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Do Web Users with Autism Experience Barriers When Searching for Information Within Web Pages?

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ABSTRACT

Elements related to cognitive disability are given lower priority in web accessibility guidelines due to limited understanding of the requirements of neurodiverse web users. Meanwhile, eye tracking has received a lot of interest in the accessibility community as a way to understand user behaviours. In this study, we combine results from information location tasks and eye tracking data to find out whether users with high-functioning autism experience barriers while using the web compared to users without autism. Our results show that such barriers exist and there is higher variance in the scanpaths of the participants with high-functioning autism while searching for the right answer within web pages.

CCS Concepts

•Human-centered computing → User studies; Web-based interaction; Empirical studies in accessibility; Accessibility design and evaluation methods;

Keywords

Web Accessibility, Autism, Eye Tracking, Accessibility Guidelines

Open Data

The materials, task descriptions and eye tracking data used in our study are available in our external repository at: http://iam-data.cs.manchester.ac.uk/data_files/32.

1. INTRODUCTION

Cognitive disabilities can impact the way people use the web and therefore their access to information, academic success and employability prospects. Previous research has identified particular issues such as: "difficulty in using the web due to limited reading comprehension, complexity, slower learning, limited fine motor control..." [12]. At the same time, elements related to cognitive issues have been assigned lower priorities in the web accessibility guidelines [1] and web accessibility for users with cognitive disabilities has been shown to lag far behind web access for other disability groups [12]. The reasons for this lag include, but are not limited to, the lack of understanding of the specific requirements of people with different types of cognitive disabilities and what difficulties they experience while using the web [12]. In this paper, we address this issue by investigating the way people with high-functioning autism search for information within web pages.

Although anecdotal evidence suggests that people with autism experience barriers and distractors when they access web pages, very limited empirical evidence is available to support this. In this paper, we present the first eye tracking study on web accessibility for people with autism, except from [7] which is a pilot study involving 4 autistic participants. Our study allows us to provide a comparable eye tracking data set from 18 people with and 18 people without autism obtained during a number of tasks for identifying information within six web pages. We show that the participants with autism are less successful compared to the participants without autism in locating the required information. We also show that the scanpaths[1] of the two groups are different, with higher variance observed among the participants with autism.

2. BACKGROUND

Autism Spectrum Disorder (ASD) is a disorder of neural origin affecting the areas of communication and social interaction [3]. It is a condition of rapidly growing prevalence, which has grown from 0.5 to 14.7 per 1,000 children over 1970-2010 [6].

A main characteristic of ASD is its heterogeneity. While some individuals at the lower ends of the spectrum may remain non-verbal and suffer severe intellectual disability, others may be highly-able and have normal or above-normal

[1]A sequence of points fixated by a particular user.

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intelligence. The latter are referred to as people with high-functioning autism. What is common between people from various degrees of autism severity as that often their attention patterns differ from the attention patterns of people without autism [13]. For example, the Weak Central Coherence Theory (WCCT) posits that the ASD cognitive profile is biased towards processing local sensory information with less account for global, contextual and semantic information [15], or, in other words, those people with autism tend to focus more on potentially irrelevant details which prevent them from perceiving the bigger picture. WCCT is in line with the stimulus overselectivity phenomenon in autism [16], where a part of the sensory information is neglected, causing "tunnel vision", a focus on detail to the exclusion of the bigger picture [18].

Idiosyncratic attention patterns among people with autism may have implications about the way they use the web and the way they search for information within web pages in particular. However, to the best of our knowledge, empirical studies investigating this problem are very limited. Although a number of autism-specific web accessibility guidelines exist (a comprehensive summary could be found in [5]), none of these were based on scientific studies. This highlights the gap between the need for accessibility solutions for this population and the lack of empirical understanding of the barriers people with autism experience while using the web. In this paper, we aim to address this gap by using comparable eye tracking data and results from information location tasks obtained from adults with and without autism.

3. EYE TRACKING STUDY

This study employed a between-group comparison design comparing the performance of people diagnosed with high-functioning autism and a control group of neurotypical participants on a web search task. While performing the task, their eye movements were recorded by an eye tracker. The stimuli used in this study (including the web pages, the questions and the procedure) were initially developed for another study involving neurotypical participants only, which served as a basis for the development of a scanpath analysis algorithm [9].

The participants were shown six web pages and asked to answer two questions per web page about finding relevant information on the page. Examples of questions are "Can you find a telephone number for technical support and read it?" or "Can you locate the link that you can download the free version of Babylon?". The full set of these tasks is provided in our repository. Those tasks could be completed without scrolling, and therefore the participants were not allowed to use any device to scroll such as a mouse.

Using the collected data, we investigate the following research questions:

1. **Success** – Is there a difference between groups in the success of correctly locating information on the web pages as a response to 12 web search questions?

   This question tests whether the participants with ASD had actual difficulties in searching for information on web pages as compared to the control group of neurotypical participants.

2. **Variance** – Is there a difference between groups in the variance of individual scanpaths?

   A main characteristic of ASD is its heterogeneity (see Section 2). This question tests whether the variance of individual scanpaths is higher for the participants with high-functioning autism, even though they all have the same type of autism.

3. **Trending Scanpath** – Is there a difference between the trending scanpaths on web pages between groups?

   This question investigates the differences between the typical paths followed by these two groups to complete their tasks. The trending scanpaths would also show us whether they use the same visual objects in the same order to complete a given task [11].

Materials: In this study, we used the screen shots of six web pages that were initially selected for and used in [9]. It means that all our participants visited the same version of the web pages. These web pages had been randomly selected from the top websites listed by ALEXA.com. The web pages had varying visual complexity, as measured by the ViCRAM tool [17]: Apple (Low), Babylon (Low), AVG (Medium), Yahoo (Medium), Godaddy (High) and BBC (High).

The areas of interest (visual elements or regions in which the raw eye tracking data is analysed) were defined by [9] based on the extended and improved version of the Vision-Based Page Segmentation (VIPS) algorithm, which segments web pages by using their source code and visual representations based on different granularity levels [2]. The segmented web pages are provided in our repository.

Apparatus: The device used for recording the gaze of the participants during task performance was a Gazepoint GP3 video-based eye tracker[2] (60Hz sampling rate and accuracy of 0.5-1 degree of visual angle). The screen shots of the web pages were presented on a 19" LCD monitor. The distance between each participant and the eye tracker was controlled by using a sensor integrated within the Gazepoint software, and was roughly 65 cm.

Procedure: After getting familiar with the purpose and procedure of the experiment, all the participants signed a consent form. The demographic data about age, gender and diagnosis was collected and a nine-point calibration of the eye tracker was performed. After the successful calibration, the participants were presented with the six web pages in a randomised order to deal with the memory effect (specifically, the pages were randomised for each participant) and asked two verbal questions per web page.

Our procedure was a replication of the procedure presented in [9] with a slight difference in the fact that the participants were only given 30 seconds to complete the search task instead of 120 seconds, so that the task could be sensitive enough to capture potential difficulties in performance.

Participants: The participants in the study were 18 adult volunteers diagnosed with high-functioning autism (12 male and 6 female) and 18 non-autistic control participants (10 male and 8 female). All the ASD participants had a confirmed clinical diagnosis of autism (formally diagnosed in the UK using the ADOS diagnostic criteria [14]) and had no developmental delay (IQ > 70). None of the control participants exhibited a high density of autism-related features

[2] https://www.gazept.com/

as measured using the Autism Quotient (AQ) test [4]. All the participants reported that they used the web daily and they had normal or corrected vision. The mean age for the ASD group was $\mu = 37.22$ with standard deviation SD $= 10.3$ and for the control group the mean age was $\mu = 34.18$, SD $= 8.05$.

Three of the ASD group participants were subsequently excluded from the analysis of the eye tracking data due to their inability to calibrate the device. We also recognised some problems in the recordings of two participants in the ASD group and one participant in the control group, and we also had to exclude them from the eye tracking data analysis.

4. RESULTS

In this section, we present our findings related to our research questions.

Success: Our first research question aims to investigate whether there is a difference between groups in the success of correctly locating information on the web pages. We compared the answers of the participants to the search questions. Each correct answer was given a score of 1 whereas each incorrect answer was given a score of 0. We then counted these scores for each participant. Our analysis indicated that the participants with ASD ($\mu = 10.83$, Median $= 11.50$, SD $= 1.72$) were less successful than the control group participants ($\mu = 11.56$, Median $= 12.00$, SD $= 0.86$) in locating the required information on the web pages. This result suggests that adults with autism tend to be less successful in locating the correct information on a web page under limited time constraints.

Variance: Our second research question aims to investigate whether there is a difference between the groups in the variance of individual scanpaths. To investigate this, we firstly generated the scanpaths in terms of the visual elements of the web pages. For example, if the user looked at the elements A, B, C, E and D respectively, his or her path was generated as ABCED. The individual scanpaths of the ASD and control groups are provided in our repository.

First of all, we used the String-edit algorithm which has commonly used in eye tracking research [10]. The String-edit algorithm transforms one scanpath to another one by using the minimum number of addition, deletion and substitution operations. The minimum number of operations shows the distance between the two scanpaths. For instance, the distance between JGHI and JGAI is equal to one because it is sufficient to substitute H with A to transform one of them to another or vice versa. The distance can then be used to calculate the similarity between the two scanpaths as a percentage. The String-edit similarity is inversely proportional to the variance. Specifically, when the variance increases, the String-edit similarity decreases. The results show that the ASD group had more variance as the mean similarity within the ASD group ($\mu = 33.4$) was lower than the mean similarity within the control group ($\mu = 37.8$). If we combine these groups, the mean similarity ($\mu = 36.7$) will be lower than the mean similarity of the control group ($\mu = 37.8$) because the ASD group will cause to decrease the similarity due to the high variance within the group. This situation is the same if we randomly select some users from the control group and some users from the ASD group ($\mu = 34.5$). This analysis can also be found in our repository.

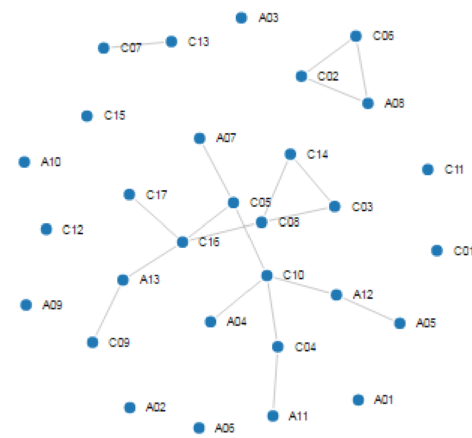

Figure 1: Scanpath similarity between participants with autism (A) and control group participants (C) produced using the ScanGraph tool [8]

We also used the ScanGraph tool which can produce and visualise a graph where similar scanpaths are connected to each other based on the String-edit similarity [8]. As an example, Figure 1 shows the advised graph (a graph with 5% of the possible edges) produced by the ScanGraph tool for the control group users (C01, C02, C03, ...) and the ASD group users (A01, A02, A03,...) on the Apple page. From this graph, we can see that the scanpaths of the control group are more similar to each other as there were more connections between control group users, and we can also see that the variance within the ASD group is higher compared to the variance within the control group.

Trending Scanpath: For our third research question, we investigated the differences between the trending scanpaths of the two already 'known' groups (based on our analysis above). We initially applied the STA (Scanpath Trend Analysis) algorithm to the individual scanpaths of the successful users in the ASD and control groups (who were able to complete the tasks by having at least one fixation on certain elements in an expected order) to identify their trending scanpaths on the six web pages [11]. This algorithm is designed to discover the most popular scanpath as a trending scanpath among users on a particular page in terms of its visual elements. It firstly takes a series of fixations for each user on a page and the visual elements of the page. It then correlates the fixations with these elements to prepare the individual scanpaths in terms of the visual elements. After that, it analyses the individual scanpaths to identify which visual elements should be positioned in the trending scanpath by selecting the elements shared by all users and the elements that get at least the same attention as the shared elements. Finally, it positions the selected elements into the trending scanpath based on their overall positions in the individual scanpaths. Especially, when a particular visual element is firstly fixated by most users, the element will be the first element of the trending scanpath. The full description of the STA algorithm can be found in [11].

We then compared the trending scanpaths of the ASD and control groups by using the String-edit algorithm again. We found that the trending scanpaths of the ASD group were not similar to the trending scanpaths of the control group.

Specifically, the trending scanpaths of the ASD group were ≈ 55% dissimilar to the trending scanpaths of the control group. However, based on these results, we cannot conclude that these user groups follow completely different strategies to complete their tasks as there were some commonalities between their trending scanpaths (≈ 45% similarity).

5. DISCUSSION

The results from the experiments presented in this paper showed that web users with high-functioning autism find it more difficult to solve information location tasks in web pages under limited time constraints. The reasons for their lower success could potentially be explained through the higher variability among the paths they follow to find the right answer. Unlike the control group, where most participants followed similar paths to identify the required information, the ASD participants were highly heterogeneous in their approaches to searching, in spite of the fact that they were all regular web users. The reasons for such heterogeneity could be explained with various effects of irrelevant elements on their paths. People with autism tend to focus more on irrelevant details [15], thus their paths may be affected by the irrelevant elements (which are not required for the completion of the tasks) at different levels. However, this should be further investigated in the future.

Further research is needed to investigate possible elements of the web pages which served as distractors for the ASD group, as well as ways in which web pages could be made more accessible for this population. However, it was shown that there are accessibility barriers to using the web even for the most able individuals on the autism spectrum and that they have different gaze patterns when searching for information. The issue must have a much bigger magnitude for adults at the lower ends of the spectrum or for children, who are only just learning to use the web. This evidence suggests that elements related to cognitive disability, and autism in particular, would need to be given higher priority in the future revisions of the WCAG guidelines.

6. CONCLUSIONS

This paper presents evidence that web users with autism experience barriers while they are searching for information within web pages. Compared to neurotypical users, users with autism are less successful in finding the relevant information on the web for them. Besides this, their scanpaths tend to be more variant in comparison with the scanpaths of neurotypical users, and their scanpaths are likely to be different from the scanpaths of the neurotypical users.

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