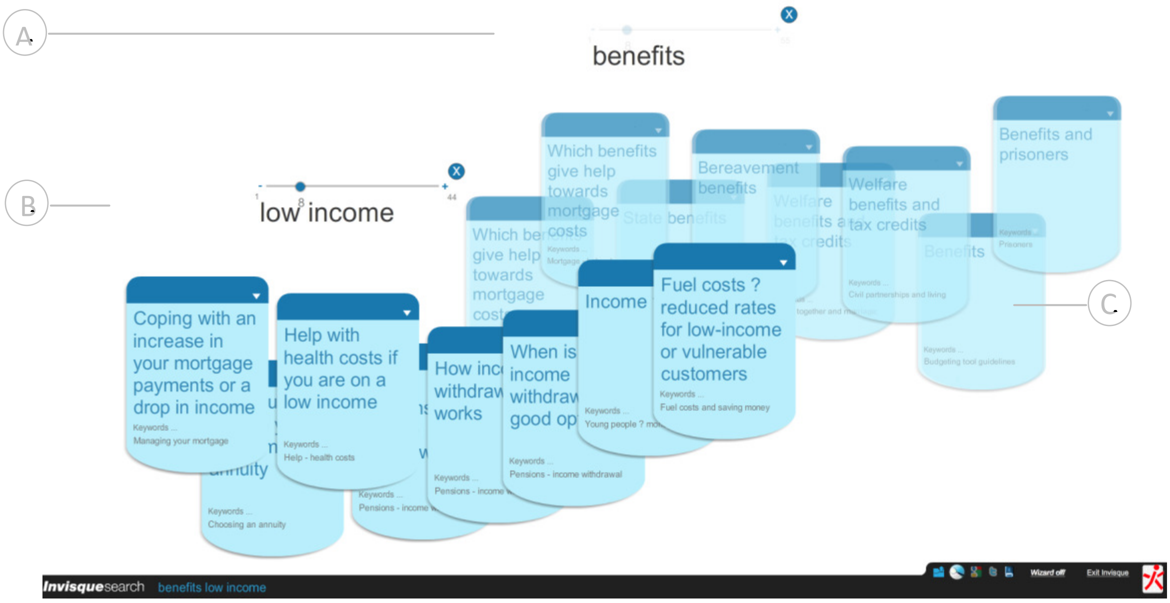

Figure 7-5. Search canvas with two search results.
A) INVISQUE search canvas, B) primary search result cluster displayed in the primary layer, C) secondary search results cluster displayed in the secondary layer

CLICK AN ITEM: Highlight common attributes and relationships

The users can also click on a subject area or on the information titles to see what other information exists in a cluster and exists across the different clusters. Rather than using lines to link the articles related by the same or related subject area or information titles, the system would highlight these index cards, and present these cards in the foreground, using the primary and secondary layers as a filtering and grouping technique by reducing visual clutter that would be created by adding lines. However, Ware (Ware, 2004) argues that connecting lines are considered to be more powerful than Gestalt principles such as proximity, colour, size or shape. Using the figure and ground principle implemented through the primary and secondary layers design, the design brings the required information to one's attention but without directing (e.g. via the connecting lines) how these information should be related. That assessment would be left to the user, if desired, and in this way facilitates users to look at the other relevant information or information with further relationships, rather than forcing a particular set of relationships reinforced by connecting lines. See figure 7-6.

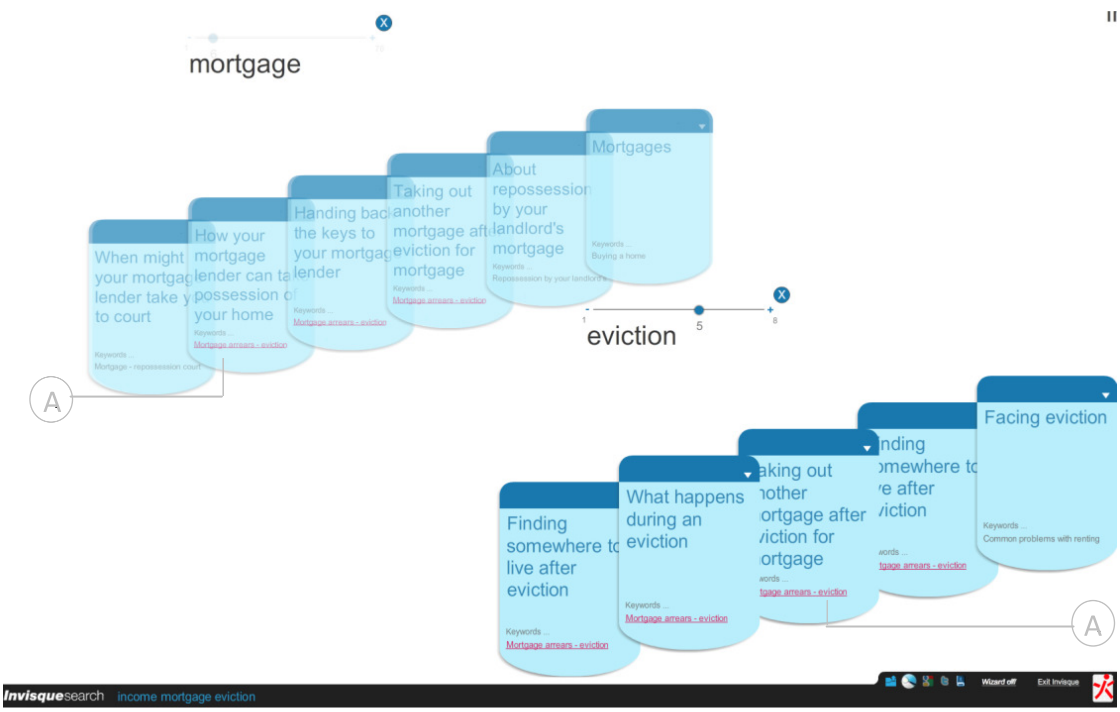

Figure 7-6. Highlighting common attributes and visualising attributes.

A) Common keyword highlighted in both clusters.

<u>MULTIPLE SELECT AND GROUP: ways for interacting with the data</u>

Individual index cards may be selected by simply <clicking> or hovering on them. The selected index card will pop forward into the primary layer, while the remaining cards will recede and fade into the secondary layer. Several cards can be selected by pressing a modifier key (e.g. Ctrl) and <clicking> the cards. These selected cards can then be moved together away from the parent cluster by direct manipulation functions. See Figure 7-7.

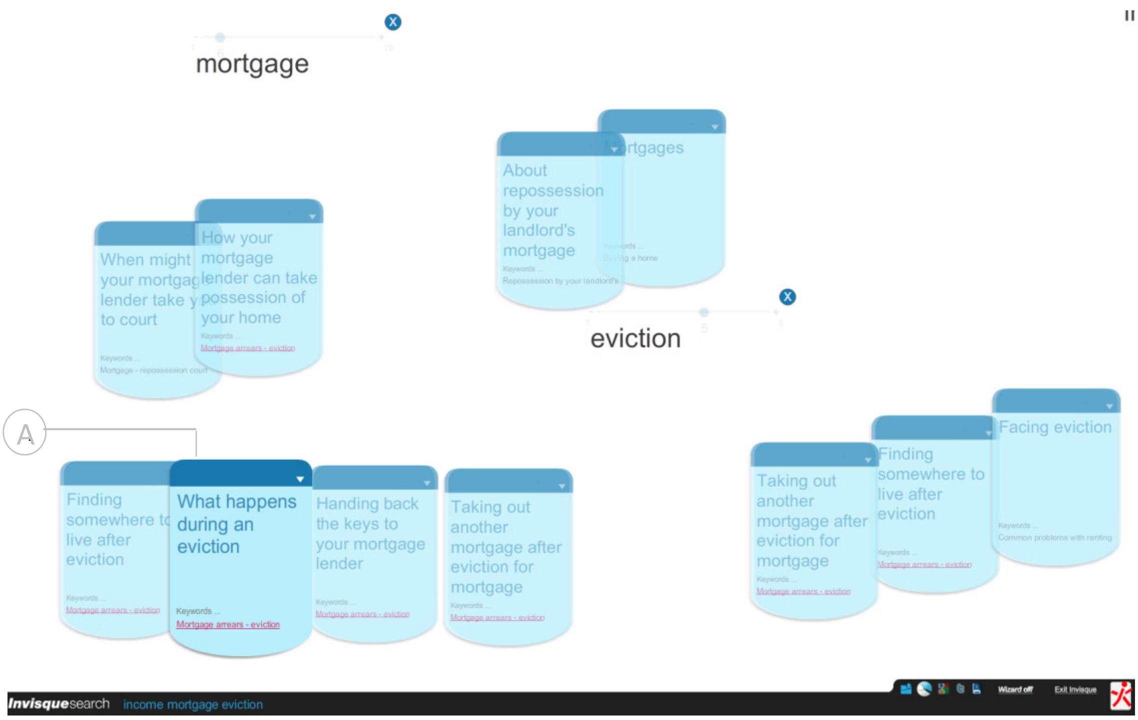

Figure 7-7. Multiple sections and grouping information.

A) Multiple index cards from mortgage and eviction cluster are selected and moved to make a new group.

MORE DIRECT MANIPULATION: Drag and drop on the Wizard

The Wizard in its current form represents two hot spots. Dragging and dropping cards on to a Wizard hot spot (landmarks) activates one of two specified functions: to discard or delete and to save items. By dragging one or a set of cards to the discard (delete) bin icon hot spot, the selected index cards will be deleted from the selection. This allows the user to filter the content by usefulness. Similarly, by dragging and dropping cards on to the save icon, the information on the cards (preferably together with the full-text article) would be saved, and the colour of the card would change to green to indicate that it has been saved. After clicking on any option, the users would still stay on the same screen all the time. See Figure 7-8.

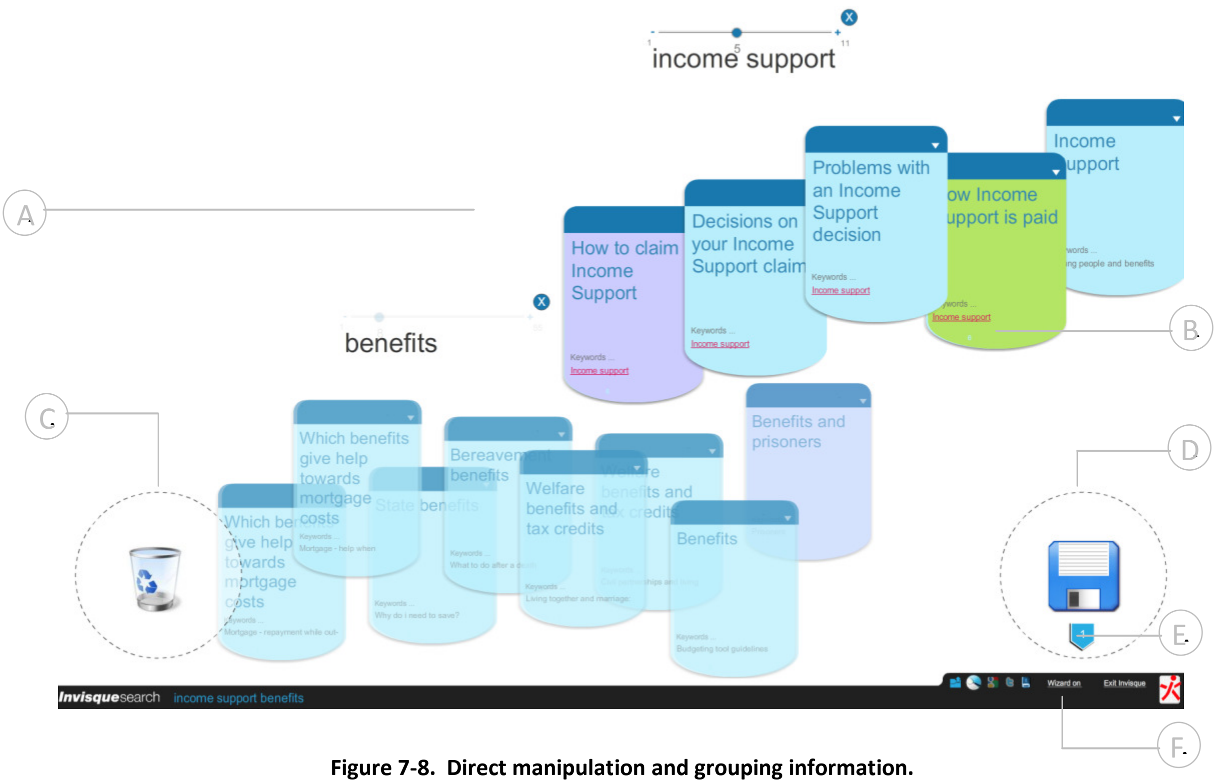

Figure 7-8. Direct manipulation and grouping information.

A) Index cards viewed or drilled down are marked in purple, B) Index cards saved marked in Green, C) to delete an index card it needs to be dragged into the delete area, D) total count of the Index cards saved, E) in order to save an index card it needs to be dragged into this area and F) Wizard icon, which switches on or off the delete and safe areas.

DRILL-DOWN LINKS FOR FULL-TEXT: supporting detail and serendipity

Invisque supports the function of drill down by clicking on the top right hand icon of the index card, and this provides a page containing more information. This is presented over the clusters and the card. This would support the necessary access to detail while still being able to see the context of the overall search, minimizing "*what was I looking for?*" (WILF-ing) and getting lost problems. The viewed index cards colour would change to purple to indicate that the detail information has been viewed. See Figure 7-9.

Figure 7-9. Drill down and viewing documents.

The *Invisque* design now developed shows how information can be visually displayed moving away from the traditional hierarchy and list base system, how they need to be presented, and how their interactions need to be carried out.

DISCUSSION

The previous chapters and literature show the differences that exist between HL and LL users during information seeking. Therefore, UI design that is intended for HL users, is likely to cause problems for LL users, such as lower performance. It is important for UI designers to identify the support mechanisms needed in order to incorporate LL users' search behaviours. This chapter proposes using Invisque as a framework to support identified behaviour challenges. Invisque is a novel, non-traditional proof of concept proposed for electronic library resource discovery system to be used as a possible framework to support identified behaviour challenges. While the focus has leaned towards bridging the gap between HL and LL users, it is hoped that the design will additionally support both literacy groups for performing search and query tasks. Evaluating *Invisque* with the current *Adviceguide* website will provide an additional understanding towards if and how LL users are able to adapt novel interactive interfaces to carry out searches. This evaluation is discussed in Chapter 8.

This chapter contributes by presenting a series of design recommendations for LL users by drawing on previous literature and lessons learned from investigations of behaviour strategies, models and mental models and packaged in a useful way.

CHAPTER 8

EVALUATING INFORMATION SEEKING PERFORMANCE BETWEEN ADVICEGUIDE AND INVISQUE

This chapter reports an experiment, which compares how *Invisque* and *Adviceguide* may be used for information seeking tasks and is based on the findings discussed in Chapters 4, 5 and 6, where low literacy (LL) users were less successful finding information compared to HL users. The results suggested that this may have occurred because their method of thinking differed to their reading level (Sherwani et al., 2009).

Four design recommendations were suggested (Chapter 7) drawing on previous research and based on the identified differences in LL users' reading, verification, recovery and mental model. *Invisque* contained suggested design recommendations and concepts that were relevant, as itemised below:

- First, *Reading strategy* - Information is boxed and presented using index cards on a white space. The index cards are clustered and ordered in both x- and y-axes depending on relevance. A slider allows the users to increase or decrease the number of index cards in view.
- Second, *Verifying* - Each index card can be dragged and placed anywhere on the canvas, allowing users to group relevant index cards that come from different searches, reducing the need for memorisation. Using the wizard to save index cards results in a change of colour to green, providing an obvious visual cue and allowing users to return to information they think is relevant. The ability to carry out multiple searches helps with verifying information on index cards as users are able to move between multiple search clusters. The multiple searches use transparencies to visually distinguish between current and previous searches.

- Third, *Recovery* - Using the wizard to delete index cards reduces clutter, helping reduce cognitive load, supporting recovery, and simplifying the verification of information and assist recovery. Participants are able to zoom to either draw focus on an area of interest, or give an overall view of the complete search space, preventing LL users becoming overwhelmed and disoriented within the system. The system also allows them to start a fresh by clearing the existing searches.
- Fourth, M*ental models* - Rather than a hierarchical menu, a search box is used in *Invisque*.

As a result, Invisque was a proof of concept mock-up containing concepts relevant to LL users. It was subsequently developed into a working prototype and evaluated with the *Adviceguide*. The aim of the experiment was to investigate whether using *Invisque* improved the performance of LL users to the same level of performance as HL users. The performance variables were: search outcome (which had three levels successful, unsuccessful or abandon); time on task; number of pages visited; unique number of pages; and number of pages revisited. In addition, users' feedback on the two interfaces was captured using questionnaires. An additional observational analysis explored how the design features may or may not have supported LL users .

Based on past literature, and as suggested earlier, LL users exhibit different characteristics and are less successful finding information compared to high literacy (HL) users due to the differences in strategies (Chapter 4), behaviour models (Chapter 5) and mental models (Chapter 6). As a consequence, a number of design principles for designing user interfaces for LL users are suggested and the following two hypotheses were identified:

1. Both HL and LL users' successful search outcomes would be higher with *Invisque* than with a traditional website.
2. The time on task and number of pages visited for both HL and LL users would be lower with *Invisque* than with a traditional website.

METHODS

Participants

An advertisement was placed in a local Citizens Advice Bureau (CAB) and staff were informed in the aim of attracting clients to participate in the study. Participants had to be 18 years old and above and have computer and internet literacy (weekly computer and internet usage between four – ten hours), but have no prior experience using the *Adviceguide* website beforehand. From the participants who participated for this study a total of 7 participants were immigrants who had settled in the UK over ten years. Three out of the seven volunteers were LL and the remaining four were HL. The participant selection criteria were same as discussed in Chapter 4. Ethics approval for the study was obtained from the School of Engineering and Information Sciences Ethics Committee at Middlesex University.

In total, 24 participants took part in the study. Twelve were HL while the remaining 12 were LL. Twelve were males and twelve females, with a mean age of 39 years (ranging from 35 to 50). The LL users who participated 7 were unemployed (over 6 months) and the remaining 5 were working at the time of the study (2 cleaners, 1 restaurant serving staff, 1 security officers, 1 builder). Two of the HL users had been made redundant in the past 2 months and remaining 10 were working at the time of the study (2 Admin staff, 2 sales reps, 1 counter workers, 1 receptionists, 1 office manager, 1 accountant and 1 nurse).

Ten of the LL users have left formal education prior to completing secondary school, and while the remaining two LL users have left prior to completing high school. Two of the HL users had left formal education prior to completing high school, while four had left prior to completing collage and finally the remaining six had degrees.

Participants' literacy was evaluated on completion of the study using UK National Skills for Life Literacy Survey[9] as used in Chapter 4. The HL participants for this study scored an average of 33 out of 40 (ranging from 30 to 38) while the LL participants scored an average of 13 out of 40 (ranging from 7 to 16).

Materials

For the purpose of this study a social service website in the United Kingdom was selected (*Adviceguide* - http://www.adviceguide.org.uk). The content of the site is relevant to the needs of both the HL and LL participants.

The data from the *Adviceguide* was imported to the *Invisque* interface. There were no changes made to the content or to the menu links, so both interfaces could be used to access the same data and, therefore, allow comparisons to be made between the two.

Experimental Procedure

Six information search tasks were developed based on advice types frequently requested by walk-in clients of the local CAB (between April 2005 and May 2007). For example, *I am currently on Income Support, what other benefits am I entitled to?* The search tasks were of varying task difficulties (easy, medium and difficult). One aspect of the task difficulty was influenced by web navigation of the *Adviceguide* website, which starts from general over view and then require users to drill down to reach more specific topics (e.g. from the home page to main sections and then, finally to subsections). Another aspect was if the webpage content focused on one or multiple concepts or topics. Finally, the third aspect was the reading levels of the text.

Participants were restricted on using external websites or other search facilities; however, there were no restrictions within the *Adviceguide* site such as using the search or the hierarchical navigation structure.

The study was conducted at the Usability Lab. Each participant performed six tasks in total, three with *Invisque* and three with *Adviceguide*. For each interface, participants performed one easy, one medium and one difficult task. Latin-squares were used to counter balance the order of interface and tasks.

[9] *Please refer to Appendix E for UK National Skills for Life Literacy Survey*

Participants were given time to familiarize prior to using the interface. The study involved only one participant at a time. In the case of *Invisque* a 2 minute video was shown, followed by time to familiarize (approximately 10 minutes). There were no set pre-tasks. Participants were allowed to ask the facilitator any questions or queries they had with regard to using the system. Participants were given one task at a time. Each search task started from the home page of the interface. In the case of *Adviceguide*, cache was reset for each task to minimize any confounding variable efforts such as cached page visits.

The wizard of Oz originally known as Oz Paradigm is used in laboratory settings to simulate the behaviour of an intelligent computer application (Kelley, 1983). Here the researcher simulated the voice communication between the participant and interface (see Figure 8-1). Searching difficulties due to spelling was overcome by using a Wizard of Oz voice technique for the purpose of this study (Buxton, Baecker, & Sellen, 2006; Gould, Conti, & Hovanyecz, 1983; Indrani Medhi et al., 2009).

The participants declared when they had either found the answer or abandon the search. If they had found an answer, they were asked to write it down on the answer sheet provided.

Participants were informed of the study procedure and gave consent for video and audio recording. Multiple Cognitive Task Analysis (CTA) methods were used to extract the participants' decision process during their tasks. Methods such as (1) think-aloud (video capture), (2) semi-structured interviews (video playback and field notes taken), (3) questionnaires focusing on the interfaces were used as data collection methods, and (4) researchers user observation (video capture and field notes taken). Participants interaction with the interface was screen recorded and level of literacy was evaluated once all tasks and interviews were completed (Williams et al., 2003).

Figure 8- 1.The study setup in the usability lab.
Participants gave permission to be recorded and photographed.

The figure above shows a participant navigating though the *Invisque* interface, while the researcher is seated at the far right enabling the wizard of Oz voice functionality for the search. Screen capture software was used to record participants' interaction with the *Adviceguide* or *Invisque* interface; further to this, a video recording was used as a backup. An audio recorder was used to record the participants think aloud and semi-structured interview data.

Data Collection

The semi-structured interviews, think-aloud, recorded video data and researcher's observations were used to determine whether participants used the design principles included in *Invisque*.

There were three search outcomes defined: (a) successful search outcome – when the participants find the relevant information, (b) unsuccessful search outcome – when participants completed the task but found the incorrect information, (c) abandon search outcome – this is when participants stopped the search because either they were unable to find any relevant information or they assumed that the information was not available.

The screen records and system log files were used to measure the time spent on the task, the number of pages visited, the unique pages visited and pages that were revisited. (a) time on task refers to the duration of the task from the moment a participant starts the task until he/she decides to stop the search (either due to finding the answer or abandon the search), (b) number of pages visited refers to the total number of pages a user views during the information task, (c) number of unique pages visited refers to the number of pages a user visits at least once during the search, and (d) number of pages revisited – is the number of pages a user visits more than once during the search.

Participants were asked to complete a questionnaire per interface. The questions rated on a seven-point Likert scale, ranging from strongly disagree to strongly agree. The questions used were compiled from previous surveys specifically designed to evaluate system usability scale (Brooke, 1996), user interface satisfaction (Chin, Diehl, & Norman, 1988), perceived usefulness and ease of use (Davis, 1989) and computer usability satisfaction (Lewis, 1995). The post-test questionnaire used for this study had ten statements. The questionnaire captured interfaces learnability, user effort, usefulness, flexibility, manuals, works the way the participants expected, similar to what users normally use, frequent usage, and finally satisfaction of the interface. In addition to the ten closed questions, two open-ended questions captured users overall impression of the interface and users' perceptions on the three tasks carried out.

Data Analysis

The researcher obtained different types of data from this study. There is non-parametric data from the search outcomes. Performance was measured based on time spent on each task (in seconds) and total number of pages visited. Further analysis of the pages visited done for number of revisited and unique page visits. The questionnaires provided likert-scale data. Finally, the semi-structured interviews, think-aloud, recorded video data and researcher's observations provided qualitative data.

When searching for information, a participant could have been successful, unsuccessful or could have abandoned the search. By comparing the search outcomes by interface, the researcher could identify whether LL users made progress. These search outcomes were analysed using the Friedman's test [10].

The less time spent on a task and the fewer pages visited, the better the participants' performance. Time spent on a task included successful, unsuccessful and abandoned searches. However, previous studies had confirmed that LL users spent eight times longer than a high literate user regardless of the search outcome and visited 13 times more pages (N Kodagoda & Wong, 2008). By using a repeated measures ANOVA analysis, the researcher aimed to identify whether the interface, level of literacy and task difficulty level influenced performance. A 2 interface type (*Adviceguide*, *Invisque*) x 3 difficulty level (E-easy, M-medium, D-difficult) x 2 literacy level (HL, LL) Repeated measures ANOVA between subjects was conducted.

Repeated measures ANOVA is a term used when the participants take part in all conditions of an experiment (Field, 2005). In the current study, all participants were exposed to the *Adviceguide* and *Invisque*. Test based on parametric data assumes that data points are independent (Field, 2005). However, this is not the case in a repeated

[10] *It is used to detect differences in treatments across multiple test attempts. The procedure involves ranking each row (or block) together, then considering the values of ranks by columns similar to Repeated Measure ANOVA.*

measures study because the data for different conditions comes from the same participants. Therefore, the data from different experimental conditions is related. The test assumes that the relationship between pairs of experimental conditions is similar and this assumption is known as sphericity. When the effect of sphericity is violated, there is an increase of probability of a Type II error (loss of power) and the F-ratio that simply cannot be compared to tabulated values of the F-distribution (Field, 2005).

If the sphericity is violated, several corrections can be applied to produce a valid F-ratio. These corrections involves adjusting the degree of freedom which is associated with the F-value by using Greenhouse and Geisser's, Huynh and Feldt's and the lower bound estimates (Field, 2005; Girden, 1992). If the $\varepsilon > 0.75$ then the Huynh-Feldt correction should be used and when $\varepsilon < 0.75$, or nothing is known about sphericity, then the Greenhouse-Geisser correction should be used (Field, 2005).

Independent sample t-tests were used as post-hoc test to help compare difference in mean values between two groups of continuous variables. There is no proper facility for producing post-hoc test for repeated measures ANOVA in SPSS, however, a paired t-test procedure could be used to compare all pairs of levels of the independent variables and then apply a Bonferroni correction (Field, 2005). Bonferroni correction is used as the criterion for statistical significance (Field, 2005). In other words, Bonferroni adjustment is made by dividing the p value to be achieved for significance by the number of paired comparisons to be made (Field, 2005).

The questionnaire data was analysed using Wilcoxon signed-rank test. The Wilcoxon signed-rank test (Wilcoxon, 1945) is a repeated-measure and matched-subject design analysis. The goal of repeated measures design is to determine whether participants changed significantly across conditions. This is a non-parametric version of the two independent samples t-test, and does not depend on the form of the parent distribution or on its parameters. This test is used as an alternative to the t-test whenever the population cannot be normally distributed. The efficiency of this when compared with the t-test has a 95% confidence. The test reports the mean positive ranked difference score and the mean negative ranked difference score.

The data obtained from semi-structured interviews, think-aloud, recorded video data and researcher's observations were revisited to investigate how well the new design principles were received by HL and LL users. The video data were compiled in to qualitative data analysis software (Nvivo). The videos were viewed through the software and participants using the new design principles at least once during a task were noted. Few quotes were extracted from the think-aloud and interview data to demonstrate and justify the conclusions made. In order to validate the results a small sample (four out of the 24 participants) of data was analysed by two independent researchers. Their analysis was 95% similar to the analysis already in place.

RESULTS

The results will be discussed in three sections. The first is the results from the analysis of the quantitative data analysis including search outcomes and performance measurements. The second section encompasses the subjective feedback from the questionnaires. Finally, a qualitative analysis was conducted to determine how the features of *Invisque* supported the need of LL users.

Results from the Analysis of the Experiment

Search outcomes

Task success identified using the written answer sheet and captured video data for each task. A Friedman test was carried out using interface (*Adviceguide*, *Invisque*) and task difficulty (E-easy, M-medium, D-difficult) as within subject factors and literacy (HL, LL) as a between subject factor.

SUCCESSFUL SEARCH OUTCOME

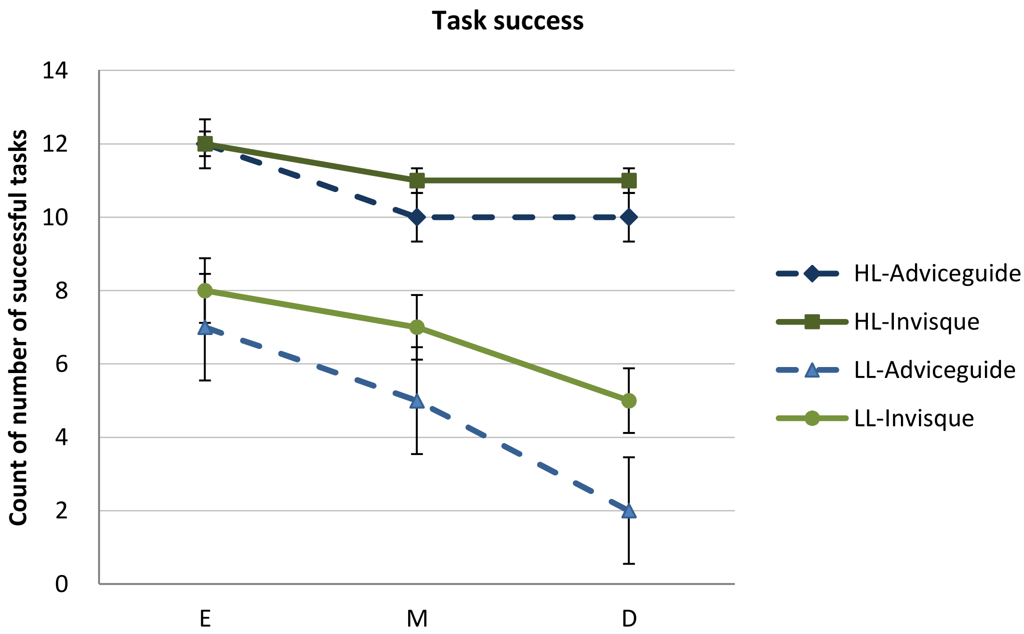

Figure 8-2.HL and LL users' successful task on Adviceguide and Invisque.
HL – high literacy, LL – low literacy, E- easy task, M – medium difficult task, D – Difficult task, (error bars show the standard error of the mean)

The Friedman test found there to be no significant effects on task success for HL users $\chi^2(5, N = 12) = 4.00$, $p = 0.55$. The test also found there to be no significant effect on success for LL users $\chi^2(5, N = 12) = 7.00$, $p = 0.22$.

Although the effects were not significant, Figure 8-2 suggests that LL users became increasingly less successful as the task difficulty increased, however, this increase was more predominant with the *Adviceguide* interface.

UNSUCCESSFUL SEARCH OUTCOME

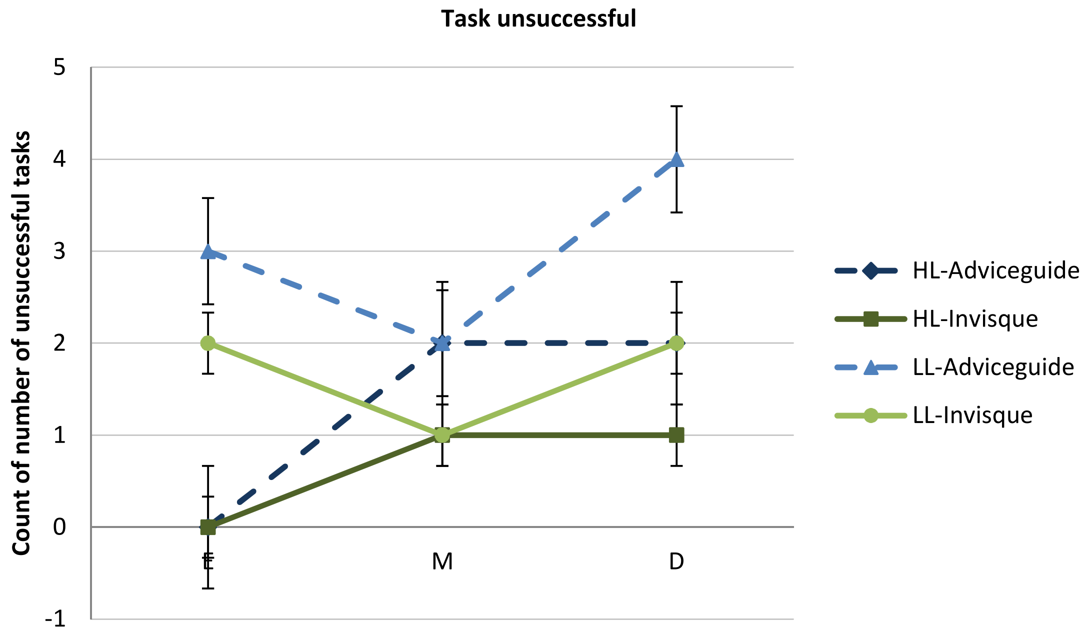

Figure 8-3.HL and LL users' unsuccessful tasks on Adviceguide and Invisque.
HL – high literacy, LL – low literacy, E- easy task, M – medium difficult task, D – Difficult task, (error bars show the standard error of the mean)

Further data analysis The Friedman test found there to be no significant effects on task un-success for HL users $\chi 2(5, N = 12) = 4.00$, $p = 0.55$. The test also found there to be no significant effect on success for LL users $\chi 2(5, N = 12) = 3.07$, $p = 0.69$.

Although the effects were not significant, Figure 8-3 suggests that HL users became increasingly unsuccessful as the task difficulty moved from easy to medium difficult, and remained similar through medium to difficult task, however, this increase was more predominant with the *Adviceguide* interface. The LL users task un-success decreased in the medium task and increased for the difficult task (the increase and decrease occurred at the same task difficulty level in both interfaces), however, again the increase was more predominant with the *Adviceguide* interface.

ABANDON SEARCH OUTCOME

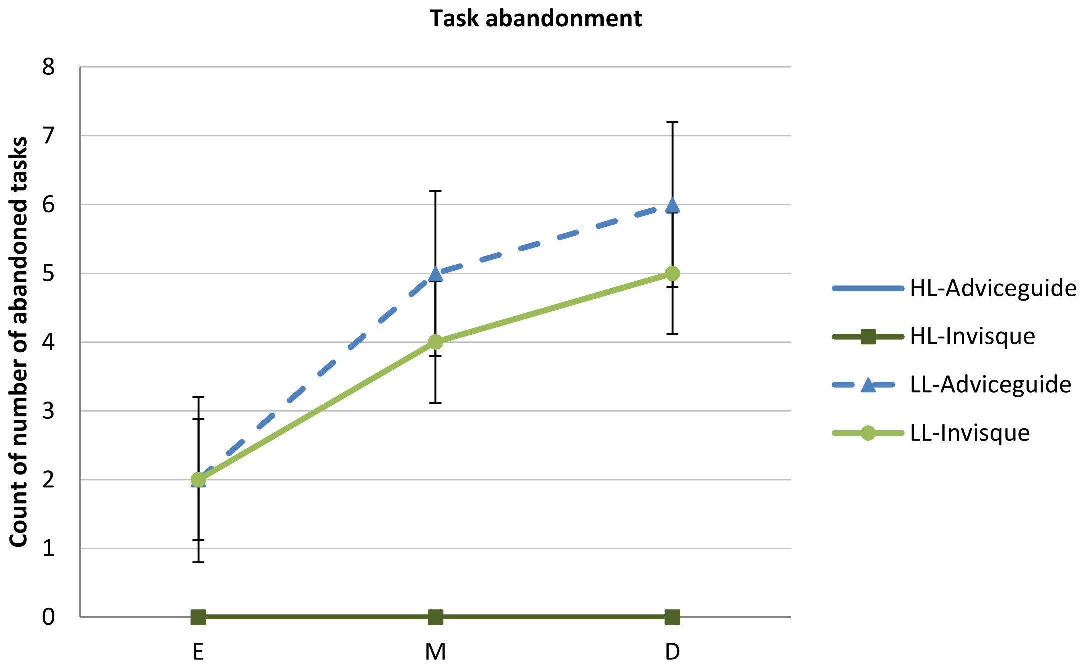

Figure 8-4.HL and LL users' task abandonments on Adviceguide and Invisque.
HL – high literacy, LL – low literacy, E- easy task, M – medium difficult task, D – Difficult task, (error bars show the standard error of the mean)

The Friedman test found there to be no significant effects on task success for HL users $\chi 2(5, N = 12) = 0$, $p < 0.00$. The test also found there to be no significant effect on success for LL users $\chi 2(5, N = 12) = 4.88$, $p = 0.43$.

Although the effects were not significant, Figure 8-4 suggests fewer LL users abandon their task when using *Invisque* than *Adviceguide* as task difficulty increases (not sig. p=.43). However, this increase was more predominant with the *Adviceguide* interface. Task abandonment was not evident with the HL users in either interface.

Performance

A 2x3x2 Repeated measures ANOVA was conducted, it included two types of interface (*Adviceguide* and *Invisque*), three task difficulty levels (E-easy, M-medium, D-difficult) and two levels of literacy (HL, LL).

<u>TIME ON TASK</u>

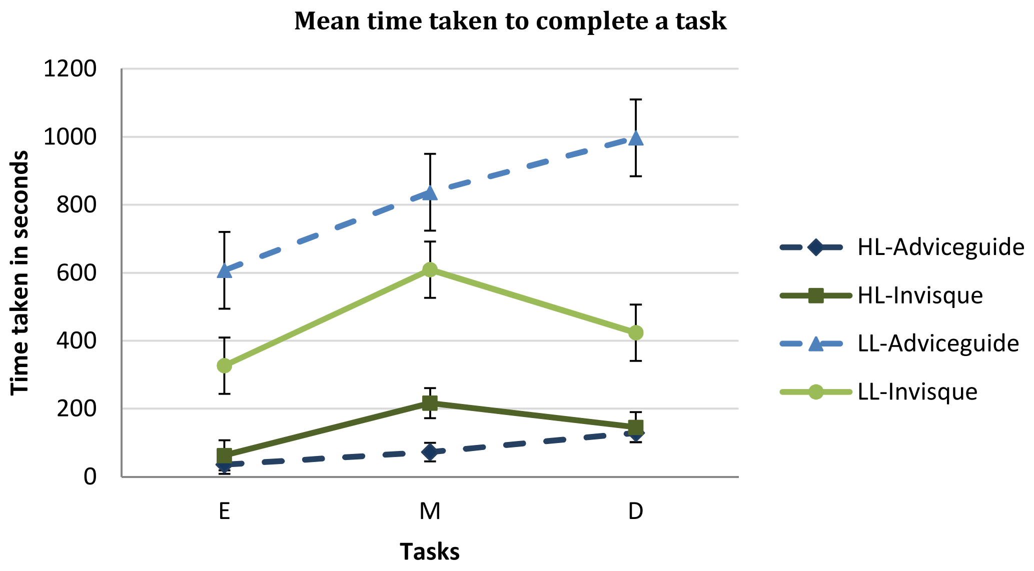

Figure 8-5.HL and LL users' time on task for Adviceguide and Invisque.
HL – high literacy, LL – low literacy, E- easy task, M – medium difficult task, D – Difficult task, (error bars show the standard error of the mean)

Specifically, the results suggest that LL users with Invisque took significantly less time to complete their tasks compared to using Adviceguide ($p<.05$). Under difficult conditions, LL Invisque users took 2.5 times less time than LL Adviceguide users – bringing them closer to HL user task completion performance. Both user groups performed the difficult task more quickly than the medium task with the *Invisque* interface (LL users spent one third of the time on Invisque over the Adviceguide, see Figure 8-5). However, the HL users were slower with the *Invisque* interface. With the Invisque interface, on average LL users took three times longer than HL users.

All significant effects are reported ($p < .05$). There was a significant main effect on total time on task for task, $F(2, 44) = 13.27$. Contrasts revealed a significant effect on total time on easy tasks were much less than the difficult tasks, $F(1, 22) = 22.93$, r =

0.71, and there was no significant contracts on between total time on medium and difficult task, $F(1, 22) = 0.07$, $r = 0.06$. There was a significant main effect on interface, $F(1, 22) = 26.20$. The contrasts revealed significant effect for total time on *Adviceguide* were much higher than the *Invisque*, $F(1, 22) = 26.20$, $r = 0.74$. There was a significant effect on literacy indicating that total time on task for HL and LL users differed, $F(1, 22) = 258.74$, $r = 0.96$.

There was a significant interaction effect between interface and literacy, $F(2, 22) = 52.89$. This indicates that total time taken during different interfaces differed for HL and LL users. To break down this interaction, contrasts were performed comparing *Adviceguide* to *Invisque* across high and low levels of literacy. The contrast revealed - significant interactions when comparing *Adviceguide* and *Invisque* interfaces to HL and LL users, $F(1, 22) = 52.89$, $r = 0.84$. Post hoc t-test were carried out taking account the Bonferroni correction 0.05/2 $\alpha=0.025$. The tests revealed that scores were significantly less for HL users on *Adviceguide* (M=79.17, SD=41.37) than in the *Invisque* (M=141.18, SD=106.91) condition; $t=-3.28(70)$, $p<0.01$. The test revealed that scores were significantly higher for LL users on *Adviceguide* (M=813.67, SD=260.20) than in the *Invisque* (M=453.28, SD=324.12) condition; $t=5.20(70)$, $p<0.01$). The LL users were quicker with the *Invisque* interface, but the HL users were in fact slightly slower (see Figure 8-5).

There was a significant interaction effect between tasks and interface, $F(2, 22) = 4.11$. This indicates that total time taken during different tasks differed for different interfaces. To break down this interaction, contrasts were performed comparing easy, medium and difficult tasks across *Adviceguide* and *Invisque* interfaces. The first contrast revealed a non-significant interactions when comparing easy and difficult tasks to *Adviceguide* and *Invisque*, $F(1, 22) = 3.44$, $r = 0.37$. There was a significant interaction when comparing medium and difficult task to *Adviceguide* and *Invisque*, $F(1, 22) = 7.00$, $r = 0.49$. Post hoc t-test were carried out taking into account the Bonferroni correction 0.05/3 $\alpha=0.016$. The test revealed that scores were significantly higher for *Adviceguide* (M=563.04, SD=452.20) than the *Invisque* (M=284.75, SD=309.20) condition; $t=2.49(46)$, $p<0.05$. The test revealed that scores were significantly higher for *Adviceguide* (M=321.67, SD=295.65) than the *Invisque*

(M=194.96, SD=169.42) condition; t=1.822(46), p=0.07. The test revealed that scores were non-significant for medium difficult task on *Adviceguide* (M=454.54, SD=453.26) and *Invisque* (M=454.54, SD=453.26) condition; t=0.367(46), p=0.72. The results suggest that both sets of users performed the difficult task quicker than the medium task with the *Invisque* interface (see Figure 7-5).

The interaction between literacy and task was not significant, F(2, 44)=2.84, and the interaction between literacy, task and interface yielded a non-significant F ratio, F(2, 44)=1.57.

NUMBER OF PAGES VISITED

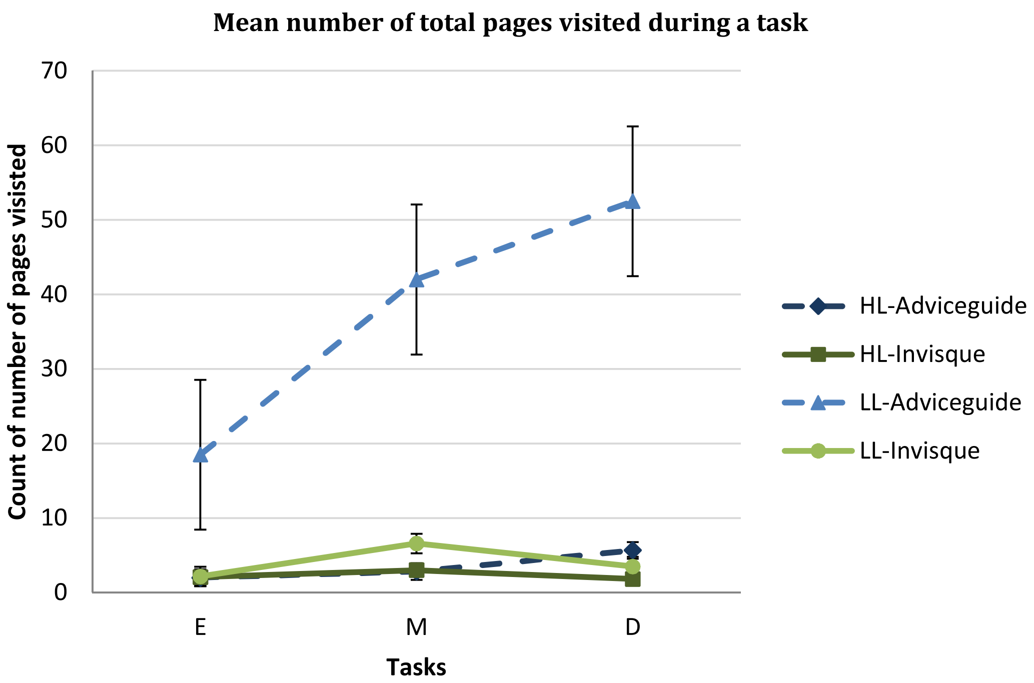

Figure 8-6.HL and LL users' total number of pages visited during a task on Adviceguide and Invisque.
HL – high literacy, LL – low literacy, E- easy task, M – medium difficult task, D – Difficult task,
(error bars show the standard error of the mean)

Specifically, the results suggested that LL users visited as few pages as HL users when using Invisque (sig. p=.04). Under difficult task conditions, LL users with *Invisque*Invisque visited about 10 times less pages than when using Adviceguide (see Figure 8-6). The HL users viewed significantly fewer pages on the *Invisque* but only for the difficult tasks. With the *Invisque* interface, on average LL users visited 1.8 times more pages than HL users.

The same method was used to analyse the total number of pages visited. Mauchly's test indicated that the assumption of sphericity had been violated for the interaction task and interface, $\chi^2(0) = 12.39$, p<.00. Therefore degrees of freedom were corrected using Greenhouse-Geisser and Huynh-Feldt respectively for estimates of sphericity (ε=0.76 for the interaction task and interface). All effect reported as significant at p < .05.

There was a significant main effect on total number of pages visited for task, F(2, 44) = 82.88. The contrasts revealed a significant effect on easy tasks were much less than the difficult tasks, F(1, 22) = 216.95, r = 0.95, and medium task were much less than the difficult tasks, F(1, 22) = 9.57, r = 0.55. There was a significant main effect for interface, F(1, 22) = 1672.41. The contrasts revealed a significant effect for *Adviceguide* were much higher than the *Invisque*, F(1, 22) = 1672.41, r = 0.99. There was a significant effect on literacy indicating that total number of pages visited for HL and LL differed, F(1, 22) = 582.03, r = 0.98.

There was a significant interaction effect between task and literacy, F(2, 44) = 58.41. This indicates that different tasks differed for HL and LL users. To break down this interaction, contrasts were performed comparing each level of task across levels of literacy. These revealed a significant interactions when comparing easy and difficult task to HL and LL users, F(1, 22) = 147.18, r = 0.93. There was a none significant interactions when comparing medium and difficult task to HL and LL users, F(1, 22) = 3.84.

There was a significant interaction effect between interface and literacy, F(2, 22) = 1450.55. This indicates that different interface differed for HL and LL users. To break down this interaction, contrasts were performed comparing each level of interface across levels of literacy. These revealed a significant interactions when comparing *Adviceguide* and *Invisque* to HL and LL users, F(1, 22) = 1450.55, r = 0.99.

There was a significant interaction effect between tasks and interface, F(2, 44) = 99.14. This indicates different tasks differed for different interfaces. To break down this interaction, contrasts were performed comparing each level of task across the two interfaces. These revealed a significant interactions when comparing easy and difficult tasks to *Adviceguide* and *Invisque*, F(1, 22) = 49.91, r = 0.83, and when comparing medium and difficult task to *Adviceguide* and *Invisque*, F(1, 22) = 28.56, r = 0.75.

There was a significant interaction effect between tasks, interface and literacy, F(2, 44) = 63.46. This indicates different tasks differed for different interfaces and for different literacy levels. To break down this interaction, contrasts were performed comparing each level of task across two interfaces and the two different literacy levels. The first contrast revealed a significant difference between HL and LL comparing easy task to difficult task when using *Adviceguide* and *Invisque*, F(1, 22) = 271.69, r = 0.96. The second contrast revealed a significant difference between HL and LL comparing medium task to difficult task when using *Adviceguide* and *Invisque*, F(1, 22) = 8.48, r = 0.52. Post hoc t-test were carried out considering Bonferroni correction 0.05/6 α=0.008. The tests revealed significant difference in the total number of pages visited during the difficult task for HL users on the *Adviceguide* (M=5.67, SD=1.43) higher than in the *Invisque* (M=1.83, SD=1.33) condition; t=6.769, (22) p < 0.01. A significant different was identified for easy task for LL users on the *Adviceguide* (M=18.50, SD=1.00) was higher than in the *Invisque* (M=2.17, SD=1.17) condition; t=39.416, (22) p < 0.01. Significant difference were identified for medium difficult task for LL users on the *Adviceguide* (M=42.00, SD=8.02) was higher than in the *Invisque* (M=6.58, SD=6.07) condition; t=12.20, (11) p < 0.01. Significant difference were identified for the difficult task for LL users on the *Adviceguide* (M=52.50, SD=5.52) was higher than then *Invisque* (M=3.50, SD=3.18) condition; t=26.657, (22) p < 0.01. There was no significant difference for easy task for HL users on the *Adviceguide* (M=2.00, SD=0.85) and *Invisque* (M=2.08, SD=1.17) condition; t=-.200, (22) p = 0.84, and medium task for HL users on the *Adviceguide* (M=2.83, SD=0.72) and *Invisque* (M=3.00, SD=1.65) conditions; t=- 0.321, (22) p = 0.75.

NUMBER OF UNIQUE PAGES VISITED

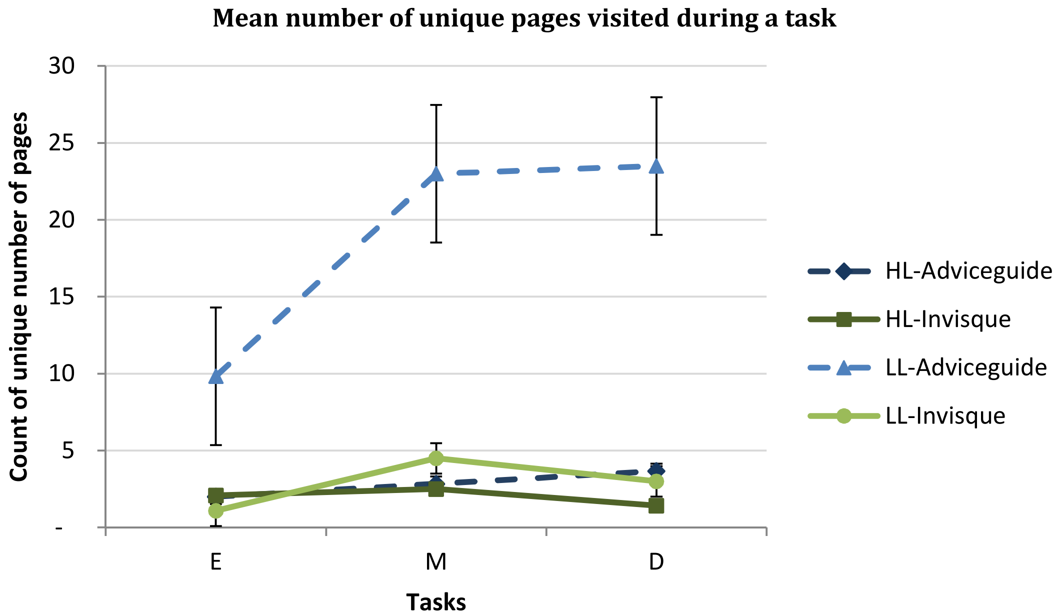

Figure 8-7.HL and LL users' unique number of pages visited during a task on Adviceguide and Invisque.
HL – high literacy, LL – low literacy, E- easy task, M – medium difficult task, D – Difficult task,
(error bars show the standard error of the mean)

Specifically, the results suggested that the *Invisque* interface significantly reduced the number of unique pages visited for LL users, to almost similar levels as the HL group. The HL users also viewed significantly less unique pages on *Adviceguide* compared to *Invisque* for both the easy and difficult tasks.However, the LL users viewed significantly fewer number of unique pages on *Invisque* for easy, medium and difficult tasks (LL users unique number of page visits eight times lower in *Invisque* over *Adviceguide*, see Figure 8-7). With the Invisque interface, on average LL users visited twice number of unique pages than HL users.

The same method was used to analyse the total number of unique page visits. Mauchly's test indicated that the assumption of sphericity had been violated for the main effects of task, $\chi^2(2) = 0.00$, p<.05, and interaction of task and interface, $\chi^2(2) = 0.01$, p<.05. Therefore degrees of freedom were corrected using Greenhouse-Geisser for estimates of sphericity (ε= 0.72 for the main effect of task, and ε= 0.74 for the main effect of task and interface). All effect are reported as significant at p < .05.

There was a significant main effect on total number of unique pages visited for task, F(1.43, 31.50) = 24.00. The first contrasts revealed a significant effect on easy tasks were much less than the difficult tasks, $F(1, 22) = 66.37$, $r = 0.86$. The second contrasts revealed a non-significant effect on medium task were much less than the difficult tasks, $F(1, 22) = 0.20$, $r = 0.09$. There was a significant main effect for interface, $F(1, 22) = 420.18$. The contrasts revealed a significant effect for Adviceguide were much higher than the Invisque, $F(1, 22) = 420.18$, $r = 0.97$. There was a significant effect on literacy indicating that the number of unique pages visited for HL and LL differed, $F(1, 22) = 156.79$, $r = 0.94$.

There was a significant interaction effect between task and literacy, $F(2, 44) = 18.10$. This indicates that different tasks differed for HL and LL users. To break down this interaction, contrasts were performed comparing each level of task across levels of literacy. The first contrast revealed a significant interactions when comparing easy and difficult task to HL and LL users, $F(1, 22) = 51.33$, $r = 0.84$. The second contrast revealed a non-significant interactions when comparing medium and difficult task to HL and LL users, $F(1, 22) = 0.07$, $r = 0.06$.

There was a significant interaction effect between interface and literacy, $F(2, 22) = 340.18$. This indicates that different interfaces differed for HL and LL users. To break down this interaction, contrasts were performed comparing each level of interface across levels of literacy. The contrast revealed a significant interactions when comparing *Adviceguide* and *Invisque* to HL and LL users, $F(1, 22) = 340.72$, $r = 0.97$.

There was a significant interaction effect between tasks and interface, $F(1.49, 32.67) = 17.89$. This indicates different tasks differed for different interfaces. To break down this interaction, contrasts were performed comparing each level of task across the two interfaces. The first contrast revealed a significant interactions when comparing easy and difficult tasks to *Adviceguide* and *Invisque*, $F(1, 22) = 72.14$, $r = 0.88$. The second contrast revealed a non-significant interactions when comparing medium and difficult task to *Adviceguide* and *Invisque*, $F(1, 22) = 1.75$, $r = 0.27$.

There was a significant interaction effect between tasks, interface and literacy, $F(2, 44) = 9.92$. This indicates different tasks differed for different interfaces and for different literacy levels. To break down this interaction, contrasts were performed comparing each level of task across two interfaces and the two different literacy levels. The first contrast revealed a significant difference between HL and LL comparing easy task to difficult task when using *Adviceguide* and *Invisque*, $F(1, 22) = 32.25$, $r = 0.77$. The second contrast revealed a non-significant difference between HL and LL comparing medium task to difficult task when using *Adviceguide* and *Invisque*, $F(1, 22) = 0.00$, $r = 0.00$. Post hoc t-test were carried out considering Bonferroni correction 0.05/6 $\alpha=0.008$. The tests revealed significant difference for easy task for HL users on *Adviceguide* (M=2.00, SD=0.85) was lower than the *Invisque* (M=2.08, SD=1.16) condition; $t=- 1.483,(22)$ $p = 0.84$. A significant difference were found in difficult task for HL users on the *Adviceguide* (M=5.67, SD=1.435) was lower for the *Invisque* (M=1.83, SD=1.34) condition; $t=6.769,(22)$ $p < 0.01$. A significant difference were found in easy task for LL users on the *Adviceguide* (M=18.50, SD=1.00) was higher than the *Invisque* (M=2.17, SD=1.03) condition; $t=39.416,(22)$ $p < 0.01$. A significant difference were found in medium task for LL users on the *Adviceguide* (M=42.00, SD=8.02) was higher than the *Invisque* (M=6.58, SD=6.06) condition; $t=12.20,(22)$ $p < 0.01$. A significant difference were found in the difficult task for LL users on the *Adviceguide* (M=52.50, SD=5.52) was higher than the *Invisque* (M=3.50, SD=3.18) conditions; $t=26.66,(22)$ $p < 0.01$. There was no significant difference for the medium task for HL users on the *Adviceguide* (M=2.83, SD=0.72) and *Invisque* (M=3.00, SD=1.65) conditions; $t=- 0.321,(22)$ $p = 0.75$.

NUMBER OF PAGES REVISITED

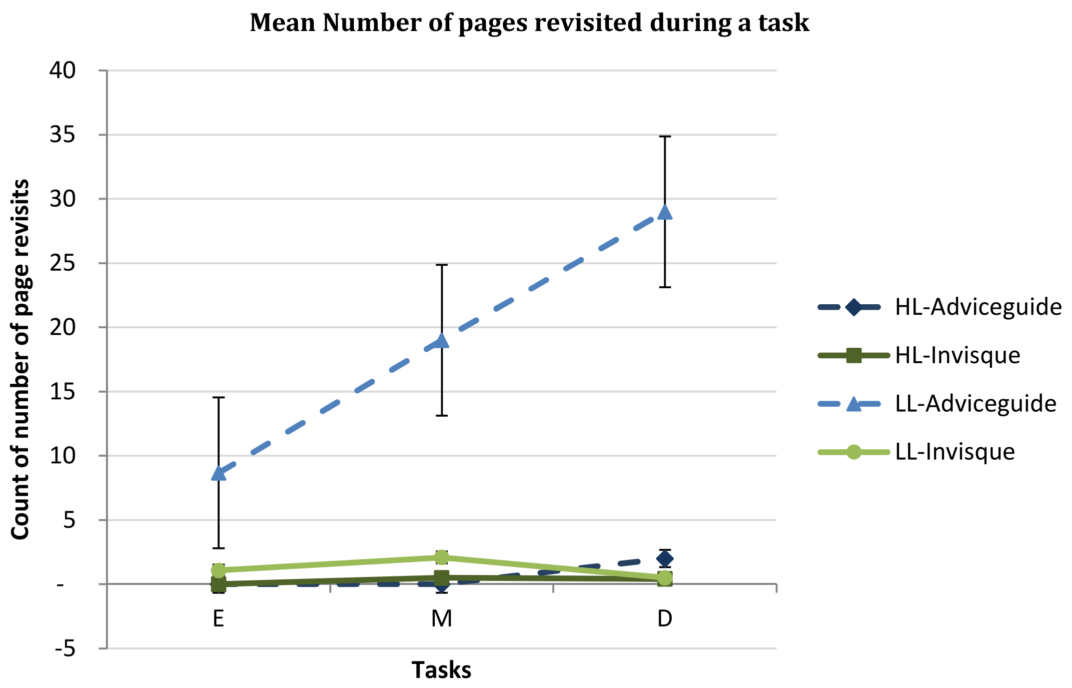

Figure 8-8.HL and LL users' total number of pages revisited during a task on Adviceguide and Invisque.
HL – high literacy, LL – low literacy, E- easy task, M – medium difficult task, D – Difficult task,
(error bars show the standard error of the mean)

Results suggest that LL users who interacted with *Invisque* re-visited fewer pages compared to when they interacted with Adviceguide ($p<.05$). Under difficult conditions, LL *Invisque* users took about 15 times less time than LL Adviceguide – bringing them close to HL user task completion performance (see Figure 8-8). The HL users revisited significantly fewer numbers of pages with the *Invisque* interface for the difficult task. With the Invisque interface, on average LL users revisited four times more pages than HL users.

The same method was used to analyse the total number of pages revisited. All effect are reported as significant at $p < .05$. There was a significant main effect on total number of pages revisited for task, $F(2, 44) = 271.88$. The contrasts revealed a significant effect on easy tasks were much less than the difficult tasks, $F(1, 22) = 434.81$, $r = 0.99$, and medium task were much less than the difficult tasks, $F(1, 22) = 106.91$, $r = 0.91$. There was a significant main effect for interface, $F(1, 22) = 2285.75$. The contrasts revealed a significant effect for *Adviceguide* were much higher than the *Invisque*, $F(1, 22) = 2285.75$, $r = 0.99$. There was a significant effect on literacy indicating that number of pages revisited for HL and LL differed, F(1, 22) = 2056.66, r = 0.99.

There was a significant interaction effect between task and literacy, F(2, 44) = 169.31. This indicates that different tasks differed for HL and LL users. To break down this interaction, contrasts were performed comparing each level of task across levels of literacy. The first contrast revealed a significant interactions when comparing easy and difficult task to HL and LL users, F(1, 22) = 434.81, r = 0.98. The second contrast revealed a significant interactions when comparing medium and difficult task to HL and LL users, F(1, 22) = 42.30, r = 0.81.

There was a significant interaction effect between interface and literacy, F(2, 22) = 2106.28. This indicates that different interfaces differed for HL and LL users. To break down this interaction, contrasts were performed comparing each level of interface across levels of literacy. The contrast revealed a significant interactions when comparing *Adviceguide* and *Invisque* to HL and LL users, F(1, 22) = 2106.26, r = 0.99.

There was a significant interaction effect between tasks and interface, F(2, 44) = 291.35. This indicates different tasks differed for different interfaces. To break down this interaction, contrasts were performed comparing each level of task across the two interfaces. The first contrast revealed a significant interactions when comparing easy and difficult tasks to *Adviceguide* and *Invisque*, F(1, 22) = 643.58, r = 0.98. The second contrast revealed a significant interactions when comparing medium and difficult task to *Adviceguide* and *Invisque*, F(1, 22) = 268.47, r = 0.96.

There was a significant interaction effect between tasks, interface and literacy, F(2, 44) = 211.88. This indicates different tasks differed for different interfaces and for different literacy levels. To break down this interaction, contrasts were performed comparing each level of task across two interfaces and the two different literacy levels. The first contrast revealed a significant difference between HL and LL comparing easy task to difficult task when using *Adviceguide* and *Invisque*, F(1, 22) = 475.17, r = 0.97. The second contrast revealed a significant difference between HL and LL comparing medium task to difficult task when using *Adviceguide* and *Invisque*, F(1, 22) = 129.72, r = 0.92. Post hoc t-test were carried out considering Bonferroni correction 0.05/6 $\alpha=0.008$. The test revealed significant difference for difficult task for HL users on the *Adviceguide* (M=5.67, SD=1.435) higher than the *Invisque* (M=1.83, SD=1.34) condition; t=6.769,(22) $p < 0.01$. A significant difference identified for easy task for LL users on the *Adviceguide* (M=18.50, SD=1.00) was higher than the *Invisque* (M=2.17, SD=1.03) condition; t=39.416,(22) $p < 0.01$. The test revealed significant difference for the medium task for LL users on the *Adviceguide* (M=42.00, SD=8.02) was higher than *Invisque* (M=6.58, SD=6.06) condition; t=12.20,(22) $p < 0.01$. A significant difference was identified for the difficult task for LL users on the *Adviceguide* (M=52.50, SD=5.52) being higher than the *Invisque* (M=3.50, SD=3.18) condition; t=26.66,(22) $p < 0.01$. There was no significant difference for easy task for HL users on the *Adviceguide* (M=2.00, SD=0.85) and *Invisque* (M=2.08, SD=1.16) condition; t=- 2.00,(22) p = 0.84, and for medium difficult task for HL users on the *Adviceguide* (M=2.83, SD=0.72) and *Invisque* (M=3.00, SD=1.65) condition; t=- 0.321,(22) p = 0.75.

Subjective Feedback on Questionnaires

This section reports some of the interesting subjective post-test feedback received from participants. A Wilcoxon signed ranks test were used to compare participants' subjective feedback for the *Adviceguide* and *Invisque* interfaces that was captured by a questionnaire using a seven point Likert scale. All effects are reported as significant at $p < .05$.

Both HL and LL users found *Adviceguide* to be significantly more familiar than *Invisque*, (HL: $p<.01$, LL: $p<.01$), and then confirmed that *Adviceguide* represents a traditional website while *Invisque* represent a type of interface that they have not seen before. HL users felt that both interfaces worked as they wanted them to, whereas there was a significant difference between the way LL users wanted both interfaces to work (HL: $p=.88$, LL: $p<.01$). This confirms that LL users are unhappy with traditional web based interfaces. This is also supported by the fact that LL users would use *Adviceguide* less frequently than *Invisque* (HL: $p=.74$, LL: $p<.01$). For statistics, see Table 8-1.

		1	2	3	4	5	6	7	M	Mrn	z	p
Interface familiarity	HL - A							100%	7.00	6.50	-3.08	<.01
	HL - I	33%	25%	25%	17%				2.25	.00		
	LL - A							100%	7.00	6.50	-3.17	<.01
	LL - I	67%	33%						1.33	.00		
Interface works as I would like it to	HL - A				50%	25%	17%	8%	4.83	6.33	-.14	=.88
	HL - I				42%	33%	25%		5.08	3.40		
	LL - A	17%	50%	8%	25%				2.42	.00	-3.17	<.01
	LL - I			17%			42%	42%	6.25	6.50		
Frequently use	HL - A	8%		8%	83%				3.75	3.00	-.33	=.74
	HL - I			33%	67%				3.67	4.50		
	LL - A	33%	58%	8%					1.75	.00	-3.08	<.01
	LL - I				8%	17%	33%	42%	6.08	6.50		

Table 8- 1.Subjective feedback for HL and LL users' on Adviceguide and Invisque.

HL – high literacy, LL – low literacy, A- Adviceguide, I – Invisque

HL users required significantly less effort to use *Adviceguide* than *Invisque*, however, LL users required significantly more effort using *Adviceguide* (HL: p<.01, LL: p<.01). Similarly, HL users felt *Adviceguide* to be more useful than *Invisque*, while, LL users felt *Adviceguide* to be less useful than *Invisque* (HL: p=.06, LL: p<.01). HL users found both interfaces easy to search, while LL users found it significantly easier to search on *Invisque* (HL: p=.07, LL: p<.01). For statistics, see Table 8-2.

		1	2	3	4	5	6	7	M	Mrn	z	p
Using the interface is effortless	HL - A				8%		50%	42%	6.25	6.82	-2.86	<.01
	HL - I				50%	50%			4.50	3.00		
	LL - A		33%	50%	17%				2.83	0.00	-3.13	<.01
	LL - I				8%	42%	42%	8%	5.50	6.50		
Usefulness	HL - A			33%	42%	25%			3.92	5.25	-2.06	=.06
	HL - I			8%	25%	50%	17%		4.47	5.56		
	LL - A	33%	50%	17%					1.83	0.00	-1.77	<.01
	LL - I				8%		42%	50%	6.33	6.50		
Easy to search	HL - A				50%	50%			4.50	4.00	-1.81	=.07
	HL - I				25%	42%	33%		5.08	5.29		
	LL - A		25%	25%	42%	8%			3.33	4.00	-2.95	<.01
	LL - I			25%			42%	33%	6.08	5.29		

Table 8-2.Subjective feedback for HL and LL users' on Adviceguide and Invisque.

HL – high literacy, LL – low literacy, A- Adviceguide, I – Invisque

Unlike HL users, LL users found *Adviceguide* significantly easier to learn (HL: p=.08, LL: p<.01), although the means were similar. Both HL and LL users felt that *Adviceguide* could be used without instructions more than *Invisque* (HL: p<.05, LL: p<.01), again there was a marginal difference between the means. Both HL and LL users felt that *Invisque* was significantly more flexible than *Adviceguide* (HL: p<.01, LL: p<.01), and that they were significantly more satisfied with *Invisque* than *Adviceguide* (HL: p<.01, LL: p<.01). For statistics, see Table 8-3.

		1	2	3	4	5	6	7	M	Mrn	z	p
Learnability	HL - A							100%	7.00	2.00	-1.73	=.08
	HL - I						25%	75%	6.75	0.00		
	LL - A							100%	7.00	4.50	-2.82	<.01
	LL - I						67%	33%	6.33	0.00		
Without Instructions	HL - A							100%	7.00	3.00	-2.24	<.05
	HL - I						42%	58%	6.58	0.00		
	LL - A							100%	7.00	3.50	-245	<.01
	LL - I						50%	50%	6.50	0.00		
Flexibility	HL - A	33%	42%	25%					1.92	0.00	-3.09	<.01
	HL - I					33%	58%	8%	5.75	6.50		
	LL - A	50%	33%	17%					1.67	0.00	-3.08	<.01
	LL - I				8%	33%	42%	17%	5.67	6.50		
Satisfied with interface	HL - A				83%	17%			4.17	0.00	-3.00	<.01
	HL - I					25%	58%	17%	5.92	6.00		
	LL - A	25%	50%	25%					2.00	0.00	-3.08	<.01
	LL - I					17%	42%	42%	6.25	6.50		

Table 8-3.Subjective feedback for HL and LL users' on Adviceguide and Invisque.

HL – high literacy, LL – low literacy, A- Adviceguide, I – Invisque

Discovering f New Design Principles Were Well Received

This section describes some of the features of *Invisque* that were predominantly used by LL users.

Wizard

The Wizard was used to either to discard index cards or mark them as important. For the delete feature, results showed that HL users used this function less than LL users (see Table 8-4). There was also an increase for the LL users as the task difficulty increased.

During the interviews, none of the HL users mentioned the delete tool. Most of the LL users who used the tool at some point during their search mentioned about it during the interviews. The LL users reacted well to the ability to filter the data by removing unwanted index cards. One of the LL users quoted as saying "… *you want and get rid of the once you don't want …*" when prompted to discuss their actions.

	HL users	LL users
Easy task	0	2
Medium difficult task	1	5
Difficult task	3	6

Table 8-4. HL and LL users who used the deleting support tool.

Similarly, for the save feature, HL users were observed to use this function less than LL users (see Table 8-5, see Figure 8-9). Again, there is an increase in usage for LL users, as the difficulty increased.

When prompted during the interviews, LL users reacted well to the save feature. One participant was quoted saying "… *I think I did another one, and I think the green one is the one I saved as that's what I was looking for and I could not find anything similar in the other* [another search cluster] …", while another one said that "… *because I look for different things in the normal sites and then I read something and then from there click on a link and go to another page and then you get lost and you cannot remember what you were looking for this was really brilliant …*".

	HL USERS	LL USERS
Easy task	0	3
Medium difficult task	3	6
Difficult task	4	7

Table 8-5.HL and LL users who used the save support tool.

Performing multiple searches

A user is classed as performing a multiple search if they have more than one search cluster open at any one time. Again, LL users made better use of this feature, and used it more frequently as the difficulty increased (see Table 8-6, see Figure 8-9).

When they were prompted during the interview, a HL user was quoted saying, "… *add another search in the same website like thing which is not possible with present day systems which was really nice …*", while one LL user said "… *I like the fact I can leave one search and start with another in the same place …*".

	HL USERS	LL USERS
Easy task	0	1
Medium difficult task	0	3
Difficult task	2	5

Table 8-6. HL and LL users who used the multiple search functionality.

Change display number of index cards

At the beginning of each search, users were presented with just eight index cards (see Figure 8-10). Both literacy groups made use of the slider to increase and decrease the number of index cards. This ability to define the search window was well received, with one HL user quoted saying "*... you can minimize or get more search results by clicking on this [slider] that was good.*", while a LL user explained "*... the fact you can vary it from 8 to how many that allows you to scan any tab [index card] you want ...*".

Distinctly identify index cards visited

Index cards already viewed show a clear distinct colour change from blue to purple (see Figure 8-9). This was particularly well received LL users who were quoted as saying "*... the colour the boxes is good to as if to get inside, when it is simple maybe I can get the information quicker ...*" and "*... this will be fantastic for people who are learning computers, because of the boxes it makes it more clear what you're going to look for, the boxes make it more easy, plus you know what you have looked at as it changed to purple ...*".

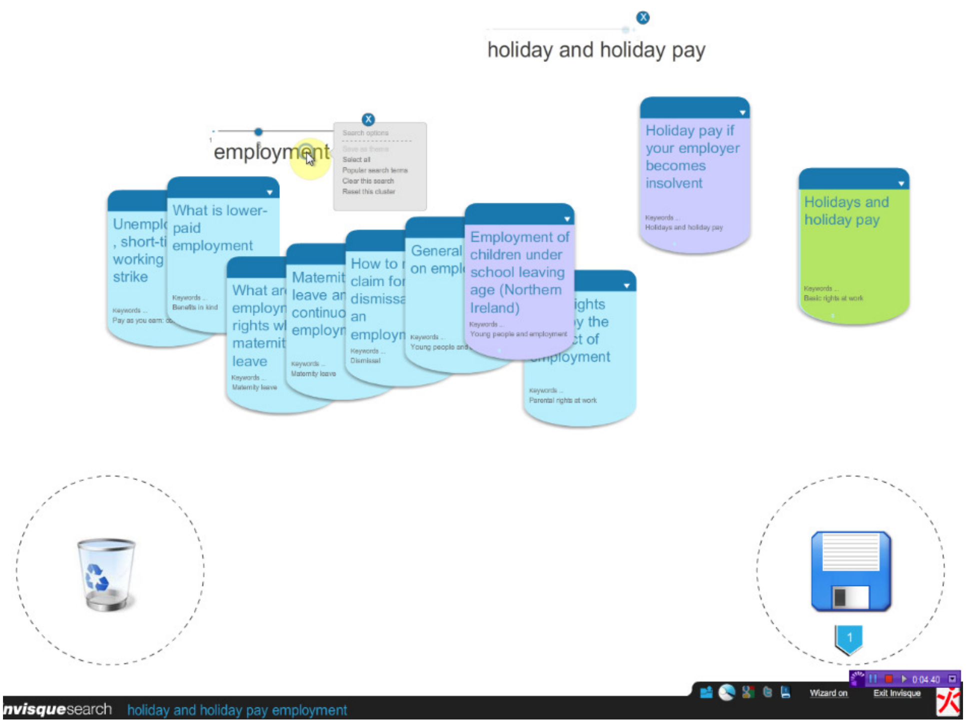

Figure 8-9.A user identifying the save support tool and drilled down items from two search clusters.

User feedback

Overall, both groups of users liked *Invisque*. The comments suggest that HL and LL users liked the way in which information was visually organized and presented in boxes. The flexibility of being able to move index cards freely around the screen gave users the freedom to organize their own information space. The users felt it was novel but learnable, and they preferred the white space and simplicity of the interface. One of the HL users said "*… information was presented in a great way…, I think I quite like it as I am able to spread my search around the screen.*", while one of the LL users were quoted saying "*… the thing that I liked was it is very straight forward, second system* [*Adviceguide*] *has a lot of lists you have to keep reading to find out what to select, so I like the first system* [*Invisque*] *because of that …*", and another LL explained "*… wow I like that system it is clear!*".

There were few negative comments from both groups about the interface. The comments suggested that all HL and LL users disliked index cards being overlapping at the start of the search (see Figure 8-9). They further raised questions on how more information could be displayed without being overlapped (see Figure 8-10). Most HL users preferred the traditional site, while almost all the LL users preferred *Invisque*. One of the HL users was quoted saying "*… if you have two searches, there is a possibility to get lost, as there will be information in different places in the screen.*", and one LL user explained "*… sometime it is a bit confusing if you have many active searches because you don't know which belongs to which, like divide when you move it.*".

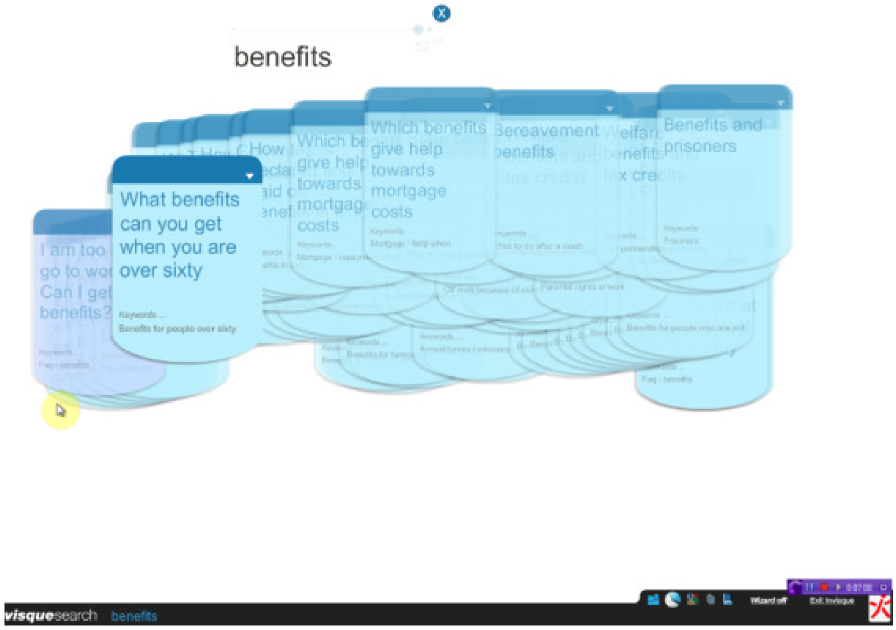

Figure 8-10. Users showing overlapping of index cards during an interview.

DISCUSSION

The comparison of the *Adviceguide* and *Invisque* interfaces yielded several interesting findings. Task success was not significantly higher for *Invisque* for both HL and LL users. However, Figure 8-2 shows that both user groups predominantly were more successful when using *Invisque*. LL users were significantly quicker with the *Invisque* interface, while HL users were slightly slower. The LL users viewed significantly fewer numbers of pages on *Invisque* for all three levels of task difficulty than on *Adviceguide*.

The boxing of information helped reduce the cognitive load of LL users by focusing attention, improving their reading strategy (which addressed early reading identified in the refined behaviour model for LL users, see Figure 5-1 box 3). This can be seen in the results where LL users spent significantly less time, viewed fewer number of pages and showed an increase in task success (although not significant) over *Adviceguide*.

Previous studies suggested that LL users, unlike HL users, did not verify information for correctness because they were being satisfied with information quickly due to higher cognitive load. LL users predominantly used the Wizard function to either remove unwanted index cards or mark important information. These LL users now revisited the information marked as important, suggesting they were differentiating and comparing information for correctness moving away from satisficing too early.

Prior studies also identified that LL users were less likely to recover from mistakes. The observations suggested that removing or deleting information of no relevance reduced unwanted clutter and prevented LL users from revisiting this information. Another observation was that LL users were likely to clear the canvas and start a fresh search as a strategy to recover. Most importantly, the lack of hierarchy meant that users were less likely to abandon a search due to differences in conceptual and mental models.

Overall *Invisque* was well received by both groups of users. The subjective feedback reinforces that *Invisque* represents a novel interface that was easy to learn. This confirms that the affordances of the system provide strong interactive and visual cues (Norman, 1988).

SUMMARY

This chapter presented *Invisque*, an interactive visualisation search tool that is based on a set of design principles that were expected to equalise LL users search efficiency with that of HL users. To test these principles an evaluation was performed to compare *Invisque* against a traditional web interface *Adviceguide* for both HL and LL users.

The evaluation of this new search interface offers significant benefits for LL users by significantly decreasing the time required to find information online (1/3rd), and also significantly reducing the number of pages viewed during a search while maintaining or improving their overall task success (12). These findings suggest that LL users' information seeking behaviour changes when they explore additional system functions.

In addition, users interact and explore the data in a tangible way that makes sense to them, and without having to change the underlying Adviceguide information. This suggests that changing the way information is visualised, interacted with, and explored, the data itself is able to show improvements in users' search performance.

Results generated from the quantitative, subjective and observational data show that these design principles were well received by LL users. Specifically, they preferred the way information was presented (boxed), the flexibility to move index cards or clusters, using the Wizard to delete or mark information as important, visual cues. Additionally, they preferred the smooth transitions (between searchers) and less clutter due to the increase in white space.

Further investigations with regards to proposed design principles and *Invisque* are required. Although LL users preferred the interface, however in some cases it affected the performance of HL users. This reinforces Neilsens' (1993) observations that new designs are likely to introduce new and unexpected problems.

LIMITATIONS

One caveat to the present study is the small sample size that could have influenced the results. The reason for the small sample size is that it was difficult to recruit participants because literacy could only be assessed after completion of the study, participants could not have any prior experience using the *Adviceguide* website and participants needed to allocate half a day to complete the study.

CHAPTER 9

CONCLUSIONS, REFLECTIONS AND FUTURE WORK

The main theme of this thesis has been to evaluate non-traditional interactive visualisation to support information seeking for low literacy (LL) users in an e-social service website. This thesis explored the digital divide and the use of interactive visualisations to support LL users during online information seeking. To determine design principles for LL users, it was crucial to investigate online information seeking strategies, behaviour models, and to compare mental models between high literacy (HL) and LL users. It also proposed a solution by adapting a search system integrating design principles and information seeking strategies identified during the exploration phase. Finally, the researcher evaluates performance of LL and HL users to determine whether the use of this non-traditional interactive visualisation techniques could support information seeking behaviour of LL users in the context of the Adviceguide website.

This research is relevant because of the tendency for government organisations to reduce face-to-face advice while transferring information online. Adults with poor levels of literacy are more likely to be unskilled or semi-skilled, have a higher likelihood of being dismissed and to experience long-term unemployment. Hence, these adults have a higher chance of being socially and financially disadvantaged and require access to social benefits.

UNDERSTANDING LL USERS IN A WAY THAT ALLOWS FOR NEW DESIGNS

Previous research confirms that LL users are less successful finding information in comparison to HL users (Jensen et al., 2010; Kodagoda & Wong, 2008; Summers & Summers, 2003). To investigate the behaviours that LL users exhibit compared to HL users, a better understanding of LL users' cognitive capabilities, information seeking strategies, behaviour and mental models was required.

Information Seeking Strategies

Results showed that HL and LL users present differences in strategies when seeking information. LL users have a tendency to read word-for-word and tend to focus narrowly on parts of the screen due to skipping sections of text. On the other hand, HL users often scanned the page for relevant information. LL users opted for early closure instead of checking and verifying that the information they found was correct. LL users have a higher tendency to get lost within a search and are unable to recover and resume the task. The search paths or trajectories employed by LL users were found to be haphazard, resembling patterns of usage by those who have little understanding of functionality or information storage. In contrast, HL users were able to develop a reasonable mental model of the information architecture and thus were able to direct their search more successfully. LL users prematurely abandoned their searches, either by presuming the information they were looking for was not available or by settling for incorrect/incomplete information. The findings from studies carried out within this thesis suggest that the search strategies employed by LL users were less successful compared to HL users.

Information Seeking Behaviour Model

Using Ellis (1989) model as a theoretical lens, two refined behaviour models were created, one for HL and the other for LL users. The findings showed that word-for-word reading by LL users occurred at *chaining, browsing and extracting stages*, which were likely to have put a greater cognitive load, resulting in poor decision making which in turn led to early closure due to satisficing and search abandonments. On the other hand, HL users scanned the information and only started word-for-word reading at *differentiating* and *extracting* stages. HL users deliberately revisited certain information to *verify* information against other previously visited information. This *verification* process was not evident with LL users. The differences between the two models observations suggest that LL users are less successful in obtaining information from their searches because they are under a higher cognitive load and are unable to *differentiate* or *verify* information for correctness.

Mental Models of users

Literature suggests that users will develop mental models of the structure of the information presented to them. An ideal system will have a strong mapping between the users' mental model and the system's conceptual model. Prior studies identified that LL users are more likely to abandon searches, assuming that the information is either not available to them or unavailable in the section they expected it to be. The high number of search abandonments suggests that there is a mismatch between LL users' mental model and the systems' conceptual model. The results of the card-sorting study showed a difference in mental models between HL and LL users. However, while there was a consistency among the mental models of HL users, mental models of LL users were heterogeneous. Previous research had shown that LL users have difficulty understanding abstract categories or hierarchical menu structures. Thus, websites that contain hierarchical menu structures may not be suitable for LL users. The difficulty of designing a website that facilitates LL users may be explained by the fact that LL users present different mental models of the system among themselves. Consequently, this lack of homogeneity presents considerable challenges to the designer.

DESIGN PRINCIPLES FOR LL USERS

While low-literacy is assessed using reading levels, it is clear that the cognitive processes are also different, contributing to the poor performance of LL users during information seeking (Chapter 4, 5 and 6). Hence, when designing interfaces for LL users, it is not only reading levels or usability that needs to be considered but also their manner of thinking (Sherwani et al., 2009). The researcher identified that LL users read text presented to them at early stages (during *chaining* stage discussed in Chapter 5), they did not *verify* or *differentiate* for correctness, for instance, LL users presented difficulties *recovering* from mistakes and they portrayed different mental models of the *Adviceguide* website among other LL participants. Once these model differences were identified, the researcher proposed a number of recommendations for designing user interfaces for LL users (see Chapter 7).

The design principles were chosen to reduce time spent by LL users in early reading, encourage *verification* for correctness, support *recovery* from mistakes and reduce search *abandonment* at early stages. To apply these design recommendations, a prototype known as *Invisque* was adapted.

To reduce the time that LL users spent in early reading, *Invisque* removes the clutter previously presented in the *Adviceguide* website by increasing white space and by boxing information as index cards to create better focus.

To support information verification for LL users, *Invisque* provided colour coding scheme to differentiate index cards that have been previously viewed from those that were not. The index card also changed colour if the user considered that it was relevant to the query.

To support recovery, *Invisque* allowed users to arrange index cards spatially in the canvas, which created perceptual landmarks that show relationships between index cards. *Invisque* also allows multiple searches that created different clusters of information. These multiple clusters were organised in primary and secondary layers, which provided an overall view of the data area with the ability to drill down to important information (focus + context). In addition, *Invisque* provided the user with the ability to delete individual index cards or entire clusters of information to reduce clutter or completely clear the canvas.

To reduce early search abandonment, *Invisque* introduces a flat-menu structure. When participants searched for information in the *Adviceguide* website, they abandoned the search as soon as they assumed that information was not available where they expected it to be. By using a flat-menu structure, they were encouraged to conduct several searches since there were no expectations built on where the information should be. *Invisque* also provides the user with the ability to carry out multiple searches in the infinite canvas without any disruption or relationship among clusters (what Hochberg refers as a discontinuous transition).

Evaluation of Invisque

The findings have shown a change in the behaviour of LL users during information seeking. Performance analysis showed that LL users spent one third of the time on a task when using Invisque compared to the Adviceguide and visited twelve times less web pages. Further analysis of the pages visited revealed that LL users were sixteen times less likely to revisit pages previously visited and were eight times less likely to visit unique pages using Invisque over Adviceguide. Even though the search outcomes (successful, unsuccessful or abandoned) showed no significant differences for *Invisque* between HL and LL users, overall it showed higher successful searches and showed fewer unsuccessful searches compared *Adviceguide*. LL users abandoned fewer searches with *Invisque* when compared to *Adviceguide*.

Both qualitative and quantitative evaluations showed that LL users preferred *Invisque* to *Adviceguide.* The qualitative data reinforces that LL users predominantly used the visual cues provided, such as the Wizard function to either remove unwanted information or marked important information. Behaviours that were not normally evident among LL users, such as *differentiating* and *verifying* during information seeking were observed when Wizard functions were made available.

This highlights the importance of taking into account information seeking behaviour strategies, behaviour models and users' mental models of specific user groups when applying design principles to influence and support current information seeking behaviour.

FUTURE DIRECTIONS

For future research, it might be useful to conduct a longitudinal study where participants use both *Adviceguide* and *Invisque* from their homes. The working environment might have an effect on their behaviour when searching information online. The effects of longer training sessions and frequent use of *Invisque* must also be evaluated. In this case, information seeking sessions by the participants could be captured using log files of web searching activities. Focus groups could be used to let participants voice their experience thereafter.

If and when more data (screen capture and log files of web searching activities) are collected about information seeking behaviours of LL users as mentioned above, more refined information seeking behaviour models as discussed in Chapter 5 could be revisited to evaluate their behaviour model when using *Invisque*. It could be assumed that when LL participants use *Invisque*, that they might evolve strategies such as *verification* and *differentiation,* while taking advantage of *making memory notes*. Furthermore, we could confirm that the use of interactive visualisation and flat-menu structures have direct effects on information seeking behaviour of LL users.

The current thesis has illustrated how interactive visualisation techniques could be used to improve performance by reducing the time spent on a task and the number of pages viewed by LL users. Future studies are required to evaluate each proposed design recommendation to find which design features will lead to what performance improvements. For example, it could be important to evaluate the marginal contribution of a specific design principle on overall performance improvement.

The information used on *Invisque* was identical to the *Adviceguide*, allowing comparisons to be made between the two systems. However, it would be interesting to reduce the existing readability of text on hyperlinks and webpage content to study the marginal contribution on performance.

The card-sort study carried out and described in Chapter 7 was not goal driven. Previous studies have confirmed that there were differences between goal driven and non-goal driven conditions in categorisation exercises. The card sorting study discussed in Chapter 7 showed that mental models of HL users in relation to the *Adviceguide* were different from the system's conceptual model. However, the mental models among HL users were similar. This may have been a result of the non-goal driven conditions. Further studies could investigate whether there are differences between how HL and LL users would classify information under goal driven conditions.

Due to its exploratory nature, there was only one study (described in Chapter 8) where a statistical analysis was appropriate. This study had a small sample size. Twenty-four participants (12 HL and 12 LL) used both the Adviceguide and Invisque and took part in three search tasks (easy, medium and difficult) on each system. The sample size was constrained by difficulties of recruiting LL participants who were walk-in clients of the Citizens Advice Bureau and who used their computers between 4 and 10 hours per week. The power of the test was affected by the small sample size.

Finally, an eye motion-tracking device could be used in future experiments. Unfortunately, the researcher did not have access to one. For example, such a device could facilitate the findings by correlating the duration and reading sections of the eye fixations that occur during searches and verify the existing findings thereby providing new insights into the way LL users seek information.

FINAL COMMENTS

This research has contributed to the field of human-computer interaction by exploring how interactive visualisation facilitates information seeking for LL users. The research targeted a real world problem where previously evaluated visualisation techniques could be applied to support LL users in an era where information is being increasingly digitised.

The quantitative findings conclude that there has been significant performance improvements for LL users with time on task and number of pages visited on the new system. There also seemed to be a shift in how LL users interact with the new system. LL users show behavioural changes as they take advantage of the incorporated design principles.

Moreover, this thesis provided a deeper understanding of the differences between HL and LL users strategies, behaviour and user mental models adapted during information seeking. This has led to proposing design principles that may address the differences identified for LL users.

While Invisque is perceived as taking longer to learn without instructions, this is not uncommon of novel technologies. The fact that participants were able to use Invisque after a two-minute video demonstration reflects its user-friendliness. Invisque is a query and search prototype that encompasses robust design techniques with appropriate affordances. Its properties allow the user to interact with the system in a more natural way supporting the development of new insights, of relationships and links between sets of information, and providing the ability to modify, filter and highlight information according to relevance, and taking advantage of the human cognitive capabilities.

Invisque was adapted and design principles were incorporated to support online information seeking by LL users. It is important to note that while the research focused on LL users, the value of extracting information easily and enhancing insight development is not confined to them alone. Invisque has the potential to be used with large datasets to support analytical reasoning in different fields and user groups.

This research has contributed to the field of human-computer interaction by exploring the utility of a non-traditional interactive visualisation. The exploration of the digital divide and the evaluation of a possible solution had shown us that technology can be adapted and be adaptive to LL user's needs.

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APPENDIX

APPENDIX – PART I

APPENDIX A

AN IN-DEPTH ANALYSIS OF LITERACY

This section introduces how severe the low literacy (LL) problem is and that it affects both developing and developed countries. Finally, an investigation on how LL affects different domains today.

LITERACY IN RELATION TO THE WORLD

Literacy can be defined as one's ability to read, write and count, while taking advantage of information sources available in the social economic environment they live in by drawing logical inferences while thinking critically to solve their day-to-day problems (Baynham, 1995; Chlebowska, 1990; Stifelman, Arons, Schmandt, & Hulteen, 1993; Wallendorf, 2001). The United Nations now estimates that 770 million, one fifth of the worlds' adult population, lives without basic literacy skills (Matsuura, 2005; UNESCOPRESS, 2005). Limited literacy is a break down in society and development as it costs business, taxpayers billions in lost wages profits and productivity annually (Smith, 2008). There is no universal definition for literacy (Chege, 2009; Lonsdale & McCurry, 2004; Walter, 1999), it has been examined in many ways, particularly from the cognitive transformations on how it affects societies (Duranti & Ochs, 1978). There are three interrelated themes which describe literacy (Goody, 1975; Greenfield, 1972; Scribner & Cole, 1978): (a) The development of abstract reasoning and thought, (b) decentring and (c) ability to decontextualise one's language. Literacy can be inspected from the perspective that it is no longer an individual's ability to read and write, and it is a skill required to function fully in a society by being literate or functionally literate (Harste, 2003; Wallendorf, 2001).

Literacy affects both developed and developing countries suggesting that it is a global challenge (Smith, 2008; Wickens & Sandlin, 2007). The citizens in the developed countries are likely to be required to read newspapers, browse the internet, send and receive emails, use the phones to send text messages and understand instructions enabling communication, and compete economically while solving day-to-day duties and problems (Lonsdale & McCurry, 2004). Likewise, citizens in the developing world, are likely expected to read directions, calculate cost of crops, read instructions on how pesticides should be used, read and comprehend how medicines should be intake which are required to help with their day-to-day living (Walter, 1999). Due to these factors, the level of literacy become a moving target as it is enforced by society expecting people to make use of written material, have higher order reasoning skills to draw logical inferences while thinking critically (Wallendorf, 2001).

Two thirds of the illiterate and LL adult populations come from countries such as India, China, Bangladesh, Pakistan, Nigeria, Ethiopia, Indonesia, and Egypt (Jain, 2004). Sixteen percent (5.2 million) of the UK's population have low levels of literacy according to the National Skills for Life Survey carried out in 2003 and The National Adult Literacy survey (OECD, 1995; Williams, Clemens, Oleinikova, & Tarvin, 2003). While in USA 23%, (40 million) display lower levels of literacy according to The National Assessment of Adult Literacy (NALS, 1992). The 2003 International Adult Literacy and Skills Survey (IALSS) carried out in Canada found 18.2% (18.5 million) had low levels of literacy (OECD, 1995).

DOMAINS AFFECTED DUE TO LITERACY TODAY

Literacy presents challenges in domains such as health, retail consumer, and public information systems, where people are required to take advantage of online information to solve their day-to-day problems. Following briefly discusses the problem domains and their challenges.

Health Literacy

Health literacy could be defined as one's ability to engage in an information rich society by seeking, finding, processing, and understanding basic health information and services required to make appropriate health decisions while gaining knowledge to solve health problems (Norman & Skinner, 2011; Ratzan & Parker, 2000; Selden et al., n.d., 2000). Norman and Skinner (2011) point out by optimising a person's experience with e-Health services six components of literacy is combined: traditional, information, media, health, computer and scientific.

Providing medical information has moved away from doctor to patient and now available via printed and online formats. This creates a gap in the knowledge and skills for adults with low health literacy causing higher health costs due to unwise health decisions made (Nielsen-Bohlman, Panzer, & Kindig, 1999). Due to low levels of health literacy the United States spends between 50 – 70 billion dollar per year (Friedland, 1998). Much work has been carried out to improve health literacy, (a) by educating patients (Doak, Doak, & Root, 1996), (b) lowering the current readability levels of text or representing the text differently or introducing writing guidelines (Leavitt & Shneiderman, 2004; Meade et al., 1989; Weis, 2007; Young et al., 1990), (c) proposing designing recommendations using different multimodalities (Houts, Doak, Doak, & Loscalzo, 2006; Medhi, Prasad, & Toyama, 2007).

Retail Consumer literacy

Some retail consumers face disadvantages over product choice due to being LL. These LL users show differences in decision making on where they are required to evaluate information in printed materials such as advertisements and product packaging (Jae & Delvecchio, 2004). Retail consumers currently required to make choices making use of printed, online, TV advertisements. However, LL users show difficulty making comparisons.

Public Information Systems (e-Government)

In recent years, most governments worldwide to improve efficiency through transparency and openness, while increase interactions across governments, citizens, and civil social organisations have moved to digitising information (e-government). According to the World Bank website (2005), e-government can be defined as: "*information technologies… that have the ability to transform relations with citizens, businesses, and other arms of government… [and] can serve a variety of different ends: better delivery of government services to citizens, improved interactions with business and industry, citizen empowerment through access to information, or more efficient government management… benefits can be less corruption, increased transparency, greater convenience, revenue growth, and/or cost reductions.*"

These e-government systems have to create need and motivation for their citizens to use it (Daly-Jones, Bevan, & Thomas, 1997; Eason, 1981), however, be simple and self-explanatory as possible (Maguire, 1997). There are many challenges and factors for failures in e-government, however, citizens level of literacy in both developed and developing nations as yet has proven to be a challenge (Chesi & Pallotti, 2005; Commission, 2006; Dada, 2006; Dwivedi & Sahu, 2008; Froud, 2002). As these types of systems cater for the public, it should take into account the variety of skill levels available.

SUMMARY

This suggests that illiteracy and low literacy are global challenges. However, the requirements of literacy manifests differently in developed and developing countries owing to the innate differences in the respective social, cultural and technological environments. Consequently designing effective visual interfaces for LL users requires to be mindful of such localised variations. Such variations also play a crucial role in one's approach to bridge the gap for the LL users to be fully participating in their digital communities.

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APPENDIX B

LITERACY ASSESSMENT METHODS

This section has been introduced to understand types of literacy assessments methods for people available and how they have evolved over the years. Similar to not having one universal definition for what literacy means, a collection of adult literacy assessments have been used over the last few decades moulded according to various experts, advisors and teachers of adults, on what they think literacy is (Sticht & Armstrong, 1994). Here assessment refers to a method for judging (empirical or test) literacy or other cognitive skills of people (Wagner, 2003). These different assessments focus on different aspects of literacy.

Prior to literacy assessments historians used counts of signatures against finger prints taken from legal documents such as wills, marriage licenses and deeds to gauge early literacy rates (Campbell, 1992). In the mid-1800s, the United States Census Bureau assessed literacy using self-reporting techniques. People who reported having the ability to read and write simple messages were classified as literate and the others as illiterate. Literacy is also associated with formal public schooling, where years of schooling is considered a form of assessment (Wagner, 2003).

Due to flaws and unreliability of self-reporting of literacy during World War I, army recruitments saw a growing need for standardising educational literacy assessments, where a change in how literacy should be assessed was required (Campbell, 1992). There has been much controversy on how literacy should be assessed especially in national surveys, whether they should be multiple choice or constructed responses or if the assessments should be focused on academic or real world scenarios (Campbell, 1992).

The literacy assessment used by the U.S. military in relation to workplace literacy, spanned during World War I (1917) up to the present (Sticht & Armstrong, 1994). The assessments focused on (a) theoretical and conceptual issues in adult literacy; (b) workforce and workplace literacy; and finally (c) family literacy and the intergenerational transfer of literacy. The findings of five military workplace literacy programs revealed that, literacy showed relationships to intelligence and aptitude while knowledge showed a relationship to literacy and job performance.

The Department of Education's National Assessment of Education Progress in the USA in 1986 assessed literacy in three areas: prose, document and quantitative literacy. Literacy and numeracy are considered the foundation of being functionally literate (Williams, Clemens, Oleinikova, & Tarvin, 2003). The skills for life survey in the United Kingdom assessed literacy in two areas: literacy and numeracy of adults. The literacy assessment checked for spelling, grammar and listening.

Literacy assessments that were carried out between World War I and today found that: people with higher education performed much better than those less education, the young adults performed better than the older, adults holding managerial post performed better than the blue-collar or unskilled workers, higher income groups performed better than those with lower income or on social welfare, and a much larger proportion of adults with higher education tend to read books, magazines and newspapers compared to those less educated (Williams et al., 2003). In general, any literacy assessment can rank adults verbal intelligence, aptitude, or literacy along with high, medium, or low literacy skills.

The Department for Education and Skills carried out the UK Skills for Life survey for Adults (16 – 65 years) between June 2002 and May 2003. The assessment comprised of two parts, a sample of respondents from the first interviews (8,730) taking part in the second (4,656). The aim of the assessment was to produce a national profile. The assessment showed differences between levels of ability corresponding with the standards described in the National Qualifications framework (see Table A2-1) (Williams et al., 2003). According to the UK Skills for Life Survey people who have, LL or low functional literacy represented categories of Entry Level 1, 2 and 3 and HL showed Level 1 & Level 2. The Literacy survey (Williams et al., 2003) tested users on eight listening, sixteen writing and sixteen grammar questions. The total score determined the level of literacy (Williams et al., 2003). The assessment is on a scale of 40: scores ranging from five to 28 defines LL or low functional literacy while scores ranging from 29 to 40 defines HL.

The Skills for Life Survey divided literacy in to five levels as shown in Table A2-1.

Literacy skill level	Score	Literacy level	General	National curriculum level
Level 2	37-40	HL	GCSE grade A+ - C	6(ages 12 and above)
Level 1	29-36	HL	GCSE grade D - G	4 to 5 (ages 11)
Entry level 3	21-28	LL		3 (ages 10 to 11)
Entry level 2	13-20	LL		2 (ages 7 to 9)
Entry level 1	5-12	LL		1 (ages 5 to 6)

Table A2- 1. Literacy qualification levels and their equivalents.

Source – C&AG's Report, Figure 1

The United Nations in their Literacy Decade publication suggested when developing assessment tools for literacy in the developing countries to consider smaller, quicker and cheaper options (Wagner, 2003). UNESCO, in order to provide worldwide statistical comparisons on literacy relies on national censuses. Most of these national literacy assessments may rely on self-assessment or a proxy such as the number of years of primary schooling to determine the level of literacy (Wagner, 2003). This raises credibility of the statistics where discussions are raised to see what can be done about the assessments. Some countries have begun to review their current literacy assessments such as the North American national surveys and the Organisation for Economic Co-operation and Development (OECD) countries.

Many literacy studies carried out in North America in the early 1990s revealed a significant proportion of the adults missed out on literacy skills in an early stage in life (Murray & Kirsch, 1995). The OECD concluded literacy levels are a threat to the economic performance and social standing (OECD, 1995). The International Adult Literacy Survey (IALS) later known as the International Adult Literacy and Skills Survey (IALSS) defines literacy in the following categories, prose, document and quantitative (Human Resources and Skills Development Canada, 2005). Prose literacy refers to knowledge and skills required to understand and use information from printed materials. Document literacy refers to knowledge and skills required to find relevant information from forms, schedules, maps, and job applications. Quantitative literacy refers to knowledge and skills required to do basic arithmetic operations for managing daily finances, balance a checkbook, complete an order form, identify the interest component from a loan application etc.

The IALS rolled out an adult (16-65 years) literacy assessment in nine countries (Canada, France, Germany, Ireland, Netherlands, Poland, Sweden, Switzerland and the United States). IALS has been criticised for its limited coverage and problems used in the modelling techniques. The results of the first International Adult Literacy Survey in December 1995 suggested that Sweden performed better in all categories while Poland was the worst, France decided to withdraw from the study, and Ireland's results were not printed out due to processing delays (Almansa et al., 2011; OECD, 1995).

SUMMARY

This suggests the literacy has no one assessment. However, over the years many literacy evaluation methods have been developed focusing on different aspects, such as listening, prose, document and quantitative skills of users. For the purpose of this thesis, the UK Skills for Life Literacy Survey, used in 2001, in an aim of assessing the UK National profile, was felt relevant. The survey assessed users listening, writing and grammar skills. The score was easily compared across UK National Skill Level and the National Curriculum level.

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APPENDIX C

MEASUREMENTS OF READABILITY LEVELS OF TEXT

For the purpose of this thesis, readability level of the text was a factor that determined the level of difficulty of a search task. The section identifies a few formulas that evaluate readability levels of text. The readability levels of text assists to determine the corresponding level literacy expected from a user.

Readability is the ability for a person to easily understand or comprehend information according to the style of writing (Klare, 1975). Dale and Chall describe readability as how effectively a group of people could read material, to which extent they could understand, to which optimal speed they could read and how interesting they found it. Readability studies have been carried out from the early 19th century with the initial publication of Flesch and Dale-Chall formulas. Various publishers, teachers and educators match reading levels of materials to the relevant user reading age. The first literacy surveys in the USA in the 1930s help match reading materials with the abilities of their readers. The National Adult Literacy Study carried out in the USA during 1993, stated that an average adult reads at a seventh grade level, which is equivalent to a person with 8 years of education (Doak, Doak, & Root, 1996; Weiss & Coyne, 1997) .

Readability of text depends on the writing style, which enables a user to read easily. Many studies have recommended (a) use of short, simple, familiar words, (b) avoid jargon, (c) simple sentences, active voice, and present as a few simple guidelines for document writing (Hackos & Stevens, 1997).

There are a few readability formulas to evaluate text (Dubay, 2004) such as the Flesch reading formulas (Flesch, 1948), Simple measure of Gobbledygook (SMOG) (McLaughlin, 1969) and the Gunning fog index (Gunning, 1952). These are discussed below.

Formulas

FLESCH READING EASE

Rudolf Flesch (1948) developed the Flesch reading ease formula, which uses factors such as number of words in the sentences and the number of syllables per word. The results range from 0 – 100 where high values result in easier reading. For Flesch Reading levels see Table A3-1. The equation is as follows

$$FleschReading = 206.835 - 1.015\left(\frac{totalwords}{totalsentences}\right) - 84.6\left(\frac{totalsyllables}{totalwords}\right)$$

Equation A3- 1. Flesch Reading.

SMOG (Simple Measure of Gobbledygook)

Harry McLaughlin (1969) developed a formula to assess the education level required to read and understand text. The SMOG formula uses the words, which has three or more syllables, number of sentences, estimate the counts square root, and adds three. For the SMOG levels see Table A3-2. The equation is as follows

$$SMOG\ grade = 1.0430\ \sqrt{hard\ words\ x\ \frac{30}{sentences} + 3.1291}$$

Equation A3- 2. SMOG reading formula.

GUNNING FOG INDEX

The readability formula was developed by Robert Gunning (1952), which calculates level of education a person needs to understand content. The formula uses the number of words in a sentence, number of sentences, and number of complex words. For Gunning Fog levels see Table A3-3. The equation is as follows

$$Gunning\ Fog\ grade = 0.4\ x\ \left[\frac{words}{sentences} + \left(100\ x\ \frac{hard\ words}{words}\right)\right]$$

Equation A3- 3. Gunning Fox index.

It is difficult to relate readability levels of text to exact adult literacy levels. The table A3-1 below was developed using few guidelines defined by the National Reading Campaign relating SMOG levels and adult literacy levels. The ranges were then related with Flesch Reading Index, Gunning Fog along with education grade and years of education.

Skills for Life Literacy Levels	National curriculum level	Flesch Reading Index	SMOG	Gunning fog
Level 2	6 (ages 12 and above)	0 - 49	13 - 19	13 and above
Level 1	4 to 5 (ages 11)	50 - 59	11 - 12	10-12
Entry Level 3	3 (ages 10 - 11)	60 - 69	9 - 10	8-9
Entry Level 2	2 (ages 7 - 9)	70 - 89	7 - 8	6-7
Entry Level 1	1 (ages 5 - 6)	90 - 100	0 - 6	5

Table A3- 1. Literacy levels and equivalent reading levels of Flesch reading index, Gunning fog and SMOG index.

There are free online tools available which evaluates text using Flesch Reading Index, SMOG or Gunning Fox index. Some of the free tools are:

1. readability test tool - http://www.read-able.com/
2. online-utility.org - http://www.online-utility.org/english/readability_test_and_improve.jsp
3. The SMOG calculator developed by the education development: innovation technologies lap - http://www.niace.org.uk/misc/SMOG-calculator/smogcalc.php

The tools allow users to paste text into a text box and the algorithms are activated using submit or calculate button. The tool evaluates and summarises the readability levels of the text.

SUMMARY

This suggests there are many different formulas and free online tool available to calculate readability level of the text. The thesis does not plan to evaluate the correctness or the accuracy of these algorithms or online tools. These algorithms only provide a rough guideline to evaluate the readability of the text. For the purpose of the thesis, evaluating the readability of the text (*Adviceguide* website content pages where information resided) was important as level of readability level of the text was considered a factor that increased the difficulty of the task. The SMOG calculator was used to evaluate the readability level of the text.

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APPENDIX D

LITERACY AND ORALITY

The theory of orality by Walter Ong has been introduced to the appendix, due to the current body of Human Computer Interaction literature which examines illiteracy and low literacy (LL) in respect to the theory of orality (Medhi, Menon, et al., 2010; Oral Tradition Journal, 2010; Sherwani et al., 2009). Orality (2002) is when ancestors and certain cultures rely on the living human memory to store and retrieve knowledge. It is important to formulate the knowledge in an easy-to-remember formulary expression (Farrell, 1977; Ong, 2002). Ong divided orality into three sections (a) totally oral, (b) residually oral and (c) a highly literate situations. Totally oral refers to when a culture is totally unexposed to any reading and writing habits; while residually oral refers to when cultures are exposed to present-day-high technology cultures, reading and writing but oral habits of thought and expression still permeate their thinking; finally, HL people refers to when they rely on writing and store information on printed books and their minds are fee to engage in other things.

Ong discusses how primary oral cultures think and express themselves through narrative in light of memory where the expressions are situational than abstract. Conceptual thinking is to some degree abstract; however, some conceptual thinking is more abstract than others are. Oral cultures tend to use concepts in a more situational and operational frames that refer closer to human life than abstract concepts.

Luria’s study in Uzbekistan and Kirghizia in 1931-2 on illiterate users found that geometrical figures were named as objects having similar shapes, classifications were practical and not categorical; there were problems with syllogistic and inferential reasoning; definitions were met with resistance; and these users had difficulty in articulating self-analysis. In an oral culture although abstraction in the form of generalizations exists, concrete or action words are much more common than abstract terms, but concreteness is frequently more rhetorical than empirical (Farrell, 1977). Farrell points out that orality and literacy foster different thinking modes.

Britton (1973) notes that the differences in languages affects the way objects are divided into categories. "*Language enables us to interpret and organises the world we experience through our senses*" Miller and Swift (1977). Miller and Swife observed that language is able to provide structure and meaning, or else it would have been just a jumble of impressions. Havelock (1971) points out abstract categories are added to language only after literacy is developed. Reading and writing involves manipulation of symbols, which is a cumulative abstracting process.

Sherwani et al (2009) drawing from the literature of orality offer a framework for Human-computer interaction for the developing world's methodology. The framework present guidelines for design and user research methodologies. Ong (2002) explained in communities where there are no books (because they can't read or write), they communicate knowledge and learning by telling stories (narratives), song and rhymes; and because of this they structure knowledge differently (e.g. possibly with lots of redundancy to facilitate re-telling); and that memorisation of the story does not mean they understand. They also recommend avoiding lists, abstract categories, and hierarchies. Content designed for literate users are probably not appropriate for oral users, and it has probably little to do with 'reading levels' as it has to do with a different way of thinking. They suggest that a better understanding of users can be achieved through concepts of orality.

Scribner and Cole (1981) in their detail study of the effects of literacy and schooling in Vai of West Africa, found student with schooling adapted a metalinguistic discourse then other groups. The researchers did not find specific effect of literacy on a number of tasks tapping general cognitive processes, including taxonomic categorization tasks, memory tasks, and syllogistic reasoning problems. However, by isolating literacy from schooling, a framework was proposed to assess the usefulness of using literacy activities to examine the cognitive implications of school practices, which are important later to function in society.

Much research has been carried out in the development model in literacy in cognitive psychology (Sticht & Armstrong, 1994). Piaget who looked at the development of children's' understanding classifies thinking and cognitive development into four stages: (a) sensory-motor (birth – 2years) refers to where intelligence is demonstrated through motor activity and some symbolic (language) abilities are developed towards the end. (b) Pre-operational (2 – 7 years) refers to the ability to classify objects by a single feature and thinking is still egocentric as they are unable to take someone else's view. (c) concrete-operational (7 – 11 years) refers to when skills have been developed to think logically about objects and events, classify objects with more features and able to order things using single dimension. (d) Formal-operational (11 years and up) refers to where logical thinking is developed about abstract propositions, ability to test hypotheses systematically, concerned with future, hypothetical and ideological issues.

SUMMARY

The theory or orality has helped examine illiteracy and LL in the current body of literature in the field of Human Computer Interaction. Orality shows how the living memory is used to store and retrieve information and how this presents a cognitive challenge. Drawing from the theory of orality a framework has been suggested for low literacy users (a) memorisation of information does not necessarily mean they comprehend the overall message, (b) their interpretations are more situational then abstract, (c) unlikely to understand hierarchy and (d) due to lower levels of education problems associated with logical thinking and other cognitive functions which are associated with learning is not available. Which suggest oral and LL users are likely to employ a different way of thinking over HL users.

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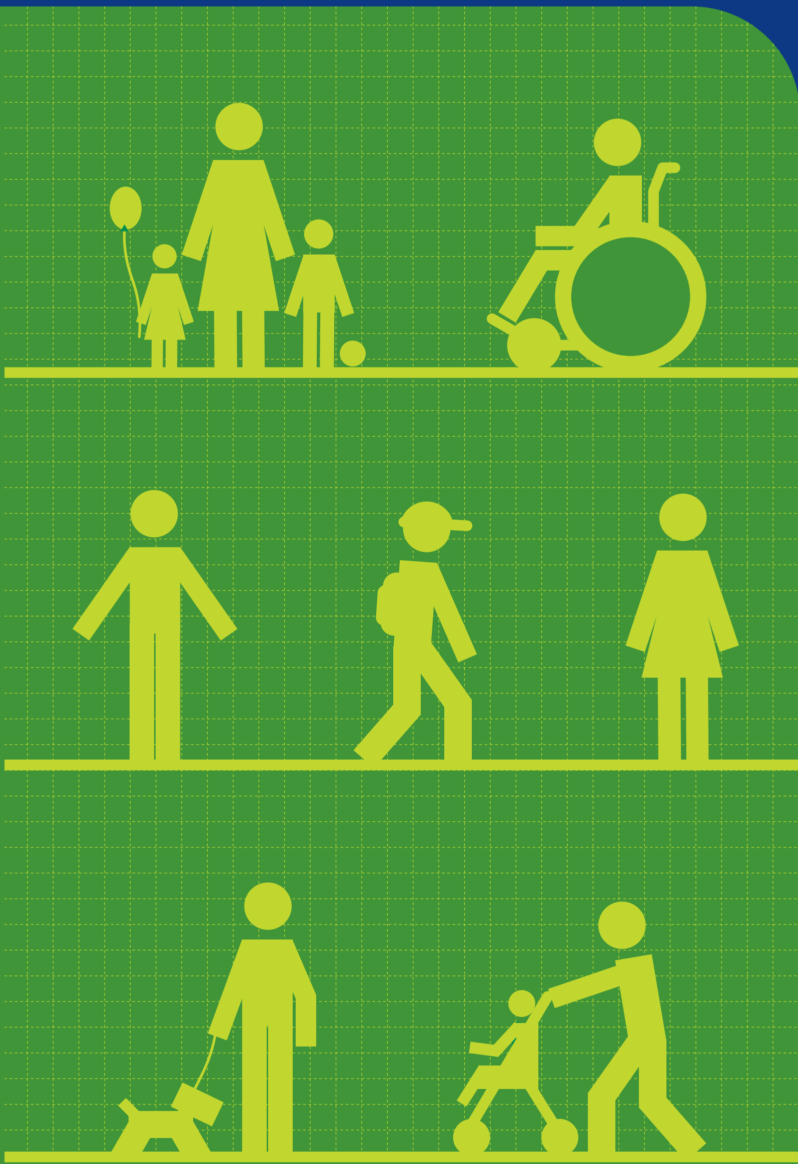
APPENDIX – PART II

APPENDIX E

UK NATIONAL SKILLS FOR LIFE LITERACY SURVEY

Skills for Life:

The national strategy for improving adult literacy and numeracy skills



Version 1

Literacy

Initial Assessment
Learner Answer Booklet

department for
education and skills
creating opportunity, releasing potential, achieving excellence

read•write•plus

This assessment is in two parts:

PART A: Listening skills (you will need a CD or audio cassette for this part).
PART B: Reading and writing skills.

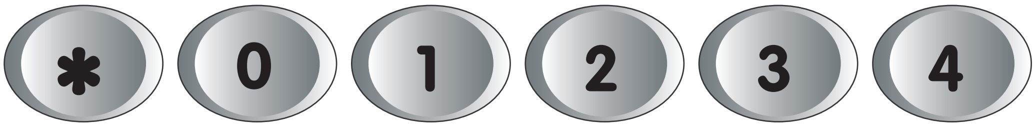
Try to answer all of the questions in the spaces provided in the booklet.
Please write clearly in **blue** or **black** pen.
Dictionaries are **not** allowed.

PART A LISTENING

Column for assessor mark.

For each of the next ten questions, listen to the audio CD/cassette and answer each question in this answer booklet. You may replay the CD/cassette as many times as you wish.

01 **Tick the correct button.**



02 **For how long has the woman interviewed worked for the company? Write A, B, C or D in the answer box.**

A Six years
B Twenty one years
C Twelve years
D Eighteen years

Answer:

Page total

Column for assessor mark.

03 **Which is the correct message to leave on a notepad for Abdul? Write A, B, C or D in the box.**

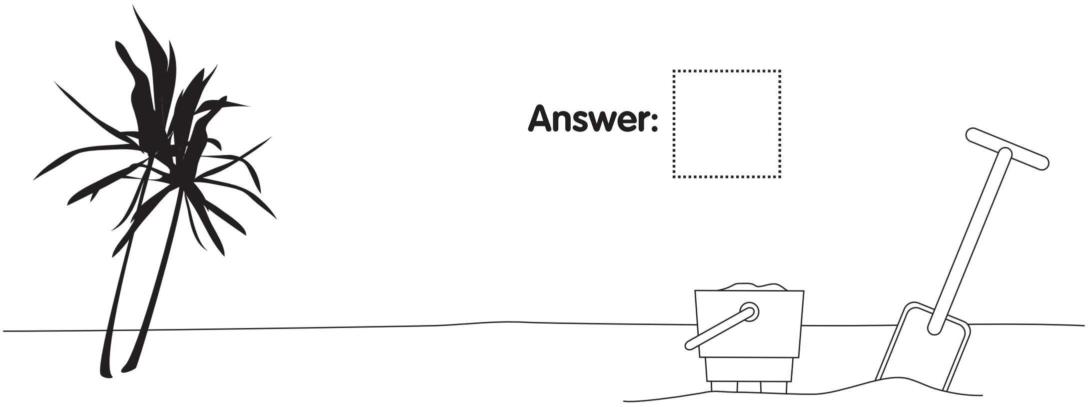
A Choice Holidays called – They are offering 30% off the cost of buying Traveller's Cheques and your tickets are ready for collecting.

B Choice Holidays called – Your tickets are ready for collecting and they are offering 50% off the cost of Traveller's Cheques.

C Choice Holidays called – Your tickets are ready for collecting, but you will need to show your passport before you can pick them up.

D Choice Holidays called – Your tickets will be ready in 30 days and they are offering 50% off the cost of Traveller's Cheques.

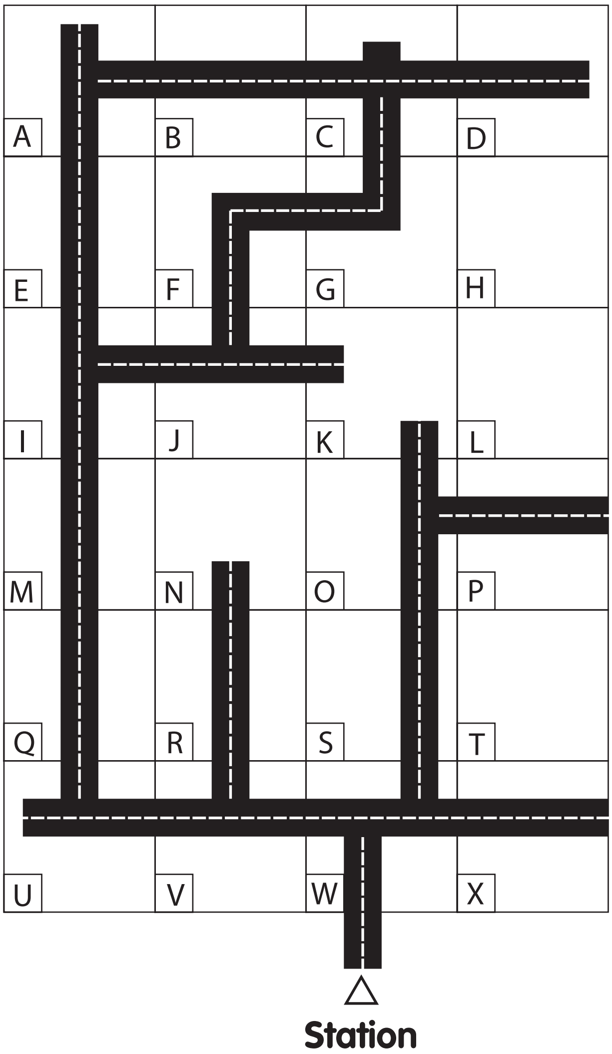
Answer:



Page total

Column for assessor mark.

04 **Listen to the recording and follow the map. In which square is the house where the party is being held?**



Answer:

Page total

Column for assessor mark.

05 **Were Emma's 'disasters' caused by her children?**

Tick one box:

- Yes ☐
- No ☐
- Can't tell ☐

06 **From what you have heard, which of the following is correct?**

Circle A, B, C or D.

A Janet left school at 14 and worked in a factory.

B Janet went straight to college when she left school.

C Janet started work after her father died in 1990.

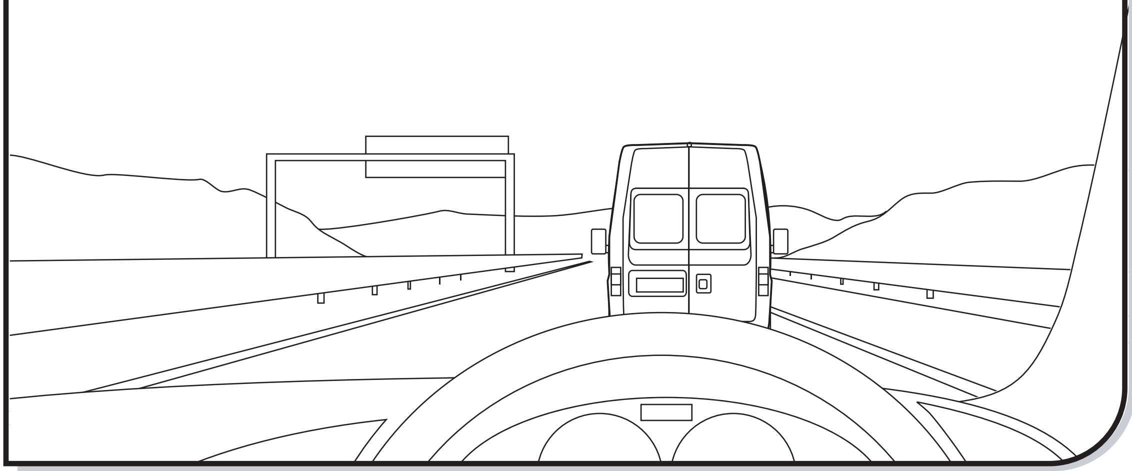
D Janet was able to start her own business in 1998.

Page total

Column for assessor mark.

07 **Write numbers below the words to show the sequence in which they appeared in the description of the accident.**

red Fiesta ☐ rain ☐ firefighters ☐ central reservation ☐ white van ☐ spin ☐



08 **From what you have heard, which of the following is correct?**

Circle A, B, C or D.

A Shirley needs Janet's advice on her wedding.

B Janet prefers an October wedding if possible.

C Shirley prefers a wedding in August if possible.

D The caterers can manage a wedding in August.

Page total

End of PART A (listening skills).

Column for assessor mark.

09 **Read the information below and then select the correct order of the instructions: A, B, C or D.**

Write A, B, C or D in the answer box.

USING YOUR PRINTER

To fit the new ink cartridge to a Combo Printer, lift the lid on the printer, remove the empty cartridge, put in the new cartridge, close the lid and then press the ink button on the printer.

A
- remove the empty cartridge
- press the ink button on the printer
- lift the lid
- put in the new cartridge

B
- lift the lid
- press the ink button on the printer
- close the lid
- remove the empty cartridge

C
- press the ink button on the printer
- lift the lid
- remove the empty cartridge
- put in the new cartridge

D
- lift the lid
- remove the empty cartridge
- put in the new cartridge
- close the lid
- press the ink button on the printer

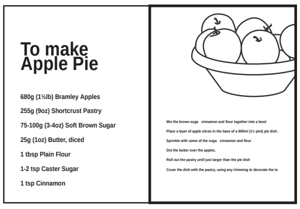
Answer:

Page total

PART B READING AND WRITING

Column for assessor mark.

10 **Draw lines to match the documents below with their correct use.**



Money | Message | Advertising | Instructions

Page total

Column for assessor mark.

11 **Which telephone number would you ring if you needed your carpet cleaning at home?**

Answer:

Page total

Column for assessor mark.

12 **Read the childminder's work sheet entry.**

What is the correct order in which the childminder should do things? Write A, B, C or D in the answer box.

CHILDMINDER'S WORK SHEET

When you arrive, prepare and sort out the breakfasts, dress the two older children for school, prepare their packed lunches and finally make sure you get them down to the school transport on time.

A dressing, breakfasts, lunches, transport
B breakfasts, lunches, dressing, transport
C breakfasts, dressing, lunches, transport
D lunches, breakfasts, dressing, transport

Answer:

13 **What is the correct spelling of the word that should go in the blank space in the sentence below? Write A, B, C or D in the answer box.**

Citizenship is about ________ being involved in their community.

A people
B poeple
C peeple
D peopel

Answer:

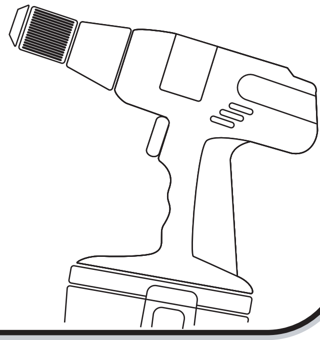
Page total

PART B READING AND WRITING

Column for assessor mark.

14 **What is the correct word that should go in the blank space in the sentence below? Write A, B, C or D in the answer box.**

To charge the drill, put the battery in the charger _______ switch on at the mains.



A but
B so
C and
D after

Answer:

15 **What is the correct spelling of the word that should go in the blank space in the sentence below? Write A, B, C or D in the answer box.**

The best month in the garden is June as it is _________ warm and dry.

A allways
B always
C alway
D allway

Answer:

16 **Underline the word in the sentence below that should begin with a capital letter.**

I will see you at 2 o'clock next monday.

Page total

PART B READING AND WRITING

Column for assessor mark.

17 **Read the sentences below. One is trying to persuade and one is trying to explain.**

Which sentence is trying to persuade? Write A or B in the answer box.

A Why not come to the party on Tuesday? It's bound to be fun!

B The party on Tuesday is to celebrate Avtar's birthday.

Answer:

18 **Read the appointment card and underline the date and the time when Mrs Omar's son can see the dentist.**

HILL HOUSE DENTAL SURGERY

9/11/05

Reference: Cancelled Appointment for: Yasir Omar

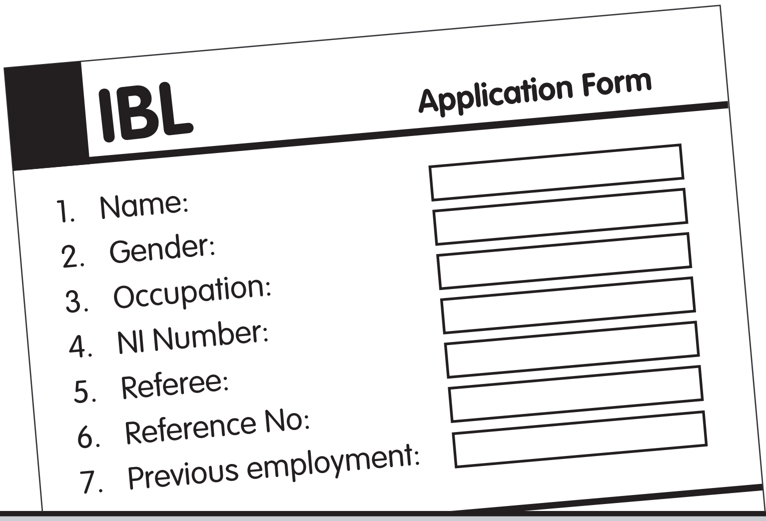
Dear Mrs Omar
The appointment for Yasir to see the dentist on 23/11/05 at 11:30 has had to be changed. The dentist can now see Yasir on 12/12/05 at 2:30. We apologise for any inconvenience this may have caused you. Please let the surgery know by 10.30 on 11/12/05 if you cannot make the appointment.

Page total

Column for assessor mark.

19 On which line on this application form (1 – 7) would you include information about your last job?

Answer:


IBL

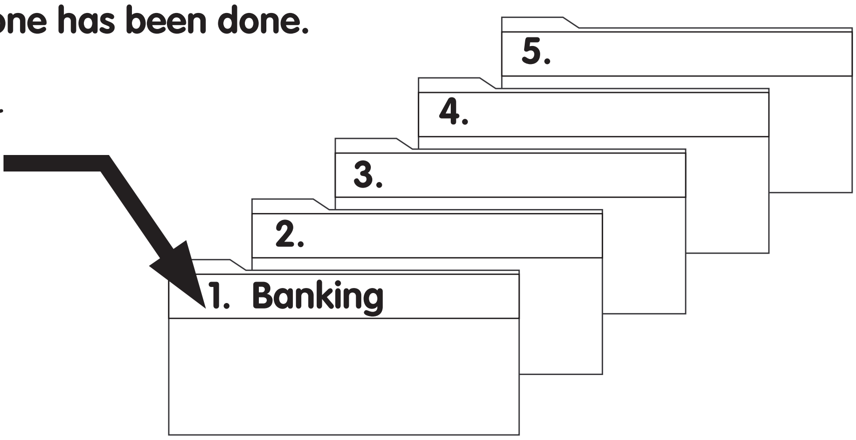
Application Form

1. Name:
2. Gender:
3. Occupation:
4. NI Number:
5. Referee:
6. Reference No:
7. Previous employment:

20 Write the headings on the cards in correct alphabetical order.

The first one has been done.

Computer
Banking
Electricity
Holidays
Car



Page total

PART B READING AND WRITING

Column for assessor mark.

21 **Underline the word that is incorrectly spelt in the letter below.**

> Dear Sir,
>
> During our talk on the phone yesterday, you said that I should put my complaint in writting. My bank statement is incorrect. Please would you sort this out as soon as possible.

22 **Complete the sentence in the box by writing the verb in the future tense.**

Ali is in Manchester.

Ali .... in Manchester.

23 **The note below needs proofreading and correcting. Underline the word that is wrongly used.**


Mum
I will be home late tonight.
I have been picked for the first team. I is very excited.
See you later.
Jim

Page total

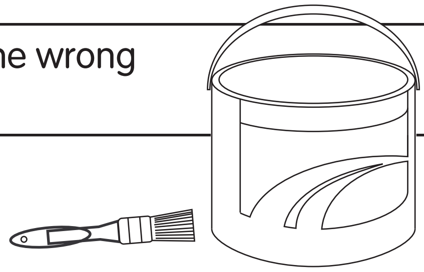
PART B READING AND WRITING

Column for assessor mark.

24 **The sentence below contains one punctuation error.**

Add the missing full stop in the correct place.

The paint you got on Friday was the wrong colour I wanted blue.



25 **Will the development in Beach Road, Brighton begin in two months time? Tick ONE box:**

Subject to final planning approval and there being no objections from the general public, the development in Beach Road should commence in two months time. A spokesperson from Developers Ltd. reported that the company is confident that the project will be approved and work will begin as scheduled.

- Yes ☐
- No ☐
- Can't tell ☐

Page total

How are you doing?

Happy to go on?
If not, tell the person in charge.

Column for assessor mark.

26 **Read this extract from a factory report.**
From the report, which of these statements is correct?
Write A, B, C or D in the answer box.

SAFETY
At the union meeting, the firm's Safety Officer reported that some safety standards are slipping. Floors are often untidy and two doorways are blocked. She said that it is important that the Management deals with these matters urgently.

A Safety is the union's responsibility.
B All safety standards are falling.
C Floors in the factory are slippery.
D Certain safety standards are falling.

Answer:

Page total

Column for assessor mark.

27 **Read the information from a driving licence application form.**

9.a Signing your photograph

To obtain a driving licence, you must supply a photograph and proof of identity. The photograph must be signed unless you are providing a UK passport for identification purposes.

Warning: The person who signs your photograph must have known you personally for at least two years, and must not be a relative or a member of the Post Office staff processing the application.

Which of the following is acceptable as proof of identity in order to obtain a driving licence?

Circle A, B, C or D.

A A current United Kingdom Passport.
B A photograph signed by a family member.
C An application signed by Post Office staff.
D A photograph signed by the applicant.

Page total

Column for assessor mark.

28 **Read this advertisement.**

Wessex Outdoor Community Centre

Applicants must have some experience of caring for young people either in a family or work situation. Qualifications in dealing with people with mobility problems are desirable, but not essential, as training will be given. Flexibility in working hours is required to fit in with the regular weekend and evening work rotas.

The work is physically demanding and some awareness of the lifting regulations within the Health and Safety Guidelines is desirable. Applicants will need to be fit and prepared to undertake some training. This is an unusual opportunity to gain experience in this kind of work.

According to the advertisement, an essential quality needed for the job is

A qualifications
B ambition
C awareness
D flexibility

Answer:

Write A, B, C or D in the answer box.

Page total

Column for assessor mark.

29 **Proofread this notice. Underline the word that is wrongly spelt.**

MEMO

For: All staff
Date: 15/04/05
From: First Aid Officer
Reference: Supplies

FIRST AID

When treating a minor injury last week, I was suprised to find an empty bottle of antiseptic in the Staff Room First Aid Kit. It is important that we are properly prepared to give emergency medical treatment at all times. In future, can staff let me know when any supplies are running low.

Thank you.

Page total

Column for assessor mark.

30 **Read the information about Liza Ono, who is preparing her CV.**

LIZA ONO – Personal Profile

Liza is 27 years old, lives with her family and is currently out of work. At school she passed 6 GCSEs and, in Year 10, did work experience in a fast-food restaurant. Liza likes clubbing, popular music and cooking. From school, she went to college and took an NVQ in Catering. Her last job was in a small hotel. Since leaving college, Liza has also worked in two restaurants.

Liza needs to write her CV in the correct order, beginning with her most recent 'history'.

Which sequence should she use?

A unemployed; hotel work; restaurant work; NVQ Catering
B NVQ Catering; restaurant work; hotel work; unemployed
C unemployed; restaurant work; hotel work; NVQ Catering
D restaurant work; unemployed; hotel work; NVQ Catering

Write A, B, C or D in the answer box. **Answer:**

Page total

PART B READING AND WRITING

Column for assessor mark.

31 **This is part of a statement about a traffic accident.**

Underline the verb that is grammatically incorrect.

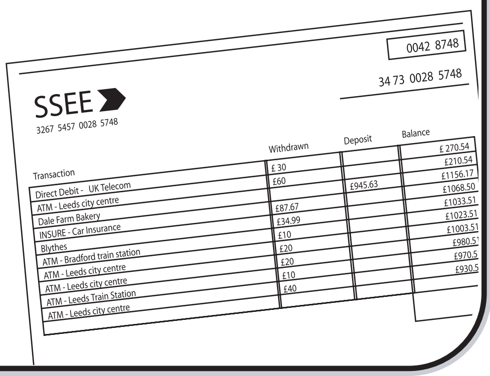
Solin and I was driving into town early this morning. I worked late the night before and had the day off today. At the junction I stopped at the lights to turn right. Suddenly there was a series of loud bangs behind us.

32 **How should the missing word in the sentence below be spelt? Write A, B, C or D in the answer box.**

I ______ a bank statement every two months.

A receive
B recieve
C receave
D receeve

Answer:


0042 8748
34 73 0028 5748
SSEE
3267 5457 0028 5748

Transaction
Direct Debit - UK Telecom
ATM - Leeds city centre
Dale Farm Bakery
INSURE - Car Insurance
Blythes
ATM - Bradford train station
ATM - Leeds city centre
ATM - Leeds city centre
ATM - Leeds Train Station
ATM - Leeds city centre

Withdrawn
£ 30
£60
£87.67
£34.99
£10
£20
£20
£10
£40

Deposit
£945.63

Balance
£ 270.54
£210.54
£1156.17
£1068.50
£1033.51
£1023.51
£1003.51
£980.5
£970.5
£930.5

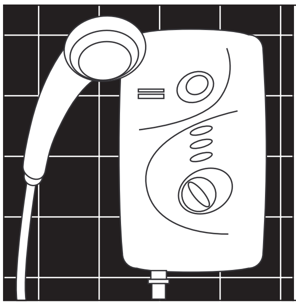
Page total

How are you doing?

Happy to go on?
If not, tell the person in charge.

Column for assessor mark.

33 **Read the information taken from a shower guarantee leaflet.**
What do the underlined words mean?
Write A, B, C or D in the answer box.



To register for your FREE shower guarantee, call 0800 076 1234 (freephone) and quote the reference number: MSGH56D

Please note, non-registration does not invalidate your statutory rights.

A If you don't register your guarantee will be worthless.
B Even if you don't register you will still be covered in law.
C You must register in order to be covered by the law.
D You need a valid reference number for the guarantee to be legal.

Answer:

Page total

Column for assessor mark.

34 **Read the information below.**

The Supermarket supervisor spoke to her team at their regular Monday meeting. She said, "Congratulations to you all. Sales must have been really brilliant over my weekend break. Judging by the empty shelves, the litter decorating the floors and the dirty footprints through nearly all the aisles, you must have all been extremely busy. I would like to thank Mikhail especially. He must have been so busy helping customers get their shopping to their cars that he had no time to collect up all the trolleys that are now scattered around the car park."

Which of the following statements describes how the supervisor is feeling about her staff?

The supervisor is:

A displeased with sales
B praising her staff
C being ironic
D happy with staff efforts

Answer:

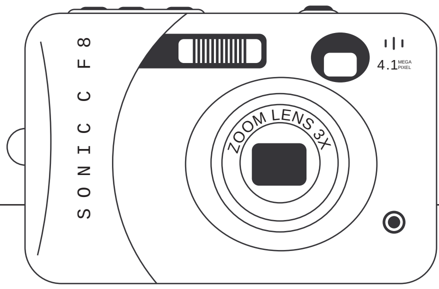
Write A, B, C or D in the answer box.

Page total

Column for assessor mark.

35 **In each case below, decide whether the person is stating a fact or giving an opinion. Tick the appropriate box.**

	FACT	OPINION
The shop's manager said that she felt the new Sonic CF8 was the best camera available in that price range.	☐	☐
The shop assistant confirmed that he was able to offer a discount of 25% on all colour printers in stock.	☐	☐
The manager said she thought that all the facts pointed to a decline in interest in digital cameras.	☐	☐
The assistant felt that the zoom lens on the Sonic CF8 camera was its best feature.	☐	☐



Page total

Column for assessor mark.

36 **Read the note below and then complete the order form.**

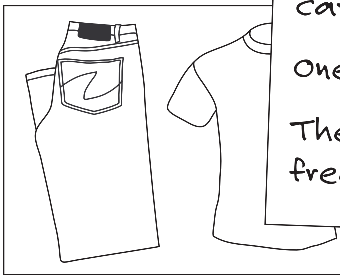
14 December 2005

Dear Mum

Would you order this from the new mail order catalogue please (page 125) - I'll pay you later!

One pair of jeans (green - medium).

The order MUST go off today so that I get the free special offer.



Description	Code	Size	
T-shirts navy green yellow	**T-shirts** G27NA G27GR G27YE	small/medium/large	£10.99
Jeans blue green black	 G28BU G28GR G28BL	small/medium/large	£19.99

PAGE 125

Order Form **Date:** -12-2005

Description of goods	Code	Quantity	Size	Price per item

Page total

PART B READING AND WRITING

Column for assessor mark.

37 **A word in this document is incorrectly spelt.**

Write the word correctly in the box provided.

Answer:

Dear Sir

I am returning the toaster that I purchased from you together with the receipt. Within a week of purchasing the equipment, the switch broke. I am a competant and well-qualified electrical engineer and worked in

38 **Punctuate this sentence correctly.**

It is important that all volunteers attend this weeks meeting.

Page total

PART B READING AND WRITING

Column for assessor mark.

39 **Read the following.**

Parents' Committee

Minutes of Parents' Committee Meeting 23 July 2005

1. The new Art Block

The Headteacher reported that the architect working for the developers and contractors involved _____ becoming increasingly worried that the new Art Block will not be ready for the new term.

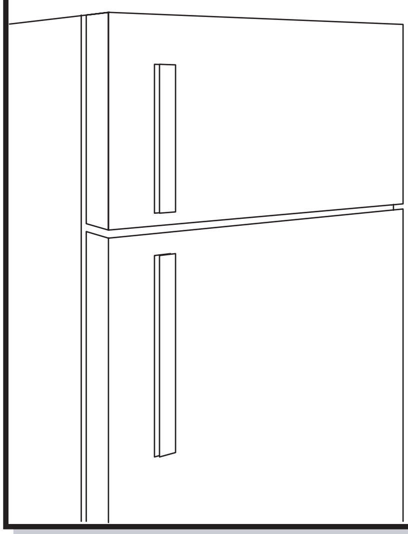
The missing word is:

A are
B were
C is
D will

Answer:

Write A, B, C or D in the answer box.

40 **Proofread the following. There is one error. Write the incorrectly spelt word correctly in the box.**



I bought a new refridgerator at your shop two weeks ago and it has not yet been delivered. Unless I receive it next week I shall cancel the order and insist on full compensation. Delivery any time after 3.00pm is convenient.

Answer:

Page total

Tool total

Level

Name:	
Centre Name:	

Scores

Overall Score ☐

Level ☐

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