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A Tangled Web? How People with Learning Disabilities Negotiate the World Wide Web: The Accumulating Evidence

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Abstract— In the 20 plus years of the World Wide Web as a mass communications and information channel, only a small body of research has studied usability issues of the Web for this cohort. This review examines historic and current research and thinking around effective web design for people with Learning Disabilities, including an exploration both of methods used and key findings. A comprehensive literature review was undertaken encompassing material from the fields of education, social sciences, computer science and health. In examining the literature, an analytical proforma was used to elicit information, evaluate and compare studies. Results suggest that, unsurprisingly, finding content from a large quantity of text, scrolling and navigating pages are all problematic. Less predictably, and despite standard guidelines on web usability with this cohort, which exhorting web developers and information providers to include images to aid content understanding, research in this area has produced contradictory findings, from having little or no benefit in terms of access to information, to significantly aiding comprehension. The wide focus of the studies, different methodologies adopted, and varying cohorts who are labelled as having 'learning, 'intellectual' or 'cognitive' 'disabilities' or 'difficulties' hampers the development of a reliable evidence base on the issues.

Keywords— Usability, learning disabilities, web site design, interface, accessible content. 'easy-read'

I. INTRODUCTION

There is a paucity of literature around website design and people with learning disabilities. Rotondi et al [1]: (p205) undertook an extensive literature search and review of guidelines addressing 'cognitive deficits' and found that 'design recommendations for persons with cognitive deficits were based on the authors' knowledge and experience with persons who had physical and sensory disabilities' (i.e. rather than intellectual or Learning Disabilities). Also, 'there has been no usability research on the types of designs that are effective for … persons [with cognitive deficits] … Virtually all published website usability studies have focused on people with standard information-processing abilities' (p204). Although these observations were made as far back as 2007, they still hold even today.

This review examines work that has been done specifically with (or concerning) people with Learning Disabilities and their use of the World Wide Web, with particular emphasis on measuring the usability of web sites and pages. Where little research has been undertaken (with regard to the efficacy of images as aids to the

understanding of text content, for example) research using other media is outlined. Clearly, this is not a perfect solution, but may nevertheless suggest issues that may pertain to an electronic medium. As this cohort, by definition, have a low level of literacy, guidelines tend to emphasise the use of images [2], [3] the issue is clearly worth exploring.

II. METHOD

Research papers were sought from the fields of education, psychology (and social science in general) computer science and health. The writer has access to the resources of two major UK academic libraries, each of which operates a 'federated search' that facilitate simultaneous searching across multiple and multi-disciplinary database resources.

Search terms included "learning disabilities" and related terms (intellectual, cognitive … etc.) usability, accessibility, "website design" along with "information provision/retrieval" etc. Literature both cited in these articles, and later papers citing *them*, were also perused. Papers were classified into primary research, literature reviews, etc. The former were also classified by area of interest (e.g. navigation, recognition of icons etc.), methods and sample type (e.g. 'cognitive disabilities', 'intellectual disabilities' etc)

III. FINDINGS

As mentioned in the introduction, empirical evidence around website usability and subsequent optimal design for people with Learning Disabilities is somewhat limited. Despite this, however, many different approaches are evident in the literature. These include looking 'globally' at website usage, either with one site as the focus [4], [5] or a comparison of sites, whether an 'accessible versus a 'mainstream' site [6], [7] or various 'accessible' websites or pages [1], [8], [9]. In addition, studies have been carried out which have been focused on specific elements, such as hyperlink representation and positioning [1], [8], [10]; specific search engines [11], [12]; use of images [9], [13]

A. 'Global' studies

These are studies examining the use generally of one or more web sites. One approach has been to test the usability of two versions of a website - a 'conventional' site and one adapted on the basis of 'easy-to-read' guidelines. Karreman et al, [6] undertook such a study, with two groups of 20 participants. One group had intellectual disabilities (ID) but could read, and the other group did not. The investigators tested whether the easy-to-read website was more accessible and usable for the participants with intellectual disabilities. 'Easy-read' and 'standard' versions of a website for a particular welfare and care organization were developed. Both versions were used by each group in answering a series of questions related to content, and tested for efficiency (searching and reading time); effectiveness (comprehension), and satisfaction.

Results showed that, in terms of site comprehension, the accessible site was significantly better, increasing understanding for both groups of participants. Regarding site satisfaction, each group liked the website best that was geared to [their needs]' (p517). Thus, there could be a 'carefully attuned mix of adapted and non-adapted verbal content' and that 'information which is visible at high-level pages could be made easy-to-read, with links to more specific, non-adapted information for those who want to know and read more' (p518).

Sevilla et al, [7] created a 'simplified' web browser, consisting of 'Back' and a 'Home' toolbar buttons only, and with no content below screen level for a standard laptop screen. This was then compared to a 'conventional' site in terms of ease of use/browsing. Twenty participants with 'mental retardation' browsed the sites, first with teacher-directed and then free navigation. Success was measured in terms of specific events observed, such as use of the back button. Results showed that participant performance (including 'searching' although no set tasks were given) improved significantly when the accessible site was used.

Williams and Hennig [8] tested 'accessible' web sites of different design layouts which used various combinations of menu position (vertical or horizontal), text size and the absence or presence of images. The aim was to determine how information can be optimally presented for people with Learning Disabilities. The designs were tested with people with low levels of literacy (104, ranging from 17 to 63 years of age). Task-time was used to determine the efficacy of the different page designs. Interface One (horizontal menu, no images and small- text) facilitated the fastest information access, and Interfaces Six (vertical, no images and large text) and Eight (vertical, with images and large text) were the slowest. Surprisingly, the small-text condition was negotiated quicker than large. Images did not appear to aid understanding or facilitate quicker access to

information, and thus have only limited value - contrary to assumptions made in standard guidelines, such as those by the World Wide Web Consortium[1].

The major finding of the study, however, was that when formally seeking information, people with Learning Disabilities appear to imbibe content in an exaggerated linear form coined by the author as 'serial access'. This means that all of the information is taken in sequentially, until the required content is reached. Serial access is not the same as linear access. The latter includes skimming/ignoring inconsequential or trivial words, whereas the former consists of the processing of information not only sequentially, but word by word, regardless of importance and without the predictive aspect of text consumption enjoyed by mainstream readers.

Thus, images were ignored until reached 'serially' via accompanying text being methodically negotiated; and that information took longer to be accessed from vertical menus, possibly because of distracting text at their side which drew the attention of the participants who felt compelled to read it. The small-text content was consumed quicker than the large-text, as the latter took up more lines – another indication of serial access in action. The added lines necessitated by the large-text condition took more time to negotiate, as it requires more eye movements to read text where more lines are present. Finally, task-time was not affected by task order - also suggesting 'serial access' behaviour. Significant decreases in task-time with task familiarity would have suggested that the imbibing of the information had become more sophisticated by speed-reading and skipping trivial words, in search of specific key words or phrases (or, indeed, of images or other non-text elements). By reading 'serially', task-time differences are minimised.

Study participants were also asked for their preferences via a 'smiley-face' rating scale and simple interviews. Preferred designs were for large text and images. This was the reverse of those facilitating fastest information-access times, a discrepancy due to preferences being judged on aesthetic considerations. Design recommendations include using a horizontal menu, juxtaposing images and text, and reducing text from sentences to phrases, thus facilitating preferred large text without increasing task times. At least one other study has shown discrepancies between preference and performance. Singer and Alexander [14] explored possible differences in comprehension between digital and print texts with under-graduates and between preferences and performance. The study found that despite a 'marked preference' for the electronic medium a significant number 'demonstrated stronger comprehension in the print medium than in the digital medium.'

Harrysson et al, [15] observed a small sample of users (seven,aged 15-44 years) as they navigated between different accessible web sites, consisting of 'minimal text' and illustrations using a standard web browser. Participants used navigational buttons and hyperlinks with ease. However, they had difficulty in writing a URL or a search term. The researchers concluded that the 'the processing of text can impede accessibility to the Internet for people with cognitive disabilities' (p141).

Williams and Hanson-Baldauf [16] tested a web site for usability that had been designed specifically for individuals with Learning Disabilities and, indeed, produced by them, which contained information around the transition from school to supported adult life. Seven individuals aged 14–16 years with mild Learning Disabilities participated in the study. Set tasks and free exploration were observed. In the free exploration condition, participants accessed a great number of pages but appeared to imbibe very little meaningful information. In undertaking set-tasks, a more considered approach was adopted, although much information was still missed through haste. Scrolling proved much more difficult for some than in the free exploration phase (although none had physical disabilities) and others did not appear to realise that pages continued below screen level.

As part of the same research programme as the study reported above, Williams [5] examined whether people with very low literacy skills were able to navigate a site by navigating using only information given by images (e.g. a photo of some coins and notes, to represent money), and access and understand audio information. Results elicited various issues including the difficulty in understanding some of the images used, due mainly to the limitations of representing abstract concepts in pictorial form; activating hyperlinks (the active area, or 'hotspot' not being large enough), and accessing the audio (some participants did not recognise the 'loudspeaker' audio button. Two accessibility issues were also found – poor mouse control and involuntary activation of the context menu, occurring when the mouse is 'right-clicked'.

[1] https://www.w3.org/WAI/people-use-web/abilities-barriers/#cognitive

B. Hyperlink representation / positioning

Rotondi et al [1] also compared various different 'accessible' website menu layouts. The aim was to 'develop an understanding of the design elements that influence the ability of persons with severe mental illness (SMI) and cognitive deficits to use a website, and to use this knowledge to design a web-based telehealth (sic) application' (p202). Ninety eight people, all with 'a severe mental illness' took part in the research.

Various website interface menu designs were developed, with testing reducing the number to three. These were:

- One: 'Strict modular abstract': two navigational dimensions - unchanging menu items across the top; context-specific items vertically.
- Two: one navigation dimension. This was a table with high level entries on the left and lower levels on the right, the latter being more descriptive/explicit.
- Three: 'flat explicit weak-modular': lower-level topic or labels (and therefore a higher number of modules or pages), achieved by using drop-down menus. (Ibid, p213).

Twenty-six participants undertook the usability element of the study, being asked to choose links where they expected to find information on a specified topic or resource. A website taking into account all the results (Model Four) included the following features:

- Long labels for links 'thus reducing or eliminating a user's need to think abstractly' (p216);
- Pop-up menus activated on 'mouse-over' (replacing dropdown menus, which had proved troublesome);
- A constant navigational bar at the top of each page, always visible.

Rocha et al, [10] investigated whether hyperlinks in menu lists are more perceptible with text or with images for people with 'intellectual disabilities'. The study was based on direct observation, video recording, interview and an eye-tracking device. Results showed that participants (n=10) found the correct links quicker when presented as images (with audio) rather than as text (again, however, with audio). There was also a greater improvement in performance with the images condition.

Williams and Hennig [8] tested whether a horizontal or vertical menu/contents arrangement facilitates faster access to content for people with Learning Disabilities. Participants were timed as they looked for and then clicked on one word "dummy" menu entries appearing along a horizontal or a vertical grid (e.g. 'girl', 'dog', 'house' etc.) in a "word-search" type activity (i.e. a picture of a girl required participants to find the 'girl' entry on the menu list – whether being presented horizontally or vertically). Once a word had been found (or the system 'timed-out) the list and images were refreshed.

Mean search times increased as the position shifted from left to centre to right and from top to middle to bottom. Thus, participants undertook the test as if it were a reading exercise, despite the images appearing in the centre of the page - so one would expect words positioned in the centre or middle of the list to be found quicker, due to the juxtaposition of word and text. The research also suggests that a horizontal menu may be more effective than a vertical one, with the most important links placed on the left.

C. Search engine usability

Rocha et al [11] were interested in the use of search engines by people with 'intellectual disabilities'. The authors point out that people with learning or intellectual disabilities tend to have low levels of literacy, and that they may therefore have difficulties with 'textual inputs (using keyboards)' (p582). They compared users' interactions with the layouts of two search engines, Google and a Portuguese system named SAPO. These were chosen as the two most popular used in Portugal (the nationality and location of the researchers). The two engines were also considered to be very different - Google to have a cleaner layout, with 'only the tools to perform search' displayed on the page; as opposed to SAPO, 'where the web search [box] is presented alongside several kinds of other contents: advertising, videos, images and text'. (p584). The researchers wished to see whether these different layouts had an impact on the effectiveness of the search experience. Twenty people undertook the study (eight women and twelve men), whose ages ranged from 19 to 44.

Users were asked to identify the search boxes for each engine, perform a search (by entering, individually, the Portuguese words for 'cat' and 'dog') and recognize the resulting hitlists. Results showed that the 'cleaner' Google search interface was significantly easier to negotiate. It had a success rate of 75 % in terms of the search box being identified, as against 50 % for SAPO. Similarly, the Google search button identification had a success rate of 85 %, with SAPO's at 65 %. The researchers were also interested in whether the second search performances were executed quicker than the first – in other words, whether the participants had learned by

experience. This was indeed the case with Google, where search times decreased by 10% on the second iteration. However, they increased for SAPO, by 12%. The researchers blamed this on users 'feeling lost when presented with a lot of information' (p586) although, of course, the interface was the same for both tasks. It might be, by contrast, that as they were performing another task, they might have expected the conditions (in this case, page layout or, at least, the position of the search box) to have changed.

Finally, with regard to this paper, the authors recognise that 'Google's speech recognition application could … be considered an alternative for interaction'. However, the researchers found (in unreported work) it to be 'prone to errors due to poor word pronunciation'.

Sitbon et al [12] observed 30 'digital natives (so-called apparently because of their relatively young ages, of between 18 and 35) with intellectual disability' using one of two search technologies (web search or video search). Four of these 'focused on the participant's current information seeking practices; they demonstrated how they would search for a piece of information on a web search engine. Eight … focused on the trial of a tablet application … designed according to universal design guidelines to retrieve videos from the Youtube platform' (p3). In addition, 30 people were observed using these platforms in an apparently naturalisti manner (no set tasks were described in the methodology).

Although participants were said to have 'a range of moderate to severe intellectual disabilities', 'Most [participants] appeared to know where the search bar was without assistance and seemed to have no problem knowing which symbol to press to enter search terms' (p4). All could use a keyboard to type in their search terms, although help was given with spelling. Results were often judged on images (presumably a YouTube preview), and titles or other textual information tended to be ignored.

Interviews also looked the context for seeking information. Participants were motivated by either emotion (e.g. seeking videos of people winning at a game or videos of sunsets), social connection (… sharing something they already know), or achieving long term goals (how to find a job …) (p4)

D. Use of images

Images, in the form of photos, icons or other pictorial representation often accompany hyperlinks, most notably in contents or menu lists. However, Poncelas and Murphy [17] note that 'there is almost no published research investigating whether the use of symbols does increase the understanding of written material'(p466). This is particularly true with regard to electronically-mediated information. Williams and Hennig [9] suggest, from the research cited above, that adding images to text or to hypertext menu entries does not aid the speed of access to information for people with low levels of literacy.

Choi and Bakken [13] created a multimedia educational Website for 'low-literate adults' attending a Neonatal clinic in the United States. This included pictographs and photographs, and an audio version of simplified text. Results showed that pictographs showing information such as how to take a baby's temperature) were well understood by the participants. However, photographs 'gave more realistic images' (p572). The authors opine that photographs 'are loaded with irrelevant details that are likely to attract the attention of low-literate users rather than key concepts' (p572).

Rocha et al [18] also explored different types of pictorial representations, but the focus was more on the *function* of the representation, rather than on the medium. The authors were particularly interested in how best hyperlinks could be represented in pictorial form, and thus relate the representations to an electronic environment. They loosely based their work around the concepts of semiotics, the science of signs. A sign is anything that communicates a meaning about or represents something. As Rocha et al point out 'Saussure has described signs as the unity between a "signifier", which is 'the actual sign embodied in some material form, such as words or shapes' and 'the signified (what the sign is supposed to mean)' (p2)

The sample consisted of 20 individuals with intellectual disabilities, aged between 22 to 49 years. The researchers asked participants to list their favourite activities and then invited them to perform a drawing activity, 'in which they had to make drawings ac- cording to four established categories, music, games, sports, movies, as we intended to unveil which kind of representation they were more familiarised with, revealing data regarding their mental models' (p4). From these drawings, three distinct functions of image representations ('signifiers') were formulated (Object, Action and Universe), 'tailored' to fit to four of the different categories (music, movies, sports, games) described as interests by participants. These were:

- 'Object' had a close connection to the 'thing' being represented, and thus being simpler to recognise (a 'signifier' looking like headphones, for example);
- 'Action' combined a graphical representation with its interpretation (mode of use, action) (p2). The example given was someone listening on headphones, and;
- 'Universe' was 'more complex in meaning, more symbolic and abstract a representation'. Thus it 'requires knowledge for their decoding' (a musical note sign).

Participants worked one at a time, look at a screen showing all the images for each category, and stating both images preferences, and those which they felt best represented each activity.

Perhaps not surprisingly, results showed that 'there was a strong preference for Object image-type representation, followed by Action image-type representation, in each category [and] little or no preference for the Universe image-type representation. The authors conclude that choices were influenced by 'activities and tasks that the participants performed and recognised on a daily basis', and that those not selected were 'too complex to decode' (p10). Thus, object-type representations are better as image hyperlinks as they better assist navigation for the cohort.

The writer also compared image types in an effort to determine the most effective depictions of transition-related topics with regard to types of photographic and artistic representation, in order to inform website design [19]. As with Rocha et al [10] the focus was on making hyperlinks easier to follow, and like that study, the idea was only to examine participants' interpretations of the meanings of the depictions, and not to compare modalities or functions of the representations. The study was undertaken in two stages. A qualitative stage explored the meanings given to various photos and icons, selected from appropriate websites and literature. Stage two consisted of an online exercise, in which participants are presented with various photos or other representations and select which category the belong to (health, work etc.). Results suggested that, whilst apparently sensible, the use of images 'may not actually aid understanding of content, because of the difficulties inherent in attempting to encapsulate concepts within a single pictorial representation. Similarities between concepts typified by groupings such as Safety, Health and Support, and Leisure, Education and Friends – all typical transition-related topics - make the task even more difficult' (p302).

Topics that were perhaps more 'concrete' or easier to visualise, such as Friends, Work and Going Out were found to be easier to represent pictorially than concepts such as Living on Your Own, Support or Safety. Of course, as argued in the paper, symbols or photographs could become familiar with further exposure on the website, particularly where usage support is offered by a carer or family member. However, 'the goal of accessibility is surely to enable people to find information without substantial prior training – this study has shown that facilitating this situation requires more than simply populating a website with images thought to be relevant by the information provider' (p302).

IV. DISCUSSION

Findings overall suggest that 'accessible sites' – such as those with fewer menu entries and buttons [7]; incorporating audio [20] and 'easy read' text [6] do facilitate information access for people with Learning Disabilities. Difficulties elicited from the literature include finding content from 'a large quantity of text' (Harrysson et al, 2004: p141), managing 'pop-ups' (Choi and Bakken, 2010), scrolling (Williams and Hanson-Baldauf, 2010), negotiating a vertical menu layout (Williams and Hennig, 2015a 2015b).

Work examining the efficacy of images or icons has had contradictory findings. Williams and Hennig [8], in a rare examination of web-based text and images, found no benefit in terms of access to information. Poncelas and Murphy [17] found no improvement in understanding when text was accompanied by symbols or icons. However, Choi and Bakken found that in a health information website, pictographs represented information clearly, and were well accepted by participants. Similarly, Jones et al [21] found that symbols significantly aided the understanding of text – as much health information/education research has also shown. Rocha et al [18] showed that images that were close to the object being represented, and that people could relate to as showing familiar activities were the most effective substitutes for text.

Finally – but perhaps most importantly – some recommendations can be elicited from the literature. In terms of content, Karreman et al [6] suggest 'high-level' pages be made 'easy to read' with more specific content available through links; and Willliams and Hennig [8], [9] that the most important text be situated at the top of a page with no distracting side menu bar. Not surprisingly, screen-readers – usually associated with web use by visually-impaired people - have been recommended [15]. In general, information repeated in different forms (e.g.

text, audio or picture) appears to aid understanding although, for readers, reliance on audio or pictures (i.e. removing text) may not be effective [20]. Rocha et al, [10], however, found that an audio with images condition aided comprehension more than text with audio – illustrating the difficulties in making recommendations based on a somewhat limited corpus of research.

Regarding navigation, [7] found that a simplified toolbar was beneficial. These researchers also recommend a page which does not require a scroll bar, although the alternative of using 'paging' (splitting content into smaller chunks on separate pages) does not appear to have been tested in the literature, despite other evidence (e.g. [16]) noting problems with scrolling. Conversely, Rotondi et al [1] recommend a large amount of content per page to reduce the need for navigation. In terms of labelling, 'long' labels may be recommended, to avoid users having to imply or think abstractly about meaning.

V. Conclusion

To conclude, as with research into the usability of mobile devices, reviewed recently in this journal by the writer and a colleague [22], the literature encompasses a huge range of methods, foci of research and varying descriptions and level of detail about the cohort of interest. The former have included comparing an 'accessible' website against an unadapted version [6], [7]; comparing various apparently accessible sites [1], [9]; examining performance on one site only [12], [15], or focusing in on just one attribute, such as menu position [8] or images and image placement [10]. These different approaches have been accompanied by a huge number of data gathering instruments: search and reading time [6]; content comprehension [21]; error frequency [6], and even non-verbal cues [7]. Also, the research is often without follow-up studies possibly because the research is undertaken to build or improve a particular web resource (e.g. [1]) which may not then be examined a second time. These factors all make it very difficult to accumulate a coherent body of evidence around this subject. However, two general conclusions may be made. The first is that what may appear intuitively to assist in usability – such as to use images to aid comprehension, or use a large text size – may have only limited or no value. Following from this, it seems clear that a policy of end-user involvement is the best policy in terms of eliciting both difficulties and solutions. This entails both adherence to inclusive research principles [23] and consideration of universal design [24]

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