When Trustworthy Information Becomes Inaccessible: The Search Behaviour of Users with Dyslexia in an Online Encyclopedia

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Abstract. The ability to search for trustworthy information has become increasingly important. Access to information is key for a democratic, inclusive society. However, poorly designed search user interfaces exclude certain user groups. For instance, search systems with high demands for correctly spelled queries have been reported to be challenging for people with reading and spelling difficulties, such as dyslexia. In a qualitative pre-study, four adults with dyslexia were interviewed about their search experiences in an encyclopedia with low tolerance for spelling errors. The participants regarded the encyclopedia as highly credible and preferred using this source for factual queries. Nevertheless, the users with dyslexia were highly dependent on Google due to high spelling demands in the encyclopedia search interface. Although the participants found relevant information on Google, they reported the search process as tiresome, since the result list assessment required a significant amount of reading. In contrast, searching the encyclopedia provided direct access to neutral, evaluated information, thus removing the evaluation phase. Moreover, searching was frequently associated with feelings such as fatigue, frustrations and failure. Results from this study imply that search user interface design affects the information searching behavior of people with dyslexia.

Keywords. dyslexia, information search behavior, search user interfaces

1. Introduction

Democracy is based on equal participation and the ability to make informed decisions. The introduction of the Web led to easy access to a growing number of online information sources for most people, challenging both the use of reference books and traditional library services as sources for factual information [1][2].

There is a close relationship between a query and the precision level of the result list. Consequently, users submitting efficient queries may be able to retrieve result lists with highly relevant documents ranked at the top [3]. However, users are potentially faced with millions of results for factual queries in web search engines, with various levels of trustworthiness [4]   Consequently, the ability to conduct well-formulated queries do not necessarily ensure reliable top-rated documents. Source evaluation is therefore an important information searching skill [5].

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Search engine result lists may be overwhelming, both in size and content. According to Turetken and Sharda [6], users rarely look beyond the top listed documents. This is potentially troublesome, since the most reliable documents may not always be ranked at the top. Moreover, the judgments of the relevance ranking algorithm and the users may not always correspond. Hariri [7] therefore suggests that users should at least examine three or four pages of the result list.

An alternative to submitting factual queries in web search engines is to search directly in a well-reputed online source, such as a peer-reviewed article database or an encyclopedia, where the content is already evaluated by trustworthy professionals. Such a strategy would require less effort on result list assessment.

In Norway, *Store Norske Leksikon* (translates *Great Norwegian Encyclopedia*, hereby referred to as SNL) is the largest edited online encyclopedia, owned by Norwegian universities. SNL consists of approximately 200.000 articles edited by 600 scholars, and is frequently used, with more than daily 300.000 readings [8]. SNL can be accessed through direct search in the SNL search user interface or web search engines. According to SNL, 92% of the searches come via Google, while the remaining 8% are queries inputted directly in SNL. The encyclopedia provides a basic search user interface. There is an autocomplete function, but no spelling correction, and high demands for correctly spelled queries (see Figure 1).

Figure 1. No results ("ingen treff") for the query "Bob Dilan" (correct spelling "Bob Dylan").

SNL provides a keyword for each article in the result list. Figure 2 is an excerpt from the result list for the query *pyton*, which is both a snake and comic book. Above the article titles, there are keywords providing contexts, namely SLANGER (snakes) and TEGNESERIER (comics).

The relationship between writing and reading skills and information search has been addressed by several researchers, and people with dyslexia are reported to find both query formulation and result list assessment challenging [9][10][11]. Moreover, a low tolerance for spelling errors has been suggested to cause particular challenges for users with dyslexia [12].

Figure 2. Example from SNL result list.

This study investigated the search behaviour of people with dyslexia in an online encyclopedia. SNL provided search logs inputted in their search user interface from 2016-2017, filtered to only include queries with zero results, a criterion that applied to 25.000 searches. An overwhelming amount of these queries corresponded with spelling errors typically associated with dyslexia, such as double consonants, consonant clusters, silent vowels and words with irregular orthography [13][14][15]. It was not possible to estimate the portion of queries actually submitted by users with dyslexia. Nevertheless, these errors implied that people with dyslexia may find this search user interface challenging and potentially inaccessible. This issue was therefore investigated further through qualitative interviews, based on the following research question:

> *RQ: How do spelling skills affect the utilisation of an online encyclopedia among users with dyslexia?*

2. Background

Dyslexia is a widespread cognitive impairment, with a prevalence of approximately 7% in every population [16]. Dyslexia is commonly associated with reading and writing challenges. However, reduced short-term memory capacity is also one of the most common markers for dyslexia [17]. People with dyslexia are also reported to struggle with poor self-esteem, due to among others negative experiences at school and in higher education [18].

Several research communities have addressed the effect of dyslexia on information seeking and searching. Al-Wabil, Zaphiris and Wilson [19] investigated people with dyslexia navigating the web and identified distinctive navigation patterns and barriers related to unclear navigation trails, alphabetical site indexes and internal search boxes that did not understand spelling errors.

A potential relationship between search performance and short-term memory capacity has been suggested. MacFarlane, Al-Wabil, Marshall, Albrair, Jones and Zaphiris [20] reported that in the experimental information retrieval system Okapi, participants with dyslexia took more time on each search, exhibited less search iterations and assessed fewer documents compared to people without dyslexia. In a later study using the same system, MacFarlane, Albrair, Marshall and Buchanan [9] found a correlation between the ratio of documents assessed relevant and the short-term memory capacity. This finding was supported by MacFarlane, Buchanan, Al-Wabil,

Andrienko and Andrienko [10], who reported that people with dyslexia were more inclined to look up and down in the search user interface compared to people without dyslexia, and suggested that reduced short-term memory capacity caused this backtracking behaviour.

According to Cole, MacFarlane and Buchanan [11], participants with dyslexia self-rated their information searching skills significantly lower than participants without dyslexia. Although they managed to successfully conduct searches, they had difficulties extracting information from the various sources. In the context of query formulation, it has been suggested that dyslexia affects search performance in systems with high demands for correctly spelled queries [12]. In contrast, this negative effect may be counteracted or removed through sufficient search user interface design such as a high tolerance for spelling errors [21].

Various search aids have been developed with an aim to support people during query formulation. One example is the autocomplete function where the user is presented with a list of query suggestions while inputting the query, thus removing the need to input the complete query. Autocomplete has been suggested to help users with spelling [22], and might therefore reduce work load of query input for users with writing impairments. Nevertheless, Berget and Sandnes [21] found that people with dyslexia did not utilise the autocomplete function, due to an intense focus on the keyboard during query input.

Sources may contain conflicting answers for many reasons, such as errors, outdated information or disagreement. In the context of relevance assessment, search aids have also been discussed. Galland, Abiteboul, Marian and Senellart [4] suggested that corroboration can be used for data quality assessment, where users vote on the quality of sources. The votes are then collocated to help the user find the proper answer. Yin, Han and Yu [23] introduced "the veracity problem", which addresses the difficulties with multiple web pages or other information sources that provide conflicting information about a topic. An algorithm called TRUTHFINDER was developed on the premises that a website containing many true facts is regarded as trustworthy, and that a fact is regarded as true if it is found on many trustworthy websites.

Dong, Berti-Equille and Srivastava [24] addressed the issues of integrated data that may be out-to-date and erroneous, such as contact information or opening hours. Dong, Berti-Equille and Srivastava [24] developed a method to find a relationship between sources and investigated how to find true information based on coverage, exactness and freshness as important characteristics.

Hariri [7] addressed the need to investigate several pages of the result list pages, among others because the user and the system may have conflicting opinions on relevance. However, the need for looking beyond the top results has also been discussed in other contexts, for instance ethics. Hinman [25] problematised the power given to the search engines when users only read the top ranked documents, claiming that the search engines are "*providing a new Rangordnung of knowledge claims that replaces traditional legitimation structures*". Moreover, social media, logging of personal information and personalisation of search results have resulted in a decrease in the information diversity presented to the users, also referred to as "filter bubbles". Bozdag and van den Hoven [26] claim that these filter bubbles represent a serious threat to democracy.

3. Methodology

3.1. Participants

The participants comprised four adults with dyslexia between 21 and 41 years (21, 28, 34 and 41 years), two were males and two females. A total of two participants had a bachelor degree, one had a master degree, while one was student. None of the participants had any relations to the interviewer.

3.2. Procedure

Personal interviews were conducted with each participant, lasting from 21 to 90 minutes. The interview started with information about the study. Interviews were conducted using a semi-structured interview guide including key topics related to information searching for factual knowledge. The questions were open-ended. The interviews were recorded, transcribed and the data was anonymised.

4. Results

The main results may be divided into three categories, namely preferred sources, search behaviour and source evaluation.

4.1. Preferred sources

The participants were asked about which sources they found trustworthy. All participants emphasised SNL. Moreover, three participants mentioned governmental resources, such as the .gov domain and regjeringen.no (the website of the Norwegian government). Encyclopedia Britannica was mentioned by one participant, another referred to articles in Wikipedia with high score, although such values were often demanding to locate.

4.2. Search behaviour

There was a mismatch between the sources regarded as reliable and the sources actually used. This gap was mainly caused by poor search user interface design, and the participants focused especially on the tolerance for spelling errors. All participants mentioned SNL as a reliable source for factual knowledge. However, difficulties with query formulations due to high demands for correct spelling were frequently used arguments against this source, for instance: "*I cannot search Wikipedia and encyclopedias and such because there are no results when misspellings occur*".

A key topic in all interviews was the use of Google, and two participants reported to be completely dependent on Google to find "*anything*". No other search engines were mentioned as sources used for factual queries. No one mentioned using this source due to trustworthy information but emphasised the ease of use because of the autocomplete and the high tolerance for spelling errors. One participant stated «*I almost never search websites, because I input so many spelling errors. It is much more*

efficient for me to search Google. Then I don't have to relate to different user interfaces either. I like Google a lot».

Information searching was associated with negative emotions. Emotions such as frustration, fatigue and embarrassment were mentioned several times during the interviews by all participants. Shame seemed to be a key issue for many, both in the present and the past. Three participants mentioned elementary school as a difficult time, for instance: "*I work in healthcare and have in many ways a practical profession. That suits me well. However, it is important to be updated on the latest knowledge. To find facts in a flash is a struggle for me. For instance, in medical databases. It is lame and brings out painful feelings from school and higher education. I know that I am not stupid, but I feel ashamed anyway*".

Despite these negative emotions, all the participants mentioned that they had accepted the dyslexia over time, and used phrases such as: "*...one gets used to it. I've always had it like that...*" Moreover, they did not want the dyslexia to affect their performance and had worked hard to cope with their dyslexia: "*... I have worked a lot with this. I did not want to be the weakest link*".

Although the participants expressed that Google was easier to search than other systems, certain queries were not understood by Google either, because of severe spelling errors. In these situations, the participants had to spend much time formulating a successful query: "*I always proceed with Google and try and try until I find the proper search terms. Sometimes I must check the dictionary on my phone, or I ask someone. Or I try to say the word out loud to see if there is for instance a double consonant. It takes time.*"

4.3. Source evaluation

All participants agreed that result list assessment was demanding and time-consuming because they had to read through large amounts of text, for instance: "*I must try many times to find the proper site or source*". The evaluation of the result list was especially demanding if they did not find familiar sources among the top-ranked documents. Consequently, the participants often skipped the relevance assessment: "*I struggle if Wikipedia or SNL or any of the other sources I know are not at the top of the result list. To assess a pile of results is almost impossible for me, I read so slowly and misunderstand a lot. Sometimes I just use the first that comes along*".

The participants often used information sources without evaluating them properly, although they understood the potential risk of retrieving information that was not trustworthy: "*Everything is online, and if there are long result lists and much text the laziness may take over. Then I simply use the first result if it looks fine. That sometimes turns out badly*". Another participant said "*I am completely dependent on Google wishing me well, in a way*".

Using familiar sources was regarded as an advantage. In addition to being a reliable source, two participants emphasised the benefits of searching encyclopaedias such as SNL because of a common structure for all articles. A summary at the top of the article was mentioned as an especially successful design feature, which made it easier to quickly assess the relevancy. Moreover, the participants all described reading as an exhausting activity, and that clear navigation was important.

A permanent, and hence predictable, structure also made it easier to find the author and the time for the last update, which also made the source evaluation easier. Further, presenting certain content at the top was an advantage: "(…) *it is frustrating to read a*

lot of text and then I realise that the information is irrelevant. Then I am tired. It's best if the most important things come first".

5. Discussion

Result list assessment may be difficult for everyone [7]. However, this task might be even more challenging for people with impaired reading skills, because of longer reading times and a higher risk of misinterpretations. This assumption was confirmed. The participants frequently expressed negative emotions associated with search, such as failure, frustration and feeling stupid. The low self-esteem among users with dyslexia is in accordance with for instance Cole, MacFarlane and Buchanan [11].

Two particular user interface features were mentioned, namely tolerance for spelling errors and clear and navigable structures. One of the main findings is a mismatch between preferences and actual use of sources. All participants were highly dependent on Google because high demands for correctly spelled queries represented a barrier for query formulation, an obstacle they did not experience when searching Google. This finding is in accordance with previous research, that dyslexia has a negative effect on search performance in systems with a low tolerance for errors [12], while low demands for correct spelling may counteract the negative effect of dyslexia [21].

A key issue with Google, however, regards relevance assessment. The benefit of successful searching with erroneous queries has the cost of retrieving thousands of documents, not evaluated by professionals. Consequently, data from this study suggests that participants with dyslexia often choose the top result without any effort to evaluate resources, because it seems like an overwhelming task. This finding is in accordance with previous work on dyslexia and information retrieval [9, 11, 20].

Simply choosing top-ranked documents is not uncommon, as reported by Turetken and Sharda [6]. However, the participants with dyslexia seem even more reluctant to spend time evaluating the result lists and may end up extracting unreliable information. Moreover, this behaviour strengthens the role of the search engines as controllers and distributers of knowledge, as discussed by Hinman [25].

Clear and predictable structures also seems important, which is coherent with the work of Al-Wabil, Zaphiris and Wilson [19]. It might be beneficial for people with dyslexia to access familiar information sources in a predictable format and with similar navigation structures. Consequently, sources such as SNL should be preferable, because of the set structure of the articles and the use of keywords in the result lists. However, the low tolerance for errors seem to make the encyclopedia inaccessible for people with writing difficulties. Implementing a spell checker and a higher tolerance for misspellings would thus increase the accessibility, also for people without dyslexia, who are also reported to input errors in queries [12]. Such measures would reduce the need for using general Web search engines where both reliable and unreliable information are presented in the same results page, demanding extensive reading abilities.

Finally, the participants mentioned looking for known sources in the result list, such as SNL. If web search engines include some visual content in the result list, for instance logos beside each result, the users may more quickly find the proper webpage in the result list without the need to read through large amounts of text.

6.   Conclusion

The results from this preliminary study indicate that people with dyslexia perceive searching as a frustrating and demanding activity. Moreover, searching is associated with negative emotions, such as frustration, fatigue and a feeling of low self-esteem, which is problematic since many people with dyslexia already struggle with negative self-esteem. Poorly designed search user interfaces seem to be an obstacle in access to certain information sources. Hence, they are not used, although the participants actually want to utilise these sources. Consequently, better search user interface design is needed to remove barriers for people with dyslexia.

Acknowledgements

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