

Research Article

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Dyslexia and Accessibility Guidelines – How to Avoid Barriers to Access in Public Services

<https://doi.org/10.1515/icom-2021-0040>

Abstract: Interaction becomes increasingly digital, including interactions with public authorities, requiring websites to be accessible for all. The strong focus on written words in digital interactions allows for assistive technology to improve access for many users. However, it might impede usability for users with reading and writing difficulties.

The present paper examines whether guidelines such as the Web Content Accessibility Guidelines (WCAG) sufficiently cover users with dyslexia and how usability can be improved for this user group. This paper expands a previously published version at the Mensch und Computer 2021 conference [1].

Using literature research and interviews with users with dyslexia and focusing on an application of the WCAG on the country level (a German law regulating accessibility for e-government websites), we confirmed and identified gaps in the WCAG for this group. We focus on within-site search, as this function is frequently used to find relevant information, esp. on infrequently visited sites such as e-government websites.

Modifications to improve search were developed based on literature and the results of the interviews. They were empirically evaluated in an online study with 31 users with dyslexia and 71 without. Results indicate that an auto-complete function, a search that compensates for spelling errors, an indicator that the search was corrected, search term summary information, and avoidance of capital letters were useful for both groups, while wider line spacing should only be used in end-user customization.

Keywords: public administration, equal access, dyslexia, usability, websites

1 Introduction

Our interactions with the government are becoming increasingly digital. According to the UN E-Gov Survey of 2020 [2], over 84 % of countries offer at least one online transactional service, with the global average being 14, and an overall trend to increased digitalization. To speed up digitalization for government services, some countries are pursuing ambitious goals, partly also set by law, e. g., in Germany through the “Onlinezugangsgesetz” (literally translated: online-access-law), an ambitious plan to make 575 services available online until end of 2022 [3]. In the last year, the Covid-19 pandemic has painfully demonstrated the need for online services, as citizens and public employees were confined to their homes, but still had to request or provide government services.

E-government represents a comprehensive public sector reform concept based on the intensive use of information and communication systems [4]. E-government enables the redesign of the various interactions with the state. Processes can be reorganized as they no longer rely on presence and paper. The goals include improvements in quality, time, and costs. Unlike businesses, public administrations direct their actions towards the common good (not towards corporate profit). This public value orientation has implications for service delivery and interactions between government institutions and citizens.

While important for commercial websites, usability, i. e., “the extent to which a system, product or service can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use” [5], is crucial for e-government websites. E-government services have to be accessible to the whole population living in the country. Thus, the users of e-government websites are heterogeneous, encompassing people with diverse attributes (e. g., abilities, interests, prior knowledge, affinity for technology interaction [6]) and also with different disabilities or disorders. With more resources put on online services and first steps to switch to digital-only [7] and mandatory self-services [8] (still with possible exemptions), equal access is crucial as well. Accessibility enables social inclusion and equal opportunities [9].

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Since no one should be left behind when it comes to public services, accessibility is frequently considered in the context of e-government. The focus is often on raising awareness about the extent and types of the most common accessibility problems based on the analysis of specific e-government websites (e. g., [10]). Further research focuses on tools that help developers implement accessibility standards (e. g., [11]). In this article, we focus on an area that might be easily overlooked when assessing government websites for usability problems.

Digital services are usually conducted via written language, which provides opportunities to make them accessible for people with disabilities, e. g., regarding perceptual abilities or motor skills. Accessibility features and apps on smartphones and personal computers can access and work with the written text, e. g., to provide different input or output modalities such as speech-to-text or text-to-speech. The Web Content Accessibility Guidelines (WCAG, at the time of writing version 2.1; [12]) have been developed to allow users with different impairments to access websites. The WCAG also informs other standards and laws, e. g., in Germany the “Barrierefreie-Informationstechnik-Verordnung” (BITV, [13], literally translated: “barrier-free-information-technology-ordinance”), which is the basis for accessibility in e-government services. Besides Germany, other countries refer to WCAG 2.0 or WCAG 2.1 in their individual guidelines within the public sector – for example Australia, China, India, Israel, New Zealand, Switzerland and the United Kingdom as well as the European Union [14].

However, the focus on written language can also make it more difficult for specific groups to use services, who would have had less problems in direct, face-to-face interaction with civil servants: users with dyslexia. They can see the written language but have difficulties reading and writing it. Thus, metaphorically, they are caught between two stools: They cannot work well with the website as it is, nor do they need a switch to another modality to completely replace the text.

As this period of increased digitization can be used to design these services in a way to make them accessible for all, we ask the questions:

RQ1: Do the Web Content Accessibility Guidelines sufficiently address people with dyslexia?

To look at a concrete example, we examine an adaptation of the WCAG for e-government websites, here the mentioned regulation (BITV) in Germany.

Based on this comparison, assisted by a literature review and interviews with people with dyslexia, we then focus on one area in which accessibility is a prerequisite for

successful interaction with e-government websites: search within e-government websites. We ask the question:

RQ2: Which designs would increase usability of search functions for people with dyslexia, while not negatively affecting people without dyslexia?

To answer these questions, we start by providing background information regarding the Web Content Accessibility Guidelines (Section 2.1), dyslexia (Section 2.2), dyslexia and website use (Section 3) and the coverage of dyslexia by the WCAG (Section 4). This information is the basis for the proposed modifications to improve the search function for users with dyslexia (Section 5), which are then empirically evaluated by users with and without dyslexia (to also avoid negatively impacting the later, Section 6). We then provide answers to the research questions in the conclusion (Section 7). This paper expands a previously published version at the Mensch und Computer 2021 conference [1].

2 Theoretical Background

2.1 Web Content Accessibility Guidelines and Country Specific Implementations

On the Web, the goal of accessibility is to allow everybody to use websites. The whole diversity of human abilities should be covered and no-one, including users with disabilities, should be disadvantaged [14].

Referring to German law, disability can be seen as an interaction between physical or mental impairments of the individual (e. g., senses, motor functions, cognition) and requirements in the environment (e. g., written text is used, or access to a building is only possible by using the stairs). Requirements in the environment become barriers when impairments prevent their use without allowing for alternatives (e. g., no audio version, or no access ramp for wheelchairs). However, as disability depends on the match between environment and individual, it can be addressed by increasing the options of the individual with assistive technologies (e. g., by using a text-to-speech app for written text) and by the design of the environment itself (e. g., the website offering an audio version, or being compatible with text-to-speech apps).

Guidelines and toolkits exist to develop products that are accessible for all, e. g., the “Inclusive Design Toolkit” by the University of Cambridge [15], or Microsoft’s “Inclusive Design Toolkit” [16]). More generally, the World Wide Web Consortium (W3C) provides recommendations

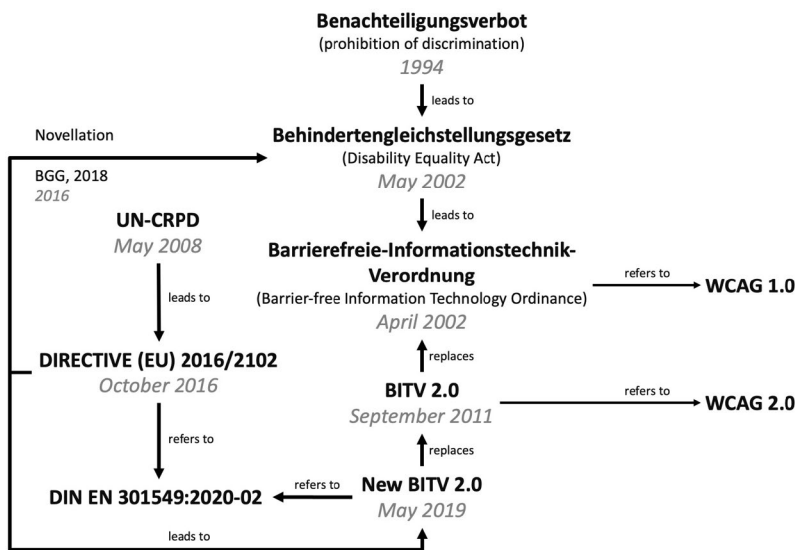


Figure 1: Legal development towards the new BITV 2.0 (own illustration).

for standardization on the Web, including the Web Content Accessibility Guidelines (WCAGs; [12]).

The WCAGs are concerned mostly with vision, hearing, cognition, dexterity, speaking, and locomotion. They set conformity levels, inform the laws in different countries regarding accessibility on the web and are accepted as norm in the European Union.

To examine a specific adaptation of the WCAG, we focus on Germany. It is currently undergoing increased digitization of public services (see Section 1) and the authors are familiar with both language and public administration in the country. Germany's laws protecting people with disabilities were strengthened multiple times, resulting – for e-government – in the “Barrierefreie-Informationstechnik-Verordnung” (see Figure 1) [13]. The BITV requires federal websites to be designed in an accessible manner, including sign language and “Leichte Sprache” (literally “easy language”, a simple version of the German language designed to improve accessibility and directed at people with low comprehension of German or low reading skills).

As the BITV is referring to the European accessibility standard EN 301 549 V3.1.1 (of which WCAG 2.1 is a part), it is also focused on senses, cognition and motor control. However, the scope of the BITV is broader than these disabilities. It states as its goal to allow for and ensure a comprehensive and basically unrestricted barrier-free design of modern information and communication technology (“eine umfassend und grundsätzlich uneingeschränkt barrierefreie Gestaltung moderner Informations- und Kommunikationstechnik zu ermöglichen und zu gewährleisten”, § 1 Abs. 1 [13]).

This “comprehensive and basically unrestricted barrier-free design” also includes users with dyslexia. But are they covered by this WCAG-based ordinance?

2.2 Dyslexia

Different definitions for dyslexia exist, here we refer to the ICD-10 definition: “Dyslexia, also known as reading disorder, is characterized by trouble with reading despite normal intelligence. Different people are affected to varying degrees. Problems may include difficulties in spelling words, reading quickly, writing words, ‘sounding out’ words in the head, pronouncing words when reading aloud and understanding what one reads” [17].

It is a specific, life-long dysfunction related to language processing [18], affects 3–7 % of the population [19, 20], and is often undiagnosed. While it results in higher error rates when reading or writing [21], there is a wide heterogeneity of symptoms ([21, 22], [19, p. 11]). This heterogeneity makes it difficult to provide suggestions and guidelines [23].

Disorders similar to dyslexia exist which are indicated by (sometimes temporally limited) difficulties in learning to read, e. g., due to socio-cultural issues such as low education level, or due to stressors such as changing schools. While the focus of the present paper is on dyslexia as a clinical disorder and persistent problem, efforts to improve accessibility for people with dyslexia should assist people with other reading difficulties as well [22].

Table 1: Relevant Empirical Articles from the Literature Research.

Src.	Basis	Short Summary
[24]	$n = 10$ (dysl.)	Determines internet usage and usage requirements of users with dyslexia and identifies several barriers. Shows how websites that are claimed to be accessible still cause problems for this group. Problems and opportunities cover back and next buttons, dynamic menus, navigation elements, site maps, and side index
[25]	$n = 7$ (2 dysl.)	Compared eye movements (scan paths) of users with vs without dyslexia to analyze the underlying cognitive processes. Navigation of dyslexic users is less strategic
[26]	$n = 30$ (dysl.)	Examined different media combinations, which can have an impact on the learning performance of dyslexic learners
[27]	$n = 14$ (7 dysl.)	Assessed ability for information search. Dyslexic users rated their ability significantly worse, used different search strategies and had difficulties finding and extracting information
[21]	$n = 130$ (65 dysl.)	Analyzed spelling errors from standardized writing tests/writing task and found that people with dyslexia had higher error rates
[28]	$n = 50$	Participants with different impairments evaluated 100 pages according to usability criteria. Main problems for dyslexic users were unclear, confusing page layout, disorienting navigation mechanisms, use of inappropriate colors and poor content-background contrast, and use of complicated language or terminology
[29]	$n = 16$ (8 dysl.)	Examined relationship between cognitive variables and search behavior. Found influence of impaired short-term memory of dyslexic users which influenced search behavior
[30]	$n = 161$ (80 dysl.)	Examined information search on websites and provides suggestions to improve search interface and search algorithm. Demonstrates differences in behavior and preferences between dyslexic and non-dyslexic searchers. Suggest consideration of readability in search engine rankings and user interfaces may be beneficial to both
[31]	$n = 50$	Participants (some with low literacy levels) evaluated website with vs. without adaptations for dyslexic users (some adaptations were generally useful)
[32]	$n = 96$ (47 dysl.)	Participants read texts that were 1) original, 2) automatically simplified, 3) manually simplified. Automatic lexical simplification through word substitution may negatively affect the reading experience, while a system that displays synonyms on request can improve comprehension for users with dyslexia
[33]	$n = 341$ (89 dysl.)	Assessment of readability and understanding of text on different background colors. Findings indicate a significant influence of the use of certain background colors on people with and without dyslexia

3 Dyslexia and Website Use

To assess usability problems of users with dyslexia, a literature research and interviews with users with dyslexia were conducted. The literature research was conducted using Google Scholar and additionally identifying researchers in this area. Search terms were, among others, “dyslexia”, “accessibility”, “usability”, “usability + dyslexia”, “accessibility + dyslexia”, “BITV + dyslexia”, “usability + search”, and “accessibility + search”. Inclusion of papers were based on fit and overall scientific quality. In total, more than 100 papers were sighted. Table 1 and Table 2 show a summary of the relevant empirical and theoretical articles.

The interviews (semi-structured) were conducted with four users with dyslexia (ages 20–29 years, two male, two female) and one expert in dyslexia research (who is also dyslexic). They focused on the intersection of dyslexia and technology usage, specifically concerning difficulties in using smartphones and personal computers. We also assessed the use of assistive technologies, perception of public service websites, good and bad accessibility examples

of websites, and evaluation of “Leichte Sprache” (see Section 2.1), navigation and search functions on websites. Using the strengths of online interviews, we also asked them to share their screen to observe their interactions with two online tasks (finding out when the day-care centers in a major city open after one of the Covid-19 lockdowns and finding out the office hours of the tax and revenue office of a specific city; the tasks were given, participants came up with search terms on their own). A qualitative analysis was conducted to identify topics (esp. usability problems).

Looking specifically at the current limitations and problems of website use of people with dyslexia, the main findings of the literature research and the interviews (see Table 5 for details) were that while speech to text software was seen as helpful, given that websites are frequently accessed on mobile devices in public, their use is not always possible due to environment conditions (noise, privacy). Text-to-speech was used selectively, not to have everything read aloud, but to have only specific words or passages read. “Leichte Sprache” (see Section 2.1) was not seen as helpful by any of the interviewees. It reduces the cognitive complexity of the content and uses a limited vocabulary to

Table 2: Relevant Theoretical Articles from the Literature Research.

Src.	Short Summary
[34]	Discusses possible improvements of learning for dyslexic users (incl. addressing different senses). Explained how learning was supported for dyslexic users via computer-assisted learning materials using the dual coding theory approach
[35]	Discusses assistive technology for users with dyslexia in learning scenarios, involving listening, reading, organization and memory, written language, and math. Web 2.0 interaction pattern technologies, such as mashups, dynamic page updates, social networking and user-created content demand specific perceptual abilities
[36]	Examined interaction patterns on websites that can impede usability for users with different impairments. Navigating Websites with dynamically changing pages requires good visuospatial skills. The extensive use of text-based search poses challenges for people with word-finding disorders
[22]	Summary of literature in the intersection of dyslexia and accessibility. Suggests that usability testing revealing a clearer profile of the dyslexic user would help further inform the practice of universal design and points to available knowledge to improve accessibility for dyslexic users
[37]	Applies problems of users with dyslexia to their interaction with computers and provides suggestions to improve accessibility. Addresses problems faced by people with reading and spelling disabilities and applies them to interaction with computers. Presents suggestions for improving accessibility of content and promotes awareness of different perceptions of content, learning styles, cognitive limitations, and learning strategies
[23]	Discusses limitations and challenges regarding dyslexia in the context of online accessibility. Describes the key challenges in studying reading and spelling disorder in terms of web accessibility: (1) Measuring the impact of reading and spelling disorder on the population; (2) limitations of current studies; (3) inclusion of reading and spelling disorder in Internet accessibility guidelines
[38]	Discusses the diagnostic of dyslexia
[39]	Examines and discusses the consequences of the ICD-10 recommendation to consider the relationship between intelligence and spelling/reading in the diagnosis of dyslexia

address readers with low educational background or limited language skills. However, people with dyslexia can understand sentences similar to people without dyslexia – if they are spoken to them [23]. They just cannot similarly process or unpack the text itself. As “Leichte Sprache” addresses the content, not the packaging, it is not helpful for users with dyslexia.

Both the literature research (e. g., [30]) and the interviews indicated problems with online search, which were also apparent in the observation of the two online tasks during the interviews. Three out of four made spelling errors during the search, which they found difficult to detect (a frequent problem, e. g., [26]).

To find information users often use the search function [40, 41]. In the e-government context, the search function is critical, as e-government websites are only visited infrequently and with a specific goal in mind (e. g., getting a new passport, to find information about public authorities, public services, or how to apply for benefits or permits). While navigation menus and reading the website content can be used to find the information, this process requires more effort for users with dyslexia, compared to using the search function. The latter leads them directly to the relevant page, if the search is usable for them (e. g., interpreted correctly despite likely spelling errors).

4 Coverage of Dyslexia by Accessibility Guidelines

How well do the accessibility guidelines, here the country-specific implementation (BITV) of the WCAGs address the specific problems of users with dyslexia? To answer this question a checklist to meet the requirements of BITV was considered [42]. For each of the 60 criteria in this list, it was determined whether this would benefit people with dyslexia or not. If it did, each point was briefly discussed as to why the decision was made.

In general, all steps that improve the use of screen readers can also be helpful for people with dyslexia, when they are strongly affected and therefore use them. However, the use of screen readers does differ from that of people who cannot see (comment from one of the interviewees, see Section 3). They can see the content but just want to have information read out loud selectively. That is why the following Table 3 does not show the BITV items that only improve the use of screen readers, because these suggestions are designed to improve usability for blind and visually impaired user groups.

However, some of the other items were found to be helpful, for example, a meaningful order of the page content assists users in quickly visually assessing what is significant. Likewise, because of test step 1.4.4a, it must be

Table 3: Application of BITV to Usability Problems of Users with Dyslexia.

BITV Criteria translated	Practical Consequence	Use for Users with Dyslexia
1.3.2a Sensible Order	Allows screen readers to read the text aloud	Allows use of screen readers
1.3.4a No limitation on screen orientation	Phones/tablets can provide information in portrait and landscape format	Landscape format can be used to display larger font sizes
1.3.5a Form fields specify content	Required information can be determined automatically	Software can provide icons to illustrate required information or enter it automatically
1.4.4a Text can be zoomed to 200 %	Text zoom	Facilitates reading
1.4.5a No text as images	Limits scale-ability and affects text-to-speech	Would make use of text-to-speech difficult to impossible
1.4.10a Automatic text breaks	Automatic line breaks in scaled-up text	Facilitates reading by avoiding the need to scroll horizontally
1.4.12a Changeable line spacing	Increase spacing between text lines	Facilitates reading
1.4.13a Overlay information is operable	Content does not vanish automatically	Allows for sufficient reading time
2.2.1a Time limits can be changed	Increases interaction time	Allows for sufficient reading time
2.2.2a Moving content can be disabled	Reading speed not set by movement speed	Allows for sufficient reading time
2.4.5a Alternative access methods	Multiple ways to access content (e. g., menu navigation and search)	Takes variety of approaches into account
2.4.6a Meaningful heading and labels	Headers provide concise and accurate description of the content	Avoids costly skimming of sections
3.2.3a Consistent navigation	Navigation quickly and easy to understand	Avoids costly re-orientation
3.2.4a Consistent labeling	Repeating elements have the same label	Avoids costly re-orientation
3.3.1a Error recognition	Additional check for errors, e. g., plausibility checks in forms	Catches (some) spelling errors
3.3.3a Support when making mistakes	Additional help, e. g., feedback if entered information is incorrect	Catches (some) form entry mistakes, e. g., entering information in the wrong field.
3.3.4a Error prevention	Prevents errors, e. g., forms before submitting	Catches (some) spelling errors

possible to enlarge the text to 200 %. Given that text breaks into the next line when enlarged and fonts remain clear assists in readability. That texts are often greatly enlarged in order to be better able to read them was one of the points mentioned in the interview and observed in the user behavior.

Given the focus on senses, cognition and motor control, some elements of the BITV are already helpful for users with dyslexia, but other suggestions are not directly applicable to dyslexia, even though it might seem that they would help. BITV does not cover suggestions on type face and proposes the use of “Leichte Sprache” (not helpful for people with dyslexia, see Section 2.1 and Section 3). Suggestions regarding screen readers cannot be applied 1:1 from users who are visually impaired to people with dyslexia, as their usage differs (the latter use them more selectively, e. g., to understand specific words, see above). Also not covered are ways to improve the search, showing synonyms for complicated words, and avoidance of all-caps.

Given the difficulties with search and its relevance to get to the needed content, how could search be improved for users with dyslexia?

5 Proposed Modifications to Improve the Search Function for Users with Dyslexia

Based on the results of the literature research, the interviews, and the gaps of the WCAGs and BITV regarding the design of search functions for users with dyslexia, hypotheses regarding the improvement of the search function were developed (see Table 4). These had to be evaluated, to make sure their implementation really helps people with dyslexia, but also not negatively affect people without dyslexia.

Based on these hypotheses, suggestions to improve the search function for users with dyslexia were developed. We continue and empirically assess the research by [30] (see also Table 1), who give an overview of previous studies regarding web search and dyslexia, and who also found differences in behavior and preferences between dyslexic and non-dyslexic searchers.

In contrast to previous research, the focus of these suggestions is on the search field/results page of the search engine itself and on assessing the features empirically. We look specifically on solutions applicable to within-site

Table 4: Hypotheses on how to improve search functionality for users with dyslexia (compared to a default mode without this function).

HNo.	Hypothesis
H1	Showing suggestions while entering search terms
H2	Search compensating for errors
H3	Showing that the search was corrected
H4	Feedback on spelling errors
H5	Speech-to-text function in search fields
H6	Multimodal hints on search results
H7	Wider line spacing
H8	Providing easy-to-read summaries
H9	Presentation of summary information on search result
H10	Ranking based on the readability of the found pages
H11	On demand display of icons to illustrate complex words
H12	Not using all caps to emphasize words

search of e-government websites, as developers have the necessary control to change the design of the search function, compared to using general-purpose web search engines such as Google, DuckDuckGo or Bing. While large commercial search engines like Google already implement some of these suggestions (e. g., speech-to-text function, automatic recognition of typed terms, error tolerance or showing alternatives when spelling errors are made), given data privacy considerations, using Google Search as within-site search is not an option for many government websites (e. g., consider the search for financial assistance being tied to a person's online profile). This situation leaves developers with the question of which search features to implement for their own website search given the limited resources, or, if they choose between frameworks with different features, which features should be rated higher. As the WCAG does not provide an answer, we assess the features empirically to determine empirically which features are helpful for users with dyslexia without impeding those without dyslexia.

Table 5 describes the proposed modifications with the underlying rationale (due to space reasons combined with the results). For images on how they were implemented, see the appendix.

6 Evaluation of the Proposed Modifications

To empirically assess whether the design proposals are beneficial for users with dyslexia, we compared each search feature to a default search field without this functionality. While modifications to improve readability for

users with dyslexia usually also benefit those without it (e. g., [18, 23]), care was taken to empirically validate this finding for our modifications. Thus, we included a comparison group of users without dyslexia as a control group.

6.1 Method

6.1.1 Design

An online-survey was used to present each of the modified search feature (dyslexic-friendly version) with the default search field without that feature. Participants could decide which version they preferred.

6.1.2 Participants

Users with and without dyslexia were recruited in information and support groups for people with dyslexia on Facebook and Instagram, via a student association forum, and on an internal chat of an IT consulting company. Postings on the social media sites were done in text and video form to make it easy for people with dyslexia to participate. In total, 178 people accessed the survey, of which 76 (3 with dyslexia and 73 without) were excluded due to incomplete answers, crossing patterns in the data, or technical difficulties with the embedded videos, resulting in $N = 102$ participants, 31 with dyslexia and 71 without. In the dyslexic group (Dys), 14 were male, 16 female, one diverse, with an average age of 27.65 years ($SD = 9.37$, 18–62 years). In the non-dyslexic group (nDys), 22 were male, 47 female, 2 diverse, with an average age of 27.38 years ($SD = 9.36$, 18–73 years). In both groups, educational background was rather high, with most having at least qualification for further education or a university degree (bachelor/master). No differences were found for Affinity for Technology Interaction between dyslexic and non-dyslexic users (Dys: $M = 4.06$, $SD = 1.29$; nDys: $M = 4.1$, $SD = 1.05$, $t(100) = 0.18$, $p = .857$).

6.1.3 Settings and Instruments

The survey was conducted with LimeSurvey with the text being designed to be more easily readable by users with dyslexia (e. g., regarding font face and font size). Sociodemographic variables (age, sex, education), whether dyslexia was diagnosed or assumed, and the use of assistive technology was assessed. To detect a possible self-selection bias regarding affinity for technology (cf. [43]),

Table 5: Proposed Modifications & Results.

Dys and nDys: One-Sample t-Test for within-group comparison against answer scale middle of 4 (Dys $df = 30$, one-sided; nDys $df = 70$, two-sided), comp.: independent t-Test (dysl. vs. non-dysl. users). Bonferroni correction applied ($p = .05/12 = .004$)				
Modification	Group	$M (SD)$	t	p
D1 Autocomplete function Search field provides autocomplete suggestions based on possible search terms, due to general difficulties with writing, recognition of words likely easier than reproduction (Interviews; [30, 31, 44, 45])	Dys	6.77 (0.67)	23.10	<.001
	nDys	6.35 (1.21)	16.40	<.001
	comp.	$df = 94.33$	-2.26	.026
D2 Search Compensates Spelling Errors If a search term is misspelled, the search provides the results for the correct spelling, e. g., if the German “Finanzamt” is written falsely as “Finanzamd” [sic], the search displays the results for “Finanzamt”. Frustrating to start a search and get no results and no information why (does it not exist or is it misspelled?), higher likelihood of spelling errors and unable to find them (Interviews; [26, 21, 24, 31, 37])	Dys	6.19 (1.62)	7.53	<.001
	nDys	5.89 (1.83)	8.68	<.001
	comp.	$df = 100$	-0.80	.424
D3 Shows that Search was corrected In addition to D2, provides “Results for Finanzamt” as information, i. e., the term that was actually searched. Provides clearer feedback that a spelling mistake was made. Caveat: Might be aversive to be confronted with spelling error (Interviews)	Dys	5.74 (1.44)	6.75	<.001
	nDys	5.73 (1.38)	10.55	<.001
	comp.	$df = 100$	-0.03	.975
D4 Automatic Spelling Mistake Feedback In addition to D3, shows the misspelled search term and allows users to search for that term. Giving users the option to use for the word they actually did write (Interviews; [26])	Dys	5.00 (2.24)	2.49	.009
	nDys	4.34 (2.32)	1.23	.223
	comp.	$df = 100$	-1.34	.183
D5 Speech-to-Text Function Providing a button for speech-to-text entry. Difficulties in spelling (esp. how to start spelling a word); accessibility feature of OS might not be known (Interviews; [30])	Dys	4.87 (2.01)	2.41	.011
	nDys	4.51 (1.80)	2.37	.021
	comp.	$df = 100$	-0.90	.368
D6 Multimodal Search Results Providing an Image to indicate the search term. Difficulties in reading [30, 31]	Dys	4.35 (2.23)	0.89	.191
	nDys	4.01 (1.78)	0.07	.947
	comp.	$df = 47.39$	-0.75	.455
D7 Wider Line Spacing Increasing the line spacing on the text to make it less “dense”. Easier to distinguish the lines [30, 46]	Dys	4.74 (2.05)	2.02	.026
	nDys	3.48 (1.64)	-2.68	.009
	comp.	$df = 47.49$	-3.04	.004
D8 Shorter Summary Texts of Results Search results are provided with very short texts to allow users to read different hits more quickly. Difficulties in reading (Interviews; [47, 29, 31])	Dys	4.71 (1.88)	2.10	.022
	nDys	4.97 (1.51)	5.42	<.001
	comp.	$df = 47.64$	0.68	.497
D9 Search Term Summary Information Showing information about the search term on the search results page (e. g., from the top hit or regarding the most frequently searched information on that page, akin to Google showing opening hours of businesses). Avoids opening another page and costly reorientation on that page, if users also search for this frequently searched for information (Interviews)	Dys	5.84 (1.57)	6.51	<.001
	nDys	5.42 (1.39)	8.62	<.001
	comp.	$df = 100$	-1.34	.185
D10 Readability Ranking Search results are not only sorted by standard search algorithms, but (optionally) also by readability. Readability as a selection criterion for search results [30]	Dys	4.42 (1.98)	1.18	.124
	nDys	3.86 (1.61)	-0.74	.463
	comp.	$df = 100$	-1.51	.135
D11 Icons as explanations for complex words Hovering over difficult words provides small icons/images illustrating this word. Difficulties in reading, providing information about these words in pictorial form [30]	Dys	4.26 (2.10)	0.69	.249
	nDys	3.86 (1.98)	-0.60	.551
	comp.	$df = 100$	-0.92	.360
D12 Avoidance of All Caps Avoidance of all-caps to emphasis words, esp. in titles. All-caps text is more difficult to read [37, 46]	Dys	5.97 (1.49)	7.33	<.001
	nDys	6.14 (1.20)	15.05	<.001
	comp.	$df = 100$	0.62	.536

the 9-item affinity for technology interaction (ATI) scale [6] was used.

The different versions of the search features were realized with React (e. g., autosuggest, react-tooltip). Images and videos were then used to present the different versions to the participants.

The preference for the dyslexic-friendly vs the default version was assessed by presenting both versions on a single page underneath each other and using a 7-point Likert scale ranging from “strongly prefer version 1” to “strongly prefer version 2”, with a neutral middle. The order of the two variants was randomized once for all suggestions to avoid position effects. Participants were also asked whether they were able to watch the videos.

6.1.4 Procedure

After opening the link to the survey, participants evaluated which options they liked better for each comparison, answered whether the videos were playable, filled in the ATI questionnaire, demographic data, dyslexia information, and could write general comments.

6.2 Results

Data were recoded so version 1 was always the default version (preference: values between 1 and 3) and version 2 the proposed dyslexic-friendly version (values between 5 and 7), with 4 being the neutral middle (no preference). To examine whether the proposed version was preferred, groups (dyslexic vs non-dyslexic) were treated separately and one-sample *t*-tests we calculated for each group against the neutral answer scale middle of 4 (see Table 5, row with Group “Dys” or “nDys”). To assess whether the dyslexic vs non-dyslexic groups differed in their preferences, *t*-Tests for independent samples were used (see Table 5, row with “comp.” for each modification). As multiple comparisons were made, the significance level was Bonferroni-corrected. The results are shown in Table 5. Non-parametric alternatives lead to similar results.

Users with dyslexia preferred the autocomplete function, a search that compensates for spelling errors, an indicator that the search was corrected, search term summary information, and an avoidance of all-caps. All other proposed modifications were not statistically significantly different from neutral middle. Users without dyslexia did show similar preferences, however, they did not like wider line spacing.

6.3 Discussion

We did show different variants of the search feature to users with and without dyslexia. Some modifications are seen positively by both groups and should be implemented: autocomplete function, a search that compensates for spelling errors, an indicator that the search was corrected, search term summary information, and an avoidance of all-caps. Showing the corrected word (e. g., “Result for ...”) was also not seen as aversive by dyslexic users.

The other modifications likely do not hurt, even though there is no statistically significant preference for them. However, wider line spacing by default should be avoided in the search results, because users without dyslexia do not like it. It is the only instance in which participants with and without dyslexia significantly disagree.

Thus, these proposed modifications increase the usefulness for users with and without dyslexia. They are also relatively simple to implement.

However, to keep the comparison to an acceptable length, esp. for the group with difficulties in reading, other suggested modifications to searches were not assessed. These include, e. g., different modes of spelling auto-correction like single choice vs. *n*-best lists [30], which are useful as users with dyslexia often do not know how to start spelling a word. As some of the spelling errors by people with dyslexia are different from everyday spelling errors (e. g., multiple wrong letters), search functions could be improved to deal with these dyslexic specific differences. Also, the presented interfaces were mock-ups, either static pictures or short videos showing the interaction. Future research should test these different interfaces in use on actual websites, e. g., via A/B-Tests. The present paper points to the interaction changes that are likely providing the best results.

As it is the search function that in many cases determines whether people find the information they are looking for, and reading the navigation and page content is taxing for users with disabilities, the implementation is well worth the effort.

7 Conclusion

Policies can only be implemented effectively if the related administrative services reach the respective target groups. For example, children can often only benefit from social services or support measures if their parents apply for them. Destitute citizens can only get support if they make

their plight known. This requires knowledge about these services as well as easily accessible application processes. The simplicity of the application process is determined, on the one hand, by the content requirements (which information do applicants have to provide) and, on the other hand, by the design of the information transfer, i. e., the usability of the tools used for the application.

Websites, especially for mandatory or literally life-saving interactions with the government, must be accessible for all. Using literature on dyslexia, interviews with people with dyslexia, and looking at accessibility guidelines (WCAG) and their country-specific implementation (BITV in Germany), we confirmed and identified gaps regarding the usability of websites for users with dyslexia, esp. regarding the search function on websites. Thus, we answer the first research question (**RQ1**) that the WCAG provides assistance for users with dyslexia, but does not sufficiently cover their specific needs, esp. regarding search functions.

Based on the literature and interviews, we empirically tested possible modifications to the search feature to find changes that are preferred by users with dyslexia, without negatively impacting those without. Based on the results, we answer the second research question (**RQ2**) that the usability of the search function can be improved for users with dyslexia by including autocompletion, a search that compensates for spelling errors, an indicator that the search was corrected, search term summary information, and an avoidance of all-caps. To avoid negatively impacting users without dyslexia, wider line spacing should be reserved for end-user customization (e. g., browser settings/plugins), as preferences of dyslexic and non-dyslexic users differed significantly for this feature.

While these features likely do improve the usability of e-government websites for those with dyslexia and those without, other measures should also be considered. Given that many people with dyslexia use a general-purpose search engine to find specific e-government web pages — as they had negative experiences with site-internal searches — government websites should allow general-purpose search engines (like Google, Bing, etc.) to index all their webpages. When it comes to the actual usage of eGovernment services (esp. transactions), forms should implement plausibility or sanity checks to formally validate for user input. Principles like “Once-Only” — while helpful for all users — will likely be a huge benefit to dyslexic users. Finally, while text is an important way for eGovernment websites to communicate to a large number of people, for those users for whom this proves to be a high bar, other contact methods (incl. telephone) should

continue to be provided. In the future, powerful voice assistants could ask for relevant data in conversations. In general, the more alternatives exist for accessing digital administrative services, the better individual user requirements can be considered.

As the search feature is an important function of websites that can quickly cut through swaths of text to provide only a small amount of relevant text, and reading text takes a lot of effort for users with dyslexia, the search function should be especially accessible and usable for users with dyslexia. The proposed and empirically assessed modifications might help to improve accessibility for users with dyslexia, and – given that spelling errors do happen to everyone – also for everyone else.

Acknowledgment: We thank the participants (interviews and survey) for their valuable feedback. Additionally, we would also thank Capgemini, who supported the thesis financially, and Tanja Wittig, who provided valuable feedback and support. We also want to thank the team of the Mensch und Computer 2021 for the Best Paper Award, which led to an invite to publish an expanded version in this journal. We also want to thank the editor of this journal for the invitation and the reviewer for the valuable feedback. Thank you very much.

Appendix A. Screenshots of the Search Function Features

The left image shows the default version, the right the dyslexic-friendly proposed modification.



Figure 2: D1 Autocomplete Function.

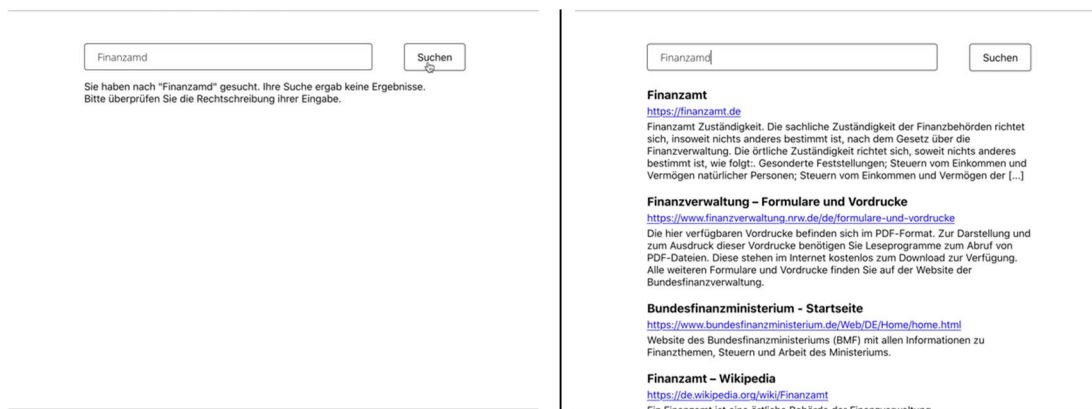


Figure 3: D2 Search Compensates Spelling Errors.

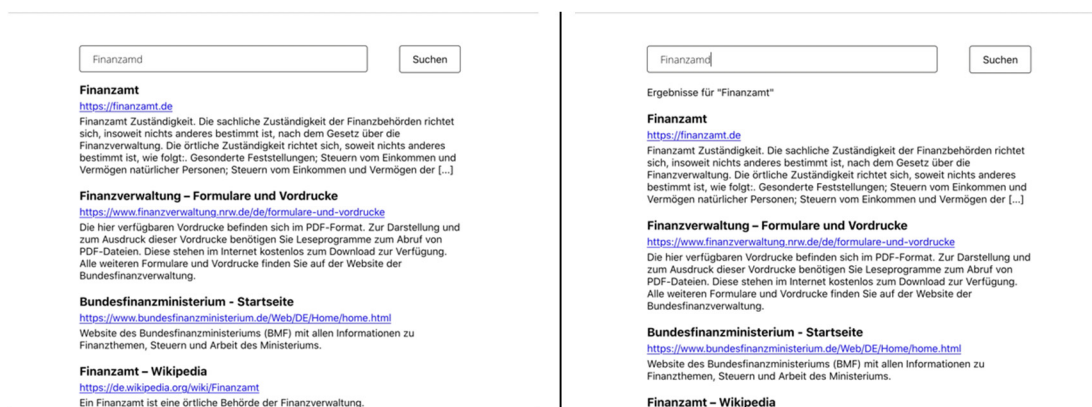


Figure 4: D3 Automatic Spelling Error Feedback.

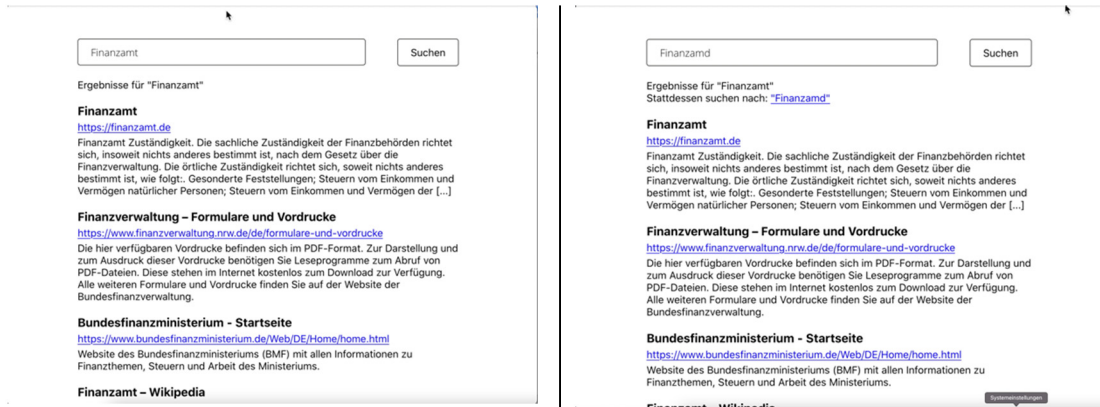


Figure 5: D4 Automatic Spelling Error Feedback with Option.

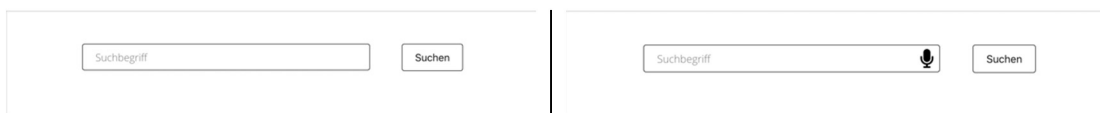


Figure 6: D5 Speech-to-Text Function.

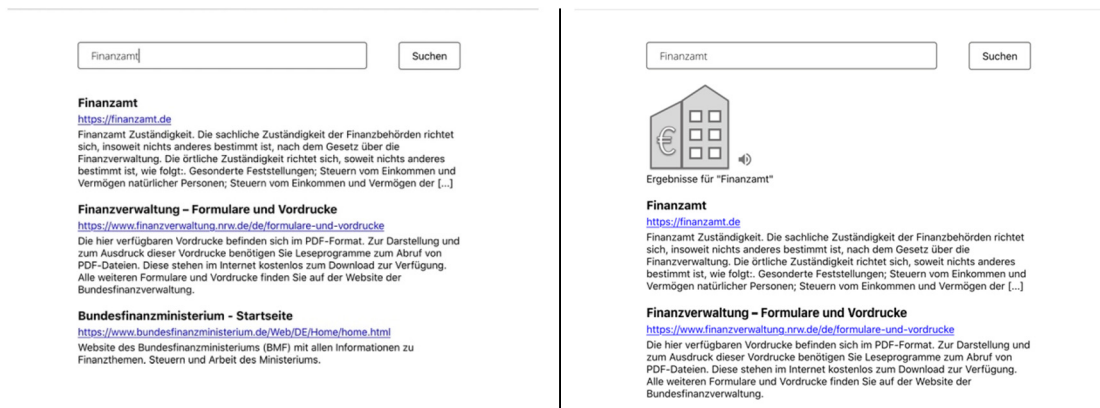


Figure 7: D6 Multimodal Search Results.

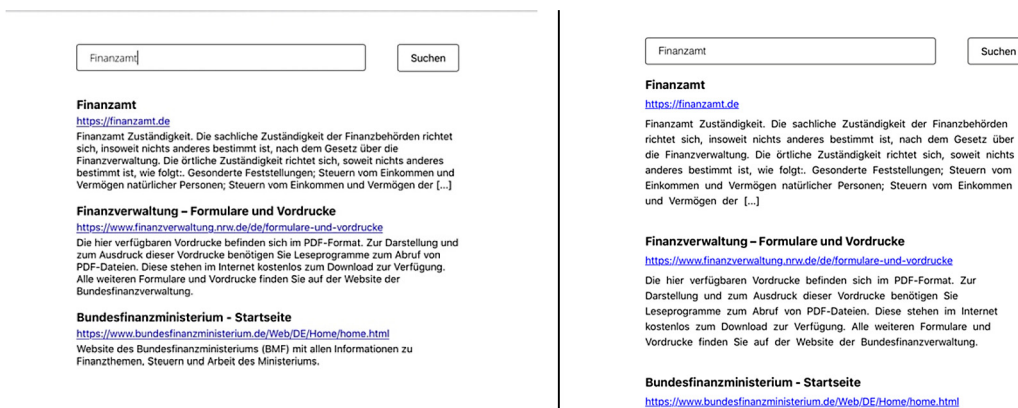


Figure 8: D7 Larger Line Spacing.

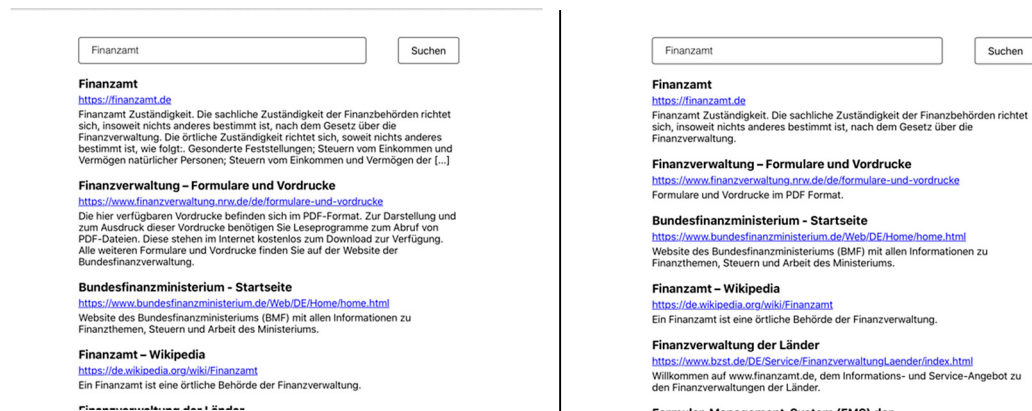


Figure 9: D8 Shorter Summary Texts of Results.

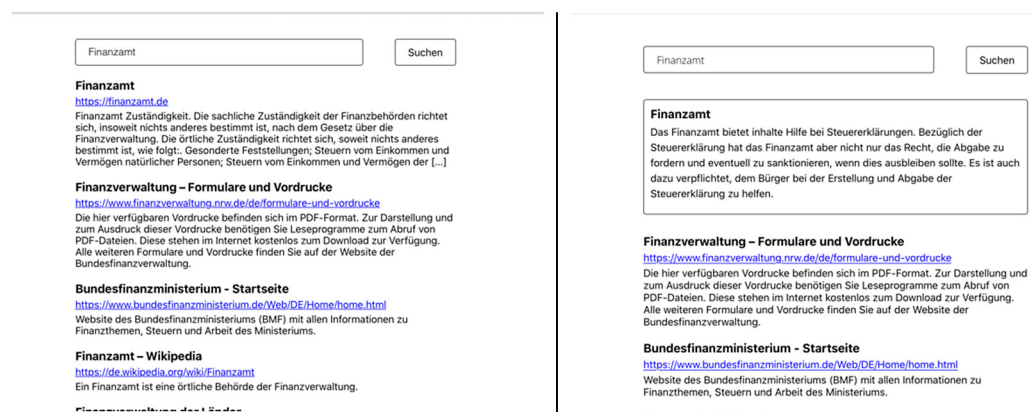


Figure 10: D9 Search Term Summary Information.

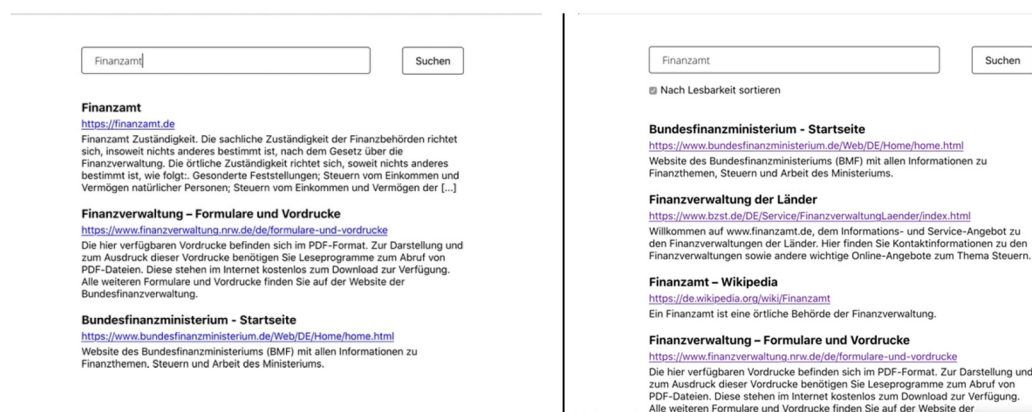


Figure 11: D10 Readability Ranking.

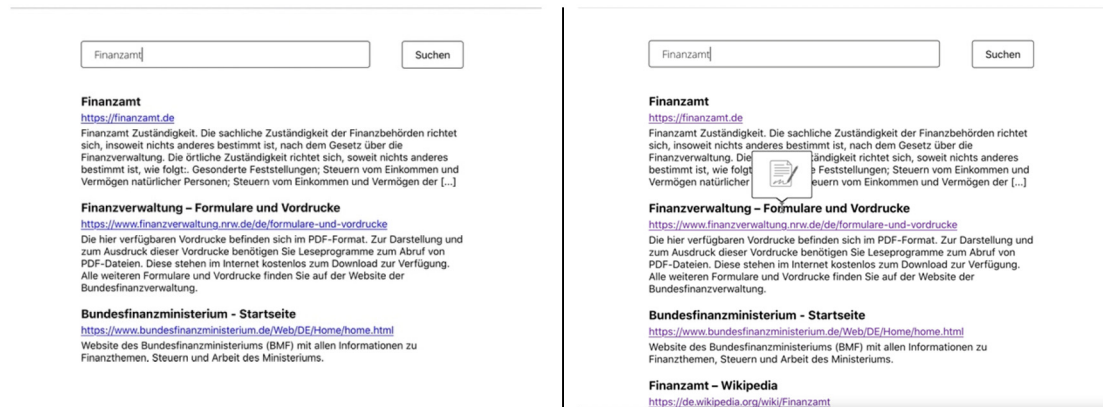


Figure 12: D11 Icons as explanations for complex words.

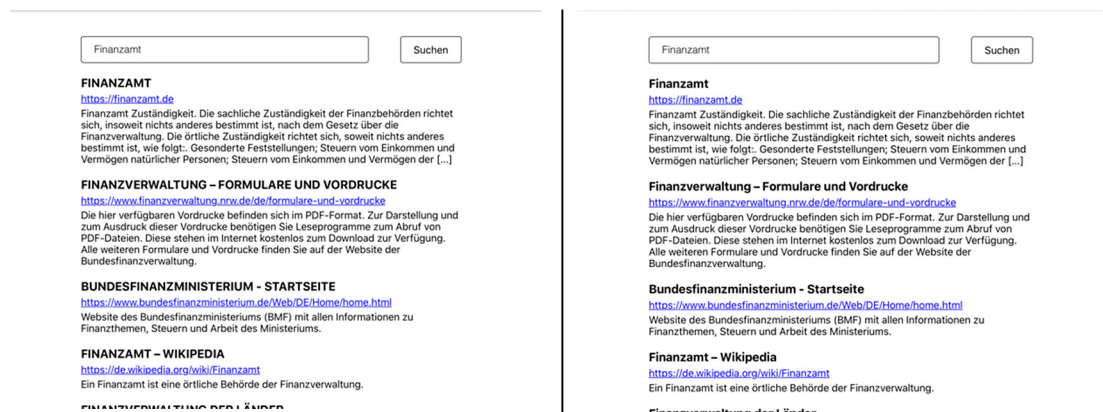


Figure 13: D12 Avoidance of All-Caps.

References

- [1] D. Wessel, A.-K. Kennecke, and M. Heine, 'WCAG and dyslexia — Improving the search function of websites for users with dyslexia (without making it worse for everyone else)', in *Mensch und Computer 2021*, Ingolstadt, Germany, Sep. 2021, pp. 168–179. doi: 10.1145/3473856.3473867.
- [2] Vereinte Nationen, Ed., *Digital government in the decade of action for sustainable development*. New York: United Nations, 2020.
- [3] Onlinezugangsgesetz vom 14. August 2017 (BGBl. I S. 3122, 3138). 2017.
- [4] K. Lenk, 'E-government in Europe: Uniform solutions for all countries?', *IP*, vol. 11, no. 3,4, pp. 189–196, Apr. 2007, doi: 10.3233/IP-2006-0099.
- [5] 'DIN EN ISO 9241-11:2018-11, Ergonomie der Mensch-System-Interaktion - Teil 11: Gebrauchstauglichkeit: Begriffe und Konzepte (ISO 9241-11:2018); Deutsche Fassung EN ISO 9241-11:2018', Beuth Verlag GmbH, 2018. doi: 10.31030/2757945.
- [6] T. Franke, C. Attig, and D. Wessel, 'A personal resource for technology interaction: Development and validation of the Affinity for Technology Interaction (ATI) scale', *International Journal of Human-Computer Interaction*, vol. 35, no. 6, pp. 456–467, Apr. 2019, doi: 10.1080/10447318.2018.1456150.
- [7] 'Mandatory Digital Post from public authorities'. <https://en.digst.dk/policy-and-strategy/mandatory-digitisation/digital-post/> (accessed Dec. 04, 2021).
- [8] 'Wave 4 on mandatory self-service'. <https://en.digst.dk/policy-and-strategy/mandatory-digitisation/self-service/wave-4-on-mandatory-self-service/> (accessed Dec. 04, 2021).
- [9] L. Ali and M. Salahat, 'E-accessibility evaluation of UAE governmental websites: Findings and implications', in *Proceedings of the 2019 3rd International Conference on E-commerce, E-Business and E-Government – ICEEG 2019*, Lyon, France, 2019, pp. 34–39. doi: 10.1145/3340017.3340035.
- [10] J. M. Kuzma, 'Accessibility design issues with UK e-government sites', *Government Information Quarterly*, vol. 27, no. 2, pp. 141–146, Mar. 2010, doi: 10.1016/j.giq.2009.10.004.
- [11] Z. Y. Lim, J. M. Chua, K. Yang, W. S. Tan, and Y. Chai, 'Web accessibility testing for Singapore government e-services', in *Proceedings of the 17th International Web for All Conference*, Taipei, Taiwan, Apr. 2020, pp. 1–5. doi: 10.1145/3371300.3383353.
- [12] 'Web Content Accessibility Guidelines (WCAG) 2.1'. <https://www.w3.org/TR/WCAG21/#comparison-with-wcag-2-0> (accessed Jan. 17, 2020).
- [13] Barrierefreie-Informationstechnik-Verordnung vom 12. September 2011 (BGBl. I S. 1843), die zuletzt durch Artikel 1 der Verordnung vom 21. Mai 2019 (BGBl. I S. 738) geändert worden ist. 2019. Accessed: Dec. 04, 2019. [Online]. Available: https://www.gesetze-im-internet.de/bitv_2_0/BjNR184300011.html.
- [14] W. W. A. Initiative (WAI), 'Web Accessibility Laws & Policies', *Web Accessibility Initiative (WAI)*, Jun. 25, 2020. <https://www.w3.org/WAI/policies/> (accessed Jun. 29, 2020).
- [15] J. Clarkson, R. Coleman, I. Hosking, and S. Waller, *Inclusive design toolkit*. University of Cambridge, Cambridge, CB2 1PZ, United Kingdom, 2007. [Online]. Available: <https://www-edc.eng.cam.ac.uk/downloads/idtoolkit.pdf>.
- [16] Microsoft, 'Inclusive Microsoft Design'. 2016. [Online]. Available: https://download.microsoft.com/download/b/0/d/b0d4bf87-09ce-4417-8f28-d60703d672ed/inclusive_toolkit_manual_final.pdf.
- [17] World Health Organization, 'ICD-10 Version:2019', 2019. <https://icd.who.int/browse10/2019/en#/F81.0> (accessed Mar. 03, 2020).
- [18] V. F. de Santana, R. de Oliveira, L. D. A. Almeida, and M. C. C. Baranauskas, 'Web accessibility and people with dyslexia: a survey on techniques and guidelines', in *Proceedings of the International Cross-Disciplinary Conference on Web Accessibility – W4A '12*, Lyon, France, 2012, p. 1. doi: 10.1145/2207016.2207047.
- [19] D. Sprenger and J. Sprenger, *Lese-Rechtschreib-Störung: ein Leben mit LRS; Wege und Chancen*. Stuttgart: Schattauer, 2014.
- [20] R. L. Peterson and B. F. Pennington, 'Developmental dyslexia', *Annu. Rev. Clin. Psychol.*, vol. 11, no. 1, pp. 283–307, Mar. 2015, doi: 10.1146/annurev-clinpsy-032814-112842.
- [21] C. Coleman, N. Gregg, L. McLain, and L. W. Bellair, 'A comparison of spelling performance across young adults with and without dyslexia', *Assessment for Effective Intervention*, vol. 34, no. 2, pp. 94–105, Mar. 2009, doi: 10.1177/1534508408318808.
- [22] J. E. McCarthy and S. J. Swierenga, 'What we know about dyslexia and Web accessibility: A research review', *Univ. Access Inf. Soc.*, vol. 9, no. 2, pp. 147–152, Jun. 2010, doi: 10.1007/s10209-009-0160-5.
- [23] L. Rello, 'Dyslexia and web accessibility: synergies and challenges', in *Proceedings of the 12th Web for All Conference on – W4A '15*, Florence, Italy, 2015, pp. 1–4. doi: 10.1145/2745555.2746655.
- [24] A. Al-Wabil, P. Zaphiris, and S. Wilson, 'Web navigation for individuals with dyslexia: An exploratory study', in *Universal Access in Human Computer Interaction. Coping with Diversity*, vol. 4554, C. Stephanidis, Ed. Berlin, Heidelberg: Springer Berlin Heidelberg, 2007, pp. 593–602. doi: 10.1007/978-3-540-73279-2_66.
- [25] A. Al-Wabil, P. Zaphiris, and S. Wilson, 'Examining visual attention of dyslexics on web navigation structures with eye tracking', in *2008 International Conference on Innovations in Information Technology (IIT)*, Al Ain, United Arab Emirates, 16–18 December 2008, Piscataway, NJ: IEEE, 2008.
- [26] N. A. Beacham and J. L. Alty, 'An investigation into the effects that digital media can have on the learning outcomes of individuals who have dyslexia', *Computers & Education*, vol. 47, no. 1, pp. 74–93, Aug. 2006, doi: 10.1016/j.compedu.2004.10.006.
- [27] L. Cole, A. MacFarlane, and G. Buchanan, 'Does dyslexia present barriers to information literacy in an online environment? A pilot study', *Library and Information Research*, vol. 40, no. 123, pp. 24–46, Dec. 2016.
- [28] Disability Rights Commission, *The web: Access and inclusion for disabled people: a formal investigation*. London: TSO, 2004.
- [29] A. MacFarlane, A. Alblair, C. R. Marshall, and G. Buchanan, 'Phonological working memory impacts on information searching: An investigation of dyslexia', in *Proceedings of*

- the 4th Information Interaction in Context Symposium on – IIX '12, Nijmegen, The Netherlands, 2012, pp. 27–34. doi: 10.1145/2362724.2362734.
- [30] M. R. Morris, A. Fournay, A. Ali, and L. Vonessen, 'Understanding the needs of searchers with dyslexia', in *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems – CHI '18*, Montreal, QC, Canada, 2018, pp. 1–12. doi: 10.1145/3173574.3173609.
- [31] J. Nielsen, 'Lower-Literacy Users: Writing for a Broad Consumer Audience', Nielsen Norman Group, Mar. 13, 2005. <https://www.nngroup.com/articles/writing-for-lower-literacy-users/> (accessed Apr. 01, 2020).
- [32] L. Rello, R. Baeza-Yates, S. Bott, and H. Saggion, 'Simplify or help?: Text simplification strategies for people with dyslexia', in *Proceedings of the 10th International Cross-Disciplinary Conference on Web Accessibility – W4A '13*, Rio de Janeiro, Brazil, 2013, p. 1. doi: 10.1145/2461121.2461126.
- [33] L. Rello and J. P. Bigham, 'Good background colors for readers: A study of people with and without dyslexia', in *Proceedings of the 19th International ACM SIGACCESS Conference on Computers and Accessibility – ASSETS '17*, Baltimore, Maryland, USA, 2017, pp. 72–80. doi: 10.1145/3132525.3132546.
- [34] N. A. Beacham, 'Dyslexia-friendly computer-based learning materials', in *Access All Areas: Disability, Technology and Learning*, York: TechDis, 2002.
- [35] E. Draffan, 'Dyslexia and technology', in *Access All Areas: Disability, Technology and Learning*, York: TechDis, 2002.
- [36] P. Fairweather and S. Trewin, 'Cognitive impairments and Web 2.0', *Univ. Access Inf. Soc.*, vol. 9, no. 2, pp. 137–146, Jun. 2010, doi: 10.1007/s10209-009-0163-2.
- [37] P. Rainger, 'A Dyslexic Perspective on e-Content Accessibility', Jan. 2003.
- [38] E. Roth and A. Warnke, 'Diagnose und Therapie der Lese-Rechtschreibstörung', *Monatsschrift Kinderheilkunde*, vol. 149, no. 9, pp. 956–967, Sep. 2001, doi: 10.1007/s001120170094.
- [39] G. Schulte-Körne, W. Deimel, and H. Remschmidt, 'Zur Diagnostik der Lese- Rechtschreibstörung', *Zeitschrift für Kinder- und Jugendpsychiatrie und Psychotherapie*, vol. 29, no. 2, pp. 113–116, May 2001, doi: 10.1024/1422-4917.29.2.113.
- [40] A. C. Smith, B. C. W. Ralph, J. Marty-Dugas, and D. Smilek, 'Loading... loading... The influence of download time on information search', *PLoS ONE*, vol. 14, no. 12, e0226112, Dec. 2019, doi: 10.1371/journal.pone.0226112.
- [41] R. Yu, R. Tang, M. Rokicki, U. Gadiraju, and S. Dietze, 'Topic-independent modeling of user knowledge in informational search sessions', *Inf. Retrieval. J.*, vol. 24, no. 3, pp. 240–268, Jun. 2021, doi: 10.1007/s10791-021-09391-7.
- [42] Daten, Informationssysteme und Analysen im Sozialen, 'Liste der Prüfschritte', 2019. <https://testen.bitv-test.de/index.php?a=dl> (accessed Jul. 24, 2020).
- [43] D. Wessel, M. Heine, C. Attig, and T. Franke, 'Affinity for technology interaction and fields of study: implications for human-centered design of applications for public administration', in *Proceedings of the Conference on Mensch und Computer*, Magdeburg, Germany, Sep. 2020, pp. 383–386. doi: 10.1145/3404983.3410020.
- [44] G. Berget and F. E. Sandnes, 'Do autocomplete functions reduce the impact of dyslexia on information-searching behavior? The case of Google', *J. Assn. Inf. Sci. Tec.*, vol. 67, no. 10, pp. 2320–2328, Oct. 2016, doi: 10.1002/asi.23572.
- [45] D. Ward, J. Hahn, and K. Feist, 'Autocomplete as research tool: A study on providing search suggestions', *ITAL*, vol. 31, no. 4, p. 6, Dec. 2012, doi: 10.6017/ital.v31i4.1930.
- [46] The British Dyslexia Association, 'Dyslexia Style Guide 2018: Creating Dyslexia Friendly Content', 2018. https://cdn.bdadyslexia.org.uk/documents/Advice/style-guide/Dyslexia_Style_Guide_2018-final-1.pdf?mtime=20190409173949 (accessed Dec. 27, 2019).
- [47] S. E. Shaywitz and B. A. Shaywitz, 'The neurobiology of reading and dyslexia', *Leader*, vol. 12, no. 12, pp. 20–21, Sep. 2007, doi: 10.1044/leader.FTR7.12122007.20.

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