Designing a Dyslexia-Friendly Interaction with News Articles

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A Master's Thesis

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Abstract

This master's thesis presents a research project focused on improving the accessibility of news articles for people with dyslexia. A significant portion of online news content is text-based, which poses challenges for individuals with reading difficulties. While there are existing digital tools for text simplification and summarization, there is a lack of solutions specifically designed for dyslexic readers, and even fewer adapt to languages other than English.

The project addresses this gap with the development of a prototype that generates simplified versions of Norwegian news articles. Adopting a user-centered perspective, qualitative research methods and literature research were conducted to provide a basis for the design process. The later developed prototype aims to provide a flexible model that can accommodate the different reading experiences and perspectives of dyslexic people.

Its main functionality lies in visual and content-related text modifications. Together with results from corresponding user tests, the high-fidelity prototype provides detailed findings on how news articles can be made more accessible. They offer insights into the requirements and needs of news consumers with dyslexia and explore the potential of automatic text simplification in this context. The results can benefit companies, institutions, and organizations that are seeking to provide accessible news content, eliminating the need for manual simplification of every article. Moreover, the research conducted in this project can support further studies on design and digital accessibility solutions.

Disclaimer:
People with dyslexia have been and are often still stigmatized as persons who have low intelligence. Therefore, it is important to pay attention to how they are talked about and referred to when writing about them as a group of people. There are different opinions on which term describes a person who has dyslexia best and it is difficult to find a consensus that everyone agrees with (Team, 2019). On one side, there is the "people-first" approach that mentions the person first and then the characteristic, so the term would be a "person with dyslexia". On the other side, some groups oppose this formulation because it appears to them as if the disorder is not part of the person, and as if it is something less important or negative. Therefore, they prefer the "identity-first" approach which uses an adjective to describe the circumstance, which would be "dyslexic person" in this case. Because of these different perspectives, both ways of phrasing are going to be used in this thesis to keep a balance and not side with only one of the affected groups.

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Abbreviations

ADHD	Attention Deficit Hyperactivity Disorder
AI	Artificial Intelligence
AS	Automatic Text Summarization
ATS	Automatic Text Simplification
GPT	Generative Pre-trained Transformer
IPL	International Plain Language
IFLA	International Federation of Library Associations and Institutions
LLM	Large Language Model
MVP	Minimum Viable Product
NRK	Norsk Rikskringkasting
NSD	Norsk Senter for Forskningsdata (Norwegian Center for Research Data)
NTB	Norsk Telegrambyrå (Norwegian News Agency)
TTS	Text-to-speech
UCD	User-Centered Design
UX	User Experience
W3C	World Wide Web Consortium
WCAG	Web Content Accessibility Guidelines
WebAIM	Web Accessibility in Mind

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1 Introduction

This chapter provides an introduction to the master's project discussed in this thesis. First, the context and resulting research problem are described. Afterwards, the research objectives and questions, as well as the project's significance, are addressed.

1.1 Motivation

Most people in the world regularly read the news. There are many news outlets and usually, they aim to reach as many people as possible with their news content. However, a large part of the news content online is text-based. This leads to some people feeling excluded because of reading difficulties. Especially readers with dyslexia make up a bigger part of the population than one might think, with around five to ten percent of the population in Norway (Helland, 2023). There are existing digital simplification and summarizing tools to practice or help with reading (see Ch. 2.6). That being said, there are not many solutions developed for dyslexic users. Also, most are directed towards the English language since it is one of the most used globally. To this day, there are no reading supporting tools for texts, especially for the news environment, in the Norwegian language.

On the other hand, quite extensive research has been carried out about how to write accessible text for different target groups, including dyslexic readers. For example, Inclusion Europe ("Information for all", 2016) created a detailed European Standard for generating easy-to-read and easy-to-understand information which is available in Norwegian. Another guideline was published by "Språkrådet"[1], the Language Council of Norway. It has a focus on writing Norwegian plain language, called "Klarspråk" (see Ch. 2.2).

1.2 Problem Statement

As mentioned, various tools can be found today that help the user with transforming the text into a more accessible version. For example, many browsers offer a "reading mode" where the user can adjust different visual aspects of the text, like the spacing between lines. But these tools do not provide an opportunity of automatic text simplification for dyslexia, not to mention combining it with visual modifications. They also

[1] https://www.sprakradet.no/

often offer a large number of different options which are not necessarily targeted towards dyslexia but towards a more general audience. A high density of functionalities could make the interaction more difficult for a dyslexic user if the useful functions are not easily distinguishable.

In this master's thesis, different ways of modification are explored to make news articles more accessible for people with reading difficulties, specifically with dyslexia. The main focus is on the development of a prototype that creates a simplified version of news articles. Because dyslexic readers have varying needs when it comes to the optimal accessible text, the idea was to develop a flexible model that can satisfy individual requirements. Additionally, in the context of language, the focus of this prototype is on simplifying Norwegian news articles since the project is carried out in Norway.

With the recent attention on artificial intelligence in Human-Computer Interaction as well as in society in general, the technology is showing potential in many areas. Due to its current fast development, relevance and versatility, it seemed beneficial to incorporate this technology into this project.

1.3 Research Question

This master's project has been developed together with Thale Kirkhorn. While this thesis focuses on the interaction design with emphasis on visual text adjustments, Thale discusses alterations concerning the text's content and providing different levels of text simplification to the user (Kirkhorn, 2023).

The overarching research question chosen for this thesis is *"How can visual and content-related text modifications work together to enhance the reading experience of dyslexic people?"*. The intention is to adopt a holistic perspective when designing and evaluating the prototype, considering the interconnections between elements, functions, and the user's needs. For further elaboration, the following sub-questions were phrased to lead through the research and design process:

1. How can the visual representation of text be effectively altered to enhance the reading experience of news articles and improve text comprehension?
2. What are suitable design elements in a reading tool that can address the individual needs of dyslexic people?
3. How can a design solution achieve a balance between the criteria of minimal distractions and necessary functionalities?

When trying to answer these research questions, a user-centered perspective is adopted. Regarding the first research question, previous studies have proposed several impactful ways of visual text modification (see Ch. 2.2.2). Those findings are supposed to be used and assessed for the concrete use case, utilizing input from conducted qualitative research in this thesis. The results should provide a selection of efficient options that

significantly improve the reading interaction for the target group.

The second question focuses on the diversity of dyslexic readers' experiences. Since a large variety of needs exists among the target group, there is not necessarily a fixed setting that works for everyone. This challenge should be met by creative design ideas that are based on constructivist research (see Ch. 3.1).

In the third question, the interaction complexity dilemma is addressed. This deals with the problem that - to provide an accessible tool to users with dyslexia - the product should have as few distractions from the main purpose as possible. At the same time, all functionalities that are required to accommodate the mentioned varying needs and requirements of dyslexic people have to be included. Therefore, a solution has to be designed to fulfill both conditions.

1.4 Contribution

The project idea is relevant in the way that it provides a possibility to make news articles more accessible to dyslexic readers. It can also apply to users who generally struggle with reading long and complex texts. Due to their reading difficulties, reading news articles available on common news portals constitutes a challenge. Hence, they have to find new ways to consume the desired news content. The prototype developed in the course of this master's project shows a possibility to support this. There has been some work on simplifying text with AI before (see Ch. 2.6), but mostly for the English language and not for Norwegian. Since reading text in a different language than the mother tongue is often even more difficult for people with dyslexia (Helland, 2023), a text simplification tool for the Norwegian language is needed.

As the project's focus is rather on developing with a user-centered approach and finding out how artificial intelligence can be specifically used in this context, it can help to work out the potential of an automatic text simplification application for news readers with dyslexia.

The result of this thesis is a proof of concept, on one side including a technical prototype with basic functionality to show a working implementation option in a rather experimental environment. On the other side, there is a high-fidelity design prototype that displays a possible working solution to the research problem based on comprehensive insights from conducted fieldwork and research. It provides information about what people with dyslexia want and need concerning their interaction with news articles. These findings can be helpful for companies, institutions and organizations that want to offer an accessible written news version for their consumers who face difficulties with reading. Journalists should not have to manually write a second, simplified version of every article. This project can aid in realizing a solution that does not require a high amount of extra time but can help news agencies to broaden their scope of active news consumers. Furthermore, the research conducted in this project and its results can support further studies regarding design and digital accessibility solutions.

1.5 Thesis outline

This thesis is divided into seven main chapters. First, the introduction in Chapter 1 briefly explains the content of, motivation for, and use of the master's project. The research scope and the corresponding leading research questions are explained, as well as the initial situation and main research problem.

Following that, in Chapter 2, background information for the research and development is described. This concerns dyslexia in general, easy language and guidelines for writing accessible text, as well as artificial intelligence and text simplification.

In Chapter 3, the utilized research methods and techniques in this project are introduced and it is explained how they are applied to advance the research for this tool.

Chapter 4 guides through all the conducted research steps, including interviews with different related parties, description of personas as well as the resulting requirements and needs of the user.

Afterwards, Chapter 5 describes the complete development process of the prototype, explaining each iteration as well as the corresponding results from user tests and feedback.

Chapter 6 discusses the project's results and evaluates them with regard to usability heuristics introduced in Chapter 3. Also, limitations in the process are addressed and the research questions defined in Chapter 1 are aimed to be answered.

Finally, Chapter 7 concludes the results and classifies them in terms of feasibility.

2 Background

This chapter provides background information about the most important aspects in this project. It also partly displays the research which was later used for the development of requirements in this thesis (see Ch. 4.4).

2.1 Dyslexia

A word recognition deficit (S. E. Shaywitz et al., 1992), also known as dyslexia, is a learning disorder that people are born with. The word "dyslexia" is derived from the Greek words "dys", meaning "bad" or "difficult", and "lexis", meaning "word", or in this case, "reading" (D. Harper, n.d.).

The disorder is defined by two processing difficulties: phonological and orthographic processing. A phonological processing disorder describes difficulties with perceiving and identifying the different sounds of letters in a word, whereas orthographic processing connects to understanding the direction and sequence of symbols, in this case meaning letters forming a word (S. Shaywitz, 2003). Thus, those affected face challenges that are not primarily related to comprehending the substance of the material. Instead, their difficulties essentially arise from the concrete act of reading words and sentences. Consequently, their reading speed is typically significantly slower than that of non-affected individuals. This can eventually have an adverse impact on overall comprehension abilities.

Dyslexia persists throughout the individual's lifetime, though with varying impacts contingent upon the person's age ("Dyslexia Basics - International Dyslexia Association", 2014). There is a significant number of undiagnosed cases where symptoms are exhibited. Since only a comprehensive assessment of reading, writing and language skills can be employed to officially diagnose a person with dyslexia, many individuals may experience signs of dyslexia throughout their lives without receiving an official diagnosis. According to the International Dyslexia Association, it is estimated that around 15-20% of the global population have those symptoms that affect reading as well as writing speed and quality (Louisa C. Moats et al., 2014). In Norway, between five to ten percent of the population are approximated to have dyslexia (Helland, 2023). It is also hereditary (S. E. Shaywitz, 1998, p. 307). Hence, having dyslexia does not indicate that the person received insufficient training in reading as a child and can not be seen as a sign of a low intellectual level ("Dyslexia Basics - International Dyslexia Association", 2014).

There are diverse ways in which dyslexia manifests for each affected person. Also, different levels of severity and the way it is dealt with can have a strong impact on how a person experiences reading and writing (“Dyslexia Basics - International Dyslexia Association”, 2014).

Even though reading is more difficult for people with dyslexia, they can have pronounced abilities in other fields that an average non-dyslexic person doesn’t have. Examples include problem-solving skills, oral skills or skills in creative areas in general (British Dyslexia Association, 2010). However, it can affect performance in school or at university when in a standard academic environment. There are ways of treatment provided by tutors, teachers or specially trained therapists in order to help with succeeding in the reading and writing aspect. These approaches are usually very structured, with clear and instant feedback. Often, different senses are used together simultaneously (“Dyslexia Basics - International Dyslexia Association”, 2014).

2.2 Klarspråk and Plain Language

This project is centered around Norwegian news articles as well as the simplification of Norwegian text in the prototype. The definitions and terminology used in this thesis will therefore be written from a Norway-centered perspective.

2.2.1 Definition and Use

Språkrådet, the Language Council of Norway, defines Klarspråk as a correct, clear and appropriate language for the recipient (“Klarspråk”, 2013). It is currently mostly used in the public sector, where important information is presented to a large audience. In the English language, Klarspråk is known as "Plain Language". There are different opinions on how to accurately define this type of writing (Petelin, 2010). The IPL Federation describes it as the following (“Plain Language - International Plain Language Federation”, 2019):

> *"A communication is in plain language if its wording, structure, and design are so clear that the intended readers can easily find what they need, understand what they find, and use that information."*

The chair of their standard’s committee, Christopher Balmford, criticises the term "plain language" itself (Christopher Balmford, n.d.). According to him, it is too much centered around language. He states that when rewriting a text in plain language, it has to be reevaluated in its entirety. That includes aspects like the design or content. This way of understanding the concept of plain language influenced this project in the decision to focus on several angles of simplification.

The "Store Norske Leksikon", an extensive Norwegian Encyclopedia, connects Klarspråk with easy-to-read text, and states that it is often suitable for people with dyslexia

(Anne Marit Godal, 2018). It further clarifies the most important points that easy-to-read text, in the following also referred to by its Norwegian term "klartekst", should follow. These are simple sentence structures, often even in an oral-resembling syntax, and avoiding long and complex words. The encyclopedia entry also talks about the aspect of the text's visual accessibility, that for example the font size and type or spacing should be taken into account when creating easy-to-read text.

Plain language is used for a diverse target group. However, persons with intellectual or learning disabilities are usually the main focus (Kerstin Matausch and Annika Nietzio, 2012). Dyslexia falls, as mentioned in Chapter 2.1, under the category of learning disabilities. Apart from that, there are various other groups of people who benefit from easy-to-read information. Among them are, for example, individuals with general low literacy, non-native language speakers or neuropsychiatric disabilities like ADHD or Autism (Misako Nomura et al., 2010). Members of the presented groups sometimes have very specific needs because they perceive text differently from one another. Moreover, they approach learning and reading processes diversely. Nevertheless, there is a general consensus that they share a broader congruence than difference. In addition, it should be regarded that disabilities or certain conditions can occur together and that they may require customized solutions. According to the International Federation of Library Association and Institutions (Misako Nomura et al., 2010, p. 6), easy-to-read text can also be directed towards the following three different age groups: Adults, young adults and children. Because of their age, they have varying requirements towards easy-to-read text.

2.2.2 Guidelines

There is an available selection of design guidelines for writing easy-read text which will be presented in this chapter. Design guidelines serve as recommendations for design principles. They are utilized during the design process to ensure a positive user experience and to enable the evaluation of a product's usability ("What is Deep Learning?", n.d.). The sets of guidelines discussed here were used as a basis in the design process of the prototype.

First, there is a European standard for writing easy-to-read text. It has been developed in the course of the project Pathways to adult education for people with intellectual disabilities by Inclusion Europe, the European association of people with intellectual disabilities and their families ("Information for all", 2016). This standard presents general guidelines about how to display information in order to make it easier to read and understand for various groups of people. It addresses different ways of communicating information, including written content. The document goes into detail about how to write easy-to-read text concerning words and sentences, but also about what should be considered regarding a text's visual aspects and included pictures. These guidelines were mainly created for people with intellectual disabilities. Nevertheless, the document also states that it can be, for instance, useful for "people who find it difficult to read" ("Information for all", 2016, p. 6). Though dyslexia does not directly fit into the

category of intellectual disabilities, it can therefore still be a useful guide to follow because there are comparable struggles when reading text.

Inclusion Europe also created an official easy-to-read logo (see Fig. 2.1). The content of wherever this logo is placed should be easy to read and in accordance with their guidelines. It can help the target group with identifying information that are specifically directed at them.

Figure 2.1: © European Easy-to-Read Logo: Inclusion Europe. More information at www.inclusion-europe.eu/easy-to-read

Next, the IFLA released a set of guidelines specifically for easy-to-read material (Misako Nomura et al., 2010). In contrast to the standard by Inclusion Europe, this document addresses additional issues surrounding the topic and gives background information. It also discussed different platforms and formats of written content in detail.

The previously mentioned Language Council of Norway released a short checklist for writing plain language text (Språkrådet, 2013). Besides talking about why there is a need for Klarspråk and the benefits of its use, it gives advice on, for instance, the choice of words and on how to structure the content.

Furthermore, the British Dyslexia Association wrote a guide on how to make written information accessible for readers with dyslexia (“Dyslexia Style Guide”, 2023). This guide covers the following aspects: Readable Fonts, Headings and Structure, Colour, Layout and writing style. It further states that this guide should be used in combination with other accessibility standards, for instance the widely recognized Web Content Accessibility Guidelines (“Dyslexia Style Guide”, 2023, p. 1).

The WCAG act as international technical standards for web accessibility and regard a broad variety of web design aspects (Andrew Kirkpartrick et al., 2018). The guidelines are categorized into the following four segments, summarized by descriptive adjectives.

1. *Perceivable:* Focus on making web content perceivable to all users, including for example text alternatives for non-text content, providing adaptable and resizable elements and ensuring readability-enhancing color contrasts.
2. *Operable:* Emphasis on creating web content that is easy to interact with, covering aspects like keyboard accessibility, providing sufficient interaction time for the users and presenting understandable navigation elements.
3. *Understandable:* Intent of comprehensible content regarding for consistency and predictability, clear and simple language as well as organization of content.

4. *Robust:* Improvement of compatibility with varying agents like assistive technologies.

The WCAG 2.0 and 2.1 are referenced by anti-discrimination laws and regulations as a recommendation or even as required standards in various countries. For example, a directive for web and mobile accessibility requires the public sector of all countries in the European Union to conform to these guidelines (European Commission, 2016). WebAIM, a non-profit organization that is committed to "expand[ing] the potential of the web for people with disabilities" (“About WebAIM”, n.d.), created a checklist that can be used to assess the general accessibility of web content related to WCAG (“WebAIM’s WCAG 2 Checklist”, n.d.).

In a study about web accessibility for people with dyslexia, the WCAG are evaluated with regard to dyslexia (Berget et al., 2016). It was found that accessibility concerning reading disabilities, especially dyslexia, is not a main focus and the needs of affected people are partly overlooked. Consequently, principles regarding this field should be improved.

In order to easily evaluate the readability of written text, the so-called "Lix" (derived from Swedish "Läsbarhetsindex") can be used as a quick intelligibility calculator (Anderson, 1983). It returns a number between one and sixty describing the input. The lower the score, the higher is the degree of readability (Lenhard and Lenhard, 2011). This formula was applied in the end of the development process to objectively evaluate the text’s quality regarding legibility.

2.3 Fonts for Dyslexia

Concerning the reading difficulties of dyslexic people, efforts have been made to create new fonts specifically for dyslexia that can be used to make reading easier for them (s. Fig. 2.2). One of them is "Dyslexie"[1]. Developed by Dutch Graphic Designer Christian Boer, this typeface’s design goes against typical typography rules and intentionally imbalances the letters’ symmetry in different ways. For example, the bottom of each letter is made thicker than the rest and their general shape is more uneven when compared to standard font types like Arial. Also, the spacing between words and letters is adjusted. All of those specific changes are supposed to increase the readability of the text. After purchase, this font can be used on different platforms in the browser, in e-reading tools or in other office-related software.

Another font named "Open Dyslexic"[2] is specifically designed for dyslexic people. This typeface was originally created by Abelardo González to help with his own reading. Since he received feedback and input from other users, it has been developed further. Just as "Dyslexie", this font uses thicker lines at the bottom of the letters and there is larger word and letter spacing. "Open Dyslexic" can be downloaded and used

[1] https://www.dyslexiefont.com/
[2] https://www.opendyslexic.org/

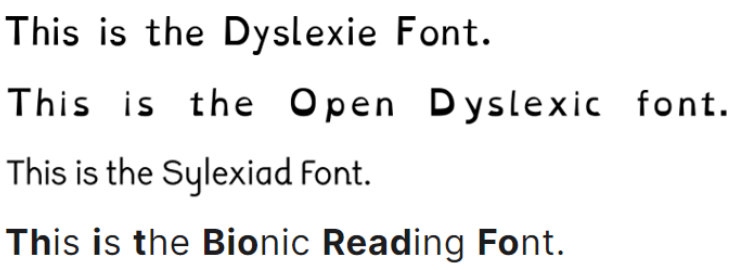


Figure 2.2: Three fonts designed for dyslexia and one for general reading support: Dyslexie, Open Dyslexic, Sylexiad and Bionic Reading (top-down)

for free.

Further, a typeface that was developed by Dr. Robert Hillier in his PhD-Project for helping with reading with dyslexia is "Sylexiad", available in a Serif and Sans-Serif version. This font was specifically designed for and tested with adult dyslexic readers (Robert Alan Hillier, 2006). In comparison to the previously mentioned fonts, it uses an approach of uniform line width, it therefore does not put more weight at the bottom of a letter. Instead, it uses thin but long ascenders and descenders, meaning lower-case letters' parts that extend the basic height of the word. There is also less word and letter spacing here when compared to "Dyslexie" or "Open Dyslexic". "Sylexiad" and two other fonts are available for free download on Hillier's website[3].

Lastly, there is the unique font or reading technique named "Bionic Reading". It was not specifically created for dyslexia, but its official goal is to facilitate better reading flow and understanding of textual content. Their target group consists of, among others, readers with dyslexia or general difficulties with reading and understanding text. The method is different to the previously described fonts since it uses visual stimuli to "guide the eye over the text" ("BR About." 2021). In contrast to the other discussed fonts, "Bionic Reading" generally looks like many commonly used fonts, using thin letters and regular word and letter spacing. However, the unique aspect about it is the fact that the first or first few letters of each word are printed in bold style, while the rest of the word's letters have a regular thickness. This is supposed to help with the fixation on each word so that the eye does not move as much as usual between letters and words when reading.

2.4 Artificial Intelligence

Artificial Intelligence (AI) has been around for several decades, but it has become especially relevant in its availability for the mainstream consumers in the last years. As development speed is increasing, interactive technology using language models like

[3] https://www.sylexiad.com

ChatGPT[4] are able to assist humans in various situations and requests. Because of its fast transforming nature, there have been different definitions of AI over the years (Ertel and Black, 2018). In this thesis, the following definition by the European Parliament (2020) is adapted:

> "AI is the ability of a machine to display human-like capabilities such as reasoning, learning, planning and creativity. AI enables technical systems to perceive their environment, deal with what they perceive, solve problems and act to achieve a specific goal. [...] AI systems are capable of adapting their behaviour to a certain degree by analysing the effects of previous actions and working autonomously."

AI has a large scope of possible applications. Examples are virtual assistants or search engines, but it is also being applied in the health and transport sector. An emerging technology that has already become a regularly accessed tool for many individuals is the mentioned conversational AI model ChatGPT. It can engage in complex text-based conversations (Kohnke et al., 2023) while regarding context and language style. ChatGPT is based on "Generative Pre-Trained Transformer 3" (GPT-3), a highly advanced language model that uses Deep Learning and large amounts of training data to respond to the user's prompts. Deep Learning is used for describing a neural network that tries to simulate features of the human brain, specifically the ability to learn large amounts of information ("What is Deep Learning?", n.d.).

2.5 Text Simplification

When initially researching about available tools related to the project idea, it was found that many of them focus on summarizing or paraphrasing text, but are not necessarily directed at simplifying it. Both automatic text summarization (AS) and simplification (ATS) are Natural Language Processing techniques, meaning that they can analyze the original text and work towards rephrasing it in some way (Casola and Lavelli, 2022, p. 3).

However, AS focuses mostly on minimizing the length of the result while the key aspects of the original text are transferred to the output. ATS aims at keeping the output short as well, but it avoids excluding information. The focus of simplification lies on the linguistic aspect as it tries to reduce the text's lexical complexity while still expressing the same content (Chatterjee and Agarwal, 2023, p. 155). Example adjustment techniques are syntactic simplification and lexical simplification (Saggion, 2022, pp. 21-45). The former describes the simplification of sentences by, for instance, dividing a sentence into two individual ones. The latter concerns the simplification of vocabulary to increase the text's readability. ATS provides therefore advantages for individuals that have difficulties with reading complex writing, for example people with reading disabilities like dyslexia (Center on Inclusive Software for Learning, n.d.).

[4] https://chat.openai.com/

2.6 Related Assistive Technology

To assist those with dyslexia, there are many tools and technologies available. A selection is presented in this chapter. First, there is the IBM AbilityLab "Content Clarifier"[5]. It is using IBMs artificial intelligence IBM Watson to transform English content into a simplified form. The open-source software is created to assist older people, English learners as well as persons with cognitive disabilities. It works not only for text but also provides help with, for example, images or maps. This software can be helpful but presents a barrier to many people as it requires advanced technical knowledge in order to use it.

The "Hero app"[6] is similar in the way that its goal is to provide simplified versions while reading text online. It is an extension for the web browser that transforms the content of any website with the click of a button. Heros approach is to match the exact reading comprehension level of the user and to only simplify the parts the user wants. Though both of these described applications - and also several others that we found - work with text simplification that could potentially be used to create easy-read articles, they use English as the processed language. It was not possible to find any application that uses Norwegian.

Another related application is the so-called Hemingway Editor[7]. It is available for purchase as a browser extension as well as a Desktop application. It also is available as a free online editor. This software gives instant feedback on written text regarding simple and concise writing in several languages. It recognises, for example, passive and active sentences, and registers the length of a sentence and its complexity. Another relevant option is the automatic detection of complicated words and the recommendation of a suitable replacement. The user also is shown an overall grade on the texts general readability, using the Automated Readability Index. The algorithm compares the complexity level of the text to the lowest U.S. school grade required to understand it (“Hemingway Help”, 2023). The Hemingway Editor is an interesting application that provided helpful inspiration for this project.

Next, there is "Rewordify"[8], a website created by teacher Neil Goldman, originally developed for his students who did not like reading (Neil M. Goldman, n.d.). It can however be helpful for people with various difficulties since it offers different learning and reading tools. One feature is a text simplification tool. Here, the user can insert a difficult text and receive a "rewordified" version back where complicated words have been replaced by easier alternatives or explanations. Further details can be accessed by clicking on the respective words in the text.

Regarding general reading support, most common browsers like Mozilla Firefox, Safari, Google Chrome or Microsoft Edge offer a reading mode. For example, when reading a text on a website using the latter, an icon in the address bar shows the availability

[5] https://github.com/IBM/Content-Clarifier
[6] https://beta.heroapp.ai/
[7] https://www.hemingwayapp.com/
[8] https://rewordify.com/

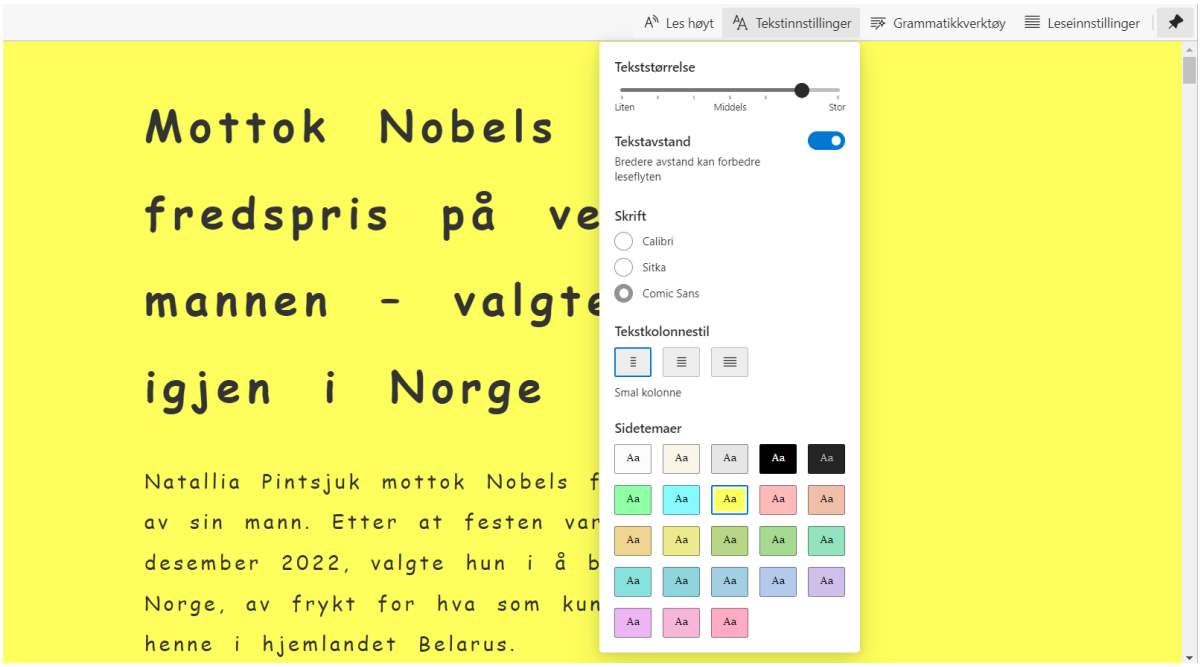


Figure 2.3: Immersive Reader in Microsoft Edge

of the "Immersive Reader" (“Use Immersive Reader in Microsoft Edge - Microsoft Support”, n.d.). When activated, the font, font size, background and text colour, and spacing change (see Fig. 2.3). Also, there is an extensive amount of options where it is possible to adjust different characteristics, like the background colour or text width. The reading mode also offers two special features. First, it is possible to activate a focus mode where the text is greyed out except for one line of text, three lines or a whole paragraph. This "focus" is moving while scrolling so that it is always positioned in the middle of the page. The second feature is an explanation tool for words. When clicking on an interactive word, one or several illustrations are shown that are supposed to explain the word.

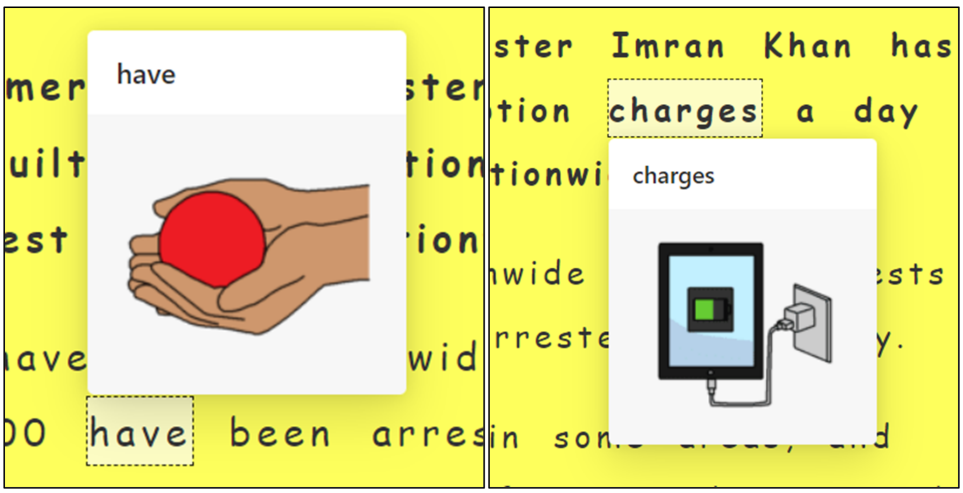


Figure 2.4: Examples for inaccurate picture explanations for words: Explanation of the word "have" in the combined expression "have been arrested" (left) and explanation of "charge" concerning charging technical devices while criminal charges are meant in the article (right)

After analyzing the reading mode in Microsoft Edge, it can be concluded that it offers many useful functionalities for a dyslexic person, especially the focus option is an interesting approach to enhancing the reading experience regarding readability. The word explanations appear to be helpful as well, though they appear to often only explain easy words while there is no explanation available for longer or more complex words, for example "telecommunication" or "requirements". Also, the pictures used as explanations are sometimes inaccurate or their meanings are difficult to understand (see examples in Fig. 2.4). Moreover, if a word can be used with several meanings, all of them are displayed as an explanation which can be confusing. In addition, it is not possible to see an explanation for a phrase or an expression that contains more than one word. It is therefore also possible that individual words are explained even though they are part of a word combination with a different meaning. For example, as shown in Fig. 2.4 where the word "have" is explained but the whole expression in the sentence is "have been arrested", so tenses are not regarded here.

3 Methodology

This chapter presents the applied research methods, perspectives and techniques in the project.

3.1 Research Paradigms

The research of this master project follows an interpretivist approach due to the characteristics of the chosen research questions and the intended type of result. It is distinguished between two main research paradigms when conducting research: Positivism and interpretivism (Williamson and Johanson, 2017). Positivist research is generally connected to "deductive reasoning", meaning that it utilizes different general premises and tries to develop an objective, logical argument or conclusion from that. It often uses quantitative research methods with a high number of participants to test hypotheses and therefore puts emphasis on measurable aspects. The goal is to discover some level of generalisability, to find out how a theory can be applied to similar cases.

However, interpretivist research is known for using inductive reasoning to develop theories. Inductive reasoning - in contrast to deductive reasoning - takes a specific instance and applies a pattern to it in order to form general statements. At the same time, the "multiple realities" of people are recognized. It is regarded that individuals experience the same circumstances differently and that those unique perspectives also are interdependent. Therefore, it is suggested to take into consideration that this also applies during research. Both the researcher and the participant have their own understanding and interpretation of the discussed topics and realities and this can influence the outcome of the research itself. For example, the researcher's perception of reality can have an effect on how they interpret the input from the participant. Following an interpretivist paradigm, this has to be taken into account when conducting research.

Typically, interpretivist research utilizes - in opposition to positivism - qualitative, ethnographic techniques like interviews or participant observation. Here, individual perspectives are brought to the fore while the sampling takes place on a smaller scale than in quantitative techniques. Using results from the research interactions, similarities and differences are extracted and mapped with the purpose of deriving principles and important aspects.

In order to ensure credibility in qualitative research, Guba and Lincoln (1985) defined four criteria. The first one is Credibility, assuring that the findings reflect the intended

purpose and do not deviate from the original research objective. The second measure is Transferability. Here, it is examined and compared where and how the research relates to different contexts and preconditions. Third, there is the Dependability criterion. It deals with assessing whether the outcome would be consistent if the same research with the same methods and context was conducted. Lastly, the fourth factor is Confirmability. The interpretivist paradigm acknowledges an existing interrelation of realities between the researcher and the participant. Therefore, it has to be demonstrated to what degree the research findings are influenced by the researcher's own perspective.

Interpretivist research involves other paradigms. One of them is Constructivism. Here, the focus of the research is on how different interpretations of reality are constructed in a subjective way. Therefore, the constructivist view is that the researcher's interpretation of the input is influenced by other factors and can not be presented entirely objectively. Constructivist research distinguishes between the personal and the social approach. The former deals with constructs that are built by individuals using their own personal reality. In contrast, the latter defines individual constructs as created by social elements, meaning shared practices like language.

When conducting research using the interpretivist framework, the research process and data analysis take place consecutively and in an iterative way. The results from one part of the data collection are used for the realization of the next research part. As the interpretivist paradigm was utilized for conducting research in this project, different qualitative research techniques were applied. Furthermore, the participants have very subjective and distinctive views on their reading experience which have been shaped by their surroundings and personal history. Because dyslexia manifests in many ways, there was a strong focus on the individual's perspective during the gathering of data. Therefore, the constructivist approach was employed, considering both the social and the personal perspective.

3.2 User-centered Design

User-centered design is a design approach that puts the target user in the center of development and applies different research methods, design techniques and tools to be able to develop from the user's perspective during the whole process ("What is Deep Learning?", n.d.). The intention of the research and development in this project is to identify the needs of dyslexic readers in relation to consuming text-based news. For that reason, it is crucial to consider the target group's reality at all times during the process and hence, the user-centered method is applied in this project. When utilizing this approach, it is necessary to involve real, potential users, both during research and development.

There are several advantages that user-centered design offers. For example, it contributes to enhancing the product's efficiency, effectiveness and safety (Abras et al., 2004, p. 11). Also, it can aid in meeting user expectations towards the product and lower user frustration. When involving the target group in the development process,

there are more opportunities for creative and effective design solutions since other perspectives than only the researcher's are taken into account. Even if the researcher is attempting to look at the research problem from the user's angle, they can never be sure about the findings' accuracy and completeness since the actual target group is not directly involved. This is directly connected to the interpretivist paradigm where the uniqueness of each user's view is recognized. Thus, user-centered design attempts to understand the diversity of reality's interpretation and experiences.

When designing through a user-centered lens, the design iterations can be divided into four phases ("What is Deep Learning?", n.d.). First, contextual factors for the system are identified. Next, user requirements are determined and specified. For these steps, various interviews (see Ch. 4.2) were conducted, personas were created (see Ch. 4.3) and a product vision was formulated (see Ch. 4.5) in the project. In later iterations, user tests were carried out as well. Subsequently, in the next phase, a design is developed on the basis of previous findings. In the last stage, the design is critically evaluated against the previously identified contextual parameters of the users. This aims to gauge to what degree the design aligns with the user's needs. For this step, user tests were conducted again to directly assess the design.

Even though user-centered design usually implies higher costs due to the involvement of individuals, it holds the potential to make a noticeable difference concerning the end product's usability. The main reason here is the increased designer's empathy with the user's life reality and the herewith created opportunity to use this as an advantage in development.

3.3 Research Techniques

As mentioned in the previous chapters, different qualitative research techniques were utilized in this project to gain insights and background information about the context and user's needs. In the following, those techniques are described and their use in this project is outlined.

3.3.1 Qualitative Interviews

A main research technique for the project were interviews. They are widely used as a substantial part of qualitative research and are closely connected to the interpretative paradigm (Flick et al., 2004, p. 203). For this use case, semi-structured interviews - as a type of qualitative interviews - were chosen. For semi-structured conversations, an interview guide with questions is created previous to the interview. Those questions are supposed to guide through the interview. The researcher can deviate from the specific phrasing or add additional questions if the context or previous answers by the participant suggest it. Using this approach, the interview structure is more flexible compared to a structured concept. The researcher has the opportunity to react appropriately to

each individual and see them with their unique perspective (Flick et al., 2004, p. 204).

In this project, a number of individual interviews were conducted with individuals who can provide knowledge from their previous experience. Interview partners were either professionally or personally connected to dyslexia, plain language, journalism or artificial intelligence. The findings from those interviews were used to better understand the problem from the affected person's point of view.

Another crucial point when conducting interviews is the questions' character. Since the purpose is to influence the participants' opinions and answers as little as possible, questions should be phrased in a way that avoids rating circumstances or attributes. Moreover, it is beneficial to ask open questions that do not suggest any direction of the answer to the participant. The intention is to discover their unfiltered perspective.

3.3.2 Personas

Personas are exemplary users that represent real users. They are fictional and illustrate mainstream users from the target group, therefore covering their primary needs and requirements (Schweibenz, 2004, p. 152). The purpose of a persona is to personify the abstract user throughout the development process (Alan Cooper and Paul Saffo, 1999, p. 124).

The shift from the developer's perspective to the view of a typical user can assist in creating a user-friendly product that addresses the real users' needs and intents (Schweibenz, 2004). Personas increase the focus on the necessary requirements (Alan Cooper and Paul Saffo, 1999, p. 130). They should be phrased precisely and ideally be described in great detail in order to function in an effective way. However, they can not be overly specific. Using a concrete user as a persona, for instance, would add unnecessary details that can divert the point of attention during development.

In the first iteration, personas were used to design and later evaluate the prototype (see Ch. 4.3). At this point of development, the product was still in its early stages. No direct user tests were conducted in this iteration and it therefore seemed beneficial to utilize representative user models when evaluating the design.

3.3.3 User Tests

User Tests are the main form of user-based evaluations that were utilized in this project. This technique is employed in order to reveal the usability issues of a product. There are two ways of structuring user tests. Either, the participants are assigned a set of interactive tasks with the product, or they can decide the structure of their interaction according to their personal preferences (Bastien, 2010, pp. 19-20). During the user tests in this project, a hybrid solution was chosen where the participants can partly explore the prototype in a voluntary order, but the test itself is roughly structured into

several self-contained parts with an overarching, general task. These steps and the general test procedure are described - similar to the interviews - by a document which is later used for orientation during the tests.

There are different data on the appropriate amount of participants in a user test in order to receive substantial results. A prevalent theory suggests that a set of five participants are adequate and that rather the number of test iterations should be increased (Nielsen, 2000). However, a study demonstrated that it is beneficial to include a higher amount of testers to maximize the detection rate of usability problems (Faulkner, 2003). It was therefore chosen to test the prototype in several iterations, using at least five but preferably more participants in each round of user tests.

3.4 Design Thinking and Iterative Design

As shown by Nielsen (1994), the iterative design process is a widely used approach in UX Design as it can provide in-depth user feedback. This method focuses on developing a product and improving it in successive phases. Its objective is to refine the result of one iteration in the next iteration. Closely tied to qualitative methods, iterative design is a user-centered process as it involves testing and designing in close exchange with the user.

Design thinking uses an interactive and iterative process (Razzouk and Shute, 2012, p. 334). It is a solution-oriented approach in which the designer attempts to find creative ways for solving a problem. Following the model by the Hasso-Plattner Institute of Design, each iteration can be divided into five stages (Gwangwava, 2021, pp. 5-6) which are described in the following (see Tab. 3.1).

Emphasize	Conduct user-centered research Get in-depth understanding of the problem
Define	Organize and analyze the findings from previous research Define the main problem
Ideate	Problem examination from multiple perspectives Generate creative solutions to the problem
Prototype	Low-level prototyping of the ideated solutions Evaluation within a limited scope
Test	Test the complete product Use results for the next iteration

Table 3.1: Phases of the iterative process

First, the researcher aims at understanding the user's experience as extensively as possible through user-centered research techniques. Then, those findings are utilized to determine the user's perspective and the challenges that arise. Following this, possible

ideas to tackle the defined problems are ideated and afterwards converted into an interactive prototype. Here, the prototype does not have to include a complete realization of the design idea. It can then be tested by actual users which provides new feedback and insights to the researcher that can lead to adjustments, new ideas and features in the next iteration. All the described steps do not necessarily have to happen in a strict linear order but serve as an orientation in the structure of each iteration (Rikke Friis Dam and Teo Yu Siang, 2020).
In the iterative process that design thinking applies, it is important to not expect perfect results after the first iteration, but aim for an incremental optimization through several cycles of development. In each iteration, the product is tested and refined based on new findings which makes it a sustainable technique, promising a high satisfaction of the target group's needs.

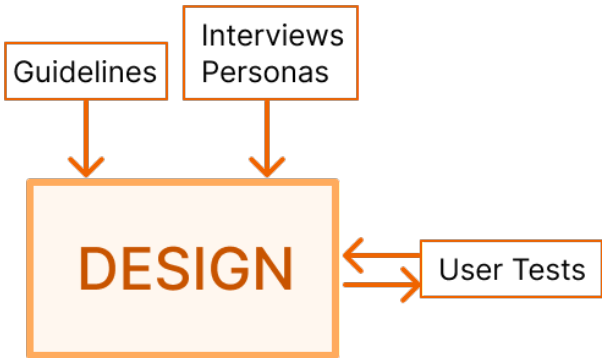


Figure 3.1: The process of applied iterative design in this project

Fig. 3.1 describes the input and process of each iteration in the development process of this project. On one side, accessibility guidelines and usability guidelines are used as a general basis for every iteration. On the other side, research techniques are applied. In the first iteration, the created personas and findings from interviews are included to develop the first prototype. In the following iterations, user tests are conducted to evaluate the changes and suggest changes.

3.5 Usability Heuristics

Jakob Nielsen formulated ten broad principles that can be used for interaction design (Nielsen, 2020). These heuristics have been applied to projects since 1994 and are still widely used, therefore they were chosen to also be utilized in this project. They can be used to - apart from user-centered research methods - evaluate the general usability of a product and avoid users' frustration and confusion. The following points can be utilized for orientation and will be reflected upon at the end of this thesis (see Ch.7):

#1 Visibility of status: The User should always be sure about their current position in the system in order to trust the interaction flow. This includes insights about the results of their previous actions as well as an overview of the available options.

#2 Match between system and the real world: The product should adapt to a design that the user is accustomed to. This concerns every aspect of the design, including for example icons, terminology or concepts.

#3 User control and freedom: The design should present clearly visible possibilities to undo, redo and escape actions.

#4 Consistency and standards: Use conventional elements as they are used in similar contexts to keep the design consistent. Follow general conventions, for example regarding colors or icons. This way, the meaning of an element often does not have to be explained, making the interaction faster and easier for the user.

#5 Error prevention: Prevent conditions for user actions that can lead to errors.

#6 Recognition rather than recall: Make relevant elements and options visible and recognizable so the user does not have to remember information.

#7 Flexibility and efficiency of use: Offer tailored design based on the user's needs. For example, experienced users should have the opportunity to skip or accelerate certain actions for their purpose.

#8 Aesthetic and minimalist design: Leave out negligible design elements to aim the user's focus at the essential information. Structure the interface in an uncluttered way.

#9 Help users recognize, diagnose, and recover from errors: Provide easy-to-understand error messages and offer solutions for errors.

#10 Help and documentation: Offer explanation for elements where needed to aid users in performing desired actions. Documentation should be easy to find and easy to access.

There are other sets of rules that are being used for designing effective user interfaces, for example eight rules by Ben Shneiderman (Shneiderman, 2010) or 20 Guiding principles by Whitney Hess (Hess, 2010). However, those principles overlap in large parts of their content. Therefore, Nielsen's ten heuristics were chosen to be applied in this project while acknowledging the value of the other mentioned rules.

4 Requirements Analysis

4.1 Target Group

During this project, individuals from the target group were engaged to take part in interviews and user tests in order to develop from a user-centered perspective. The target group is described as adults with dyslexia who consume news. Dyslexic persons can often receive support at a young age through individual training, tools or exam regulations in school. However, the same help is often not provided in adult life, for example at work or online. Therefore, this project could contribute to increasing the accessibility of text for dyslexic adults.

4.2 Interviews

In the research phase of this project, several interviews were conducted, both with potential users who have dyslexia and with individuals that have a professional connection to either news articles, Klarspråk or dyslexia.

By evaluating the interviews with both dyslexic people and those working in a related field, it was possible to get an overview of the interplay between news articles and reading with dyslexia, as well as where critical points are that can be dealt with.

In order to reach potential test subjects, different recruitment methods were used, such as personal contacts, announcements on social media, and hanging up physical posters. Later feedback from interviewees suggests that prejudices against dyslexia in society hinder the recruitment of individuals who are comfortable discussing personal experiences. This was also experienced in the interviewing phase of this project. However, several interview partners were found that were interested in sharing their opinions and observations.

4.2.1 Readers with Dyslexia

4.2.1.1 Structure

Six interviews were conducted with subjects that experience daily life with dyslexia themselves and could therefore give first-hand information about their experience with reading on a day-to-day basis. The interviews were conducted with participants from

Norway and Germany, in either Norwegian, English, or German. In those cases where the interview was not held in English, the transcription was additionally translated into English afterwards for easier comparability of the findings in the evaluation.

The structure of the interviews was following a previously created interview guide (see App. A). It contained different questions, but since the interviews were conducted in a semi-structured way, it was possible to deviate from the original question and ask additional follow-up questions when necessary or useful.

4.2.1.2 Findings

In conclusion, it appears that many dyslexic readers experience similar challenges when consuming news, especially when focusing on written news. When asked about any irritating characteristics of a news article, every interview partner was stating points that are commonly described when talking about dyslexia. Those are for example missing distance between lines of text or fonts that are difficult to read because of their forms.

Another aspect that most of the participants mentioned were repetitive parts in news articles as they often are written in a way that content is being described that has already been stated before. This is often used by journalists in order to refer back to a previous circumstance in order to add new information or to connect it with another situation. This can occur in one article alone or between several articles if it is an ongoing situation. In this case, the interview subjects explained that it confuses them whether they have read this specific article before or not.

The interviewees also got asked about the usage of and experience with browser extensions, programs or mobile apps that are supposed to help with reading. The majority had never used any of these. There were several reasons for that but the main argument was that they had never thought about using it before. Since they are used to having a disadvantage when it is purely about reading text from an early age, they had not thought about if there were any existing tools available for dyslexia. The only one that some mentioned that they had heard about before was a typical listening function where an automatic voice reads a desired text for you, for example when using Google Translate. But exactly this usually used artificial voice is often perceived as too monotone, robot-like and boring by the participants that mentioned it. This can lead to loss of concentration and to a state where the person's thoughts are drifting away, not listening and taking in the article's content anymore. It also leads to them losing interest in the article, so they eventually stop reading it. One last point mentioned was the variety of different tools and that the obstacle can also be finding one that fits one's needs since that process would also be quite time-consuming for a person with dyslexia. As a consequence, some of the subjects did not see it as a worthwhile process. One participant is using reading tools but mentioned that most of the ones he knew or was using were rather designed to help the person train their reading abilities. This would not help them directly to read faster or more easily immediately.

When asked about their reading habits and how they experience reading in general, ev-

ery interviewee stated that it usually consumes a lot of time and energy to actually sit down and read a whole article if it is not a topic they are absolutely passionate about. Further, many stated that they usually first read the headline and introduction. They then base their decision about if they will read further on how interesting the topic seems to them. The introduction paragraph at the beginning of each article was mentioned as a very important factor in order to get an overview of the article.

Other points mentioned that often constitute an obstacle in the reading process are difficult words or foreign words. They take the readers even more time to read and understand their meaning, it might even be necessary to google them. Hence, this is a much more time- and energy-consuming process than it is for readers without dyslexia.

Another thing that was mentioned by several of the participants are "special articles". Often about a popular or important topic, the articles do not only consist of the usual text and pictures but also include for example different colors, moving backgrounds, animations, and special effects, such as a parallax scrolling effect. This effect is achieved by at least two elements on a website representing three-dimensional layers that are placed behind each other from the user's viewpoint. As they move at different speeds when scrolling, an illusion of depth is created on the screen (Frederick et al., 2015). These elements are added to the normal text in order to make the article more engaging and fun to read for the majority of readers. The problem is that people with different reading difficulties - including dyslexia - do not benefit from this kind of design since many of these elements match the opposite of their needs in an article. The different colors, forms and animations usually make the reading experience difficult, distracting and exhausting for this group of readers.

On the positive side, there are also points that the interview subjects mentioned as helping in terms of readability. A majority consider pictures as an important component of a news article. It divides the text into smaller parts which makes it easier to concentrate on the reading. Further, photos can help with grasping the basic direction the content of the article is going in, without reading any text at all. This can help with getting a feeling of what kind of words could be used in the article or what to expect in general. However, at the same time, it was criticized that cover pictures can often be misleading or attention-seeking. Many participants stated that - in this case - they lose interest in reading the article and often do not open it at all. The same applies to exaggerating or click-baiting headlines. As said by some interviewees, they would rather want to know what the article is about directly instead of being lured into opening articles about topics they are not interested in in the end.

4.2.2 Journalists, Developers and Dyslexia Experts

In addition to these interviews with dyslexic readers, several interviews were conducted with different organizations and companies. The goal here was to collect different perspectives on the topic. Organizations and individuals from Norway and Germany were contacted. Those who agreed to be interviewed, however, were all from Norway.

At the beginning of the research phase, a conversation was held with an employee at Dysleksi Norge[1] who has dyslexia himself. Dysleksi Norge is an organization dedicated to supporting people with dyslexia in Norway. Their respondent could give insights both from his personal and his professional perspective. This provided additional useful insights into how news articles are perceived by dyslexic people, what the main difficulties can be and how news portals can make their articles more dyslexia-friendly.

Afterwards, in order to learn more about the journalism perspective on our project, interviews were conducted with several employees at the Norwegian news agency NTB[2] (Norsk Telegrambyrå). Most of the interviewees were journalists and some of them also have a background in computer science, so they also work partly with machine learning and/or automation. Also, some are working as data scientists and have experience in machine learning and language technology. Hence, they represented different perspectives on the project idea. The findings of these interviews provided a very interesting and helpful basis for this project. In every conducted interview at NTB, the first questions were about the person's general tasks at the job, their background and current or previous projects that are thematically connected to this project's idea. From there, more questions were asked about these projects to get a better insight into different processes during the development. From the journalists, it was interesting to hear about their experiences with writing easy-to-read and simple text.

Another interview was conducted with a respondent from Klar Tale[3], an independent newspaper that writes all its articles in plain language. Their main target group consists of people with reading difficulties (e.g. dyslexia), blind people, and people who are learning Norwegian as a second language. In their work, they create both original content as well as rewrite existing articles. They provided detailed insights into the writing process of their articles and explained the tools and options they offer to the readers. For example, users can listen to articles in a podcast or they can directly adjust different visual characteristics of the text, like font size, font style, and background color. Since the newspaper is not solely directed at dyslexia, there are also features that are potentially not specifically helpful to a dyslexic person, but all in all, it is regarding many different aspects in an article that theoretically can help dyslexic people with easier reading.

A problem that Klar Tale mentioned was also that they would like to focus more on writing their own articles by conducting their own research, doing interviews etc. But at the time of the interview, a huge part of their published articles are mostly standard articles that they receive from news agencies like NTB and that they rewrite into an easy-to-read version. Concerning the writing of easy-to-read articles, Klar Tale uses many rules and principles in order to get a good article as a result. For example, they give attention to the handling of numbers or shorten sentences by dividing them or rephrasing them. Also, they regard the fact that different difficulties, disorders and disabilities can occur together, so they think about how to write their articles so that people

[1] https://dysleksinorge.no/
[2] https://www.ntb.no/
[3] https://www.klartale.no/

with different needs can read them.

Further insights were gained in two individual conversations with representatives from Aftenposten Junior[4]. This branch of the widely consumed Norwegian newspaper "Aftenposten"[5] is aimed at children and offers news content on various topics to promote and encourage the consumption of news among young readers. The respondents provided insights into their writing process and presented important implemented accessibility functions on their website. One of them is the possibility to listen to published news articles. A notable aspect of this option is the utilization of a human narrator who recorded extensive audio data to be used in each article. This feature appeals to many users as it avoids the use of frequently employed monotonous voices, such as those found in Google Translate.

4.3 Personas

Two personas were created to represent the target group. These personas facilitated envisioning potential users of the future prototype and fostered a user-centered perspective in the development process. This specifically applied to the evaluation of the first iteration (see Ch. 5.2.3). These two fictional people and their characteristics are based on previously conducted research for this project. Additionally, the personas are supposed to present differing characteristics, so that a comprehensive coverage of the target group is offered. Main aspects that were focused on during the persona design are for example the person's age, occupation or relation to dyslexia.

Persona A (see Fig. 4.1) is Ingrid Evensen. She is a 24-year-old Bachelor's student living in Ålesund. She got her dyslexia diagnosis towards the end of her school time even though she had struggled with especially reading text from a young age. Ingrid is affected by the disorder in her daily life and she tries to find ways and tools to work around it.

Persona B (see Fig. 4.2) is Harald Ødegård, a 46-year-old electrician who lives with his family in Voss. He has not formally been diagnosed with dyslexia even though he has difficulties with both reading and writing.

4.4 Requirements and Needs

Using the findings from the initial research, the following functional requirements for the project were formulated:

- Present the news article in a "reader mode" without any advertisements or other distracting elements

[4] https://juniorskole.no/
[5] https://www.aftenposten.no/

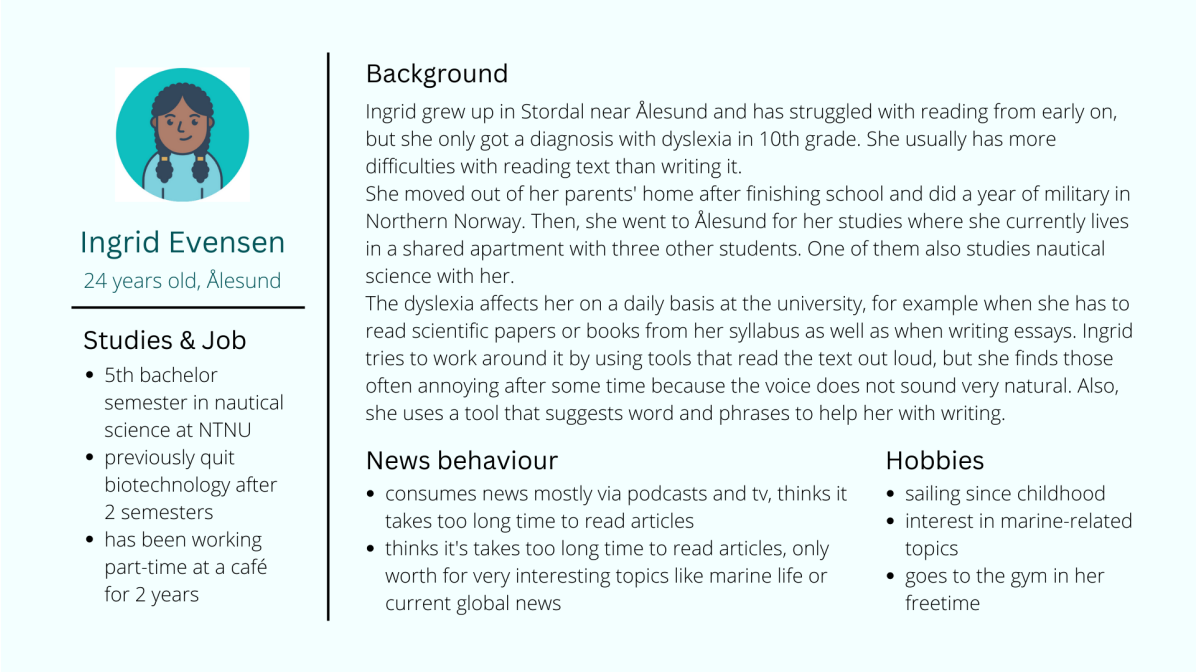


Figure 4.1: Persona A: Ingrid Evensen

- Shorten and simplify text
- Replace difficult words with easier ones
- Rephrase difficult phrases or sentences
- Provide three available levels of simplified text in addition to the original text
- Menu with different adjustment options
- Explain difficult words with a pop-up directly in the text
- Button for changing the font type
- Buttons for changing the font size

On one hand, defining requirements is important to discover the needs from a UX perspective. On the other hand, it helps to explain later why certain measures or features have to be made.

The here defined requirements are revised and, where necessary, adjusted after each iteration in the development process. This is to ensure that at all times, the prototype is developed as close to the user's needs as possible.

4.5 Product Vision

After receiving extensive input and knowledge from the interviews and literature research, a product vision for the planned prototype was created. A product vision can be defined as a "high-level description [...] of a product that does not yet exist [...]" (João Luís Guilherme Benassi et al., 2011).

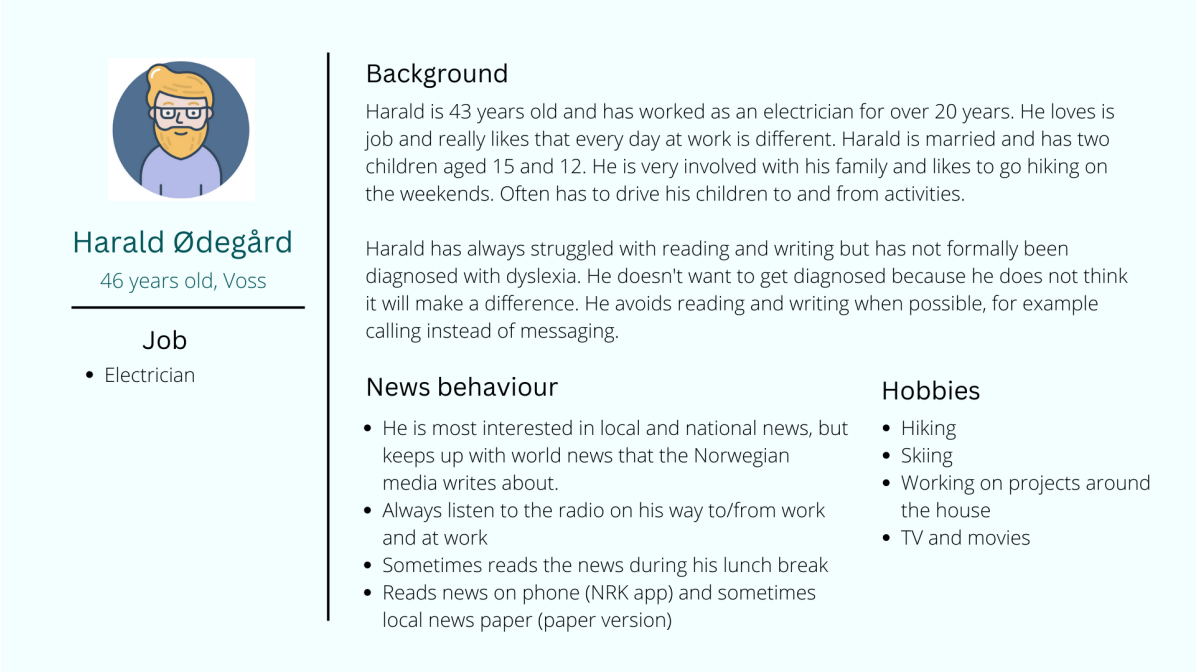


Figure 4.2: Persona B: Harald Ødegård

Regarding the project's name, the word "enkl." was chosen. It is a short version of the Norwegian word "forenklet" which means "to simplify". This is what the tool is all about, to "forenkle". The thought here was to also simplify this word in a way and therefore, the decision fell on "enkl.". On that basis, the following product vision statement was formulated:

> For readers with dyslexia who want to read accessible news, "enkl." is a reading aid that transforms online news articles into an adjustable easy-read version.
>
> Unlike similar simplification tools, the product is developed for Norwegian news articles and specifically designed for readers with dyslexia.

5 Development

This chapter will discuss the development process of the prototype, describing each iteration including evaluation and output for the following one. The results are eventually assessed and interpreted.

5.1 Prototyping

After collecting knowledge and insights from initial interviews and literature research, this chapter is going to describe the development phase from the first drafts to the final prototype. First, a minimum viable product (MVP) was created. After that, the focus shifted towards the usability of the prototype and the visual aspects of the interface.

5.1.1 Iterations

The prototype underwent four iterations (see Tab. 5.1). In the initial iteration, previous drafts and insights from fieldwork were utilized to create a functional MVP consisting of both a technical and a design component. Subsequently, the prototype was evaluated and revised in three additional iterations. It incorporated feedback from various groups, including the target group that extensively tested the tool at different development stages.

Testing the second version followed the objective to collect first impressions and insights from the target group. The results and respective changes were then tested again in a third iteration to gather further feedback. Here, both the four initial testers and six additional participants that were unfamiliar with the prototype were engaged. This allowed for comparative analysis and filtering of feedback influenced by participants' novelty to the product, capturing "first impression" feedback. Moreover, the experienced participants acted as a "control group" to complement the findings from the second round of user tests. Having encountered the previous version, they were more attuned to changes. Furthermore, they were already familiar with the news article from the first test round, enabling them to discern and highlight distinct aspects of the prototype.

Following, a fourth version of the prototype was developed, aiming at further improvement. Representatives of companies and organizations concerned with the project's topic provided final feedback on this version, resulting in a small number of final ad-

justments.

Iteration	Applied methods	Proposed Changes	Number of Participants
1	Qualitative Interviews Personas	Definition of Use Case Access through browser extension Use of three simplification levels	6 persons with dyslexia 7 field experts
2	User Tests	Adjustment of simplification levels Change menu positioning	4 persons with dyslexia
3	User Tests	Three color options Button to save current settings	10 persons with dyslexia
4	Expert Feedback	Simplification of word explanations TTS button	11 field experts in 4 groups

Table 5.1: Overview of development iterations

5.1.2 Recruitment

Testing the prototype required engaging potential users from the target group who were open to trying it and providing honest feedback. Given the project's focus on individuals with dyslexia, participants with this learning disorder were actively sought. However, encountering similar challenges as experienced during the preceding interview process, finding willing participants proved difficult. Nonetheless, the engagement of participants was successful. It proved helpful to contact testers with the help of organizations they trust, such as Dysleksi Norge, Dysleksi Bergen[1], and Dysleksi Ungdom[2]. Also, contacts from interviews were utilized.

5.1.3 Research Ethics

The Nielsen Norman Group defines Research Ethics as "the careful consideration of the rights, well-being, and dignity of people involved in research activities" (Maria Rosala, 2019). This was applied to every user test and interview conducted in connection with this project.

For both methods, a notification form was sent to the Norwegian Centre for Research Data (NSD), containing information about the project. This included which and how personal data were planned to be collected as well as the corresponding information letter and consent form. The processing of personal data was assessed by NSD and found to be lawful with the legal basis of articles 6 and 9 of the General Data Protection Regulation (European Parliament and Council of the European Union, 2016).

[1]Dysleksi Norge branch, located in Bergen (https://dysleksinorge.no//dysleksi-bergen/)

[2]Dysleksi Norge branch dedicated to members between 18-30 years (https://dysleksinorge.no/dysleksi-ungdom/)

The information letter accompanying the interview consent form for both the interviews and user tests includes several points over multiple pages concerning the handling of personal data in the project. With the purpose of making the process easier for the interview partner who has dyslexia, efforts were made to simplify and shorten the sentences as much as possible while simultaneously not omitting essential information. However, mandatory parts still had to be included in the document. The result was a four-page information letter. The consent form and the letter were both sent to the participants in advance so that they could read it without a potential feeling of time pressure. In addition, it was offered to go through the document together with the person at the meeting. It was important to make sure that every aspect was clear and understood, especially since participants revealed personal data about their experiences with dyslexia during the interviews.

5.2 First Iteration: Interviews & Personas

In the first iteration of the development process, the results from previous research and interviews (see Ch. 4.2) as well as the created personas (see Ch. 4.3) were used to create a first low-fidelity prototype and a technical proof of concept. This initial iteration was utilized for rather exploratory purposes to orientate and establish a baseline for subsequent iterations. Hence, it exhibits notable deviations from iterations two, three, and four, acting as a quasi-preliminary iteration within the development process.

5.2.1 Design Prototype

Visual Design and especially the quality of interactive design is crucial when developing an online tool for a specific target group. Poor-quality interaction design diminishes the likelihood of sustained user engagement and thus should be avoided. The product must prioritize easy accessibility, comprehensibility, and user enjoyment to reduce potential frustration or monotony over time. Therefore, this project emphasizes a strong focus on interaction design.

The first version of the prototype can be divided into a design component and a technical component. This design part explores methods through which potential users can access and interact with the technology. The first draft (see Fig. 5.1) shows a simple website with a white text box. In this interface, users have the option to paste the text they want to simplify. Additionally, a help button next to the headline provides instructions on how to navigate the website. By clicking on the submit button below the box, the user receives the simplified text in a dyslexia-friendly format (see Fig. 5.2). Versions with different colors were created to later evaluate and decide on the most supporting ones. Those specific color combinations are based on the results of the study about the accessibility of colors for people with dyslexia (Rello and Bigham, 2017).

This and the following versions of the design prototype are created in Figma[3], a graphics editing tool that offers a broad variety of options regarding visual design and in-

[3] https://www.figma.com/

Figure 5.1: First low-fidelity design prototype with different color variations (selection on the right side)

teraction processes. Acting as an attractive tool for UX Designers when designing an interaction mock-up, it was chosen as the main development tool in this project.

5.2.2 Technical Prototype

To demonstrate the technical aspects of our project idea without implementing a fully integrated product, a component separate from the design was developed (see Appendix B). Due to time constraints, this part serves rather as a proof of concept, showcasing the intended utilization of AI, instead of a complexly coded, high-fidelity solution.

For this technical component, a local website was created with a primary focus on incorporating AI for the purpose of simplifying arbitrary news articles. The goal of this prototype is to enable users to input their own text of choice and receive a simplified version by simply clicking a button, as described in the previous chapter.

During the development of the website, careful consideration was given to selecting the appropriate language model. Research was conducted to explore various options and evaluate their compatibility with the project idea.

Among the models investigated, the IBM Watson Natural Language Understanding

Figure 5.2: First design prototype showing the simplified result

Module[4] and the IBM Watson Natural Language Classifier Module[5] showed promising results. However, their integration and navigation proved to be challenging for non-advanced programmers.

Ultimately, the decision was made to use the language model provided by OpenAI, known as GPT-3. This choice was based on several factors. Firstly, it offers an easy implementation, making it accessible to users with limited prior experience in artificial intelligence and machine learning. Secondly, it is versatile and can be personalized to suit specific needs. Lastly, comprehensive documentation is available, offering valuable support, particularly during the initial stages of the project. These advantages streamlined the process surrounding technical implementation, allowing for more time to be dedicated to the development and testing of the user interaction.

Another aspect to consider was the choice of platform for the tool's development. Initially, it was uncertain how the AI would be utilized and in what manner the text would be presented. Ultimately, the decision was made to develop a website primarily targeting PCs or laptops, which typically offer larger screens compared to mobile phones or tablets. This choice aimed to mitigate potential challenges associated with screen sizes, such as the placement of the menu or the visibility of features when using a capacitive screen with a bare finger or stylus. By opting for this approach, it was possible to focus more on the general interaction itself, including the display and formatting of text.

[4]https://www.ibm.com/se-en/cloud/watson-natural-language-understanding
[5]https://www.ibm.com/docs/en/opw/8.1.0?topic=ui-watson-natural-language-classifier

5.2.3 Redefinition of Requirements and Use Case

Following the development of the initial prototype version, the outcomes were assessed, incorporating the personas (see Fig. 4.1 and 4.2) to adopt a user-centric approach. In the following, the main findings and resulting measures are described.

First, the format and way of accessing were found to show potential for improvement. Although it is generally easy and relatively self-explanatory how to use the first prototype, obtaining the desired output text can be time-consuming. This is primarily due to the required number of clicks and the manual process of copying and inserting an entire article text. Therefore, for the following iterations, it was decided to switch to a browser extension as a target access format. Installing an extension provides convenience, allowing users to activate it directly in the desired tab when needed. This is more efficient compared to the repetitive process of opening a new tab and navigating to a specific website when the tool is needed. Eventually, when implemented, this browser extension should be available for all main browsers since readers use different operating systems and browsers.

Further, a decision was made to focus on the design part in the following development iterations instead of further developing the technical component. This is mostly because of time limits. As the prototype is available as an MVP at this stage, it seemed reasonable to shift the focus towards only one part. Since the project is developed from a UX design point of view, the focus should be on this perspective. Therefore, the following described development iterations concern the user experience and design decisions and less about technical realization.

In addition, the decision was made to incorporate three levels of text simplification in subsequent iterations to adapt to the diverse needs of people with dyslexia. While further testing was required, the idea was motivated by the expressed variations in preferences during the interviews, indicating the importance of creating this variety.

After evaluating the first development iteration, a use case was defined. This use case describes a standard interaction between a player and a system from start to finish (Asana, 2022). In this context, the player is a potential user and the system is represented by the developed prototype at the corresponding stage. At the beginning of the interaction, there is a trigger that causes the player to interact with the system in order to reach a certain goal or result. The use case is described by the different steps and actions that are necessary to reach an objective. In this instance, the starting point is the user's intention to read a news article. The aim is to facilitate the user's access to the main information about the article's topic, thus requiring the article text to be user-friendly and easy to read. The following steps are supposed to lead to a satisfactory outcome for them:

1. Visiting the NRK news website.
2. Choosing an article that sounds interesting.
3. Open the chosen article.

4. See that the browser extension symbol is visible and interactive.
5. Open the browser extension.
6. Try out the different options in the menu.
7. Find a combination of settings that fits best for the user's needs.
8. Read the article in its simplified version.
9. Close the current window and finish the interaction.

This use case can be applied to the prototype to test it with a persona as the protagonist. Its evaluation helps with visualizing the direction when developing further, ensuring that basic functions for the user are present. It also verifies that the development is following the needs of the target group in every iteration. Tests with real-life users are then conducted to gain more in-depth feedback.

Furthermore, the list of functional requirements was reworked and extended by new points that were added to use in the next iteration (see Tab. 5.3).

Status	Requirement
new	Always available info-button with an easy explanation of the simplification levels
new	Button to change the color of the text and the background planes
new	Slider to adjust line spacing
new	Slider to adjust word- and letter spacing
new	Toggle-button to turn the reader mode on and off

Table 5.3: Additional functional requirements after the first iteration

5.3 Second Iteration: User Tests #1

The concept of each version shares a common basis, but its implementation varies and is improved with each iteration. Generally, every version is implemented in Figma as a simulated Safari Browser extension that the user can activate when desired. The interaction starts on the selected news article website. The user first sees the original article, but when the extension is activated, it appears in a more dyslexia-friendly format. The interface includes various tools to customize the text, such as adjusting word/letter spacing, and selecting different colors or fonts. There are also options to modify the simplification level and length of the text. The underlying idea for the simplification is to utilize the GPT-3 language model to generate different levels of simplified text for individual articles. Additionally, the prototype features a word explanation function where users can click on challenging words to receive concise definitions. Ideally, GPT-3 is also leveraged to generate these word explanations.

5.3.1 Prototype version 2

For this iteration and the following, an example news article had to be chosen that the mock-up program could be applied to. This article had to fulfill a few conditions. First, it should have a common article length so that it can roughly represent most of the usual news articles that are published online. Further, the topic should neither be too specific nor too general. It should contain a balance of complex, specialized and lengthy terminology to show simplification potential. Simultaneously, it should avoid excessive technicality that could deter users from engaging with its content. Furthermore, major political issues or other contentious topics were avoided as the subject matter. This precaution is taken to prevent the user's attention from being overly fixated on the article's content rather than the overall prototype. Furthermore, the chosen article should revolve around a subject that maintains its relevance and interest for an extended period, considering the planned multiple iterations.

After researching current articles on different news websites, the choice fell on the following: *"150 soldater har blødd neseblod i militærleir på én måned: Vi ser svært alvorlig på saken"*[6] on NRK's news portal. This article talks about a military camp in Norway where an above-average number of cases of nosebleeds occurred among the soldiers and what different involved parties claim as the reason.

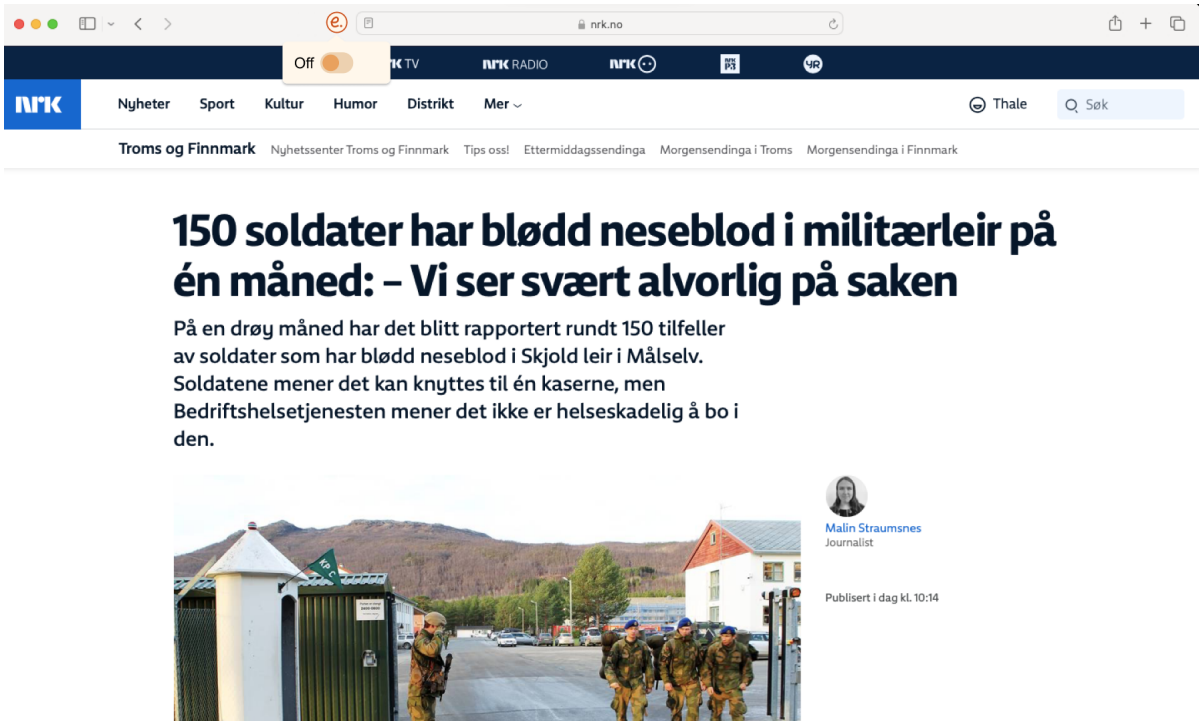


Figure 5.3: Access to using the extension

Following that, a new prototype was created in Figma using this news article as an example text. Since the prototype is depicting a browser window in Safari browser,

[6] https://www.nrk.no/tromsogfinnmark/hundrevis-av-tilfeller-av-neseblod-hos-soldater-i-skjold-leir-i-overbygd-i-malselv-1.16299271, last access 31 May 2023.

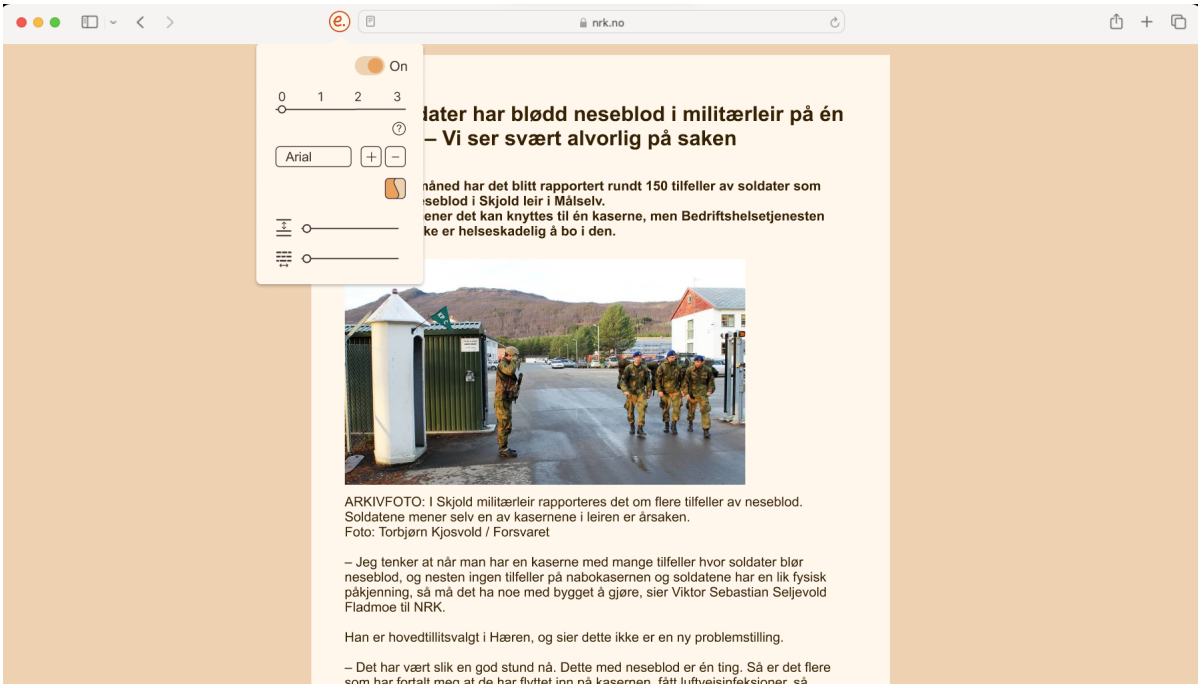


Figure 5.4: Reading mode with open menu

certain browser characteristics are shown as they can be found in Safari. For example, the positioning of the browser extension icons on the left side of the address bar. In this first iteration's version, it is possible to access the browser extension by clicking on the extension icon (see Fig. 5.3) and to activate it via the On/Off-Button. The text appears in a reading mode and the user can see and interact with the corresponding menu by adjusting different properties (see Fig. 5.4): First, the text simplification level can be selected, level "0" showing the original text without any adjustments. For the additional three simplification levels, different prompts were chosen that were sent to GPT-3 to receive automatically created easy-to-read versions. For the first level, the instructions *"Rewrite the following text in an easy-to-understand language for people with dyslexia."* were used. Afterwards, a few manual adjustments had to be made for a presentable article. For the second simplification level, further alterations were made to the text. For the highest level, the following prompt was formulated: *"Rewrite the following text with easy and short words."* Here, again changes had to be made in the result. The outputs of both used prompts did not deliver satisfying results which is why manual adjustments were necessary to be able to use the different texts in the user tests.

There are also options to adjust the font type and font size. It is possible to enlarge the text from 16pt up to 20pt. Concerning different font types, Arial, Helvetica, and Verdana were chosen, as well as the specifically for dyslexia created font "OpenDyslexic" (see Fig. 5.5). Previous studies could not give a clear answer about if it actually improves a text's readability for people with dyslexia, but are rather suggesting the opposite (Wery and Diliberto, 2017). It was decided to offer it as an option in the first round of user tests to get an additional impression from the participants. This should help with the decision of whether to include this font in the final version.

Further, there are four different color schemes that the user could choose from (see

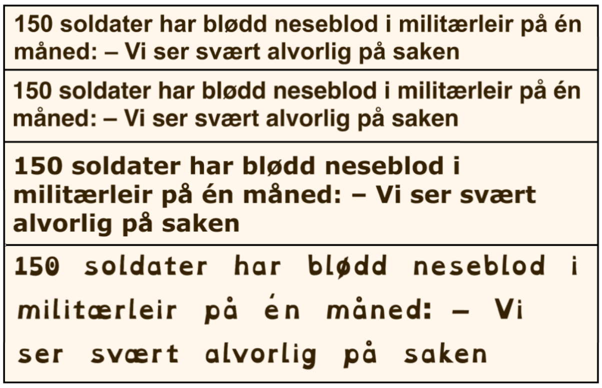


Figure 5.5: Selectable fonts (top-down): Arial, Helvetica, Verdana, OpenDyslexic

Fig. 5.6). When considering which colors to include, decisions were based on different studies about colors for people with reading difficulties (Rello and Bigham, 2017) and on insights from the previous interviews. Using too high contrast was avoided, as well as very dark or neon colors. The color scheme was applied to the text, the text's background, as well as to the background of the page. For example, the standard black text color was replaced by a soft brown, gray, or green on a soft light pastel-like background, while the page's background had a stronger color like orange or green.

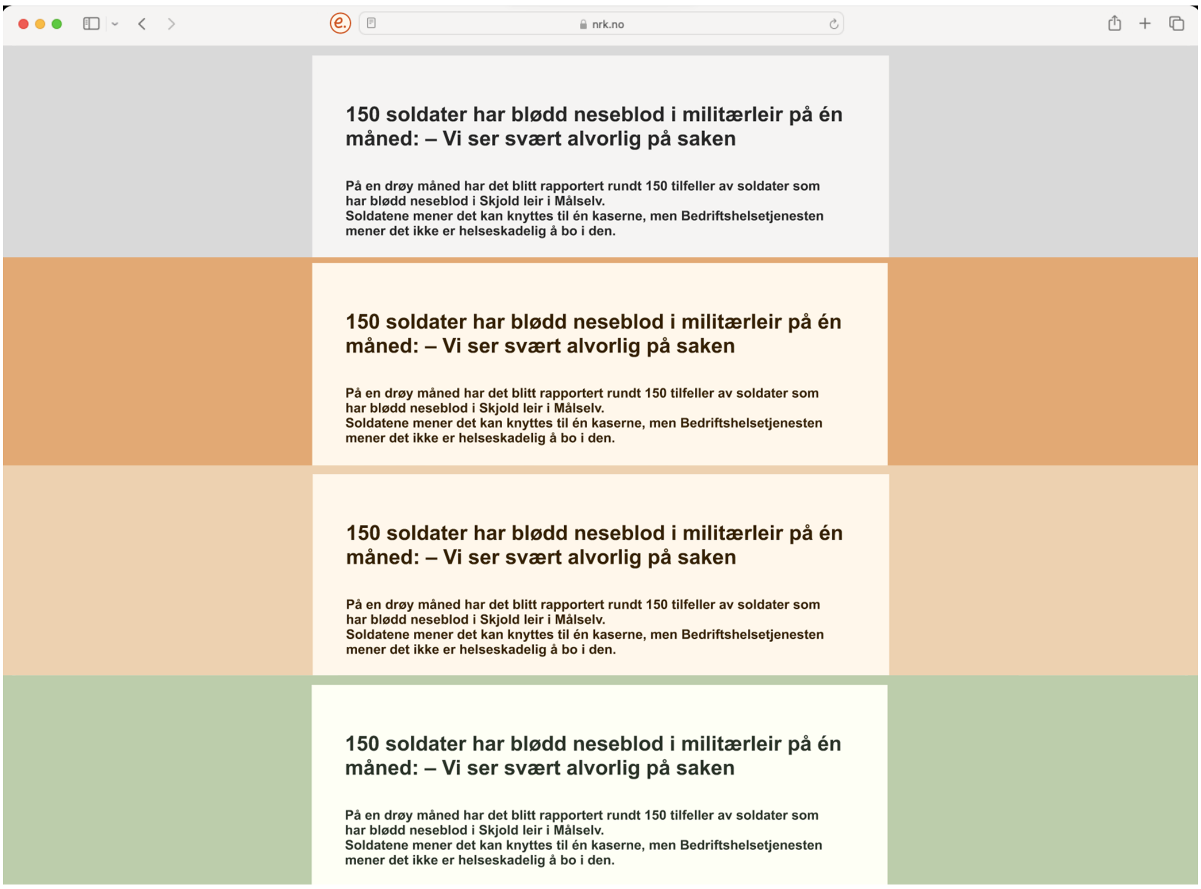
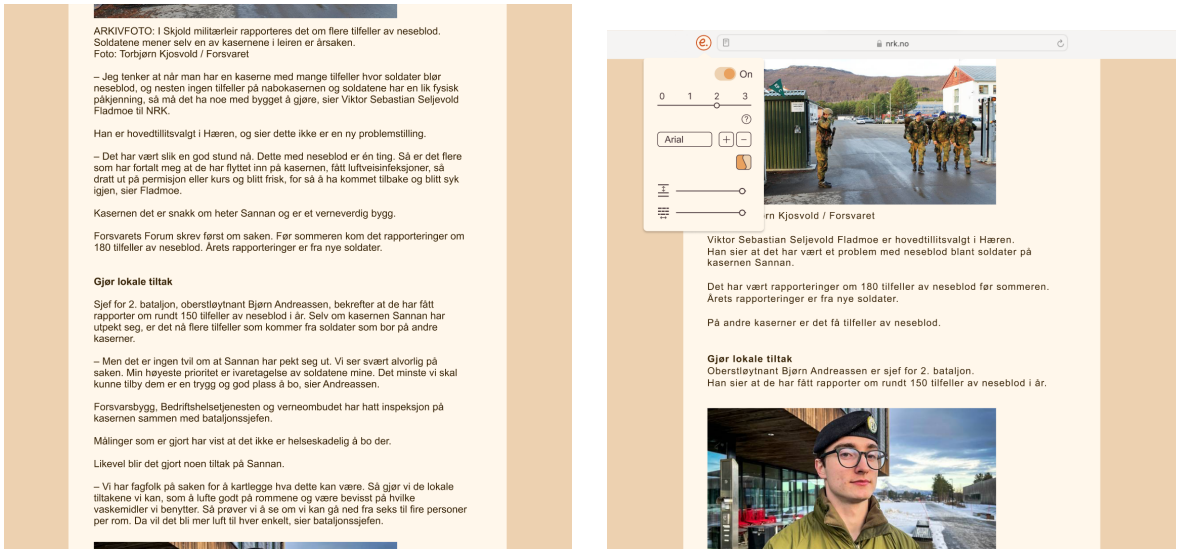


Figure 5.6: Available color combinations in version 1

There are two options at the bottom part of the menu for adjusting word and letter dis-



(a) Original article with regular word and line distance *(b) Simplified article with long word and line distance*

Figure 5.7: Comparison of the original article with a possible preference of settings

tance as well as the distance between lines. Both sliders have three possible marker positions, so there are two additional levels to each option. Level 0 just shows the original distance on both options. For the line distance option, level 1 equals a so-called paragraph spacing in Figma of 1, and level 2 has a paragraph spacing of 2. Concerning the second option, level 1 corresponds to a letter spacing of 3% and level 2 to a letter spacing of 6%. In this version, only the letter spacing is adjusted in the second option (see Fig. 5.7).

Another important part of the prototype are the word explanations. In this first iteration, the usability of the interaction with an explanation was tested with the participant. The prototype comprised three ways of interacting with the explanation. The first variant showed the interactive word highlighted in a light orange-beige and the explanation of the word is shown by hovering over it with the cursor. This hover effect is applied to all three variants. The second draws attention to the interaction by the word being underlined in an orange tone. Lastly, the third variant doesn't indicate any visual indication of possible interaction with the word at all.

5.3.2 User Tests

The User tests in this iteration were divided into different parts. After an introduction, the participants were shown the chosen original article from the NRK website. Then, after turning on the reading mode via the Toggle-button, the person could describe their first impression and explain the expected function for each option in the menu, without interacting with it yet. After that, each option's meaning was clarified and the participant could try the simplification slider. The task was to test out the different levels of simplification for the applied text and read through some parts or skim them to get an impression of its readability. Then, they were supposed to give their perspective on each of them and choose the one that fit their needs best, the one they would most likely

use.

Afterwards, they were able to try out the other options in the menu. The aim was to gather feedback on participants' preferences, both positive and negative, regarding the available options, as well as their overall impressions. For the options where they could choose between different variations, meaning the color and font selection, the participants got asked about their preferences in general as well as among the available options. In the last step of the test's interactive part, the explanation tool for difficult words was shown and questions about them were asked.

The second part of the user tests contained the following related questions about the previous interaction experience with the prototype (translated from Norwegian to English):

1. Are there some functions/aspects that you think are useful or more useful?
2. Are you missing any functions?
3. Would you use a tool like this one?
4. Were there some parts of the simplified text that were difficult to read? If so, why?
5. How would you prefer to use/access a tool like this? For example as a Browser extension, a website, a Desktop program, an app, directly on the news website, etc.
6. How/Where do you usually read news articles?
7. Do you have any questions or something you want to add?

5.3.3 Findings

Four user tests were conducted in this iteration, one of them online. On most of the points, all participants reported similar experiences. Only a few minor optimization aspects were mentioned by just one or two users. The results of the user tests are going to be described in the following.

Concerning the simplification slider option, it was difficult for all participants to comprehend its function without any prior explanation. Nevertheless, after a brief introduction, it was easy for everyone to remember its use in the following interactions. Consequently, an explanation for this function seems to be necessary, even if it is just for the first time of interaction.

Opinions differed regarding the content of the different text versions, as participants' varying degrees of dyslexia resulted in distinct needs for specific simplified versions. One participant expressed a preference for even shorter sentences and simpler words, finding level three (the highest level of simplification) still too complex and lengthy. Conversely, another participant felt that level three was too brief, leaving them with a sense of missing out on substantial information. Additionally, some participants noted

too minimal differences between version one and two.

Also, the inclusion of sub-headlines in the articles was suggested to facilitate comprehension, as they break the text into smaller, more manageable sections. Further, grouping sentences into paragraphs was proposed as a means to achieve a similar effect.

The remaining options in the menu were automatically understood by the participants. While some mentioned that they personally might not utilize the font size adjustment buttons, they acknowledged the potential usefulness for other individuals.

The selection of font types was supported by all participants, except for OpenDyslexic. Unanimously, they agreed that OpenDyslexic did not assist with reading and instead made the experience more exhausting. Moreover, participants noted that Helvetica and Arial appeared very similar, leading to the conclusion that including both fonts might not be necessary in this context.

Concerning the available colors, participants held diverse opinions. For everyone, the contrast between the text and the two background colors was important. However, some preferred high and some less contrast. The third color option (see Fig. 5.6) was one participant's favorite combination while it would be the last choice for another. Also, some were more in favor of lighter colors and others of darker ones. Therefore, it is assumed that color preferences have an additional individual part. A common denominator is, however, to avoid extremes in contrast. This includes both very high and very low contrast, for example black font on white background. Everyone agreed during the user tests that this was a hindering factor in terms of readability. Another point mentioned was that preferences would differ depending on the target device. On the smartphone, for example, a night mode might be useful at certain times while the same on a laptop might seem too dark and unreadable.

Furthermore, both spacing options in the menu were perceived as important for the quality of the reading experience. For both the line spacing as well as word and letter spacing, it was requested by every participant to further extend the maximum value.

Another positive regarded option is the word explanations. The participants all mentioned it as a helpful function. However, there were different opinions on the preferred design to indicate an available explanation for a word. Some chose the underlined word because it appeared less distracting to them while reading. Others were reminded of word correction tools since it has a resembling color and design to the read underlining indicating wrong spelling or grammar. Therefore, they liked the highlighted word better. In addition, it was suggested to instead use a lighter color for the underline, The option without any visible visual design was rejected. With these results, it was decided to test this part again in the next iteration to include more opinions.

In addition, a participant noted that the indication of an explanation using the hover effect was not optimal. They would rather see first that there is a possible interaction with the word and then decide on if they want to click and see it. Also, in case the cursor

Status	Requirement
changed	Menu next to the article with different adjustment options
changed	Short one-sentence explanation of difficult words in a pop-up window at the current position
deleted	~~Toggle-button to turn the reader mode on and off~~

Table 5.5: Adjusted and deleted functional requirements after the second iteration

was somewhere in the middle of the text and the user scrolled further down, the cursor might pass an interactive word automatically and directly show its explanation. This could be a disturbing factor in the reading experience.

Lastly, it was called attention to that the menu covers part of the article which could be irritating and disrupt the user's reading flow. Therefore, a logical conclusion was to move the menu to the side, away from the text.

After evaluating the second iteration's findings, the functional requirements for the prototype were updated again. The changed points are listed in Tab. 5.5.

5.4 Third Iteration: User Tests #2

5.4.1 Prototype version 3

In the third iteration, the feedback received in the previous testing round was incorporated, particularly paying attention to individual opinions that differed from the majority. Recognizing the various ways in which individuals with dyslexia experience reading, the objective is to develop a tool that caters to the needs of all users with this specific disorder.

One of the main changes was to move the menu away from the top where it covers part of the text to the free space on the right side of the article. The menu in this version is open during the whole interaction with the tool and the reading mode is automatically turned on when the browser extension is activated. There is no use for an On/Off-Button anymore and therefore, it was removed. Instead, a logo was added at the top of the menu (see Fig. 5.8). When creating the logo, the aim was to reflect the essence of the tool. Consequently, a minimalistic logo featuring the product name was selected. The logo's color scheme aligns with the dyslexia-friendly tones utilized in the menu.

A point that received criticism during the initial round of user testing was the lack of clarity regarding the purpose of the slider at the top of the menu. This suggested the need for additional explanation to ensure users understood its function and presented an issue anticipated before during the previous iteration, hence the question mark button below the slider in version two. An explanation was, however, not incorporated yet as the intent was to gather user input on it before. There were different ideas on how to implement it best (see Fig. 5.9). In the final draft of this version, the explanation slides

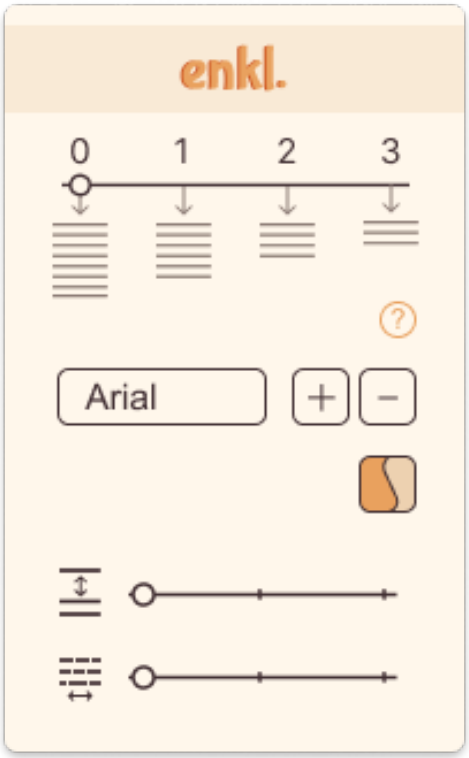


Figure 5.8: New menu with logo

down on-click and appears below the slider. The amount of lines below a position on the slider is supposed to show the degree of simplification of the selected news article, including also its relative length compared to the other levels.

Concerning available font types in this version, the decision was to only implement Arial and Verdana since these two fonts were evaluated as best readable. In addition, an example text snippet was created using the previously introduced font "Bionic Reading" (see Fig. 2.2) in order to show it to the test users in this iteration and to get an insight into their reading experiences with it. This font was chosen to be tested because it was mentioned as a positive example by a participant in the first round of user tests. Therefore, the opinion of other readers with dyslexia was sought.

Also, the three provided font sizes were slightly adjusted. The new sizes were 16pt, 19pt and 22pt as well as 25pt, 28pt and 30pt for level 0, 1 and 2 respectively.

Regarding the two bottom sliders, the distances corresponding to the level of spacing were adjusted. The line spacing was changed to "Auto" line height in level 0, 180% in level 1 and 300% in level 2. The headline line height was set to "Auto" in levels 0 and 1, and to 150% in level 2. Because the headline is several sizes larger than the rest of the article, the line height has to be modified accordingly. Also, the word spacing was improved. Compared to the first version, now also the distances between words and letter spacing were adjusted. In level 0, the spacing remains unmodified. For levels 1 and 2, the word spacing was changed to the length of two and four space characters accordingly. There is no option in Figma to alter word spacing automatically up to this

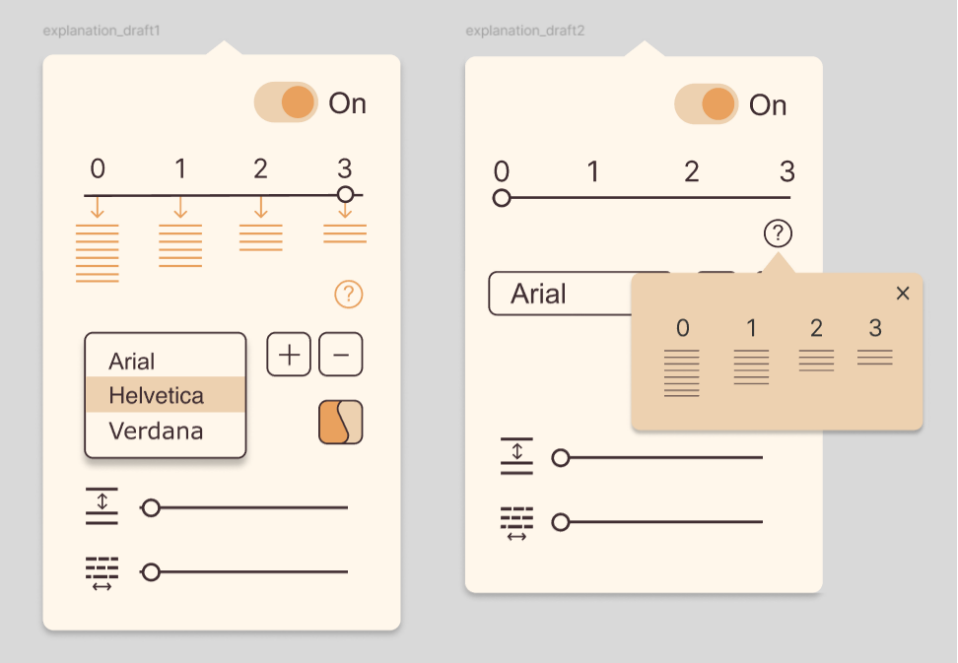


Figure 5.9: Drafts for explaining the top slider's function visually

date, therefore it had to be done manually.

After receiving a lot of diverse feedback on the color combinations in the previous version, an experimental approach was adopted in this iteration to explore additional variations. The plan involved incorporating a wide range of colors and later refining the selection based on a comprehensive evaluation using results from user tests. A total of six different color combinations were included in this version (see Fig. 5.10).

Regarding the previously tested word explanation function, some small changes were made. In this new version, users are required to click on the highlighted or underlined word to access the explanation. The visual indication for this feature was not finalized yet, as it was going to be tested with first-time users in this iteration's round of user tests to gather more feedback.
Additionally, the different levels of simplification were adjusted based on the findings from the first round of user tests. Also, the prompts used to receive an automatically created simplification by GPT-3 were adjusted as follows after testing several variations:

> ***Level 1:*** *"Rewrite the following text in an easy-to-understand language for people with dyslexia"*
>
> ***Level 2:*** *"Rewrite the following text in an easy-to-understand language for people with dyslexia and remove long, difficult words"*
>
> ***Level 3:*** *"Rewrite the following text in a short, easy-to-understand language for people with dyslexia and remove long, difficult words"*

Except for level 0, presenting the original text, each level was further shortened and simplified. Level 3, which represents the highest level of simplification, underwent a

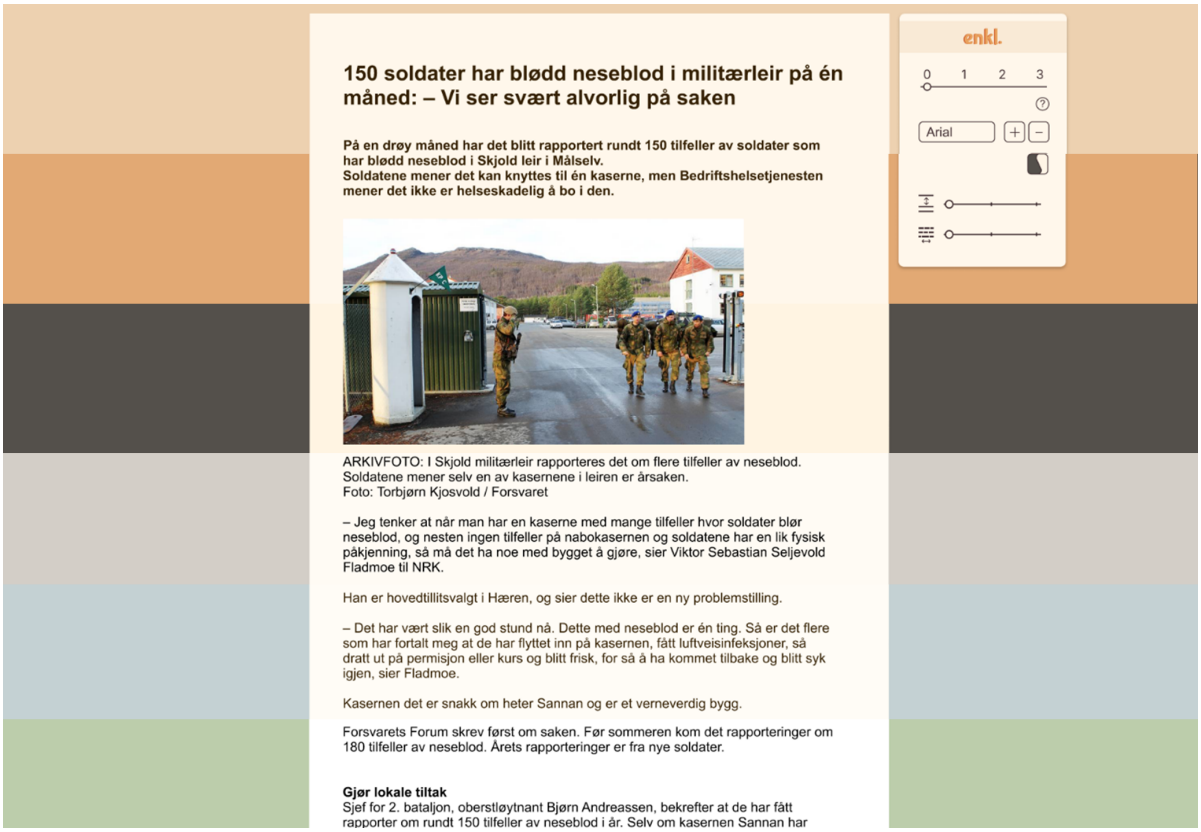


Figure 5.10: Available color combinations in version 2

significant reduction in length (see Fig. 5.11). This was based on feedback from some test users in the second iteration who indicated that the text in simplification level 3 was still challenging to read in case of severe dyslexia. At this level, sentences should also not exceed one line, preferably less, in their original form without any spacing adjustments. Furthermore, the introductory section of the article was condensed and presented in shorter bullet points.

5.4.2 User Tests

In the second round of user tests, there were ten participants. Four had already taken part in the previous iteration, and the remaining six were interacting with the prototype for the first time.

In comparison to the first test round, the general structure of the tests was kept the same. The interaction started with the original article on the NRK website. Then, the users had to activate the browser extension and look at the menu. If they had not taken part in the previous tests, questions were asked about their first impression and about their assumption on which functionality the different options in the menu provided.

Then, the task was to select the help button to see the explanation for the simplification slider and to evaluate whether this would be sufficient to understand its meaning. Since some of the subjects had used the prototype before and some had not, it was observed

Figure 5.11: Manually adjusted text with simplification level 3

if there was a significant difference in the answers between both groups. This was to ensure that no false conclusion would be made.

Afterwards, the users could try and select the different color and font type options. After getting an impression of the different available variants, they should name and give reasons for their favorites among them.

They also were instructed to try out the different simplification levels and give their thoughts about the readability and general usability. Moreover, the word and line spacing as well as the different font sizes were tested again. Ultimately, the participants were asked to customize their preferred settings for all menu options and share their thoughts on their decision.

After the interaction part, the users had to answer additional questions about different aspects of the prototype. The first questions were about their opinion on the menu's positioning and whether they would want to be able to move it, for example by dragging it to the desired spot on the screen. Also, the following questions were asked (the following list is translated from Norwegian to English):

- What do you think about the menu options being visible at all times? Would you prefer to be able to collapse or close the menu?
- Would you like to have the option to save the current settings so that the tool remembers them next time?
- Would you like to have your own button for saving the settings or do you think the amount of buttons in the menu is already high enough?
- Are there aspects or parts of the menu that are unclear?

- (If the user had taken part in the previous test:) Is there a difference compared to the prototype's last version that you like more or less?
- Do you think the spacing between lines and words is sufficient or would you want larger distances?
- Do you think the selection of font sizes is reasonable or are you missing one?
- Are there any additional functionalities that you are missing in order for you to use the tool?

5.4.3 Findings

There were different opinions on the offered selection of colors in this version of the prototype. Some liked it more if there was a higher contrast between the different colors on the website because it made the reading easier. Others preferred low contrasts. Also, some of the participants liked dark colors more, while others would pick light ones. An argument mentioned for the former was that it helps to bring focus to the text. However, in favor of the latter, it was stated that it makes the website appear more calm, making it less distracting. Apart from that, a strong majority liked the standard color combination.

Some participants mentioned that they found it slightly annoying that they had to click on the same button five times in order to select the sixth color combination. At the same time, they did not approve of adding additional buttons because that could have an overwhelming effect. There were three planned color options for the end product and the comments made by the respective users supported this idea. Furthermore, some participants even stated that around three colors would be a good number. In addition, it was mentioned positively that the user can already see the next color before clicking on the button.

An interesting thought from a participant was to match the product's colors with the colors of the news website the article is picked from. This could make the experience feel more natural.

Concerning the different presented font types, everyone was satisfied with the offered selection. A mentioned positive aspect of Verdana were broad lines, yet those were said to be too thin by a different participant. The preference is therefore suggested to be influenced strongly by subjective patterns. An argument in favor of Arial was a more serious look. Some test subjects mentioned also Times New Roman as a generally preferred font type. The argument here was its frequency of occurrence in media, so the readers are used to it and have developed a comfort in reading it.

When shown the additional typeface "Bionic Reading", a large majority strongly disapproved of its readability. Two participants liked it. However, one was unsure about how they would like the experience in a longer text. Since they were only looking at a few sentences written in this specific font type, it could result in a contrasting impression when used in a complete news article. Mentioned reasons for its poor legibility were

on one hand its unusual appearance, making it more distracting. On the other hand, it was stated that the bold part of the word seems to show something important and can therefore be misleading.

When asked about preferences regarding the line spacing option, everyone mentioned it to be generally helpful. Most stated that they would use level 1, referring to the middle position on the slider. Only one person expressed that they might not use this option. Also, some pointed out that they might choose level 2 if the text had a more extensive length.

Word spacing was considered a supportive option as well. Especially level 1 was mentioned as assistive. Nevertheless, several test subjects suggested that the spacing within level 2 appeared excessively wide and would therefore have to be adjusted.

When hearing for the participants' perspectives, it was ascertained that the differentiation of word and letter spacing as discrete options is not preferred.

With regard to the different available levels of text simplification, a variety of perspectives stating preferences for different positions on the slider were expressed among the subjects. Some voiced positive aspects of level 3 are the short sentences and paragraphs as well as that it conveys a summary of the original article. In contrast to that, it was stated by two persons that level 3 felt like information was missing. One test user stated that they are used to remembering text photographically, so they immediately saw where content was missing when switching to high-level simplification. But then, if one would want to read more details, it would be possible to select one of the lower levels. Even though most users had a preference for one simplification level, some described how they would use the text of different levels for different purposes. For instance, if they had a strong interest in a specific topic, they would rather read the complete article to get all the details. However, if it was a more general topic or a case that was more difficult to understand, they would opt for a more simplified version. Here, the subheadings in the article were a positive aspect that was specifically pointed out. According to the participants, they make it easier to orientate within the article as well as to move from one paragraph to the next while reading.

When trying out the word explanation function, it was found to be highly assistive by all subjects and often mentioned as one of their favorite features in the prototype. This is because they usually have to search for an explanation of difficult words themselves, which can take time. Also, the best available explanations, for example by Wikipedia or dictionaries, can still be difficult to understand or very long. When asked about the available explanations in the example article, it was stated that they are short and precise. Also, some noted that it might help with expanding one's vocabulary.

The indication variant of highlighting the particular word or phrase was the majority's favored alternative. Many mentioned that colorfully underlined words remind them too much of text correction tools, indicating a writing mistake. According to the test users, when highlighting interactive words, there should be enough contrast to clearly indicate available information. At the same time, it should not display a too strong color as

this could disturb the reading flow. Another mentioned aspect was that the word spacing in the explanation pop-up should match the general spacing in the article.

There were also some additional comments made on the different features and characteristics of the prototype. According to some participants, it should be avoided to display a large number of options or buttons in the menu. This could lead to the user spending more time adjusting the text than actually reading it, so it would not necessarily be a good aid time-wise. However, when asked about the current number and selection of adjustment options in the menu, all test users approved.

Regarding the placement of the menu, a large majority preferred it to be on the right side of the article, as they experienced it during the test. Many are used to this placing from other applications and found it therefore to be less disturbing. Also, those in favor stated that it was easier to recognize. Only one test subject expressed a preference for the left side. The argument against the right side was that it would catch the focus of the reader after reading a sentence in the middle of the page since it was situated right "after" it. Therefore it could disturb the reading flow. Furthermore, it was noted as positive that the menu keeps the same position on the screen when scrolling through the article.

Additionally, regarding the possibility of closing the menu or moving it out of sight, many said that they would appreciate it but would not like it to disappear completely. That would be counterproductive since it could lead to the user not being able to open it again when needed. It would therefore be a good alternative to be able to collapse and expand the menu so that it disappears from the main focus when reading.

In terms of the article's content, it was mentioned that it would be helpful to have the option to access previous articles related to the topic on the page. This would save the user time to look for them if they are interested in reading more about it. Furthermore, if the topic is ongoing or complex, it was suggested to display a box with basic facts about it to spare the reader time to look for background information.

Lastly, when asked about a possible function to save the currently selected settings for the next use, many participants approved of this idea. Some, however, voiced a preference for standard settings every time they open the extension. Therefore, a solution that provides possible customization is needed in this context.

Based on the findings, the functional requirements were revised again (see Tab. 5.7).

5.5 Fourth Iteration: Expert Feedback

5.5.1 Prototype version 4

In the fourth version of the prototype, no further adjustments in the text itself or of the menu's positioning were applied. Instead, visual options were added or improved.

Status	Requirement
new	Introductory section in level 3 is written in bullet points
new	Sentence length in level 3 does not extend one line
changed	Short one-sentence on-click explanation of difficult words in a pop-up window at the current position
new	Indicate an available word explanation by highlighting the respective word(s)
new	Button that saves settings preferences for the next use
changed	Button for changing the font type, including Arial, Verdana and Times New Roman
changed	Buttons for changing the font size, using 16pt, 19pt and 22pt as available options for the main article text and 25pt, 28pt and 30pt for the headline respectively

Table 5.7: Adjusted functional requirements after the third iteration

These changes were derived from the evaluation of the second round of user tests that were done before. First, a "Save settings" option was added. When activated, the same settings will be applied on the next use. This option is available in the prototype in the top right corner of the menu in the form of an unfilled heart shape that appears filled when selected (see Fig. 5.13). The reason for this new function was to avoid the extra steps to set the same settings every time a new article is selected. Also, the users who don't want automatic settings can still start from standard settings every time if they don't activate the option, offering a solution for both preferences.

Furthermore, the selection of available colors underwent further improvements based on comprehensive feedback from the user tests. In order to maintain clarity and simplicity, three color options were introduced, all accessible through the color button in the menu. The colors displayed in this button show the subsequent color combination that the page would transition to upon clicking (see Fig. 5.12). The chosen color palettes for this project included the original orange-beige combination. This had been used since the initial development stages to provide a light and warm color scheme with low contrast. Additionally, a lighter and cooler variant with low contrast was created using a grayish-blue combination. Lastly, a third option was introduced, featuring a dark brown color paired with a soft, glowing yellow. This selection aimed to offer a variant with higher contrast and also serve as a "night mode" option, reducing eye strain despite the increased contrast.

Regarding font types, it was decided to keep Arial and Verdana. However, Times New Roman was added as a third option since several of the test users in the previous iteration mentioned this font. Even though it is not known as a very dyslexia-friendly typeface, many are used to it from other websites, books and sources, and have therefore adjusted to it in a way.

Concerning font size and line spacing, there were no further changes made in this ver-

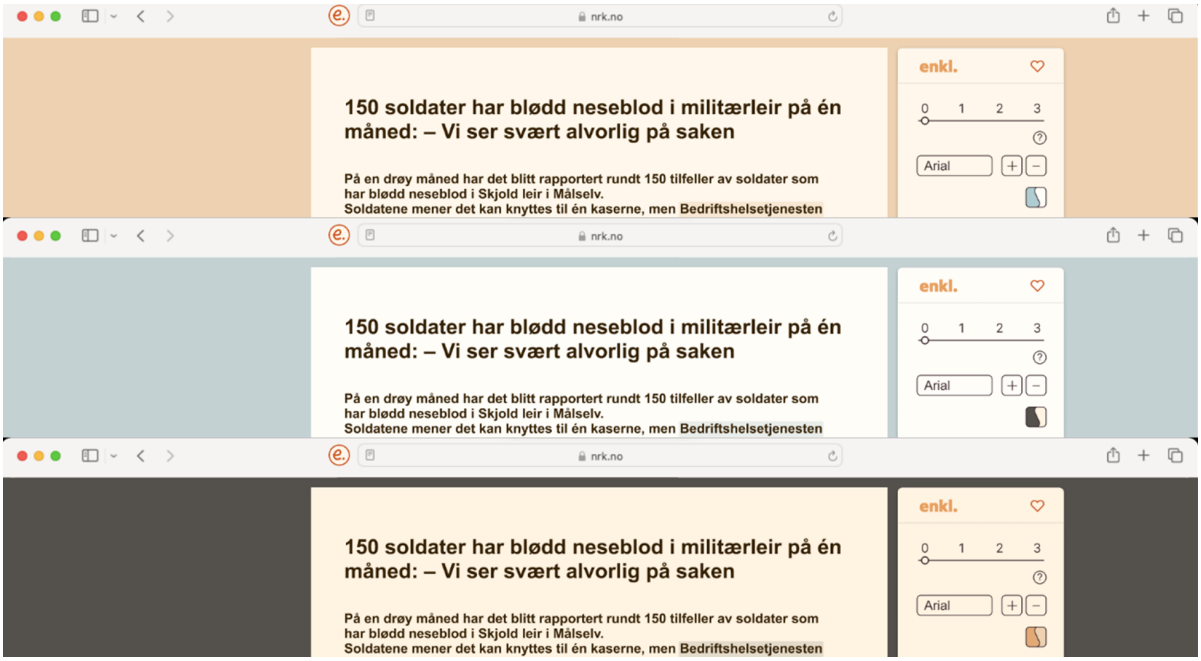


Figure 5.12: Available color combinations in version 3

sion. However, after receiving feedback that the word spacing was slightly more than needed, it was slightly reduced so that level 1 responds to 3% letter spacing, one space character, and level 2 to 3% as well, but with 2 space characters between words.

Also, it was decided to use word highlighting to indicate where an explanation is available since it was the preferred way by the majority of test users. The spacing in the explanation box for a word was adjusted corresponding to the general text settings as well.

Lastly, the logo was changed slightly so that it is just the word "enkl." but without any background color.

5.5.2 Feedback

Instead of retesting this slightly changed version of the prototype with dyslexic users, the intention in this iteration's evaluation was to showcase it to individuals, organizations, and companies. These stakeholders either have experience in the field or with the topic, or could potentially be working with this technology in the future if it was fully developed. The interactive Figma prototype was presented to Dysleksi Norge, NTB and Arkitekst, as well as Klar Tale.

The received feedback from the different parties was overall positive. Some pointed out that it would be helpful to have an additional function that would read the text for the user when selected. Though this option had been previously considered, it had not been implemented due to two factors. First, it deviated from the primary project focus. Second, technical constraints in Figma made its implementation infeasible in the given

development environment.

5.5.3 Additional changes

After receiving feedback on the results of the fourth development iteration, slight adjustments were applied to the prototype. Since it was noted several times that a listening function would be a valuable option, a listening icon was added to the menu (see Fig. 5.13). It indicates the option to read the complete article to the reader. In Ch. 6.1, a possible realization is further described.

Another change was made by graying out the font-sizing buttons when disabled. For example, when the lowest available font size is selected, the minus-button is displayed in light gray, indicating its inactivity (see Fig. 5.13).

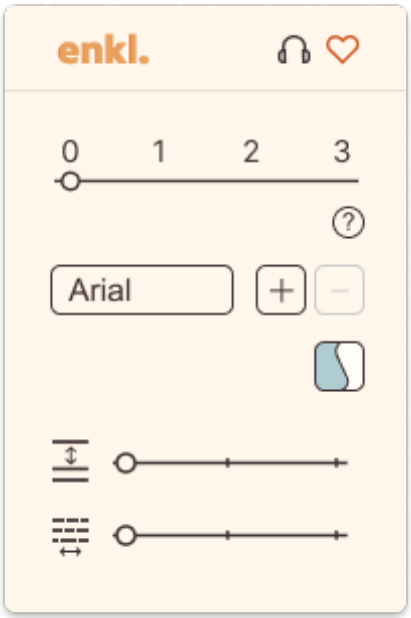


Figure 5.13: Final and revised version of the prototype menu

Lastly, the word explanations were replaced by automatically created descriptions by GPT-3. After thorough internal testing of prompts, the following was found to be most effective, delivering the most concise and understandable results: *"Forklar <ord> i en kort setning med enkle ord"* which translates to *"Explain <word> in a short sentence with simple words"*.

After final changes, the functional requirements were updated to a final version (see Tab. 5.9). Examples of designs from the result can be found in App. C.

5.6 Non-functional Requirements

After developing the described prototype with a focus on the interaction design, it is possible to implement it in a technical way. For this, the following list of non-functional requirements was created, based on the findings from the current prototype.

- Minimalist design with a limited number of selected features to meet the user's needs and avoid redundant or confusing elements. "The goal is to create an intuitive and focused user experience, where the user does not feel overwhelmed by a large variety of features or complexity, and can easily navigate and perform the necessary tasks without unnecessary distractions."
- One second maximum waiting time when changing simplification level
- Immediate response to changes in the level of simplification so that the user can quickly see the results of the changes they make to the text
- Minimize the average reading time for dyslexic users
- Available as a browser extension for PCs and tablets, as well as a mobile application
- Available download as an extension in all major browsers, including Mozilla Firefox, Google Chrome, Safari, and Microsoft Edge
- Support screen readers and keyboard navigation on all devices to make the tool accessible to users with different disabilities.
- Capability to handle large amounts of text without compromising response time, so that the user can use the tool efficiently regardless of the amount of text.

Status	Requirement
o	Present the news article in a "reader mode" without any advertisements or other distracting elements
o	Shorten and simplify the text
o	Replace difficult words with easier ones
o	Rephrase difficult phrases or sentences
o	Provide three available levels of simplified text in addition to the original text
o	Introductory section in level 3 is written in bullet points
o	Sentence length in level 3 does not extend one line
o	Menu next to the article with different adjustment options
o	Always available info-button with an easy explanation of the simplification levels
o	Short one-sentence on-click explanation of difficult words in a pop-up window at the current position
o	Indicate an available word explanation by highlighting the respective word(s)
o	Button for changing the font type, including Arial, Verdana and Times New Roman
o	Buttons for changing the font size, using 16pt, 19pt and 22pt as available options for the main article text and 25pt, 28pt and 30pt for the headline respectively
new	Display disabled buttons in gray
new	Listening button with text-to-speech option
o	Button to change the color of the text and the background planes
o	Slider to adjust line spacing
o	Slider to adjust word- and letter spacing
o	Button that saves settings preferences for the next use

Table 5.9: Complete list of functional requirements after the fourth iteration ("o" = no changes)

6 Discussion

6.1 Further Development

Several of the test users and representatives of institutions stated that they would like to see this project developed further and made available to the public. With thought to that, multiple points could be implemented or changed to improve the overall user experience of the product and facilitate the accessibility of news articles.

Firstly, it would be helpful to implement a listening function where the article is being read to the user on click. This point was mentioned several times since it is a common function in related products. The only point of critique about those is the fact that the reading voice often sounds quite monotone and artificial, which makes it more exhausting to listen to. It has been found that the voice quality in text-to-speech has a significant effect on the interaction experience (Cambre et al., 2020). An example of good realization of TTS in longer segments is the reading function in Aftenposten Junior (see Ch. 4.2.2) where they use a human narrator for their listening function.

Another important point would be to offer a mobile version of the technology. Since a majority of people read news on their phones nowadays - which could also be learned from the interviews and user tests -, the product should offer this as well. In this case, the positioning of elements in the application would have to be adjusted because of the different screen sizes and formats. For example, the menu might be better situated at the top of the screen as a navigation bar, but further testing and research would have to verify this.

Another addition could be the possibility to drag the menu to any desired position. In case the user is not happy with the current positioning - like one participant during the user tests - they can move it to a place where it does not interfere with the reading flow or where it feels most natural for them. Furthermore, it could be helpful if one could collapse and expand the menu with one click. Those users who do not need to make alterations several times while reading could minimize the potential distraction from the text by this. Also, it could be helpful to reduce the contrast and increase the transparency of the remaining menu bar when it is collapsed and does not have focus by hovering over it with the cursor. With this, the distraction by the menu would be minimized as much as possible while still making it easy to re-access the different settings when needed.

A potential solution for the issue of the top slider's function in the menu being unclear

#1 Visibility of status
#2 Match between system and the real world
#3 User control and freedom
#4 Consistency and standards
#5 Error prevention
#6 Recognition rather than recall
#7 Flexibility and efficiency of use
#8 Aesthetic and minimalist design
#9 Help users recognize, diagnose, and recover from errors
#10 Help and documentation

Table 6.1: Ten Usability Heuristics by Jakob Nielsen

is to introduce a brief tutorial that appears when users first interact with the product. This tutorial would be clickable, showing the use and meaning of every option in a short and easy-to-understand way, for example with animations and pictures. The objective is to provide users with important knowledge about the tool right from the start so that they can then use the browser extension or app without encountering any difficulties.

Because the research leading up to the results presented in this thesis was conducted in both Germany and Norway, extending the application of the prototype beyond Norwegian news articles and exploring its potential application to German or other languages were considered. Of course, individual features are unique for each language, so there would have to be an assessment of the feasibility of this idea.

Another point that was mentioned by some test users would be to make the technology not only available for news articles but also for research papers or other sources that often include complex or difficult text.

Furthermore, an idea was to show the reading progress to the user via a progress bar, for example at the side of the page. This could further help the reader to orientate within the text and get a feeling of how much they have to read until the end.

6.2 Assessment and Interpretation of Findings

6.2.1 Usability Heuristics

The results from the prototype are assessed in the following, applying the ten usability heuristics by Nielsen (see Tab. 6.1) introduced in Ch. 3.5.

Regarding the first point about "Visibility of status", the prototype immediately responds to changes in the menu by changing the visual representation of the text. No other changes are made other than those administered by the user, therefore they have complete control over the alterations made to the text. The user can also always see the current settings in the menu. They are indicated by, for example, markers on sliders or printing the name of the font type in the respective button. The chosen color combination is visible on the page as it is immediately applied when selected. Furthermore, the available actions at the current status are visible. If the highest or lowest possible font size is reached, the option's inactivity is indicated by a grayed-out button. Moreover, the next available color choice is displayed on the color button. Furthermore, the "Save settings"-button clearly displays if it is active by changing its design and it is therefore always clear whether the option is in use.

The second and fourth rules are evaluated together as they are closely linked. They concern following standards, enabling consistency, and adapting to design that is familiar to the user. These criteria are applied in the various parts of the prototype. For instance, sliders like those implemented in the project are a common way to adjust a flexible value in an option. Also, the icons for each button were chosen using those that are often automatically associated with each other. The decisions for choosing each icon are based on other applications that use similar options and on personal experience. The test users confirmed the choices, as they were able to identify almost every option's functionality, except for the simplification slider. This option, however, does not provide a commonly used functionality and the rules are therefore difficult to apply. Furthermore, standards for accessibility were followed in, for instance, the choice of colors, but mostly with the text simplification option. A number of adjustments were made over the course of iterations to produce an output that fulfills general accessibility criteria and especially those for dyslexic people.

The third rule in the list demands that the user should have easy options for reversing performed actions. Since the menu is visible at all times, the user can always undo settings by selecting the respective position on the slider or by clicking a maximum of two times on the offered buttons. In the same way, reversed actions can be redone if needed.

The fifth rule addresses error prevention. There are no possibilities for "real errors" when interacting with the menu in the prototype, so this point is less regarded. However, if errors are defined as "unwanted results by accidental actions" in this case, the consistency described in the fourth rule creates a low probability of misunderstood functionalities. This connects to rule nine regarding the identification and solving of errors. There are no possibilities for error messages in the current prototype, this point can therefore be neglected. However, this could become a crucial aspect if the prototype is also technically implemented since error probability related to technical problems would increase.

Following the sixth rule, the user should be able to recognize important interaction elements. Every available function in the prototype is visible and, as discussed related to points two and four, easy to identify except for the text simplification option. As a tutorial for this function was suggested to further develop the prototype, this would fa-

cilitate a better understanding. Furthermore, the word explanations are indicated by an underline of the respective word or phrase and are therefore easy to detect.

Rule seven assesses the product's flexibility regarding the user's requirements. In this case, assuming the initial tutorial is implemented, it is a function that experienced users do not need. Therefore, they can directly adjust the text when opening the browser extension. Furthermore, the option for saving the current settings provides a shortcut specifically for non-beginners. This option saves time and redundant actions because the user can directly access preferred configurations.

Regarding the eighth rule concerning minimalist and structured design, the prototype restricts its amount of options to the essentials. It therefore avoids unnecessary items and confusion for the user. Also, the menu is kept in a minimalist design, both regarding its elements and positioning. The elements are grouped together thematically, for example, the two options regarding spacing are situated at the bottom, using the same slider design.

Finally, according to the last rule, difficult-to-understand elements should be explained in an easily accessible manner. As the text simplification feature was often hard to comprehend without further information, the corresponding help button below its design element is supposed to give an explanation. In the user tests, the meaning appeared to be recognizable after an initial clarification. This applied also to a longer period of time as those users that participated in both tests could still remember the option's use in the second round. Regarding the complete prototype, the tutorial that was suggested for further improvements can help to solve any remaining misunderstandings or general questions.

In conclusion, the results are generally in line with the usability heuristics and therefore suggest a high degree of usability in the developed prototype, supported by findings from the conducted user tests and expert feedback rounds. However, further efforts can be made to improve the comprehensibility of the simplification option.

6.2.2 Research Questions

At the beginning of the thesis, research questions were established. In this chapter, the findings of the development process are discussed and assessed using the research questions presented in Ch. 1.3.

The first research question *"How can the visual representation of text be effectively altered to enhance the reading experience of news articles and improve text comprehension?"* can generally be answered by the results of the development phase. Colors, font size adjustments, different spacing between lines and words, as well as the chosen font type all influence the reading experience for people with dyslexia. As discovered over the two rounds of interviews in the development process, text comprehension

was significantly improved when including the named adjustment features. The list of functional requirements, which was developed over the course of four design iterations, provides concrete details on how the interaction of dyslexic readers with news articles can be improved.
When trying to answer the second question *"What are suitable design elements in a reading tool that can address the individual needs of dyslexic people?"*, the different categories of needs from the findings have to be outlined first, providing a general basis to establish a tool for this context. The difficulties that were mentioned during the initial interviews were often caused by particular elements. Examples were click-bait titles and photos or attention-seeking layout decisions for specific articles, such as implementing moving objects on the article page. The findings proved a variety of features that were, subjectively, making the reading experience more exhausting. From the interviews, a selection of negative examples in terms of interaction with news articles was derived. However, the research question asks for the opposite, meaning helpful elements that can improve the reading experience. Furthermore, it is important to always keep in mind that the experiences of dyslexic people may vary from person to person. Therefore, they might also have different demands towards the characteristics of accessible text, even though they are all diagnosed with the same disorder. This can pose an issue when the preferences of individuals are colliding with each other since it then can be challenging to find creative solutions that fulfill both, or more, priorities.

An example of the addressed dilemma is discovered in the third iteration. Regarding the placement of the menu, a large majority preferred it to be on the right side of the article, as they already experienced it during the test. Many said that they are used to this positioning from other applications and found it therefore to be less disturbing. Also, those in favor stated that it was easier to recognize. Only one test subject expressed a preference for the left side. The argument against the right side was that it would catch the user's focus after reading a sentence in the middle of the page since the menu was situated right "after" it. Thus, it could disrupt the reading flow. In this case, two different needs come together and require a solution that fits both. The preference for having the menu on the right side was mostly derived from habits. On the other side, the individual dyslexia characteristics made positioning the menu on the left more attractive to the respective individual. A solution in this case could be the in Ch. 6.1 proposed option to incorporate a dragging and collapse function for the menu, making this aspect highly adjustable and personalizable.

Other design elements that attempt to meet the various needs of dyslexic readers are for example the sliders on the menu, used for the spacing and text simplification options. If they would be technically implemented in an interactive browser extension, the markers on the sliders could move smoothly, without any set configurations that the user can choose between. Therefore, it enables a high potential for personalization of the slider's value. The font, color and font size options were designed in a different way. Although online, a finite amount of possible values is offered, the previous thorough user testing suggested the offered options as sufficient. Here, the participant's opinions were not as diverse regarding preferences.

Also, the decision to use this kind of realization connects directly to the third sub-

question. A first thought regarding the previously described options could be: Why can not every possible variant of an option be offered for selection to the user? Especially regarding the functionality to adjust the color scheme in the article, the number of selectable options decreased from one development iteration to the next. The choice might initially seem unreasonable.

However, the variation of offered options is not the only factor affecting the outcome in terms of usability for the user. In the third sub-question *"How can a design solution achieve a balance between the criteria of minimal distractions and necessary functionalities?"*, the issue of satisfying needs coming from two - in their extreme form colliding - perspectives is addressed. As demonstrated during the development process in the user tests, interviews, and expert groups feedback round, the goal was to learn as much and as detailed as possible about the user's experiences with reading and their resulting needs. This was grounded in the objective to design the prototype as close as possible to the target group's requirements for support in reading news articles.

Two main findings regarding the selection of options were the following: On one side, it is good usability if as many individual requirements as possible are met by the offered functionalities. As already described in Ch. 6.2.1, it is good design if the user can personalize their interaction to a high degree. On the other side, implementing too many options and features can make the application seem cluttered and confusing. This was also mentioned during the user tests in iteration 3. In addition, especially with dyslexia, it is crucial to design a clear and concise, structured interface. Each additional element holds the potential to make the reading interaction harder for dyslexic users. The color picker option combines three color combinations in a single button. If the user could choose between ten different colors instead, for instance, either many individual buttons would be necessary to access each option, or it could be realized using just one button. Then, however, many clicks would be involved for the user every time they want to navigate to a specific color. This is why design has to adapt both angles and find a middle ground in each case in order to generate a good solution. The options available in the final prototype were tested several times and were then decided to be adequate. For the presented ideas for further development in Ch. 6.1, solutions would still have to be tested and revised with real users for several times.

The leading research question for this thesis was ***How can visual and content-related text modifications work together to enhance the reading experience of dyslexic people?***. After addressing the more detailed sub-questions, the answer to this question is described by the general interconnectedness among the single functionalities of the prototype. Those can be distinguished by contributing to visual changes concerning the layout or by influencing the phrasing of the displayed text. The latter is mostly utilized by the text simplification option. With the developed three additional versions of the article, substantial resources for users with dyslexia and general reading difficulties, are delivered. Also, using analyzed and tested-out prompts to send to GPT-3 in order to receive the different levels of simplification, offers one way of working towards a more accessible news article representation. On the other side, there are options regarding visual alterations of the selected news article which have been thoroughly described in this thesis. As each of the individual features in the tool functions as a small optimiza-

tion, the target group would not necessarily use one of them just by itself as the effect is not major enough. Also, referring back to the second sub-question, dyslexic news consumers often experience reading in heterogeneous forms. Therefore, offering a pool of essential optimization options to the reader, while including both the visual and the lexical approach, provides a strong advantage over other tools with similar target groups.

6.2.3 Further Evaluation

To verify the participants' subjective perceptions in the user tests concerning the text simplification levels, a calculation of the Lix-score[1] was applied to all four levels which were used in the final version of the prototype. The used inputs for the score were the automatically generated texts that were later manually modified. The results were the following:

Original article (Level 0): 35

Level 1: 35

Level 2: 28

Level 3: 20

The scores for the texts generated by GPT-3, without any additional adjustments, were 40, 35 and 25 for levels 1, 2 and 3 respectively. Because of this and related to further analysis as discussed in Thale Kirkhorn's thesis (Kirkhorn, 2023), it can be suggested that GPT-3 aids in generating a simplified version of the text but needs further adjustments to meet the requirements. Also, the Lix-score should not necessarily be used as the only measuring tool. For example, as demonstrated in the list above, levels 0 and 1 received the same score, although the respective texts differ in many aspects. If those values were regarded as the main mean of measurement, the evaluation of results could be distorted. This also demonstrates the importance of qualitative research where individual perspectives are strongly valued and explored.

6.3 Limitations

The project and its related research also have their limitations which have to be considered with the presented results. First, there were general time constraints that restricted further elaborating development of the prototype. Another point that was impeding the implementation of further functionalities was the chosen design tool Figma. Though it acted as a helpful prototyping tool, some functions were missing. For instance, it was not possible to add a playable sound file to simulate the text-to-speech function. Also, implementing a progress bar representing the current position relative to the article length was not possible with the functions and time constraints provided.

[1] https://skriftlig.no/liks/

Another limitation is presented by the handling of the chosen example article in the prototype. Due to the limited time, it was not possible to use different articles in every iteration which can have affected the output. However, an applied measure to work against this effect was having both experienced and novice users during the user tests in the second iteration. In this way, some participants could work as a control group because they saw the article for the first time. At the same time, the other persons could take part in the test, providing further insights, especially from an experienced perspective.

Additionally, the employed qualitative methods provided subjective feedback which is an advantage on one side since it can include perspectives that are not necessarily measurable. On the other side, there is the possibility that some aspects are not regarded or problems are not discovered because they are not connected to the participants' needs. Moreover, the test user's demographic was partly imbalanced. Most participants were students and/or between 18 and 30 years old. This might have the effect, that the results apply more for younger people or individuals with a student background. The requirements and needs of older people might be covered less.

7 Conclusion

This chapter draws a conclusion from the previous chapters, focusing on conducted research and the resulting findings of this master's project.

The research, which was carried out over the time of the entire master project, was aimed to identify means on how to improve the readability of news articles for people with dyslexia. Based on conducted interviews, personas, literature research, and performed user tests for evaluation, a high-fidelity interface prototype was developed over four iterations.

This prototype proposes a solution for a current gap in technology. People with dyslexia comprise a significant part of the global population, yet a supporting tool for reading news, designed for this concrete learning disorder, is hard to find. In the use case of this master's project, the objective was to create a solution for news articles in Norwegian. This was decided due to the fact that the project was realized in Norway and because of the nonexistence of a similar tool tailored to the Norwegian language. The prototype answers this master's guiding research question "How can visual and content-related text modifications work together to enhance the reading experience of dyslexic people?". It incorporates on one side lexical alteration to a selected news article. For the offered four different levels of text simplification, artificial intelligence was used in combination with additional manual adjustments. On the other side, the tool provides multiple ways of modifying the appearance of the applied article, which plays a strong factor in the readability for a dyslexic person. An additional option provides on-click explanations for words that have the potential to be difficult to read.

Mostly due to time constraints, not every idea could be implemented in the project. However, a list of possible further development points is available. The results of this master's project provide important findings that can be utilized in further studies on design and digital accessibility solutions.

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Appendix A: Interview Guide

This Interview Guide (originally in Norwegian and later translated to German and English) was utilized during the initial interviews described in Ch. 4.

Interview Guide

- Greet the participant
- Introduce yourself
- Thank the participant for taking part in the interview
- Give a short introduction into the topic of the interview
- Let participant sign consent form
- Start recording

1. Have you read any news today? Can you tell us a bit about what it was about?
2. What kind of news are you most interested in?
3. What is your relationship with news? How often do you seek out news?
4. How do you seek out news (online newspaper/podcast/paper/mobile/computer, etc.)?
    a. What makes you choose this way of accessing news?
    b. If multiple: what do you use most/prefer, why?
5. What do you usually do when you read an article (e.g. look at headlines/pictures etc.)
6. Do you practice skim reading or do you usually read the whole article?
7. Is there anything you don't like or find obstructive when reading an article? Can you give examples (e.g. long/complicated sentences, long words, long text, complicated words)?
8. What makes an article feel interesting and easy to read? Can you give examples (e.g. layout, sentence structure)?
9. What makes you stop reading an article?
10. Have you tried browser add-ons that support the user in their online reading?
    a. Which add-ons and what did they do (e.g. speed up text)?
    b. Do you still use it, or what made you stop using it?
11. Is there anything else you would like to add or do you have any questions?

- Stop the recording
- Thank the participant for taking part in the interview

Appendix B: Code

Python-file dysleksi.py:

```
# Import the necessary libraries
from flask import Flask, request, render_template
import openai
import logging
import os


# Insert valid OpenAI API key
openai.api_key = "<apikey>"

# Create a Flask app
app = Flask(__name__)

# Define the route for the home page
@app.route('/')
def home():
  print("1")
  return render_template('home.html')

# Define the route for the result page
@app.route('/result', method=['POST'])
def result():
  # Get the input text from the form
  input_text = request.form['input_text']
  print("2")


  # Use the OpenAI GPT-3 model to rewrite the text
  completion = openai.Completion.create(
    engine="text-davinci-003",
    prompt=f"Rewrite the following text in an
    easy-to-understand language for people with dyslexia:
    {input_text}\n",
    temperature=0.5,
    max_tokens=1024,
    top_p=1,
    frequency_penalty=0,
    presence_penalty=0
  )

  # Get the rewritten text from the Completion object
  dyslexia_friendly_text = completion.get('choices')[0].get('text')
  print("3")
  # Render the result template and pass the rewritten text to it
```

```
45    return render_template('result.html',
46    dyslexia_friendly_text=dyslexia_friendly_text)
47
48  # Run the app
49  if __name__ == '__main__':
50    app.run(debug=True)
```

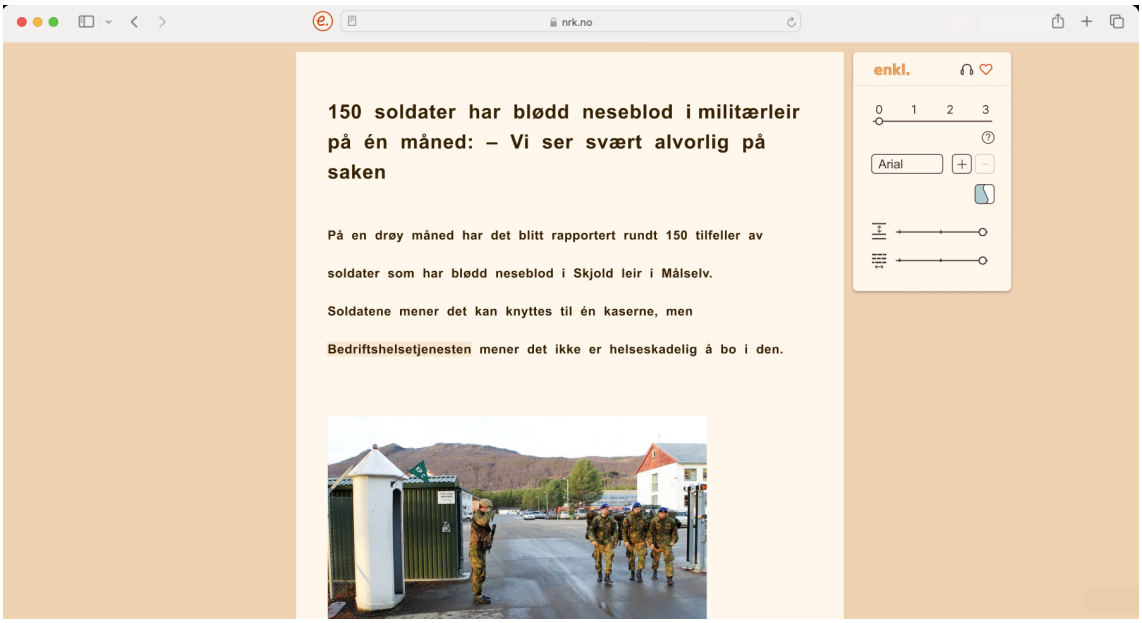
HTML-file "home.html":

```
 1  <!DOCTYPE html>
 2  <html>
 3    <head>
 4      <meta name="viewport" content="width=device-width">
 5      <link rel="stylesheet" type="text/css" href="style.css"/>
 6      <title>Tekstforenkling for dysleksi</title>
 7    </head>
 8    <body>
 9      <div class="page">
10        <div class="heading">
11          <div class="page_text">
12            <p id="headline">Tekstforenkling</h1>
13          </div>
14          <div class="help-tip">
15              <p>Skriv teksten din i boksen under og klikk på
16              "Skriv om" for å gjøre teksten mer lettlest.</p>
17          </div>
18        </div>
19        <div class="inp">
20          <form action="../templates/result.html" method="post">
21            <div class="textbox" contenteditable="true"
22            name="input_text" rows="10" cols="50">
23            </div>
24            <input class="input_button" type="submit"
25            value="Skriv om">
26          </form>
27        </div>
28      </div>
29    </body>
30  </html>
```

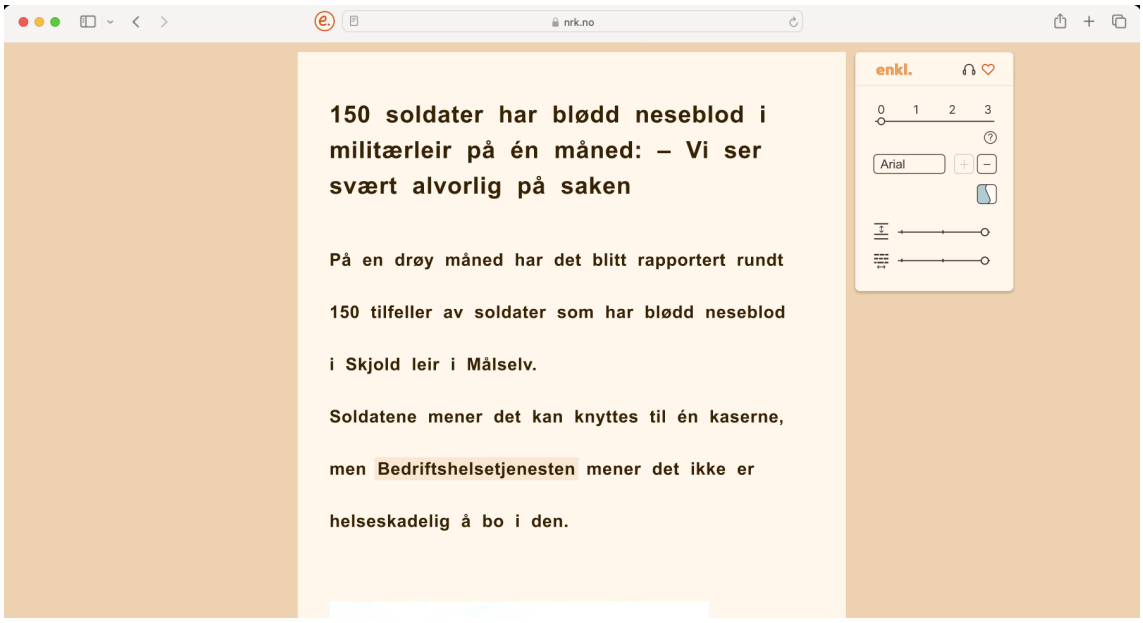
Appendix C: Examples of the final version of the Figma Prototype

1. Final Prototype: Selected simplification level 0, smallest font size, no extra spacing, Arial

2. Final Prototype: Selected simplification level 0, smallest font size, both spacing sliders on level 3, Arial



3. Final Prototype: Selected simplification level 0, largest font size, both spacing sliders on level 3, Arial



4. Final Prototype: Selected simplification level 2, medium font size, both spacing sliders on level 2, Arial

5. Final Prototype: Word explanation example with selected simplification level 0, medium font size, both spacing sliders on level 2, Times New Roman