Accessible Text Tools: Where They Are Needed & What They Should Look Like

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ABSTRACT

Many people have problems with reading, which limits their ability to participate in society. This paper explores tools that make text more accessible. For this, we interviewed experts who proposed scenarios and tools. Frequently mentioned scenarios are public administration, the medical domain, and everyday life. The accessible text tools proposed by experts support readers by improving how text is compressed, expanded, reviewed, and experienced. We provide the Accessible Text Framework to help researchers understand how the different software tools can be combined and discuss how individual tools can be implemented.

CCS CONCEPTS

• **Human-centered computing** → **Empirical studies in HCI**; **Empirical studies in interaction design**.

KEYWORDS

Accessibility; People With Intellectual Disabilities; Non-Native Readers; Easy Language; Plain Language; Text Summarization

ACM Reference Format:
Hendrik Heuer and Elena L. Glassman. 2023. Accessible Text Tools: Where They Are Needed & What They Should Look Like. In *Extended Abstracts of the 2023 CHI Conference on Human Factors in Computing Systems (CHI EA '23), April 23–28, 2023, Hamburg, Germany*. ACM, New York, NY, USA, 7 pages. https://doi.org/10.1145/3544549.3585749

1 INTRODUCTION

The ability to read is an important prerequisite for participation in society, both online and offline. Up to 13.7% of people worldwide are illiterate [55]. These people cannot read or write a short, simple statement in their everyday life [54]. Another large group of people is functionally illiterate. The United Nations considers a person to be functionally illiterate if he or she "cannot engage in all those activities in which literacy is required for effective functioning of his [or her] group and community and also for enabling him [or her] to continue to use reading, writing and calculation for his [or her] own and the community's development" [54]. Illiteracy and functional illiteracy can be found in many countries, even if the overall literacy of the country is high. The reading score in Germany in the Programme for International Student Assessment (PISA) is above the average [53]. Nevertheless, 12.1% of German citizens are either functionally (8,1%) or fully (4,0%) illiterate [19, 20].

Our investigation aims to provide the foundation for software tools that enable as many people as possible to engage in all those activities in which literacy is necessary. Primary stakeholders of such tools are people with intellectual and cognitive impairments. Research on this user group is limited [31], especially for the large group of people who may not have support through caregivers or others and whose needs may not be easily recognizable [19, 20]. The tools are also helpful for non-native readers like immigrants, expats, and tourists. However, following the principles of universal design [50] and design for all [4], our vision is to develop tools that make text accessible to anybody.

To provide accessible text tools, we examine scenarios where software tools would be helpful and what kind of accessible text tools are needed to support users. We operationalize the term accessible text tool as any socio-technical intervention that can make text more accessible. To empirically study what accessible text tools should be developed, we interviewed 18 experts from different fields. We answer the two research questions:

- RQ1: In what scenarios would accessible text tools be especially useful?
- RQ2: What features should an accessible text framework have?

2 BACKGROUND & RELATED WORK

The proposals that we encountered in the investigation expand on existing work on text simplification and text summarization. Text simplification has been studied for a variety of languages, including frequently spoken languages like English [14, 57], Spanish [6], French [8] and German [28, 49] as well as less frequently spoken languages like Swedish [15], Danish [29], and Basque [18]. This paper focuses on German, the most spoken native language within the European Union and the 12th most frequently spoken language worldwide [56]. Germany is a country in which literacy is highly important and where many people could potentially benefit from accessible text tools. Our work is informed by investigations of the user experience of translation systems [30], which showed that poor quality translations can lead to conversations breakdowns and overall frustration of users [22, 59]. Prior work also showed that even well-performing machine translation systems require users to assess the translation and to identify errors [27], which can be challenging for users.

This paper investigates scenarios in which such tools are helpful and who would benefit the most. A special focus is on people with intellectual and cognitive impairments. A 2004 investigation

CHI EA '23, April 23–28, 2023, Hamburg, Germany

ACM ISBN 978-1-4503-9422-2/23/04.
https://doi.org/10.1145/3544549.3585749

in the U.S. by Wehmeyer et al. identified several barriers that limit Internet use by people with intellectual disabilities [52]. These barriers include 1. limited access to computers, 2. lack of appropriate and cognitively accessible software, 3. the complexity of operating systems, and 4. the amount of reading that is required. A 2017 investigation in Spain by Chiner et al. found that 90% of people with intellectual disabilities use smartphones, compared to 69% who use a laptop and 61% who use a computer [12]. As popular Internet use cases, they identified listening to music (84%), watching videos (77%), and chatting with friends (70%). Reading texts online is an activity that only every third (33%) person with intellectual disabilities (IDDs) reports doing. In addition to that, only every fourth person (25%) with IDDs reads a newspaper. These findings indicate that tools that make text more accessible could support many people with IDDs who use technology but do not read text online. The numbers are corroborated by a 2019 study from Sweden by Ågren et al. [62]. In this sample, 67% of adolescents with IDDs have access to a smartphone, compared to 98% of adolescents without IDD. Half of people with IDD (52%) report having contact with their friends on social media. This number is considerably lower than the 93% of people without disabilities who do. The largest difference can be observed for those who search for new knowledge or information online. Only 20% of young people with IDD search for knowledge and information online, compared to 86% of young people without IDDs. Ågren et al. also asked people with IDD about the difficulty of understanding information on the Internet. One out of five people with an IDD (21%) state that they never understand information on the Internet. Another 24% of people with IDDs find it very difficult to understand information. With accessible text tools, we want to enable more people with and without cognitive impairments to search for new information and knowledge online, especially news. This motivation connects to Hu and Feng, who empirically examined how people with cognitive impairments search for information online. They found that people prefer search engines to the browsing condition, where they frequently visit incorrect categories [24]. In a 2010 study, Feng et al. also specifically investigated computer usage of children with Down syndrome [17]. They identify cognitive limitations, e.g., language difficulties and frustration, general cognitive difficulties, physical limitations, e.g., regarding typing or mouse usage, software problems, and societal difficulties.

Al-Thanyyan and Azmi provide an overview of resources and corpora, evaluation metrics, and simplification approaches [1]. These approaches include lexical-, syntactical-, machine translation- and hybrid approaches. A number of researchers developed such automated text simplification [1, 2, 38, 41, 43]. In their seminal work on the automatic induction of rules for text simplification, Chandrasekar and Srinivas explore natural language processing (NLP) methods to automatically transform long and complicated sentences into simpler ones [11]. Considering the complexity of hand-crafted rules, they propose inducing the simplification rules from data. More recent approaches follow this approach and leverage statistical machine translation [45, 58], deep recurrent neural networks like long short-term memory networks [36], or deep reinforcement learning [61]. For instance, to simplify Spanish text, Saggion et al. [40] developed a modular system that performs syntactic and lexical simplification. They evaluate the system using readability metrics for Spanish as well as human evaluations. The system's performance is comparable to the state of the art in English text simplification.

Table 1: The interviewed experts worked in one or more fields: plain language, accessibility and technology, linguistics and translation, and special or remedial education.

ID	Plain Language	Accessibility & Technology	Linguistics & Translation	Special Education
P01		✓		✓
P02		✓	✓	
P03	✓	✓		
P04	✓			
P05	✓			
P06	✓		✓	
P07	✓			✓
P08	✓		✓	
P09	✓			
P10	✓			
P11	✓	✓		
P12	✓		✓	
P13		✓		✓
P14				✓
P15				✓
P16	✓		✓	
P17	✓		✓	✓
P18			✓	

3 METHODS

The review of related work showed that although some promising technical approaches exist, it is unclear in what scenarios accessible text is most needed (RQ1) and what features an accessible text framework should have (RQ2). To answer these research questions, we interviewed 18 participants (9 females). Participants were recruited using snowball sampling. A large number of people with cognitive impairments do already have access to support through caregivers or others. Our goal was to understand how those without such resources can be supported through socio-technical interventions. Since requirements for accessible text were first made mandatory by the German Equal Opportunities for People with Disabilities Act [9], we collaborated with the Central Office for Accessible Information Technology of the State of Bremen in Germany. We started with the leader of this office as a seed for our interviews. She made recommendations for others to interview, who, in turn, made more recommendations themselves. We stopped when people started to recommend people that we had already interviewed. We focused on expert interviews to approach the topic of accessible text tools as broadly as possible and to identify primary stakeholders. We aim to provide a starting point for in-depth participatory research with stakeholders [26, 46, 47].

Table 1 shows that the interviewed experts worked in one or more of the following fields: plain language, accessibility and technology, linguistics and translation, and special or remedial education. In the recruitment, we clarified that we searched for people with expertise and experience with accessible text. We included

experts with a strong background in accessibility and technology who knew what is technically possible with contemporary natural language processing tools. One participant is, for example, a technical manager in a startup that develops tools that check text for comprehensibility and provide tips on how to simplify texts. Another participant was involved in the most extensive study on people with Down syndrome ever conducted.

In the semi-structured interviews, each participant had to imagine a system that can automatically translate texts from everyday language into accessible text. We asked them "In what situations and contexts would such a system be used?", "Who would use the system?", and "How would the system be used?". We also asked them "How should such a system be implemented technically?" and what opportunities and risks they see in using such a system. We performed a thematic analysis of the transcribed interviews [7]. We identified themes and concepts in an iterative process of inductive coding by moving back and forth between the interviews several times. The codes were merged and split as needed following axial coding principles [13]. After the initial assignment of potential themes, the different codings were reviewed repeatedly to ensure that the themes correspond to the interviewees' statements. The different codings were grouped into themes and subthemes. The first author performed the coding.

All interviews were conducted in German. We recorded the audio of the interviews and hired a professional transcription service to transcribe the audio. The transcriptions were translated into English using professional translation software. Informed consent and permission to record the audio (in line with the European General Data Protection Regulation) were sought and granted from all participants. The responsible authorities granted institutional review board-equivalent approval before the investigation.

4 RESULTS

In the following, we will report the scenarios (RQ1) and features of an accessible text framework (RQ2) that our experts discussed.

4.1 In What Scenarios Are Accessible Text Tools Especially Important? (RQ1)

The most frequently mentioned scenario is **Public Administration** (P02, P03, P04, P05, P07, P09, P14, P17). Examples of this include forms, notices, general orders (P17), official websites (P14, P17), and tax notices (P02). Experts also referred to child benefits (P05, P02), training assistance (P02), and assistance plans for people with disabilities (P09). Other examples include naturalization assistance for immigrants (P02), work permits (P07), unemployment benefits or welfare benefits (P02), and applying for a new ID card (P14). Experts also commented on the role of elections in relation to the government. Election-related texts include information on the ballot (P10), explanations of the election procedures (P05), and information about the election program of political parties (P02, P05).

Experts also commented on scenarios in **Everyday Life** (P05, P14, P08, P10, P15, P17), e.g., receiving mail from an electricity supplier (P05), or encountering news on TV or in a newspaper (P10, P14, P15), e.g., about COVID-19 rules and restrictions (P10). Other examples include searching for knowledge online (P10). Experts also discussed tasks like buying things online (P15), buying tickets for a bus, train, or airplane (P10, P15), reading manuals (P15, P08), or understanding legal texts (P09, P16).

According to our experts, the **Medical Domain** would also benefit from accessible communication (P01, P02, P04, P07, P08, P16, P17). They mentioned examples like doctor-patient communication (P04, P07) and health information (P01, P17). Examples in this domain also included leaflets or package inserts for medicines (P08) and information about health insurance (P02).

4.2 What Features Should an Accessible Text Framework Have? (RQ2)

In the following, we will present the accessible text tools proposed by experts. We grouped these tools based on whether they are about 1. Compressing, 2. Extending, 3. Experiencing, and 4. Reviewing Text.

4.2.1 Compressing Text. Many participants commented on the importance of the **Summary and Prioritization** of Text (P02, P07, P14, P04, P10, P16, P17). P01 highlights the importance of identifying the core statements of a text. P17 argues that summaries that filter the core statement are necessary for some texts. P02 thinks it would also be helpful if the tool could identify tasks formulated in the text, e.g., that the recipient of a letter must write an e-mail to a specific person. P01 highlights important risks associated with summarizing or prioritizing information. She poses the question: "Who defines what the core message is?" P04 warns that the coherence of a text may be negatively affected by summaries. P05 argues that it could be stigmatizing if a text in plain language does not include everything in the original. He criticizes that this would mean that information "is being withheld".

Lexical Simplifications were mentioned as a way to compress text to make it more accessible (P06, P18, P03, and P10). P05 believes that there are complex or foreign words in German that can be conveyed much more easily. P06 and P03 imagine a system that makes several suggestions to see which word is the most appropriate in a particular context. P18, for instance, argued that it would be helpful to provide "alternative words", e.g., based on a thesaurus. P10 envisioned an interface that highlights all words that could be a "source of unrest". P03 thinks that the system could also help disambiguate the different meanings of a word and help users or authors decide which simplification to choose. Similarly, P08 proposed a tool that analyzes whether certain words are understood by a particular demographic.

Another aspect that a large number of experts commented on is **Reducing the Reading Volume** (P02, P07, P14, P03, P04, P10, P16, P17). P16, for instance, cites making sure that texts do not become too long as one of the challenges translators face. P04 argues that it is a big challenge to keep the amount of text generally low or at a manageable level for readers with reading difficulties. P14 thinks the goal is to abstract things and say more with fewer words. P03, however, warns that shortening a text means that the linguistic complexity of the text is even more compressed because the text contains more information. P17 is worried that modified texts could become too long because it is hard to recognize a text's core message.

4.2.2 Expanding Text. Many experts commented on **Explanations** that can make texts more understandable (P02, P05, P01, P10, and P16). P01 describes this as providing examples to explain a context better. P02 argues that it is important to ensure that readers understand what a text is trying to convey, e.g., whether it tries to inform a reader or is advertising something. P14 argues that for specific "abstract terms", it is necessary to convey everything that is "hidden behind this term". For this, interviewees described a tool that explains terms (P18, P10, P16). P15, however, warned that explanations that the user does not need could make the reading more difficult.

Experts also referred to a tool that improves the **Structure and Flow** of a text (P07, P03, P04, and P17). P03, for instance, argues that the sentences of a text may not be in the optimal order. P03 believes that sorting the sentences logically and avoiding jumping back and forth would benefit reading. This proposal connects to P04, who thinks that the main task of professional translators like herself is to "bring structure into the texts so that the reader can follow it logically". She reports that there are "a lot of bad original texts that only tell you at the end of the text what it is actually about".

4.2.3 Reviewing Text. Several experts commented on tools that act as a **Quality Check** (P06, P07, P11, P18, P03, P08, P12, P13, P17). P03, for instance, thinks that a tool should check whether a text is consistently worded and presented simply and understandably. She hopes such a tool could make quality checks as commonplace as spelling and grammar checks. P06 describes a tool that provides an overview of aspects that inhibit comprehension of texts. The tool could, for example, mark all instances of passive text in yellow. All passages that contain technical terms could be marked in orange. P07 proposed a tool that analyses a text and suggests what should be improved to achieve a certain level of comprehensibility.

Regarding the review of text, experts also commented on the importance of **Reviews by the Target Group** and how tools can support this (P05, P14, P18, P01, P04, P10, P13, P16, and P17). P01 and P14 argued that it is crucial to present texts to people with intellectual and cognitive impairments and ask them: "Did you understand that?" P05 believes that there is no way around such reviews. P02 also thinks that the target group should frequently review the texts. P06 argued that the ideal reviewer comes from the target group and has expert knowledge about the text's topic. Some experts like P04 and P13 already involve the target group as "co-researchers", who review the texts produced by their companies. However, other researchers like P07 and P14 criticized this approach. P07 is worried that reviewers will learn with experience. He believes that at some point, they "are probably just too good to judge a text in easy language". P09 also argues that "of course, they [the reviewers] learn". P07 and P14 also warned that reviews are not representative. This may, however, not be a problem in practice. P13 argues that the reviewers in her project were able to assess the comprehensibility of a text both for their own demographic and other target groups. P04 also highlights that reviews occur in a professional setting where everybody is aware of their role. She thinks that such reviews have only advantages and no disadvantages. Based on her practical experience, P04 thinks that such reviews are "very, very useful" even though it can be challenging to find reviewers (P04, P09).

4.2.4 Experiencing Text. P02, P01, P10, and P12 commented on **Visual Factors** like illustrations. P02 discussed how important it is to present accessible text visually with pictures, the right font, and the good contrast. P10 emphasizes that it is about the text, illustrations and font size. P02 warns that this visual perspective is frequently disregarded because many of the practitioners in the field have a background "in print". P01 argues that it "must not be noticeable at all" that a text was modified.

Another vital experience factor discussed by several experts is the potential adverse effects of **Stigmatization** (P01, P05, P06, P07, P09, P10). P10, for instance, believes that it is important to provide user interfaces and descriptions that are not defect-oriented, exclusionary, or defamatory. She does not want people to feel that they are not taken seriously. P05, P07, and P09 warned against using infantile or children-like language or illustrations, marking readers as people with a visible need for support. P06 urges designers and developers to exercise caution when marking things as more understandable because this could scare off people.

Experts also commented on the importance of the **Personalization** of tools (P05, P07, P11, P15, P18, P03, P13, P17). P15 highlights the importance of finding technical solutions for very individual situations to reach those strongly impaired. P07 thinks it would be great if the "AI" could "learn" what kind of support a user needs and likes. P13 describes such adaptive interfaces as "supporting the user according to his or her current needs".

5 DISCUSSION

In the following, we summarize our findings, describe the Accessible Text Framework to guide the design and development of accessible text tools, and discuss how it can be implemented using contemporary natural language processing techniques. We also summarize the open challenges associated with accessible text tools.

In prior work, text simplification is often framed as a translation task from everyday language to "plain language", akin to a system that translates from English to French. Informed by such prior work [14, 28, 36, 39, 49, 57], we expected the accessible text tools to be primarily focused on end-to-end translations from more complex to more simple language. However, our investigation suggests that sentence-by-sentence translations might frequently not be what stakeholders need or want. Many experts even argued that sentence-by-sentence translations are impossible or unwanted (P05, P14, P01, P04, P12). P10, for instance, thinks that the "translation" is not a simplification but an effort to make something more understandable. P04 and P16 describe the challenge translators face as filtering the relevant information and extracting what needs to be explained further (while ensuring that the texts do not become too long). Beneficial accessible text tools include the Summarizing Key Messages, Explanations of Difficult Words, Reducing the Length of a Text, and Providing Alternatives for Difficult Words.

5.1 Accessible Text Framework

To guide future research on making text more accessible, we compiled the Accessible Text Framework. The Accessible Text Framework relates the different categories to each other. 1. Expanding Text and 2. Compressing Text tools both transform a text into a new version. 3. Experiencing Text tools affect how text is presented

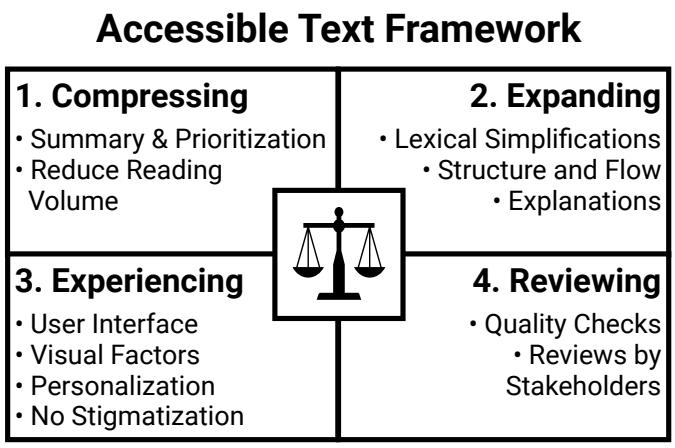

Figure 1: The Accessible Text Framework distinguishes between 1. Expanding, 2. Compressing, 3. Experiencing, and 4. Reviewing Text. This framework systematizes the accessible text tools that we identified in the interviews.

and how the different simplification steps are implemented. 4. Reviewing Text describes tools that facilitate the feedback loop used to iteratively improve the text based on feedback from readers. The visual representation of the framework shown in Figure 1 illustrates the tension between 1. Compressing and 2. Expanding Text and outlines how tools that facilitate 3. Experiencing and 4. Reviewing Text can help designers and developers overcome these tensions. As highlighted by the symbol of a scale, the components of the Accessible Text Framework need to be balanced.

Our interviews showed that a balance between making a text as short as possible (1. Compressing Text) and making a text as long as necessary (2. Expanding Text) is needed. As our investigation of the different scenarios showed, this balance depends on the content and the context of a text. It is also highly dependent on the readers of a text. The components in the 3. Experiencing and 4. Reviewing Text categories provide a way to achieve this balance between compressing and expanding text. The user interface plays a crucial role in how the expansions and compressions of text are presented to users. The decision to expand and compress a text should only be made in close consultation with readers. Our interviews indicate that a promising way to achieve this is by employing people from the target groups and empowering them to review the text through technology. A positive side effect of this is that it could create interesting and varied jobs for people with cognitive impairments and others.

5.2 Technical Feasibility Analysis of the Accessible Text Framework

The 1. Expanding Text and 2. Compressing Text categories are directly related to existing research on text simplification [14, 28, 49, 57] and text summarization [1, 39]. While much of this research is focused on English, the described approaches can be applied to German, the language we studied, and other languages. Our findings indicate that accessible text tools may relate more closely to text summarization than text simplification. Prototypes for solutions from the Summary & Prioritization category can be easily implemented, e.g., using established graph-based techniques [16, 33] as well as deep learning [60]. Explanations and Lexical Simplifications from the 2. Expanding Text category could leverage existing resources like the Simple English Wikipedia and Hurraki [25]. Synonyms, hyponyms, and hypernyms can be extracted from established hierarchies like WordNet [34] or GermaNet [21].

Researchers could also explore how systems for argumentation mining can be leveraged to automatically trace the argumentation of a text [10, 44, 51] and how this can be used to improve the structure of a text. Emerging technologies like Generative Pre-trained Transformer 3 (GPT-3) can also be applied to summarize text automatically [48]. The OpenAI application programming interface provides an option to "Summarize for a 2nd grader" that can be used to translate difficult text into simpler concepts [37]. However, such large language models are connected to a number of challenges, including their propensity to hallucinate [42].

5.3 Limitations & Future Work

The primary goal of this paper is to inspire and motivate work on accessible text tools. The findings are based on interviews with a diverse, gender-balanced snowball sample of experts from different fields. Even though our snowball sample was seeded with an expert from accessibility, we reached experts with backgrounds in linguistics, technology, special education, and plain language. This focus on experts allowed us to identify features of an accessible text framework applicable to functionally illiterate people and others who will benefit from readable text, especially people with intellectual and cognitive impairments as well as non-native readers. Our focus on experts rather than end users is also a central limitation. Following the "Nothing About Us Without Us" mantra [32, 47], future work should involve these stakeholders in designing, developing, and evaluating accessible text tools using participatory design [5, 26, 35]. This involvement is especially important considering the complexity of machine learning-based systems [3, 23].

Our investigation is also limited by the fact that we focused on perceived helpfulness. Further work is needed to implement the accessible text tools, e.g., as mobile apps or as a browser extension, and to evaluate their helpfulness in user studies. Another limitation is that our investigation focused on German. While many of the insights likely apply to other languages, especially Germanic languages like English, further research is needed to confirm this.

6 CONCLUSION

Considering the many people who struggle with reading, better tools are needed to make text more accessible. We identified relevant scenarios and provided a framework to shape what accessible text tools can and should look like. Based on expert interviews, we describe in what scenarios such tools may be especially useful (RQ1) and what features an accessible text framework should have (RQ2). Based on our empirical findings, we propose the Accessible Text Framework as a way to highlight the tension between information that needs to be compressed, e.g., by summarizing information and by reducing reading volume, and information that needs to be expanded, e.g., by providing explanations and by improving the structure and flow of a text. The framework also presents a socio-technical solution to the problem of balancing these two extremes, e.g., by putting readers in the loop and personalizing the experience. We believe that the insights provided in this paper can empower researchers, activists, and civic hackers to design and develop tools that make text more accessible, thus helping the millions of people who struggle with reading.

ACKNOWLEDGMENTS

This research has been supported by the German Research Foundation, Grant No. 374666841 (SFB 1342), and the National Science Foundation under Grant No. 2107391. We thank all participants and reviewers for their insights.

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