Cognitive Usability: Using Human Factors to Influence Future Online Usability Requirements

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ABSTRACT
Inaccessible websites can cause a variety of problems for the older adult population. While most contemporary accessibility research is geared towards creating solutions for users with visual or motor difficulties, in comparison, very little work has been undertaken to evaluate users’ cognitive abilities. As a result of this, little is known about the impact of cognitive factors on web design and how this can affect a user’s individual understanding of content that is made available. This paper explores ‘cognitive usability’, combining the areas of cognitive psychology and web usability. This is done in order to investigate the relationships between cognitive attributes and website interfaces, then to suggest methods that may improve the cognitive usability of websites. By reporting on initial findings and describing current research activities, this paper demonstrates potential techniques that can help older adults become more engaged within the digital economy in order to positively impact their digital lives.

Categories and Subject Descriptors
H.3.3 [Information Systems]: Information storage and retrieval—Search process, H.5.2 User interfaces—Theory and methods; J.4 [Computer Applications]: Social and behavioral sciences—psychology.

General Terms

1. INTRODUCTION
The theory of fluid and crystallised intelligence, introduced by Cattell [4], examines how an individuals’ cognitive abilities can be split into differing factors. Fluid intelligence is described as the ability to adapt to a particular situation because of an individual’s problem solving abilities, whereas as crystallised intelligence is described as adaption based on previous knowledge of a particular domain. Cattell’s theory was then complemented in later years by Carroll’s ‘Three Stratum Theory’ [3], where cognitive intelligence is broken down into a further 6 broad categories. These two theories were combined and the CHC Model (Cattell, Horn and Carroll) of general intelligence was introduced.

Horn established that as people age, changes occur within their cognitive functions [13]. While the extent at which cognitive decline in aging has been questioned and defended many times [2, 12, 14, 17], the one common factor is a deterioration in performance on fluid intelligence factors from the late teens. In contrast, crystallised intelligence continues to grow until later life and then rapidly deteriorates [13].

The decline of users ability can differ greatly between individuals, and this can be influenced by factors including social, cultural and personal aspects [11]. This is echoed as far back as 1972 with Chown stating that ‘it is not possible to produce a single measure of how ‘old’ a person is; we can only produce a profile which will tell us how ‘old’ he is on a number of different measures’ [6]. It has been shown that the usage of new technologies by older adults is a very complicated issue and is affected by a vast number of factors – of which these cognitive abilities are only a subset [8].

This paper presents findings within a research study concerning the problems faced by older adults when searching for information online. This draws on aspects of cognitive ability, previous Internet usage, and Internet experience to act as indicators as to how effective information retrieval based tasks can be carried out online. By developing a greater understanding of the links between Internet usability and user cognitive factors, it is hoped that additions can be made to current usability guidelines in order to aid future design within the web community.

2. RESEARCH METHOD & RESULTS
2.1 Preliminary Study
An initial study was used to examine behaviours when searching for information online. This was undertaken in order to gain an understanding into potential cognitive measures that act as influencers into web searching tasks.

<table>
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<th>Table 1 - Older Adult Performance Groupings</th>
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<tr>
<td>Low (N=6)</td>
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<td>M</td>
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<td>Fluid Intelligence</td>
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<td>Internet Usage</td>
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Older Adults (N=12) between the ages of 61 and 78 (M=67.17, SD=5.357) were recruited from within the SiDE user pool [20]. Participants underwent a series of testing that allowed grouping to occur by their fluid intelligence (tested by letter sets [10]), crystallized intelligence (Shipley vocabulary [18]), processing speed (number comparison [10]) and Internet usage (computation span [16]). The created high and low groups were tested using an
independent sampled t-test and were all shown to be statistically different from each other (see Table 1).

Once completing all cognitive measures, participants were invited to take part in a one-to-one session where they were given a set of different online scenarios to carry out. Participants were given three different scenarios to work through, providing information about their methods of using search engines and navigating through websites. The scenarios simulated some of the websites that may be visited when booking a holiday, such as buying flights, finding a destination and discovering attractions in the local area.

Screen capture software was used throughout the study, as well as microphone audio recordings of the conversations between researcher and participant. These media sources were analysed and individual pieces of data retrieved that were relevant to generating an understanding of search habits. Variables collected are shown within Table 2.

Multivariate ANOVA testing was carried out on the collected data with no interaction occurring between any variants. However, a standard ANOVA testing (summarised in Table 2) indicated that crystallised intelligence could be used as indicators of the speed at which older adults can both carry out search queries and influence the amount of pages they will visit per minute. This result were as expected, with higher level of crystallised intelligence supporting the knowledge driven (top down) approach to information retrieval suggested by Chin et al. [5]. It was also concluded that previous technology usage acts as an indicator, which was again an expected result: the more time that an individual spends doing a particular task, the more efficient they become in completing it.

2.2 Current Work

By continuing to look at the effect cognitive abilities has upon individuals internet usage (as discussed in the preliminary study), the current work focuses more on the usability problems that exist when carrying out information retrieval tasks. This is being done to look for correlations between cognitive abilities and usability metrics. Recruitment of participants is done through the same methods as used within the preliminary study, with the addition of cognitive testing regarding short term memory (tested by auditory number span test [10]) and long term memory (meaningful memory [21]).

Participants are invited to take part in a one-to-one session where they answer a series of fact-finding questions by carrying out search tasks on specific websites. 30 websites have been selected and an individual question created for each one in order to test how a user navigates through the site. Sites are selected from the top 100 websites in the UK with questions grouped into six categories (health, shopping, news, government, banking and local information). Each question task required the participant to visit between two and five pages on the optimum path. However, the number of pages that a participant may visit will increase if they use an alternative path.

Data logging is taking place during the study to monitor participants search behaviour, with pages visited, time spent on each page and the overall path created through a particular website being extracted from the created web history file at the end of the study. During each question, the researcher takes notes on how often the participant refers back to the question asked in order to remember the search topic, the use of any additional website features used that may not be picked up by the web history file and whether each question is answered correctly or passed on. After each question, the participant fills in a short questionnaire detailing how easy they found the particular website to use and how lost they felt while trying to find the information. This questionnaire is taken from [1], a study comparing automated measures of website complexity to individual participant responses. The system used in order to carry out this study is described within [7].

Information regarding usability of individual website pages has been collected with reference to various government usability guidelines that are freely available online [9, 19]. These are being processed to create a single combined set of guidelines that can be used as a reference set both within this work and also future practice. Once this reference set has been completed, it will be used in order to analyse individual pages visited within the current research study. This reference set will then be combined with cognitive ability factors and correlative analysis will occur based upon these two aspects. This will allow for a further insight into the ways in which cognitive factors can impact upon web usability.

2.3 Future Work

While current work looks at identifying any correlative factors between web usability and cognitive factors, future research will work on the validation of any correlations that are made. In order for this validation to take place, further analysis of these web usability metrics will be required, with a focus on testing individual metrics within website development. By looking at how usability metrics relate to cognitive functions and using this as a method of developing websites, it is hoped that further understanding of the relationships between the two can be achieved.

3. CONCLUSION

This paper reported on initial findings that have emerged from a study investigating the problems faced by older adults when searching for information online. It has indicated that differences in varying cognitive factors and computer experience can act as indicators to web performance within older adults. This was followed by describing how current work is expanding previous results by using a more detailed approach in order to further increase an understanding in this area.

When investigating the different cognitive characteristics of individuals, and using this as a basis for examining usability problems that occur on websites, correlations between cognitive problems and usability issues bring a new way to examine online usability in a more user focused manner. Further research within this area could potentially be of great impact to the usability community as a whole. This further work may help stimulate more older adults to be engaged with online technologies and can increase their participation within the digital economy.

4. ACKNOWLEDGMENTS

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ACKNOWLEDGMENTS
5. REFERENCES


[18] Shipley Shipley Institute of Living Scale.


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* p < .05. ** p < .01.