

# How to design cognitively accessible digital design patterns for booking tickets: A participative study with Easy-to-Read users.

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## Abstract

Accessibility of digital services needs to be improved, in particular for users with cognitive and learning disabilities. Our focus is on digital design patterns that have the potential to increase comprehension for users with low cognitive and reading skills by combining short and simple text with effective design. We conducted a case study with 43 easy-to-read (ETR) users and 12 university students in a control group in which users select a theater play, find a date, and order tickets. In a participatory design process with four co-researchers and a User Experience (UX) expert, we created test material with high ecological validity. Subsequent testing collected quantitative and qualitative data to provide a clear picture of the context of use, the differences in success of the three variants, and the challenges of a multi-step ordering process. Our contributions are an enhanced participatory design process involving UX experts, insights into ETR users' context of use, and proposals for cognitively accessible design patterns for ticket selection, appointments, and an exemplary simplified ordering process that can be applied to similar digital services.

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## CCS Concepts

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

## Keywords

Easy-to-Read (ETR), cognitive accessibility, digital design patterns, interaction design, usability, accessibility, inclusion

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## 1 Introduction

Digital participation is essential in today's decentralized yet interconnected society [82]. Tasks like booking a doctor's appointment or purchasing tickets now require digital and reading skills, which presents challenges to people with disabilities. With the COVID-19 pandemic accelerating online services and payments [21, 82], the 2019 European Accessibility Act mandates accessible products and services throughout the EU by 2025 [30], highlighting the urgent need for inclusive (digital) design.

The concept of accessibility encompasses a broad spectrum of motor, visual, auditory, and cognitive requirements. Cognitive accessibility addresses people with cognitive and learning

disabilities related to the mental processes of perception, memory, and reasoning [73]. Since cognitive disabilities are highly diverse, our study focuses on a specific subgroup: Easy-to-Read (ETR) users. ETR was developed to support people with intellectual disabilities (ID) who can read at a basic level. We will use the term ETR users throughout this article to refer to this subgroup of people with cognitive and learning disabilities.

Despite most of society's transition to online platforms, current digital participation among people with ID remains low [21]. Furthermore, this group is underrepresented in research [5, 27, 69, 91, 92]. The low number of studies on user interface (UI) design decisions results in a significant gap in design practices and interface evaluation, hindering the practical implementation and effective testing of operability-tailored applications for this group [27, 47]. A recent study demonstrated that ETR users are capable of interacting with standard digital design patterns [95], and previous research shows that simplified language is not the only key to understanding. They also benefit from clear typography, abundant design, and a reduced cognitive load [7, 12, 14, 94].

The term 'design pattern' originated in architecture [3] and has been adopted by design research and software engineering. Most design patterns work effectively because they directly correlate to our perceptual system, facilitating intuitive interaction, rather than relying solely on explicit learning [97, 108]. Although the underlying principles are rooted in perception, users still need to grasp the specific implementation of these patterns within a given interface to fully operate it.

Software engineering defines design patterns as generic, reusable solutions to common problems [4, 38] and UX design further differentiates them into components (e.g. cards, lists, footer), elements (e.g. buttons), tokens (basics such as typefaces, colors), and interaction patterns (e.g. scroll, swipe) [37]. Digital products are based on design systems to ensure consistency [31]. These systems are a set of standards that shape the visual language of a user interface (UI) and contain design patterns to keep a product's look and feel consistent.

Digital services, such as booking tickets, use a set of patterns that need to be applied. It is unclear how ETR users cope with multiple design patterns in a search and booking process, which we use as tasks to identify how different design patterns compare in terms of cognitive accessibility. This study builds on a solid understanding of ETR users' context of use and investigates the selection and purchase of theater tickets on a smartphone, a relatable and ecologically valid use case identified through participatory design (PD). We address the following research questions (RQs):

- RQ 1: What is the context of use when designing digital products for ETR users?
- RQ 2: How can we adapt existing co-design approaches and integrate professional UX design knowledge to suit ETR users' needs?
- RQ 3: Which design patterns help ETR users select an event?
- RQ 4: Which design patterns help ETR users find and select a suitable date?
- RQ 5: What sociotechnical issues beyond usability have to be considered when it comes to order processes?

We review related work, present a novel PD process for the prototype, and an experimental study with 47 ETR users and 12 control

participants, testing three design versions. Our findings highlight the most effective design patterns for ETR users and their broader applicability. Key contributions include an enhanced participatory approach with UX expertise, insights into the ETR users' context of use, and cognitively accessible design patterns validated for the ETR users group, leading to future research opportunities. Our findings represent a valuable foundation for the expansion of the WCAG guidelines, thereby facilitating accessibility for individuals with cognitive impairments such as ETR.

## 2 Related work

In this section, we provide a brief definition of the ETR group and reflect on the relevant guidelines, studies, and digital products. We also discuss studies on the use of digital media by a wider group of people with ID, as well as methods for creating and testing with this group.

### 2.1 Easy-to-Read (ETR) and requirements for products targeting ETR users

The concept of 'easy-to-read' involves simplifying text to make it understandable for people with ID [28]. It was developed in the 1970s, driven by the self-advocacy of people with ID [83]. A central component is the involvement of those affected [28], which reinforces the general demand of "nothing about us without us" [70, 100]. For a text to be considered easy-to-read, it absolutely must have been developed and tested with the target group [28, 66]. This is a key difference from other forms of simplified language, such as 'plain language' [22]. ETR users constitute a specific subgroup of people with ID. Although they self-identify since 1985 as "people with learning difficulties" to reduce stigma, this terminology conflicts with the academically established term "learning disability", which denotes language, speech, and communication challenges in individuals with average or above-average intelligence [63].

The emphasis that ETR users have cognitive limitations associated with ID is crucial. Their needs are substantially different from individuals with specific learning disorders (like dyslexia or ADHD) and only partially align with age-related cognitive issues. Regarding dyslexia, for example, Orero et al. state, "ER [Easy-to-Read] will never rehabilitate people who have dyslexia as their condition" [81]. Therefore, effective ETR design requires a dedicated focus on the specific cognitive and informational needs of ETR users. Key recipient issues identified in the literature [23] include low retention [61], challenges with inference—specifically, linking disparate pieces of information within a text or integrating new information with prior knowledge [16, 19]—and problems related to suppressing irrelevant meanings [39].

### 2.2 Accessibility guidelines regarding ETR users

Adherence to the aforementioned critical co-design requirement poses significant methodological and ethical challenges: It is difficult to recruit a large enough sample of participants and to obtain ethical approval, as they are often under guardianship. Data collection can be difficult due to fatigue and reduced speed in test situations. As a result, digital products are rarely tested with people with ID [70], despite the potential to better meet their needs [40]—a review published in 2024 of 101 ACM studies from the last 25 years

found that only four focused on low literacy and two on learning disabilities [5]. A review of 104 articles researching the application of Large Language Models (LLMs) criticized the limited number of studies investigating the needs of disabled people. In fact, no studies involving people with ID were found [89].

The limited data available is reflected in accessibility guidelines. Although WCAG [107], ISO standards [24], Access Guides [6], and UX heuristics [59, 60, 62] establish accessibility standards, cognitive disabilities are largely overlooked [27, 99]. An accessibility review found that 30–50% of issues of people with ID were not addressed by WCAG 2.0, WCAG's accessibility guidelines [17]. The Cognitive and Learning Disabilities Accessibility Task Force (COGA) has published techniques to address this gap. For example, the COGA 'roadmap' addresses online payment issues [67], and the 'techniques' suggest minimizing the cognitive skills required by providing a clear structure, consistent layout, simple writing style, and the use of symbols and images to convey meaning [68]. A large body of HCI research on dyslexia focuses on visual crowding, typographic augmentation [18, 104], and micro-level modifications, such as increased letter spacing and digital reading rulers [76], or LLMs [112] to improve comprehension of static text and reading speed for users with different visual sampling strategies [35]. However, these do not meet the needs of ETR users. Specific ETR guidelines focus on linguistic simplification and the implementation of print materials, disregarding visual aspects of text comprehensibility [14, 93, 94] and the requirements of digital media. It was not until 2025 that the German DIN specification [32] addressed visual aspects and revised incorrect specifications, such as the recommendation to use the Arial font [32, 94]. However, with regard to digital media, the DIN refers to the WCAG and COGA guidelines and does not provide any specific recommendations for ETR users [32]. The aforementioned review concludes that "future research should broaden community representation, more deeply incorporate co-design practices, and evaluate tools in real-world, sustained contexts" [5].

### 2.3 Tools for ETR users, test materials, and practical implementation

This lack of specific guidelines hinders design for ETR users. A literature review analyzes UX and UI principles and their benefits for users with low levels of education and literacy. While all publications agreed on the importance of clear language and simple design, there was disagreement over what this actually means. The authors propose twelve guidelines, such as, "White space is extremely important for separating content and giving the user room to breathe" [45]. Studies often struggle to translate these guidelines into test material because they are too vague. Consequently, several digital products that aim to adapt content for ETR users have design issues. The Spanish 'Easier' tool aimed to propose 'cognitive accessibility design patterns' and translated the COGA techniques into an application offering a glossary of simplified texts. Problems with button recognition were identified in the initial design and were only partially resolved in the second version [73]. The 'EasyReading' tool is a browser add-on designed to improve the cognitive accessibility of websites by either simplifying the layout and content (e.g. hiding graphics and images) or clarifying it (e.g. adding symbols or images) [29, 55]. The participatory project did

not involve user testing. From a UX design point of view, the aforementioned WCAG and UX standards may not be met, and the user may need to make an effort (and thus customize) to operate the tool. Another tool that aims to achieve (cognitive) accessibility is the 'accessiBe' plugin [26]. Although it uses state-of-the-art UI design, it does not account for the low reading skills of its target audience. Its extensive settings and standard language might overwhelm the average user with low reading skills and cognitive disabilities. Its settings also fail to consider the hidden interdependencies of typography and perception. Since factors such as font choice, size, word and line spacing, and color contrast are all interdependent, the tool permits dysfunctional combinations that can result in completely unreadable interfaces.

In 2023, the US Centers for Disease Control and Prevention (CDC) developed a guide to help create products for adults with intellectual and developmental disabilities and extremely low literacy levels. Despite extensive research, they found no evidence-based principles or standards for communicating health information to this group. The guidelines presented are fairly standard (focusing on essentials, straightforward sentences, and literal, realistic images) and do not offer any practical suggestions for designing user interfaces [101]. Web accessibility experts and professionals face similar implementation issues. A 2024 study explores the perceptions of Finnish experts and reveals that, while they advocate for cognitive accessibility in digital services as it benefits all users, organizational barriers and a lack of information on how to achieve cognitive accessibility in practice are also identified [64].

To summarize, the lack of guidelines and tested best practice examples not only leads to difficulties, but also to the creation of tools and test material that violate either the existing WCAG or the UX heuristics regarding cognitive accessibility.

### 2.4 Academic studies of user interfaces for ETR users

We identified only two studies that developed interface designs for ETR users from scratch. The first study (2024) involved designing an interface in a participatory design setup to demonstrate the results of a study on ETR, which was then tested with people with ID who use ETR [95]. The researchers found that ETR users are familiar with standard design and interaction patterns, such as buttons and the 'hamburger' menu icon, as well as swipe and scroll interactions as they use them in everyday life. Less common patterns, such as the back-to-top button, caused difficulties [95]. This relates to Jacob's Law, where Yablonski states that digital knowledge is acquired through the daily use of common applications [111]. Based on psychological research indicating a reduced cognitive capacity of ETR readers [7, 23], the authors suggest optimizing standard design patterns for low cognitive load, hence creating an 'easier' language and design [95]. The second study from 2023 took a pragmatic approach to application interface design: They assumed that most ETR users were familiar with modern Android or iOS applications and followed the guidelines of Google's open source 'Material Design' system to implement components and navigation similar to widely used applications [103].

Some studies involved redesigning apps for groups similar to ETR users. A 2024 study improved and tested the interface design of

an existing museum app for people with moderate ID. The redesign was based on the Apple Assistive Access User Guide [6], turning the navigation into buttons with icons and text [27]. Another study of 60 elderly users via an online survey [71] aimed to improve the design of Google Maps by hiding unnecessary information and providing text labels with icons. Unfortunately, it was only presented as a screenshot and was not actually operated, so it is unknown if the perceived enhanced usability actually works in practice. As cognitive accessibility might also serve non-impaired users, one study investigated mobile navigation patterns (WhatsApp, Facebook, and Instagram) with 136 students. The navigation was redesigned to include icons with labels, a floating action button, and a settings button, which improved the user experience [85]. A Swedish bachelor thesis investigated the cognitive accessibility criterion of a progress bar and found that user satisfaction and success were reduced [87]. They reported difficulties in creating test material as the criteria lacked concrete implementation suggestions.

Several studies focus on use context by people with ID. A recent Swedish study found that they use the internet unaided mainly for entertainment and communication, but needed help from carers for more complex activities such as searching, logging in, scheduling appointments, and financial transactions. They reported wanting to play a more active role in digital society, but faced obstacles [77]. While they benefit from digital reminders for medical appointments, a Swiss survey reports they tend to avoid complex online processes due to concerns about potential errors [57]. Another study examined online security for older adults, with findings indicating they ask family members to oversee their online activities, particularly financial transactions. The study proposes a system wherein carers can review transactions and preemptively halt any potential financial threats [72].

All studies agree that simplification in terms of text and cognitive load is key. Relying on recognition rather than recall helps to overcome memory issues [27], and using familiar design patterns is helpful [95]. Regarding scrolling, two studies produced different results: in the study with ETR users, all 20 participants managed to scroll [95], while another study found that scrolling was an issue for two out of ten test participants with ID [27].

## 2.5 Lack of involvement of ETR users in study designs and testing

In terms of methodology, participatory design (PD) approaches are suggested yet rarely applied: out of 101 ACM studies, only three employed such methods [5]. Another factor of ecological validity, the reading level, has only been reported by three studies [5]. Additionally, the small number of test participants often makes it difficult to understand the heterogeneous abilities of ETR users. Similar results were found in a literature review on Accessible Technology for Adults with Down Syndrome. Only three of the 20 identified studies used a PD approach. The authors emphasize the need to involve the target group to create technologies that truly meet their needs [65].

This lack of involvement of the target group is evident in several of the aforementioned studies. The CDC guidelines use proxies, meaning caregivers answered the questions rather than those with ID [101]. The ‘Easier’ tool was only tested with three elderly people

and three people with intellectual disabilities on a desktop PC [73]. The ‘EasyReading’ tool needed training to be operated, which was offered in the ‘EVE4All’ project. However, the project had difficulty reaching ETR users and instead interviewed caregivers. Only nine ETR users provided feedback in a focus group, and they experienced difficulties with the validation methods used, such as an online questionnaire. In addition, the add-on was optimized for desktop use, which probably does not reflect the reality for people with ID who are more likely to own a smartphone [51]. A literature review describes positive experiences with digital media by people with ID in terms of communication and information, along with barriers such as lack of literacy skills, support, and safety [20]. Barriers were often articulated by others, sometimes with an overprotective attitude [15]. Another study confirms that carers often see the internet as unsafe for people with ID. They focus on risks rather than benefits, lack internet safety training themselves [46], and might give biased answers.

Improving guidance for cognitively accessible design requires essential collaboration and systematic testing with the target audience. A well-established approach from practice is human-centered design (HCD), where the context of use is identified, user requirements are defined, and prototypes are iteratively created and tested until the requirements are met [33]. Research uses PD or co-design, which goes even further in involving future users in the ideation and design phases [88]. Hendriks et al. conducted a literature review and a series of workshops on how to co-design with those having cognitive or sensory impairments. They ultimately advocate to adjust co-design techniques individually to address issues such as balancing the viewpoints of stakeholders, ethical challenges, and data collection and analysis [52]. An exploratory study provides evidence that the use of digital prototypes deepens the engagement of people with ID in co-design activities [96]. Other studies for inclusive co-design focus on methods like scaffolding [99], and Heitplatz et al. developed methods of questioning as well as user typologies for the media behavior [49]. Newell et al. suggest extending human-centered design to user sensitive inclusive design. Involving users with disabilities not only creates usable products for them, but also “gives them the dignity of being treated in the same way as all other users of products” [74]. Two interdisciplinary, participatory German studies on ETR employed co-researchers, created and tested an ethical consent form in ETR and standard language, and established a study design whereby participants were rewarded with ten euros per test session. A demographic questionnaire was developed and made use of an established reading test [13, 42, 43, 78, 106].

## 2.6 Gaps in the design of interfaces specifically serving ETR users’ needs

In summary, three key issues emerge. Firstly, existing guidelines are too vague to enable the creation of cognitively accessible user interfaces to serve ETR users’ specific needs. Secondly, it is challenging to engage with the target group, and using proxies is problematic as they may not reflect the realistic context of ETR users. Thus, thirdly, user interfaces and design patterns are rarely tested with the target group of ETR users, let alone developed with their involvement. We need to identify the specific abilities and challenges of ETR users, adapt existing co-design approaches to suit their capabilities, and

use these to enhance existing design patterns more closely aligned with their needs. Our study directly addresses these issues by implementing a co-design approach with ETR users and UX designers, followed by systematic evaluation of selected design patterns. The results are integrated into recommendations for future guidelines for ETR users. Additionally, we investigate the heterogeneity of the ETR user group and their sociotechnical issues beyond interface usability in real-life interactions with interfaces.

### 3 Research method

#### 3.1 Participants

Aligned with human-centered design and participatory design best practices, the test material was designed across three workshops with four ETR co-researchers: one woman and three men, aged between 25 and 56, with an average age of 35.75 years. The tests were carried out with 47 participants in two test sessions. Four participants were excluded due to low reading level or not attending the second session. Of the remaining 43 participants, 17 were female, 24 were male, and two did not identify as either gender. Age ranged from 15 to 74 years with a mean of 30.12 years. We recruited participants through a variety of institutions to ensure a representative mix. The inclusion criteria were having a cognitive impairment, ability to read at a low level (verified in a reading test), and comfortability with using digital devices. Besides ETR users, we decided to also include a control group. This decision was not driven by the idea that the control group would constitute a “normal standard”. Rather, we strived to verify how designing for cognitive accessibility impacts other user groups. The control group consisted of university students and their professors: 4 females and 8 males, aged between 19 and 60, with a mean of 28.75 years.

#### 3.2 Ethical approval and consent

Ethical approval was granted by the Ethics Committee of the Faculty of Medicine of the University of Hasselt on 23 January 2024. We were able to build on the material of two previous German studies on ETR [78, 106]. We slightly adjusted the consent form in both ETR and standard language to meet legal requirements and make it accessible to ETR users and their legal guardians.

#### 3.3 Test material

We used a questionnaire to gather data on socio-demographics, internet and technology use, reading habits, event attendance, ticket purchases, and online ordering. For the prototype, we integrated participatory design (PD) with UX expertise to ensure strong ecological validity. This process included two PD workshops with co-researchers followed by a UX expert designing scenarios, which were then reviewed and refined in a third PD workshop. A comprehensive description of the process is provided in the Results section.

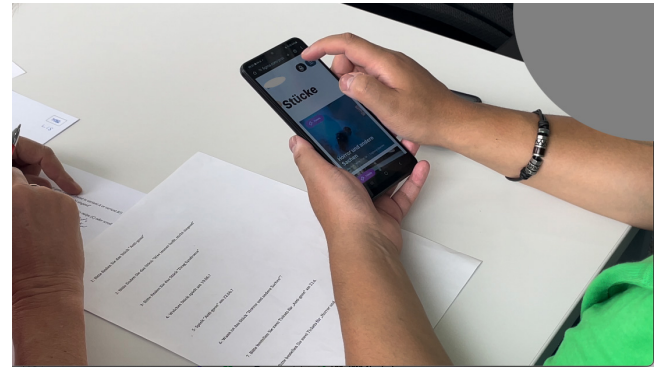
#### 3.4 Prototype, tasks, patterns tested, and rationale

We tested the prototype with 47 ETR users and 12 people from the control group. Each participant performed three experiments with three tasks each as shown in Table 1. The screen designs are shown

in figure 2. The links to the two prototypes in Figma are available at <http://bit.ly/4sSKurl> and <https://bit.ly/4qAUiVy>.

#### 3.5 Procedure

We conducted study sessions in institutions with the support of a trusted social worker. We created a relaxed atmosphere with snacks and small talk and allowed the participants to settle down before the test started. They were rewarded with 10 euros for each session, which were given at the beginning of the session. The first session took place in groups of 3–4 people. The participants gave their ethical consent and completed a reading test and questionnaire. In the second session, the most salient aspects of the questionnaire were discussed, giving participants space to express themselves. The experiments were then conducted with the tasks written on paper and read aloud. After each experiment, we asked them which variant they preferred and their impressions of the test (figure 1).



**Figure 1: A photo of the test situation: The list with written tasks is lying on the table, the test participant L22 holds the Samsung test device in his hands, and starts the test by clicking on the search icon.**

#### 3.6 Study design

Experiments 1 and 2 were 3 x 3 within-subjects designs with ETR users and a control group. The independent variable is three UI versions for selecting an event and three UIs for choosing a date. Test conditions were a Figma prototype on a Samsung Galaxy A12 mobile device. Dependent variables were task completion, mode (scroll/swipe in variant 3), and alternatives used (menu/search/google search). Control variable was a handheld device, sitting position in a room at the familiar institution. Experiment 3 was a usability test of two subsequent ordering processes.

#### 3.7 Data measurement

To determine reading level, we used the lea diagnostic tool, which has been used in previous studies. The ‘lea’ reading levels range from 1 to 6, with ‘lea’-level 6 corresponding to level 1 of the International Adult Literacy Survey [43, 44]. We did not test the control group, as all its members had achieved at least level 6 in order to gain university admission. The majority of participants had levels 3 or 4 (see table in appendix). Level 3 readers can read individual words in the context of sentences and follow simple instructions,

particularly when accompanied by images. Level 4 readers could identify individual words in a text and extract one or two pieces of information, either verbatim or indirectly, from short, simple texts with explanatory images [43].

Socio-demographic data and user preferences were collected in a questionnaire and in a semi-structured interview. The test sessions were recorded on video, audio, and with screen recordings. We used participant observation and structured interviews to document behavior in vivo and participants' reactions immediately after the interaction [36].

### 3.8 Data analysis

We use the McNemar test, the Kruskal-Wallis test, Fisher's exact test [86], and multinomial logistic regression model [2]. All statistical analysis was performed in R [34] by the fourth author. Details can be found in the appendix. The audio recordings were transcribed by the Department of Phonetics at Ludwig Maximilian University of Munich (LMU), and coded and analyzed in MAXQDA24 [41]. For the qualitative analysis, we follow Strauss and Corbin's Grounded Theory [102] as it allows the combination of qualitative and quantitative data [58] and exploits the theoretical sensibility that a design researcher brings through professional experience [102]. The double coding process was conducted by the first and second author, who repeatedly discussed and agreed on their coding. We employed a triangulation approach to integrate quantitative and qualitative data, thereby facilitating a comprehensive evaluation of task success and facilitating a profound comprehension of the underlying causes.

## 4 Results

### 4.1 RQ 1: What is the context of use to be considered when designing digital products for ETR users? How do they differ from the control group?

The results of the questionnaire allow us to highlight fundamental technical requirements: Test and control group have 100% access to the internet and own smartphones: However, Tablets and PCs serve fewer ETR users: Tablets (35% T, 58% C) and PCs (23% T, 100% C) and Samsung was more present in the test group (51% T, 8% C) than Apple (37% T, 92% C).

The reported usage of apps provides insights into user habits and familiar digital design patterns: Both groups use WhatsApp (93% T, 100% C), Photos (70% T, 92% C), Instagram (39% T, 41% C), and TikTok (25% T, 8% C). For search, both groups use Google (81% T, 100% C) and 42% of C uses speech input. The test group favors entertainment applications (games 74% T vs. 33% C), while the control group uses ChatGPT (49%) and digital newspapers (32%), which none of the test groups uses. 35% of the test group (0% C) need help reading and 47% (0% C) got help using the internet. The screen time of the control group was higher, however, 56% of the test group spent more than 4 hours a day on a digital device (83% C). Qualitative data underlines the ubiquity and personal value of smartphones, whether to access their medication (O58), to enjoy privacy, and watch even porn (A3). We saw several content producers: One test person (lea-level 2) claims to have their own app, which turns out to be their WhatsApp status, which they meticulously curate and proudly display (A3). Participants with lea-level 3–4 use Instagram

to post for their workshop group (L30), curate a page for their dog (L22), or help a friend sell fake Gucci products (M39). One person creates CapCut and TikTok videos (M37). Translation apps (M39) and bilingual keyboards (M34) allow communication with family in other countries. Some apps allow users to focus on audio and visuals, e.g. drawing and puzzle apps (A10), makeup tutorials (M32), or taking screenshots to aid in memory (A12). They orient themselves with numbers (M32, A10), visuals, or spatial arrangements (A9), e.g. Google's voice input was identified by the microphone icon (L21 and L27). One test person stated that Manga dating games (A6) help them reduce shyness and overcome social isolation.

Despite reading and vision problems, only 12% of the test group (0% C) had a screen reader installed because of fear of stigma (A9, M38). Instead, they tried persistently or asked friends and family for help. Employed strategies were adjusting built-in settings (four instances test and three control group), using voice input (nine instances test group), or holding the device close to the eyes to cater for low vision, concentration issues, and speech issues (ten instances test group). While most see digital media as beneficial, some see it as a potential threat, fearing making mistakes (O61, A9), being ripped off (A3, M39), receiving fake messages (L30, M31, M37), and addictive behavior (A9, L21), or had negative experiences being bullied or racially insulted (O58, O61). Often use is prohibited at school, at work, or by parents (eight instances), encouraging some to find workarounds like waiting until the parents are asleep.

The online shopping experiences differ widely: 92% of the control group shop online regularly, only 21% of the test group do so (often with family members). Similarly, 92% of the control group order tickets online (5% T) and 100% visit events (81% T) and find related information online (100% C, 81% T). The main reasons are guardianship and a low budget, which affect most test subjects. They prefer to shop in person (eight instances) and the few with their own bank account are cautious, preferring invoices (A5, A9) or cash withdrawals (A10, A14, O59) and only compare prices online (M39). Some have had bad experiences regarding shopping (six instances). Some are happy to have things organized for them (L27), but most agree on workarounds with their carers, such as choosing online and sending a screenshot or link to order (eight instances), sharing accounts with their family (three instances), or ordering with their carers (four instances). Others struggle with their limitations and want to buy a present for their fiancé, ignoring prohibitions: "Because I'm so old, I wanted to order something myself instead of always asking others to order for me" (O57).

### 4.2 RQ 2: How can we adapt existing co-design approaches and integrate professional UX design knowledge to suit ETR users' needs?

The lack of compliance with WCAG and UX standards, as well as design issues identified in previous studies led us to integrate a professional UX designer (third author) into the PD process. We used the first author's expertise in design and research to translate the co-researchers' abstract descriptions into tangible sketches and paper prototypes.

**4.2.1 Step 1: PD Workshops.** In the first workshop, we explored digital media use and scenarios, leading to the selection of a local theater ticket ordering process as topic. Participants shared their frustrations with buying tickets, as tickets seen online were no

**EXPERIMENT 1: Find a play**

	Question	Design and interaction patterns	Rationale
<b>Task 1</b>	Please find the play 'Anti-gone'.	Cards of the plays (in vertical orientation) Headline-Image-Combination with text below image Interaction pattern 'scroll' Not tested, but available patterns: Navigation, Search, Menu, Hero, Footer, Ticket Button	Is the concept of a list understood? Does the design of the cards work? Is scrolling successful? Is the title of the play identified and read?
<b>Task 2</b>	Please find the play 'Wer immer hofft, stirbt singend'.	As above with text on image	Is the concept of a list understood? Are full image cards more effective? Is scrolling successful? Is the title of the play identified and read?
<b>Task 3</b>	Please find the play 'Drag Syndrome'.	As above + Event-teaser as slider (horizontal orientation) Interaction patterns 'scroll' and 'swipe'	Is swipe or scroll used? Is the slider used/understood? Are larger images more effective? Is the title of the play identified and read?
<b>User survey</b>	Which variant do you like?		Are design differences noticed? Are there preferences? Which are the arguments in favor? Is text on the image legible?

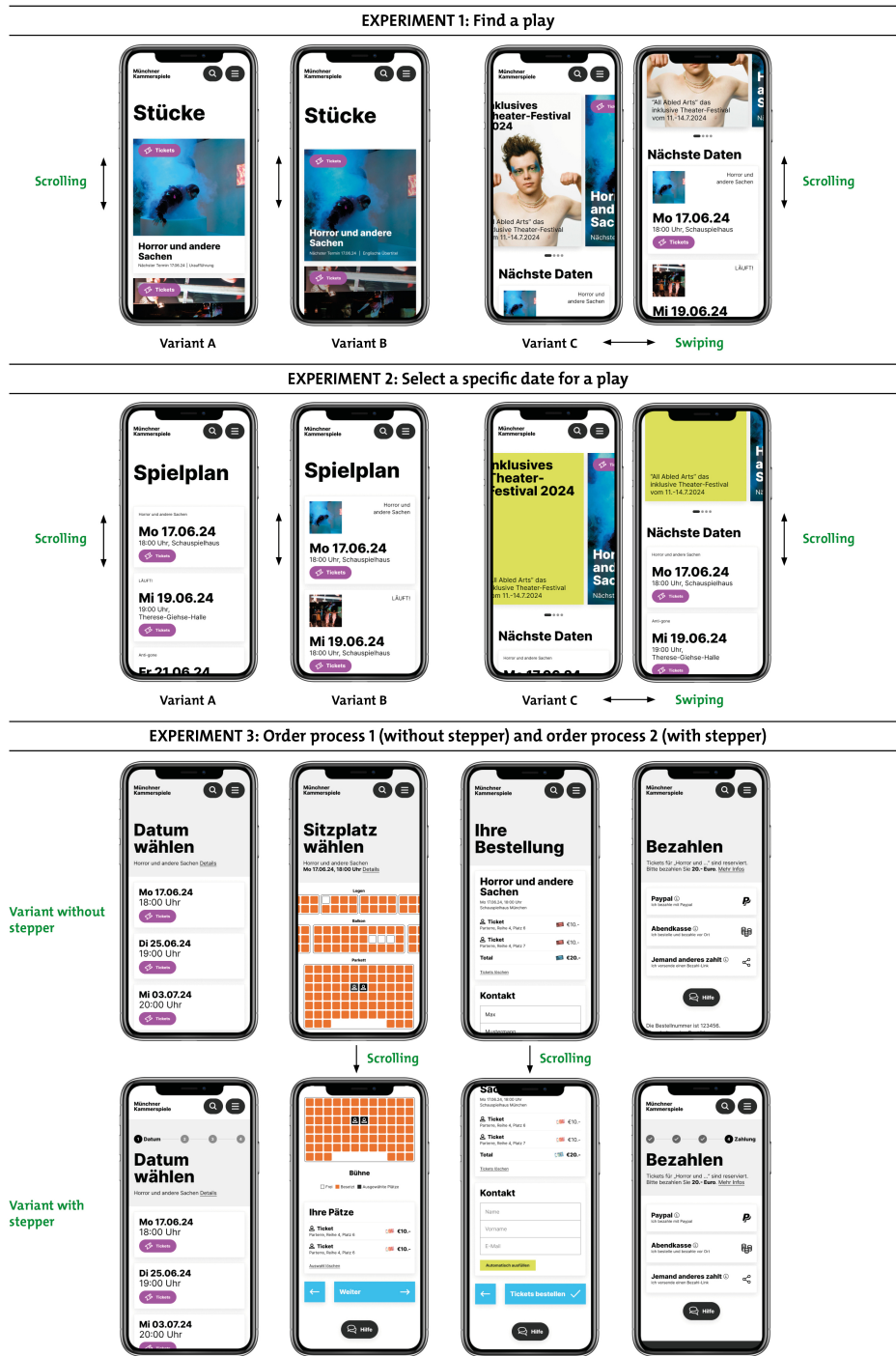
**EXPERIMENT 2: Select a specific date for a play**

<b>Task 1</b>	Which play is performed on June 19th?	Date-teasers as cards (vertical orientation) with purely typographic information Interaction pattern 'scroll'	Is the date found and correctly identified? Is the play correctly identified/read? Is scrolling successful?
<b>Task 2</b>	Is 'Anti-gone' performed on June 22nd? If not June 22nd, then which date is it performed?	Date-teasers as cards (vertical orientation) with image and text information	Is the date found and correctly identified? Does the participant realize that the play is not on this particular date? Can they find the correct play in the list? Are additional images effective?
<b>Task 3</b>	When is the play 'Horror and other things' performed?	Slider with images and text on image Date-teasers as cards (vertical orientation) with image and text information 'scroll' and 'swipe'	Is swipe or scroll used? Can they find the correct play in the slider? Are larger images more effective? Is text on the image successful?
<b>User survey</b>	Which variant do you like?		Are there preferences? Which are the arguments in favor? Is text on the image legible?

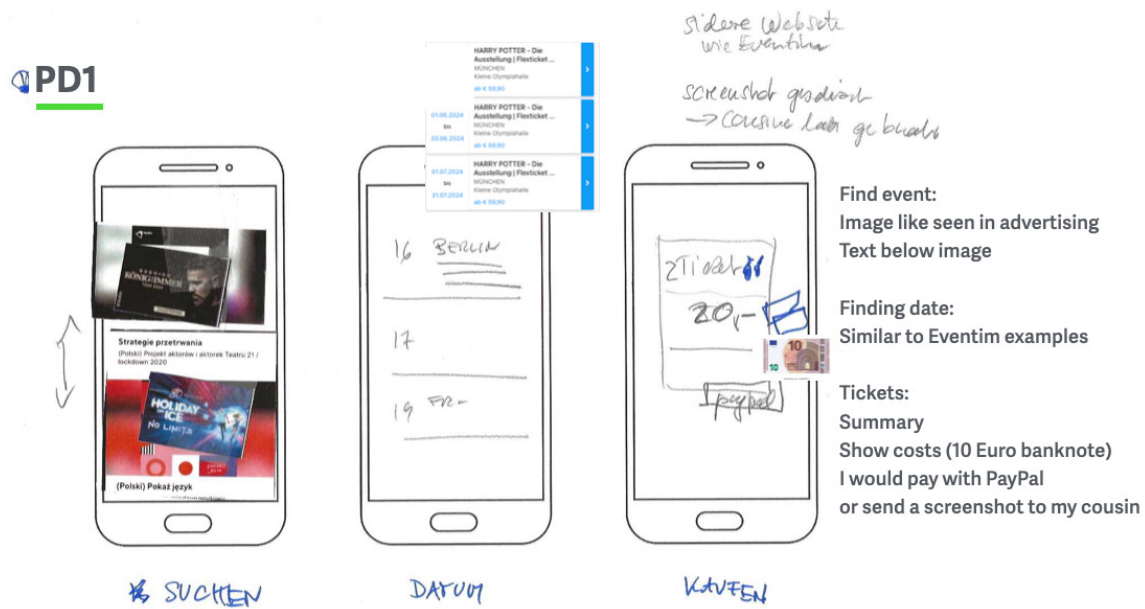
**EXPERIMENT 3: Order process 1 (without stepper) and order process 2 (with stepper)**

<b>Task 1</b>	Please order two tickets for 'Anti-gone' on June 21st.	All patterns of test scenarios 1 and 2 + Ticket Button Seat Plan with caption Order Summary Contact Form/Autofill Continue Button Help Button	Is the event and correct date found? Is the ticket button understood and operated? Is the seat plan understood and operated? Is the summary understood? Is the continue button used? Is the contact form/autofill familiar and used? Is the 'buy tickets' button used? Are the payment options understood? Are icons used to understand the buttons? Which paying method do they prefer? Is the help button used/familiar?
<b>Task 2</b>	Please order two tickets for 'Horror und andere Sachen' on June 17th.	All patterns + Stepper	Same as order task 1. Additionally: Is stepper familiar and preferred?
<b>User survey</b>	Which part was easy/difficult? Did you like the test? Would you order alone?		Can multiple steps be executed? Which design patterns are easy or complicated? What is the attitude to and issues with ordering online?

**Table 1: Tasks, questions, design patterns tested, and rationale of all three experiments. Please refer to figure 2 for the corresponding screens.**



**Figure 2: Screens for experiments 1, 2 and 3. Variant A and B use ‘scroll’, Variant C ‘scroll’ and ‘swipe’. The first order process has no stepper, the second order process incorporates a stepper. The two screens in the middle of the last row show the screens above when scrolling down. Please open test screens on your mobile phone (preferably on a Samsung Galaxy A12, the test device) and select the corresponding screen from the menu: "Stücke", "Spielplan": <http://bit.ly/4sSKurl> or <https://bit.ly/4qAUiVY>. For experiment 3, execute an order process.**



**Figure 3:** A sheet with the paper prototypes and written notes given in speech by co-designer PD1. The left screen tackles the “search for a play” (German: “Suchen”), the middle screen “date” (German: “Datum”) shows a real-life example of a list of dates demonstrated by the co-researcher on his phone. The sketch indicates that the numbers should be more prominent. The screen on the right is the payment screen (German: “Kaufen”) and sketches the requests of the co-designer: a summary with a photo of the bills and a link to PayPal.

longer available at the box office. Some joined disability groups for ticket access, while others expressed interest in self-guided online shopping, despite carers’ restrictions. In two instances family members aided the use of PayPal. The selected use case was explained to the professional UX designer who analyzed the ten most common industry ticket ordering processes and identified pain points as well as potentially accessible patterns which were printed out for the next step.

The second workshop focused on designing and creating paper prototypes (see figures 3, 4). All co-researchers contributed ideas and showed examples on their phones or chose design patterns from the print-outs. Testing the theater’s current ordering process revealed fears of making mistakes, cost concerns, and familial objections, strengthening pain points of the UX designers’ analysis. We discussed alternatives and came up with a summary, including images of banknotes and ideas for payment: box office with online reservation and on-site payment, links to forward to carers, and PayPal.

In the third workshop, we compared the professionally designed Figma prototype to see if it corresponded to the initial ideas of the participants, which was the case and a source of pride for the participants. Furthermore, the task formulation was developed.

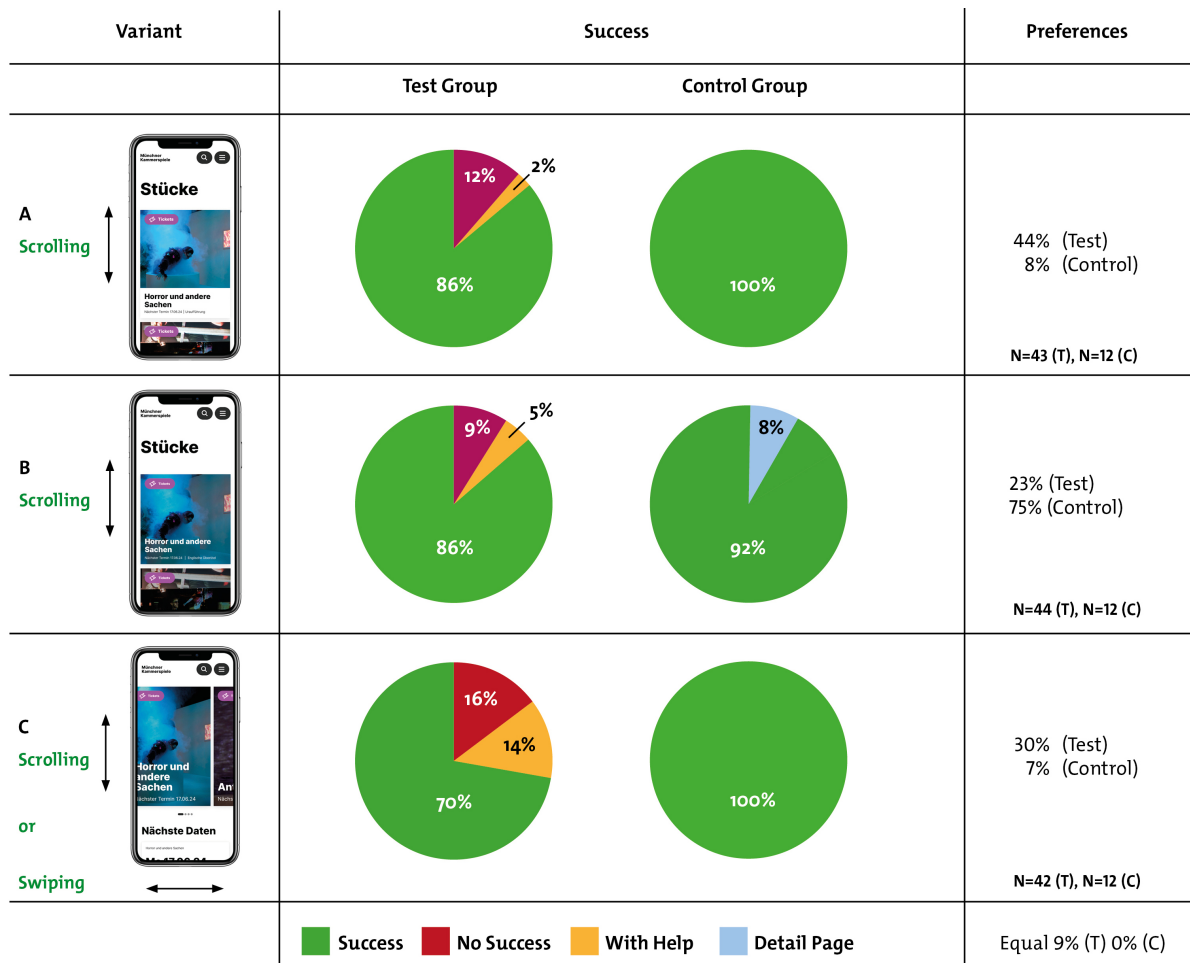
4.2.2 Step 2: Professional UX Design of the Prototype. To create sustained, real-world contexts (as demanded by [5]), we asked the theater for permission to use its text, images, and corporate identity. Using the corporate identity enables the addressees to correctly



**Figure 4:** First author and one of the co-researchers creating paper prototypes in a participatory design setting (second workshop).

classify the offer by identifying the sender, thus enhancing comprehension [93].

In an iterative process, we reduced the cognitive load of the patterns and the process itself by minimizing the number of steps required. We applied industry and accessibility standards as basic requirements, namely the WCAG and COGA techniques [67, 109].



**Figure 5: Experiment 1: Variants and success level in finding a play and the preferences for variants. Both the test and control group tested variants A, B, and C in randomized order within subgroups I, II, and III, which could later be combined. The right column shows preferences for each variant.**

The UX designer contributed their knowledge of UX heuristics, as well as the best practices of UX writing and graphic design.

For example, we created clear typographic hierarchies. We reduced the amount of text per screen (a WACG and COGA requirement) and combined concise texts with icons, allowing for two ways of access (as suggested by A11y [84] and a 2024 study [95]). Design patterns such as teaser-cards with shadows, primary buttons, and image carousels were designed according to gestalt principles [56] and UX heuristics [111] to help users intuitively understand which elements belong together or perform similar actions (see Fig. 2 and 5.3.1 for details). In order to get a largely functional prototype, we also included two menus: the navigation and the footer.

We reduced the complexity of the order process by breaking it into four steps. Each step had a brief one or two word description: ‘Datum wählen’, ‘Sitzplatz wählen’, ‘Ihre Bestellung’, ‘Bezahlen’ (German for ‘select date’, ‘choose seat’, ‘your order’, and ‘pay’) that clearly communicated the task at hand. In the order summary, we structured the information using digits for tickets and prices, and

added banknote icons for visual information. We chose an autofill option in the contact form, as we hypothesized it would be used to accommodate limited writing skills. The three payment options in the final step of the process were designed as single selection buttons with icons. We introduced a stepper in the second ordering process to investigate whether it serves as an additional visual aid. On each screen, we included a help button to provide a clear indication of the required action on the page, and/or to provide a direct line of communication to a carer.

### 4.3 RQ 3: What design patterns help ETR users select an event?

Figure 5 shows the success rates of the design patterns for selecting an event and the preferences. We carry out statistical tests, e.g. to see if randomization was successful. The Kruskal-Wallis test does not show significant differences in success rates (no, with help, yes) between the three subgroups (subgroup I (A/B/C), II

(B/C/A), and III (C/A/B)) of the test group (p-value = 0.42). The same is true for the control group (p-value = 0.13). The results of subgroups I, II, and III should now be combined. Immediately after the experiment, we asked the participants for their preferences on the variant used. Using Fisher's exact test, we found there were no differences in the proportion of the preference levels of each variant A, B, or C between three subgroups of the test group (all p-values > 0.05). The association between success while using variant A or B and preferences for the corresponding variant is not statistically significant (all p-values > 0.05). However, participants who preferred variant C are more likely to have success while using variant C than those who did not prefer it (p-value < 0.05).

Some (28% T and 58% C) started the test by clicking on the search button, and 12% T and 25% C would have completed the task using the menu. The results of the McNemar test indicate that the proportion of participants who reported using search functions in the questionnaire (irrespective of test or control group) is significantly different from the proportion of participants who clicked on the 'search button' (p-value < 0.05).

The qualitative results reveal detours and additional time requirements. The behavior toward the interaction patterns of 'scroll' and 'swipe' ranges from some hesitant progress to casual and rapid one-handed operation, and one person had motor difficulties. Some scroll all the way to the footer and back before starting to read. Others get lost in the footer and start clicking all over the place, accidentally opening subpages. For level 2 readers, a strategy is to compare the instructions with the text displayed on the screen. Even readers at levels 3 and 4 occasionally require verification (seven instances), particularly in the case of 'Anti-gone' (M38). The unfamiliarity of the Greek play is increased by the hyphen. One person in the control group mispronounces it as the English word 'gone'. We also notice an orientation on the number of cards ("I found it on the fourth!", M32) and on the images, which is reflected in the preferences. Large images are described as more exciting, stylish, and easier for orientation, thereby providing an overview (L16, L25) or a first impression of what kind of play to expect (O60). Interestingly, both participants who prefer text on images and those who prefer text below images say that their preference was easier to read. Text on images is perceived as attractive ("I just like the style when the text is on the image", M32). An individual with low vision expresses profound satisfaction with the font size stating, "A positive experience I did not expect ... really nice and big" (A9).

The control group has no problems with the tasks, hardly noticed differences in the variants, and favored text on image.

#### 4.4 RQ 4: What design patterns help ETR readers find and select a suitable date?

Table 2 shows the results of experiment 2 for all variants combined across three tasks. Again, the statistical test allows the results of the three subgroups to be combined (see full statistics in supplementary material).

We checked if the success levels in the two experiments can be explained by the reading level, age group, or device usage of the participants in the test group. We found that the odds of 'success' compared to 'no success' are significantly higher for participants

with a reading level above 2 than those with a reading level of 2 (p-values < 0.05). The effects of age groups on the success levels are not statistically significant. We did not find a significant relationship between the amount of time using a device and having 'success'. However, the odds of having 'with help' in success compared to 'no success' are significantly higher for participants who spent more than 1 hour a day than with those who spent less (all p-values < 0.05).

Variant	Success	Control	Test	Control %	Test %
A	detail page	4	1	33%	2%
A	no		16		37%
A	with help		3		7%
A	yes	8	23	67%	53%
B	detail page	3	1	25%	3%
B	no		16		40%
B	with help		5		12%
B	yes	9	18	75%	45%
C	detail page		3		7%
C	no		6		14%
C	with help			0%	0%
C	yes	12	33	100%	79%

**Table 2: Experiment 2: Success of all variants without considering scrolling/swiping.**

Experiment 2 was a more cognitively demanding process including two steps: Finding the date (date found) and finding and reading the name of the play (play found). The task asking for the play 'LÄUFT' had dissonant results (see Figure 6): We observed an unexpected strategy: users clicked on the card and navigated to the detail page. As the prototype was not fully functional, it only had two detail pages and the page 'Horror...' was opened. Thus, the participants' response 'Horror' indicated that they had not read the first screen.

The qualitative data revealed that in variant A and B participants read the location and assumed it was the play (eight instances). However, this never happened in variant C. Other participants struggled to read the location (six instances) or sometimes good readers can not identify 'LÄUFT' as a play name ("There is no play. It doesn't say anything. It just says running." O60, six more instances). Even the control group wondered if 'LÄUFT' is a play name (seven instances). They tend to rely on the detail page and express confusion ("It only says running. I am a bit confused now," L25, K50, K54). The comments suggest complex problems of comprehension, triggered by both linguistic and design issues.

#### 4.5 RQ 5: What sociotechnical issues beyond usability have to be considered when it comes to order processes?

The controlled settings of Experiments 1 and 2 lacked external validity, whereas Experiment 3 modeled a complex, multi-step process. Table 3 shows the success rates of each step.

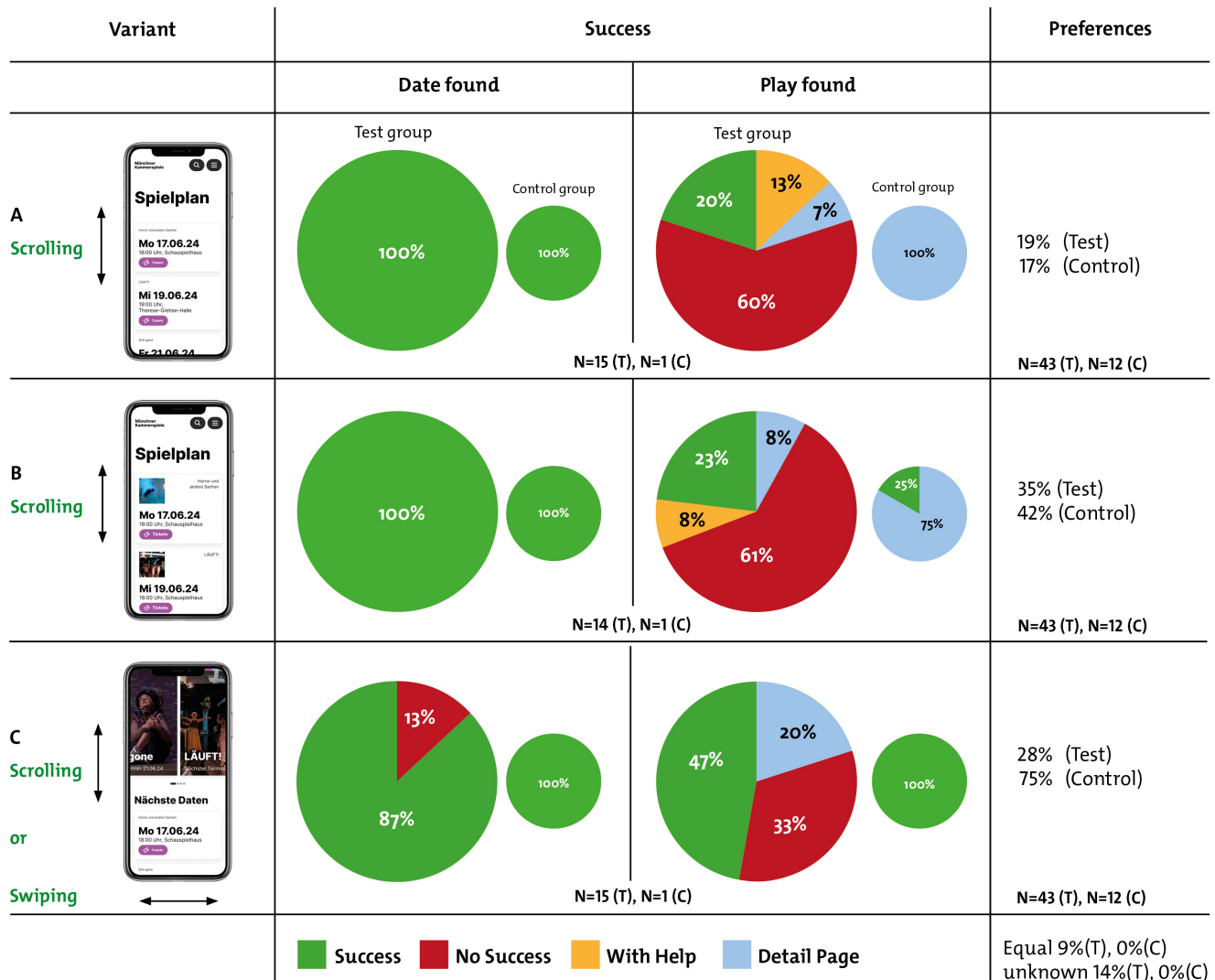


Figure 6: Experiment 2: Task 1 ‘LÄUFT’: variants, success levels in the two steps. Right column: preferences over all 3 tasks.

Although the quantitative data demonstrates some success, the qualitative evidence reveals issues such as socioeconomic constraints, lack of contact details, and payment methods—issues that go beyond the pure usability of an order or payment interface. Several participants never ordered before and adopt a hesitant approach, relying on their family (L27, L28), strictly following an order protocol (“I think I do not want to do this; I only order with my mum,” L30, L21), or applying real-life strategies: “We get tickets at the box office” (eight instances). Some cannot understand the nature of the test and are afraid to actually order a ticket (six instances). Data security is a major concern, with some being aware of the nature of sensible data (O61, M40, A9, L18, O59) and some referring to restrictions: “My mum and my friend said I should be careful” (O57). Using email as a contact method is problematic; some people have no email address, some have forgotten it, cannot spell it, or have multiple addresses (M39 had 15 email addresses in order to

get a free burger meal). Payment is difficult. Only 32% know PayPal, and some still struggle despite having learned about it with their family (A4, A6). The ‘Abendkasse’ box office is familiar, but our idea of booking online and collecting the ticket from the box office is rarely understood. The third option (“Someone else pays; I send a payment link”) provokes a range of emotions. Some are unsure whether anyone would pay for them (A6, A9, L18, L19), amused (O58), dislike the idea of someone else paying (five instances), or find it helpful (L22).

Some participants with low literacy and cognitive skills could operate certain design patterns in terms of usability, but failed to complete the entire process, often due to socio-technical issues. Their strategies were clicking on the dominant buttons (eight instances) and visual orientation: “Here’s the money: 10 euros.” (four instances); “Just tap on the pink” (M34, A7); “The arrow!” (O58);

Action	Success	ORDER PROCESS 1				ORDER PROCESS 2			
		Control	Test	Control (%)	Test (%)	Control	Test	Control (%)	Test (%)
Find play	No		5		12%		2		5%
	No data					1	1	8%	2%
	With help		2		5%				
	Yes	12	36	100%	84%	11	40	92%	93%
Select date	No		8		19%		5		12%
	No data					1	1	8%	2%
	With help		2		5%		3		7%
	Yes	12	33	100%	77%	11	34	92%	79%
Ticket button	Yes	12	43	100%	100%	12	43	100%	100%
Seat selection	No		12		28%		4		9%
	No data					1	1	8%	2%
	With help		3		7%		6		14%
	Yes	12	28	100%	65%	11	32	92%	74%
Proceed to summary	No		7		16%		3		7%
	Unknown					1	1	8%	2%
	With help		6		14%		2		5%
	Yes	12	30	100%	70%	11	37	92%	86%
Enter contact	No		19		44%		7		16%
	Unknown					1	1	8%	2%
	With help		3		7%				
	Yes	12	21	100%	49%	11	35	92%	81%
Payment chosen	Box office	1	20	8%	47%		23		53%
	Cash		4		9%		1		2%
	Link		5		12%		3		7%
	None		1		2%		2		5%
	PayPal	11	2	92%	5%	11	2	92%	5%
	No info		11		26%	1	12	8%	28%

Autofill familiar	No		16		37%
	Not sure		1		2%
	Unknown		4		9%
	Yes	12	22	100%	51%
Help button familiar	Unknown	1		8%	
	Yes	11		92%	
Help button used	No	11	31	92%	72%
	With help		1		2%
	Yes	1	11	8%	26%
Stepper familiar	No		17		40%
	Unknown		8		19%
	Yes	12	18	100%	42%

**Table 3: Experiment 3: Success rate for order process design patterns (Yes / No / With Help / No data): The lower part of the table includes "Unknown" to indicate unfamiliarity with the design patterns in question.**

and “little men on the seats” (O60). Other participants were overwhelmed and frustrated (seven instances).

A challenging step for most was the seat plan. Users try three-finger zooming and activating other available seats and get frustrated when it does not work (see limitations). The order summary

provides reassurance and most find the 10-euro notes as visual aids beneficial. The functionality of the contact form is mostly understood and the autofill option appreciated to overcome tedious typing, also new for some (“Fascinating,” “The world is getting modern,” “Can you install this on my smartphone?” L23, L19, A10).

The second-order process was extremely fast for participants with sufficiently high literacy and digital skills (five instances). However, they would never order digitally in real life (“I am not allowed to order.”). This highlights socio-technical barriers that extend beyond simple usability.

The control group goes through the ordering process extremely quickly, except for the prototype problems with the seat plan. The majority uses PayPal as a payment method, citing its practicality, convenience, and reliability. Reactions to the ‘somebody else pays’ option are mixed again, ranging from amused approval to finding it useful. They like the stepper because it gives them a sense of safety and progress and prevents mistakes (four instances). The overall impression of the test is positive: “It has less text and fewer tasks, which is good” (K48), “Caters for my laziness to read” (K49).

## 5 Discussion

This section summarizes the key findings of the study. A primary observation is that the context of use is critical; our data indicate that ETR users are proficient in navigating conventional applications. Consequently, several widely accepted guidelines—particularly those concerning swiping interactions and text-on-image overlays—were not supported by our findings. Users’ familiarity with these elements may render some existing recommendations obsolete, while others require adaptation to better meet the specific cognitive load requirements of ETR users. Based on these results, we provide evidence-based recommendations for design patterns such as buttons, cards, and lists, which may serve as a basis for future guidelines. However, further research in these areas remains necessary.

We also evaluate the efficacy of our participatory design (PD) process, advocating for its adoption as a standard framework—a significant methodological contribution. Furthermore, we examine the sociotechnical facets of ordering processes to facilitate future customization for the heterogeneous ETR user group. Finally, this research and our experiments are not intended to test or implement artificial intelligence (AI), however, knowing its burgeoning importance in everyday circumstances, we do propose direction for the integration of AI, incorporating critical perspectives on ethics and cognitively accessible design.

### 5.1 Context of use of ETR users indicates basic technical and design requirements

Our findings can be used as a valuable building block for expanding the WCAG guidelines and established HCI theories to meet the needs of underrepresented groups of ETR users and people with similar cognitive issues. Demographic data and user habits help us understand how ETR users engage with the technology and derive basic technical and design requirements [5, 81]. Their strong preference for Android/Samsung systems and smartphones is most likely due to cost accessibility. The lack of use of assistive technology apps may be related to difficulties installing apps and receiving little help. However, built-in features (e.g. screen zoom, voice input) are used. This forces the design to prioritize conventions and built-in accessibility features, especially on Android. The successful use of familiar smartphone applications suggests integrating established design patterns and optimizing existing technologies, rather than

creating entirely separate tools [77, 95]. Also, users may feel stigmatized using assistive technologies, so solutions must avoid aesthetic or cultural isolation [105].

The fact that some of the control group use built-in accessibility features and appreciated our new designs highlights usability benefits for all users, in line with COGA recommendations and universal design [48, 91, 98]. Optimized layouts minimize text usage, utilize clear visual aids, and implement well-defined typographic hierarchies to support reading order. The heterogeneity of ETR users in terms of reading and cognitive abilities calls for personalization, which will be discussed in section 5.5. Digital products should also address specific needs of ETR users, such as social communication, access to essential information, and medication management, while facilitating support from carers or family members.

### 5.2 Enhanced participatory design process involving UX experts

We build on our experience in interdisciplinary, participatory research projects and previous work on PD processes involving people with ID [51, 52, 74, 78, 81, 88, 95, 96]. This was accomplished by creating a relaxed and trusting atmosphere in a familiar environment with familiar social workers present. To circumvent the common pitfall of low-fidelity, ecologically invalid prototypes often found in academic accessibility research [27, 54, 65, 87], we instead selected an existing high-fidelity use case and integrated a UX expert with industry experience. The co-researcher’s choice of a local theater with an inclusive ensemble aligns with findings indicating that relevant content leads to better reading engagement [8]. It also supports their views about online shopping.

The UX expert used the findings from the first workshop (ETR user needs) and their expert UX analysis of ticket systems to inform the second workshop, injecting industry-standard UX patterns from which to choose the paper prototypes. The creation of the three design pattern variants in Figma was guided by intensive discussions between the UX expert and the first author, who served as a translator of ETR user needs. This process leveraged the first author’s design and research expertise and their strong acquaintance with the ETR user group.

The initial collaboration between co-researchers and the UX expert was successful. Co-researchers appreciated the professional implementation and equal treatment. The expert, in turn, gained access to detailed, firsthand user responses superior to typical industry personas [53]. While integration was time-consuming, it proved highly effective and straightforward, offering broad implications for accessible digital design for ETR users beyond the presented case.

We propose our UX-enhanced PD process as a new academic concept. This process is a methodological advance that effectively translates academically valid PD findings into industry-quality UI designs, ensuring ecological validity with low, acceptable expense.

### 5.3 Design patterns helping ETR users to select events and dates

Our test results provide clear guidelines on the ability-based design requirements for ETR users. As our test material is based on an existing theater website, we can offer specific recommendations on

optimizing this particular use case while maintaining the theater's corporate design. Rather than testing design patterns in isolation or in an overly simplified environment, we embed them in a truly functional setting with real-world requirements. By definition, design patterns are generic, reusable solutions to common problems [4, 38]. The positive response from the control group to the tested design patterns demonstrates their potential usefulness for a much larger group in terms of universal design. For example, they could benefit people with temporary limitations, such as the person who has just started wearing bifocal glasses (K57). In the following, we will highlight the meta level that will enable them to be applied to various other situations.

**5.3.1 Elements (e.g. Buttons).** We adapted the WCAG 2.2 standards regarding general accessibility (perceivable, operable, and understandable, as well as color contrast and button target size), to fulfill the specific requirements of ETR users with regard to low cognitive load and memory. To help users identify the purpose of each button and understand which elements belong together or perform similar actions [56, 111], we visually differentiated between button types using different color schemes and visual details such as border radius, icons, and size. For example, the primary ticket button was pink with rounded corners, the navigation buttons in the order process (forward/back) were rectangular and blue, and the help button was black and always placed above the footer for maximum consistency (see Figure 2). We opted for an abundant design that allows for both visual and textual approaches, and we designed buttons featuring icons and short descriptive texts. This led to 100% of both groups successfully completing the ticket button task. The success of abundant design is in line with previous studies [71, 85]. Another important point to note is that ETR users recognize reduced icons, such as the ticket icon or the arrow for 'continue'. This is important in real-life scenarios where several button types in an interface might be needed. Large buttons with detailed pictorial representations (as suggested in [27]) would require too much space and distract from the photos of the theater plays.

**5.3.2 Components (e.g. Cards and lists).** For simple tasks, such as a straightforward selection process like finding a play, the design patterns 'cards' and 'lists' in vertical and horizontal orientation is well suited: Between 70% and 86% (see success of test group for variant A, B, C in Fig. 5) are able to operate one of the variants. Text on image performs best, is often preferred, and even more successful for more complex tasks. In this case, variant C with text on image and a list enriched with images (see top row in Fig. 2) has better results. Interestingly, dates written in digits are read quickly and confidently, in contrast to reading text. This is supported by earlier research on digit legibility [9, 90]. Our results indicate that these findings with non-impaired readers also apply to ETR users. We did adhere to the WCAG 2.2 success criteria 1.4.5 (Text as text and not image), 1.4.6 (Contrast), and 1.4.8 (Large text size) [107], but contrary to recommendations [1], we did place text on images. One possible explanation for this component's success might be the growing use of apps employing this design, such as Instagram (39% T) and WhatsApp (93% T).

**5.3.3 Interaction patterns (e.g. scroll and swipe).** The design of the lists and cards incorporated both vertical scrolling and horizontal

swiping. While this is standard in UI design, it is not recommended for users with ID. As stated in Section 4.3., all users except one were able to use either interaction pattern and often changed between the two. The success of these patterns is surprising, given that WCAG 2.2 advises against bidirectional scrolling (1.4.10) [107] and previous studies found 20% of people with ID had problems scrolling [27]. However, a 2024 study found that ETR users have no issues with scrolling [95]. Again, we tend to attribute the success to the familiarity with apps using such patterns, e.g. the Photos app (used by 70% T) or WhatsApp (93% T).

## 5.4 Issues beyond usability to be considered for order processes

**5.4.1 Linguistic issues.** We have unintentionally adopted some linguistic issues with the original theater titles. Participants found the date, but could not name the play 'LÄUFT'. This German word can be translated as 'going on' or 'running' and is used colloquially as a synonym for 'doing well', so several participants (even in the control group) wondered whether a play was being performed or whether this was the name of a play. Variant A, which is purely typographical, causes the most problems. Adding a picture improves the results (variant B). Variant C, which offers a slider with full-size images and text, produced the best results. Even the least successful participant, A14, was successful with this variant only (and failed to complete any of the other tasks). Linguistic issues were also found with the play titles 'Drag Syndrome' (two instances) and 'Anti-gone' (six instances). Studies suggest that visual segmentation of compounds in the ETR language may be counterproductive [25], which is supported by our results for 'Anti-gone'.

**5.4.2 Sociotechnical issues in complex (order) processes.** Our qualitative findings regarding the ordering process provide valuable insights into the cognitive, socioeconomic and technical barriers that prevent ETR users from completing complex, multi-step forms. Following the GT methodology, we extracted codes describing user conduct, synthesized categories and identified user types to explain the observed phenomena.

- Fearful type: Restrictions by parents, bad experiences → hesitant, seeking reassurance
- Lazy type: Comfortable in current situation, relies on carers → lacks motivation and initiative
- Child type: Low cognitive abilities → overwhelmed, cannot understand requirements (e.g. order from)
- Reluctant type: Not interested in theater, fears to be obliged to visit a theater play → refuses to proceed
- Adventurous type: Wants to be independent, orders despite restrictions → clicks and proceeds without fully grasping consequences
- Independent type: Uses digital platforms like Instagram to create opportunities and to overcome obstacles → combines online and offline strategies
- Cash type: Prefers tangible banknotes, found workarounds in real life → uses box office and cash

Similar user types (anxious avoiders, help-seeking realists, confident all-rounders) were found in a recent study by Heitplatz et al. [50]. Although we provide cognitive accessibility design patterns

that enhance the usability for all users, complex tasks such as ordering and payment require considerations of ETR users' specific needs, the associated risks, and the group's heterogeneity. Two types require special attention: The cash type prefers to do business in person. These acquired skills should be supported by an in-person option for services (a real-life agent as opposed to a virtual agent). The adventurous type is successful by simply clicking without understanding the consequences. The reported real-life outcomes were involuntary purchases. For this type, applications need built-in risk management that adapts to a user's known adventurous behavior. A recent study [11] defines 'accessible security' as ensuring that digital products and services are secure and accessible to all, underlining this point.

### 5.5 Future avenues: Design principles for GenAI, LLM tools, and safe extensions

Our use case involved a website without generative AI (GenAI) tools, and our questionnaire revealed that none of our test subjects had used ChatGPT. Since 42% of test subjects used speech input in Google searches, one might assume that GenAI could help them overcome writing and reading issues, e.g. OpenAI's 'Operator' [80] and 'Agentic Commerce Protocol' [79] simplify a selecting or order process. However, they may also encourage more unintended purchases, and thus fail to consider the protection needs of people with ID or ETR users. The adventurous type identified above requires a system of risk-based personalization rather than only a simplified ordering process. Our serious concerns are supported by Weisz et al., who states the urgent need for guidance on designing effective and safe UX for GenAI applications to avoid potential harm to users [110]. They also highlight the lack of data on minority groups in the training data. Our data could contribute to help understand the needs of ETR users and inform their proposed design principle, 'Design responsibility' [110].

Another aspect is Nielsen's considerations. He identified a new UI paradigm, 'Intent-Based Outcome Specification'. This shift in control from the user to the AI models represents a fundamentally different form of interaction that needs to be understood and utilized. Nielsen highlights an urgent usability issue with current GenAI tools: He estimates that half of the population struggles to articulate effective prompts, consequently failing to achieve good results. This is potentially the case for all people with ID. He argues that "visual information is often easier to understand and faster to interact with than text". Therefore, new hybrid user interfaces need to be developed [75]. This perspective strongly supports the value of our design contributions aimed at enhancing cognitive accessibility. We suggest that these new hybrid UIs should address long-neglected, unfair (deceptive) design patterns relating to consent and in-game purchases in order to protect vulnerable groups who are active online but unable to detect pitfalls (see test participants experiences in Section 4.1.).

Our ETR user-validated design patterns could also be used to enhance existing accessibility testing tools based on large language models (LLMs). Although there is a lot of data on accessible code and language, accessible visual design is mostly overlooked. Specific accessibility tools based on LLMs, such as chatbots or agents, offer personalized support and help in the execution of complex tasks.

However, tools have only been developed for blind, elderly, and autistic people [89]. No tools for ETR users are known so far. We provide validated visual designs for buttons and cards, which are necessary accessible containers for any AI-simplified content.

As a bridging solution, personalization tailored to the above-outlined user groups and integrated into existing payment platforms could provide individualized usability and protection. These extensions could enable certain budget amounts to be spent without confirmation—for instance, for surprise gifts or to protect privacy regarding video choices—while larger amounts could be confirmed by a carer, similar to the review option of Mentis et al. [72]. This would address the ongoing trade-off between privacy and independence faced by impaired users [10]. Future work is required to investigate how AI could be leveraged to monitor such (and other) user behavior to dynamically trigger personalizations adapted to the needs of ETR users.

## 6 Limitations

We created a Figma prototype as this is the industry standard and facilitates the iterative design process, allowing us to quickly create and discuss multiple variants. Disadvantages include reduced functionality. For example, the test device's built-in accessibility features (zoom and voice input) and advanced ordering features cannot be integrated. This limits the significance of the seat plan. In addition, our prototype had limited functionality (no search, missing subpages, and no functional autofill). Experiment 2 is clearly a suboptimal card design, as discussed in detail. A study with fully functional coded test material would be desirable to verify our results and to further explore critical patterns such as the seat plan. Much larger test groups are needed to reflect the heterogeneity of the test group. Our test setup was task-driven, so more testing in similar scenarios is needed to allow generalization. Use cases in practice are complex and require careful consideration of which elements trigger which reaction.

## 7 Conclusions

We present a novel, UX-enhanced PD process that has proven highly effective in generating real-life applications for testing. This leads us to recommend its adoption for the development of cognitively accessible digital services and test materials. We rigorously tested three design variants and provided empirically validated, generalizable cognitive accessible design patterns. The detailed description of designs and potential pitfalls in Section 5.3 and 5.4 allows designers to create ability-based designs for other use cases. The appreciation of our designs by the control group shows their potential to enhance general usability and cater for mild or temporary impairments (ADHD, lack of time, low vision), which were relevant to members of the control group. In the outlook, we set forward future avenues for integrating our findings into GenAI applications and personalized payment profiles. Until these issues are resolved, theaters and other institutions should always offer the option of purchasing tickets in person—a real-life agent—to meet ETR users' needs.

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## References

- [1] Level Access. 2025. *Text over Images: The Impact on Accessibility*. WCAG blog. <https://www.wcag.com/blog/content-over-images-how-does-this-ux-trend-impact-accessibility/>
- [2] Alan Agresti. 2013. *Categorical data analysis* (3rd ed ed.). Number 792 in Wiley series in probability and statistics. Wiley, Hoboken, NJ.
- [3] Christopher Alexander. 1977. *A pattern language: towns, buildings, construction*. Number 2 in Center for environmental structure. Oxford university press, New York.
- [4] Andrei Alexandrescu. 2001. *Modern C++ design: generic programming and design patterns applied*. Addison-Wesley, Boston, MA.
- [5] Oliver Alonzo and Saad Hassan. 2025. A Review of 25 Years of Human-Computer Interaction Research on Reading Support Technologies for People with Disabilities Published in the ACM Digital Library. In *Proceedings of the 27th International ACM SIGACCESS Conference on Computers and Accessibility*. ACM, Denver Colorado USA, 1–21. <https://doi.org/10.1145/3663547.3746355>
- [6] Apple. 2023. *Assistive Access User Guide*. Apple. <https://support.apple.com/en-gb/guide/assistive-access-iphone/welcome/iosAccessed:2024-09-20>.
- [7] Barbara Arfè, Lucia Mason, and Inmaculada Fajardo. 2018. Simplifying informational text structure for struggling readers. *Reading and Writing* 31, 9 (Nov. 2018), 2191–2210. <https://doi.org/10.1007/s11145-017-9785-6>
- [8] Saminda Sundeepa Balasuriya, Laurianne Sitbon, Jinglan Zhang, and Khairi Anuar. 2021. Summary and Prejudice: Online Reading Preferences of Users with Intellectual Disability. In *Proceedings of the 2021 Conference on Human Information Interaction and Retrieval* (2021-03-14). ACM, Canberra ACT Australia, 285–289. <https://doi.org/10.1145/3406522.3446039>
- [9] Beier, Sofie; Bernard, Jean-Baptiste; Castet, Eric, Sofie Beier, Jean-Baptiste Bernard, and Eric Castet. 2018. Numeral Legibility and Visual Complexity. In *DRS Design Research Society*. Design Research Society, Limerick, Ireland, 1841–1854. <https://doi.org/10.21606/drs.2018.246>
- [10] Jeffrey P Bigham and Patrick Carrington. 2018. Learning from the Front: People with Disabilities as Early Adopters of AI. In *Proceedings of the 2018 HCIC Human-Computer Interaction Consortium*. ACM, Nevada, USA.
- [11] Arwa Binsedeeq, Steven Furnell, Kirsi Helkala, Naomi Woods, Darren Chadwick, Chris Fullwood, Xavier Carpent, and Nicolas Gervassis. 2025. Assessing the Cybersecurity Needs and Experiences of Disabled Users. In *Human Aspects of Information Security and Assurance*, Nathan Clarke and Steven Furnell (Eds.). Vol. 721. Springer Nature Switzerland, Cham, 355–369. [https://doi.org/10.1007/978-3-031-72559-3\\_24](https://doi.org/10.1007/978-3-031-72559-3_24) Series Title: IFIP Advances in Information and Communication Technology.
- [12] Bettina Bock, Ulla Fix, and Daisy Lange (Eds.). 2017. *Leichte Sprache" im Spiegel theoretischer und angewandter Forschung [Easy-to-Read in theory and practise]*. Number Band 1 in Kommunikation - Partizipation - Inklusion. Frank & Timme, Verlag für Wissenschaftliche Literatur, Berlin.
- [13] Bettina M. Bock. 2019. „Leichte Sprache“ – kein Regelwerk: sprachwissenschaftliche Ergebnisse und Praxisempfehlungen aus dem LeISA-Projekt [Easy-to-Read – No set of rules: linguistic findings and practical recommendations from the LeISA project]. Number Band 5 in Kommunikation – Partizipation – Inklusion. Frank & Timme, Verlag für wissenschaftliche Literatur, Berlin.
- [14] Bettina M. Bock. 2020. Makrotypografie als Verständlichkeitsfaktor: Empirische Studie zum Erkennen von Textsorten am Beispiel der „Leichten Sprache“ [Macrotypography as a comprehensibility factor: Empirical study on the recognition of text types using the example of “easy-to-readlanguage”]. *Zeitschrift für Angewandte Linguistik [Journal for Applied Linguistics]* 2020, 73 (Sept. 2020), 181–212. <https://doi.org/10.1515/zfal-2020-2050>
- [15] Åsa Borgström, Kristian Daneback, and Martin Molin. 2019. Young People with Intellectual Disabilities and Social Media: A Literature Review and Thematic Analysis. *Scandinavian Journal of Disability Research* 21, 1 (June 2019), 129–140. <https://doi.org/10.16993/sjdr.549>
- [16] Cain K, Oakhill JV, Elbro C. 2003. The ability to learn new word meanings from context by school-age children with and without language comprehension difficulties. *J Child Lang*. 2003 Aug;30(3):681-94. PMID: 14513473. 30, 3 (2003), 681–940.
- [17] Rocío Calvo, Faezeh Seyedarabi, and Andreas Savva. 2016. Beyond Web Content Accessibility Guidelines: Expert Accessibility Reviews. In *Proceedings of the 7th International Conference on Software Development and Technologies for Enhancing Accessibility and Fighting Info-exclusion* (Vila Real Portugal, 2016-12). ACM, 77–84. <https://doi.org/10.1145/3019943.3019955>
- [18] Murilo Crivellari Camargo, José Angelo Barela, Leticia Faria Teixeira, and Luis Carlos Paschoarelli. 2024. Facilitating Reading for People with Dyslexia: A Narrative Review of Recommendations for Text Formatting. 21, 2 (n. d.). <https://doi.org/10.51358/id.v21i2.1189>
- [19] Judy Cantor and Randall W. Engle. 1993. Working-memory capacity as long-term memory activation: An individual-differences approach. *Journal of Experimental Psychology: Learning, Memory, and Cognition* 19, 5 (1993), 1101–1114. <https://doi.org/10.1037/0278-7393.19.5.1101>
- [20] Sue Caton and Melanie Chapman. 2016. The use of social media and people with intellectual disability: A systematic review and thematic analysis. *Journal of Intellectual and Developmental Disability* 41, 2 (April 2016), 125–139. <https://doi.org/10.3109/13668250.2016.1153052>
- [21] Darren Chadwick, Kristin Alfredsson Ågren, Sue Caton, Esther Chiner, Joanne Danker, Marcos Gómez-Puerta, Vanessa Heitplatz, Stefan Johansson, Claude L. Normand, Esther Murphy, Piotr Plichtha, Iva Strnadová, and Eva Flygare Wallén. 2022. Digital inclusion and participation of people with intellectual disabilities during COVID19: A rapid review and international bricolage. *Journal of Policy and Practice in Intellectual Disabilities* 19, 3 (Sept. 2022), 242–256. <https://doi.org/10.1111/jppi.12410>
- [22] Deborah Chinn and Susann Buell. 2021. Easy Language in the UK. In *Handbook of Easy Languages in Europe*, Ulla Vanhatalo (Ed.). Frank & Timme, 623–657.
- [23] Ursula Christmann. 2017. Wie leicht darf Leichte Sprache sein? Empirische Lücken in einem gut gemeinten Konzept [How simple can easy-to-read be? Empirical gaps in a well-intentioned concept.]. In *Leichte Sprache" im Spiegel theoretischer und angewandter Forschung [Easy-to-Read in theory and practise]*. Frank & Timme, Verlag für Wissenschaftliche Literatur, Berlin. [www.psychauthors.de/psychauthors/index.php?wahl=forschung&uwahl=psychauthors&uwahl=p00420UC](http://www.psychauthors.de/psychauthors/index.php?wahl=forschung&uwahl=psychauthors&uwahl=p00420UC)
- [24] Technical committee User interfaces. 2023. *ISO/IEC 23859:2023: Information technology – User interfaces – Requirements and recommendations on making written text easy to read and understand*. International Organization for Standardization (ISO).
- [25] Silvana Deilen, Silvia Hansen-Schirra, Sergio Hernández Garrido, Christiane Maaß, and Anke Tardel (Eds.). 2023. *Emerging fields in easy language and accessible communication research*. Number vol. 14 in Easy – Plain – Accessible. Frank & Timme, Berlin.
- [26] Shir Ekerling and others. 2023. *accessiBe*. <https://accessibe.com/>
- [27] Andrea Esposito, Shana Dedò, Leandro Soares Guedes, and Monica Landoni. 2024. Advancing Accessible Interfaces: Evaluation of Design Patterns and Recommendations for Users with Intellectual Disabilities. In *Proceedings of the 11th International Conference on Software Development and Technologies for Enhancing Accessibility and Fighting Info-exclusion*. ACM, Abu Dhabi United Arab Emirates, 408–417. <https://doi.org/10.1145/3696593.3696613>
- [28] Inclusion Europe. 2014. European standards for making information easy to read and understand. <https://easy-to-read.eu/european-standards/>
- [29] European Commision. 2022. Easy Reading: A Framework for Personalised Cognitive Accessibility when using Original Digital Content. <https://cordis.europa.eu/project/id/780529> doi 10.3030/780529.
- [30] European Commission. 2019. European accessibility act (EEA). <http://data.europa.eu/eli/dir/2019/882/oj>
- [31] Therese Fessenden. 2021. Design Systems 101. <https://www.nngroup.com/articles/design-systems-101/>

- [32] DIN Institute (German Institute for Standardization). 2025. DIN SPEC 33429:2025-03, Empfehlungen Für Deutsche Leichte Sprache (Guidance for German Easy Language). <https://doi.org/10.31030/3594547>
- [33] International Organization for Standardization. 2019. Human-centred design for interactive systems ISO 9241-210:2019. <https://www.iso.org/standard/77520.html>
- [34] R Foundation for Statistical Computing. 2019. R Core Team. R: A language and environment for statistical computing.
- [35] Léon Franzen, Zoey Stark, and Aaron P. Johnson. 2021. Individuals with Dyslexia Use a Different Visual Sampling Strategy to Read Text. 11, 1 (n.d.), 6449. <https://doi.org/10.1038/s41598-021-84945-9>
- [36] Barbara Friebertshäuser, Antje Langer, and Annedore Prengel (Eds.). 2010. *Handbuch qualitative Forschungsmethoden in der Erziehungswissenschaft [Handbook of Qualitative Research Methods in Education Science]*. Juventa Verlag, Weinheim.
- [37] Brad Frost. 2016. *Atomic Design*. Brad Frost.
- [38] Erich Gamma (Ed.). 1995. *Design patterns: elements of reusable object-oriented software*. Addison-Wesley, Reading, Mass.
- [39] Morton Ann Gernsbacher and Rachel R.W. Robertson. 1995. Reading Skill and Suppression Revisited. *Psychological Science* 6, 3 (May 1995), 165–169. <https://doi.org/10.1111/j.1467-9280.1995.tb00326.x>
- [40] Ryan Colin Gibson, Mark D. Dunlop, Matt-Mouley Bouamrane, and Revathy Nayar. 2020. Designing Clinical AAC Tablet Applications with Adults who have Mild Intellectual Disabilities. In *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems*. ACM, Honolulu HI USA, 1–13. <https://doi.org/10.1145/3313831.3376159>
- [41] Consult. Sozialforschung GmbH. 1989. MAXQDA, Software for qualitative data analysis. <https://www.maxqda.com/>
- [42] Anne Goldbach and Daniel Bergelt. 2019. *Leichte Sprache am Arbeitsplatz: sozialwissenschaftliche Ergebnisse und Praxisempfehlungen aus dem LeISA-Projekt [Easy language in the workplace: social science findings and practical recommendations from the LeISA project]*. Number Band 6 in Kommunikation - Partizipation - Inklusion. Frank & Timme, Verlag für wissenschaftliche Literatur, Berlin.
- [43] Anke Grotlüschen (Ed.). 2010. *lea - Literalitätsentwicklung von Arbeitskräften: Diagnose = lea-Diagnose [Literacy development of workers: diagnosis = lea-diagnosis]*. Waxmann, Münster, Westf. <https://fiona.uni-hamburg.de/8fdb2b39/lea-diagnose-web.pdf>
- [44] Grotlüschen, A., et al. 2016. *Adults with Low Proficiency in Literacy or Numeracy*. OECD Education Working Papers 131. OECD. <https://doi.org/10.1787/5jm0v44bnmnn-xn>
- [45] Leonor Guimarães, Nuno Martins, Leonardo Pereira, Eliana Penedos-Santiago, and Daniel Brandão. 2022. Interface design guidelines for low literature users: a literature review. In *Proceedings of the 2022 6th International Conference on Education and E-Learning*. ACM, Yamanashi Japan, 29–35. <https://doi.org/10.1145/3578837.3578842>
- [46] Marcos Gómez-Puerta and Esther Chiner. 2022. Internet use and online behaviour of adults with intellectual disability: support workers' perceptions, training and online risk mediation. *Disability & Society* 37, 7 (Aug. 2022), 1107–1128. <https://doi.org/10.1080/09687599.2021.1874300>
- [47] Margareta Hardiyanti, Taufik Kemal Thaha, Nanang Arifudin, and Muhardi Saputra. 2023. Evaluation and Design Recommendation of Interactive Mobile Learning Application for Individuals with Intellectual Disabilities. 4, 2 (n.d.), 8–14. <https://doi.org/10.22146/jise.v4i2.10112>
- [48] B. Harrysson, A. Svensk, and G. I. Johansson. 2004. How people with developmental disabilities navigate the Internet. *British Journal of Special Education* 31, 3 (Sept. 2004), 138–142. <https://doi.org/10.1111/j.0952-3383.2004.00344.x>
- [49] Vanessa N. Heitplatz, Christian Bühler, and Matthias R. Hastall. 2020. I Can't Do It, They Say! – Perceived Stigmatization Experiences of People with Intellectual Disabilities When Using and Accessing the Internet. In *Universal Access in Human-Computer Interaction. Applications and Practice*, Margherita Antona and Constantine Stephanidis (Eds.). Vol. 12189. Springer International Publishing, Cham, 390–408. [https://doi.org/10.1007/978-3-030-49108-6\\_28](https://doi.org/10.1007/978-3-030-49108-6_28) Series Title: Lecture Notes in Computer Science.
- [50] Vanessa N. Heitplatz, Christian Bühler, and Matthias R Hastall. 2022. Usage of digital media by people with intellectual disabilities: Contrasting individuals' and formal caregivers' perspectives. *Journal of Intellectual Disabilities* 26, 2 (June 2022), 420–441. <https://doi.org/10.1177/1744629520971375>
- [51] Vanessa N. Heitplatz, Leevke Wilkens, Nele Maskut, Miriam Bursy, and Susanne Dirks. 2024. Overcoming Challenges in Questioning People with Intellectual Disabilities Regarding Their Digital Media Usage: Lessons Learned from the EVE4all Project. In *Universal Access in Human-Computer Interaction*, Margherita Antona and Constantine Stephanidis (Eds.). Vol. 14697. Springer Nature Switzerland, Cham, 171–185. [https://doi.org/10.1007/978-3-031-60881-0\\_11](https://doi.org/10.1007/978-3-031-60881-0_11) Series Title: Lecture Notes in Computer Science.
- [52] Niels Hendriks, Karin Slegers, and Pieter Duysburgh. 2015. Codesign with People Living with Cognitive or Sensory Impairments: A Case for Method Stories and Uniqueness. 11, 1 (n.d.), 70–82. <https://doi.org/10.1080/15710882.2015.1020316>
- [53] Anika Henke. 2019. *Using Persona Profiles to Test Accessibility*. Accessibility in government. <https://accessibility.blog.gov.uk/2019/02/11/using-persona-profiles-to-test-accessibility/>
- [54] Peter Heumader, Klaus Miesenberger, and Tomas Murillo-Morales. 2020. Adaptive User Interfaces for People with Cognitive Disabilities within the Easy Reading Framework. In *Computers Helping People with Special Needs*, Klaus Miesenberger, Roberto Manduchi, Mario Covarrubias Rodriguez, and Petr Peňáz (Eds.). Vol. 12377. Springer International Publishing, 53–60. [https://doi.org/10.1007/978-3-030-58805-2\\_7](https://doi.org/10.1007/978-3-030-58805-2_7) Series Title: Lecture Notes in Computer Science.
- [55] Peter Heumader, Klaus Miesenberger, and Tomas Murillo-Morales. 2020. Adaptive User Interfaces for People with Cognitive Disabilities within the Easy Reading Framework. In *Computers Helping People with Special Needs*, Klaus Miesenberger, Roberto Manduchi, Mario Covarrubias Rodriguez, and Petr Peňáz (Eds.). Vol. 12377. Springer International Publishing, Cham, 53–60. [https://doi.org/10.1007/978-3-030-58805-2\\_7](https://doi.org/10.1007/978-3-030-58805-2_7)
- [56] David Hillmer. 2023. *The 6 Gestalt Principles – Cognitive Psychology in UI/UX Design*. Die 6 Gestaltprinzipien – Kognitionspsychologie im UI/UX Design (The 6 Gestalt Principles – Cognitive Psychology in UI/UX Design). <https://davidhillmer.com/archive/3483>
- [57] Yves Hoffmann and Boryana Milova. 2024. EnableMe Insights: Barrieren und Alltagschürden von Menschen mit Behinderungen im Digitalen Raum [Barriers and everyday obstacles for people with disabilities in the digital space]. [https://www.edi.admin.ch/edi/de/home/fachstellen/ebgb/digitale\\_inklusion\\_und\\_dienstleistungen/fachtagungendesebgb/tagung\\_e-access\\_24/programm.html](https://www.edi.admin.ch/edi/de/home/fachstellen/ebgb/digitale_inklusion_und_dienstleistungen/fachtagungendesebgb/tagung_e-access_24/programm.html)
- [58] Hülst, Dirk. 2010. Grounded Theory. In *Handbuch qualitative Forschungsmethoden in der Erziehungswissenschaft [Handbook of Qualitative Research Methods in Education Science]*, Barbara Friebertshäuser, Antje Langer, and Annedore Prengel (Eds.). Juventa Verlag, Weinheim.
- [59] Jakob Nielsen. 1996. Accessible Design for Users With Disabilities. <https://www.nngroup.com/articles/accessible-design-for-users-with-disabilities/>
- [60] Jakob Nielsen. 1994. 10 Usability Heuristics for User Interface Design. <https://www.nngroup.com/articles/ten-usability-heuristics/>
- [61] Marcel A. Just and Patricia A. Carpenter. 1992. A capacity theory of comprehension: Individual differences in working memory. *Psychological Review* 99, 1 (1992), 122–149. <https://doi.org/10.1037/0033-295X.99.1.122>
- [62] Kholmatova, Alla. 2017. *Design Systems*. Smashing Magazine, Freiburg.
- [63] Samuel A. Kirk. 2014. Republication of "Learning Disabilities: A Historical Note". 50, 2 (2014), 125–128. <https://doi.org/10.1177/1053451214531393>
- [64] Terhi Kärpänen. 2024. Co-creating Value with Cognitive Accessibility Features in Digital Services: Enablers and Barriers. In *Universal Access in Human-Computer Interaction*, Margherita Antona and Constantine Stephanidis (Eds.). Vol. 14697. Springer Nature Switzerland, Cham, 32–50. [https://doi.org/10.1007/978-3-031-60881-0\\_3](https://doi.org/10.1007/978-3-031-60881-0_3) Series Title: Lecture Notes in Computer Science.
- [65] Hailey L. Johnson and Bilge Mutlu. 2025. Accessible Technology for Adults with Down Syndrome: A Scoping Review. *ACM Transactions on Accessible Computing* 18, 3 (Sept. 2025), 1–57. <https://doi.org/10.1145/3748333>
- [66] Camilla Lindholm and Ulla Vanhatalo. 2021. *Handbook of Easy Languages in Europe*. Frank & Timme.
- [67] Lisa Seeman, Michael Cooper, and W3C. 2025. Cognitive Accessibility Roadmap and Gap Analysis. <https://w3c.github.io/coga/gap-analysis/>
- [68] Lisa Seeman, Michael Cooper, and W3C. 2025. Techniques for the The Cognitive and Learning Disabilities Accessibility Task Force (COGA). <https://w3c.github.io/coga/techniques/>
- [69] Kelly Mack, Emma McDonnell, Dhruv Jain, Lucy Lu Wang, Jon E. Froehlich, and Leah Findlater. 2021. What Do We Mean by "Accessibility Research"? A Literature Survey of Accessibility Papers in CHI and ASSETS from 1994 to 2019. In *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems*. ACM, Yokohama Japan, 1–18. <https://doi.org/10.1145/3411764.3445412>
- [70] Jennifer Mankoff, Gillian R. Hayes, and Devva Kasnitz. 2010. Disability studies as a source of critical inquiry for the field of assistive technology. In *Proceedings of the 12th international ACM SIGACCESS conference on Computers and accessibility*. ACM, Orlando Florida USA, 3–10. <https://doi.org/10.1145/1878803.1878807>
- [71] Xelia Mattick, Aysegül Dogangün, Judah Boadu, Nadine Jansen, and Christian Meske. 2024. Design for Older People: Improving the Usability of Mobile Apps through Targeted Design Recommendations. In *Proceedings of the 36th Australasian Conference on Human-Computer Interaction*. ACM, Meianjin | Brisbane Australia, 147–158. <https://doi.org/10.1145/3726986.3727000>
- [72] Helena M. Mentis, Galina Madjaroff, and Aaron K. Massey. 2019. Upside and Downside Risk in Online Security for Older Adults with Mild Cognitive Impairment. In *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems*. ACM, Glasgow Scotland Uk, 1–13. <https://doi.org/10.1145/3290605.3300573>
- [73] Lourdes Moreno, Helen Petrie, Paloma Martínez, and Rodrigo Alarcon. 2024. Designing user interfaces for content simplification aimed at people with cognitive impairments. *Universal Access in the Information Society* 23, 1 (March 2024), 99–117. <https://doi.org/10.1007/s10209-023-00986-z>
- [74] Alan F. Newell and Peter Gregor. 2000. "User sensitive inclusive design"—in search of a new paradigm. In *Proceedings of the 2000 conference on Universal Usability - CUU '00*. ACM Press, Arlington, Virginia, United States, 39–44. <https://doi.org/10.1145/3411764.3445412>

- //doi.org/10.1145/355460.355470
- [75] Jakob Nielsen. 2023. *AI: First New UI Paradigm in 60 Years*. Nielsen Norman Group. <https://www.nngroup.com/articles/ai-paradigm/>
- [76] Aleena Gertrudes Niklaus, Tianyuan Cai, Zoya Bylinskii, and Shaun Wallace. 2023. Digital Reading Rulers: Evaluating Inclusively Designed Rulers for Readers With Dyslexia and Without. In *Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems* (New York, NY, USA, 2023-04-19) (CHI '23). Association for Computing Machinery, 1–17. <https://doi.org/10.1145/3544548.3581367>
- [77] Claude L. Normand, Catharina Gustavsson, Kristin Alfredsson Ågren, Vanessa N. Heitplatz, Darren D. Chadwick, and Stefan Johansson. 2024. "Mum Helps Me When the Internet Messes Up...": Accessibility of eHealth Services for People with Intellectual Disability. In *Universal Access in Human-Computer Interaction*, Margherita Antona and Constantine Stephanidis (Eds.). Vol. 14697. Springer Nature Switzerland, Cham, 213–230. [https://doi.org/10.1007/978-3-031-60881-0\\_14](https://doi.org/10.1007/978-3-031-60881-0_14) Series Title: Lecture Notes in Computer Science.
- [78] University of Leipzig. 2014-2018. *Leisa-Projekt*. University of Cologne, University of Leipzig. Retrieved Nov 17th, 2025 from <https://research.uni-leipzig.de/leisa/>
- [79] OpenAI. 2025. *Buy It in ChatGPT: Instant Checkout and the Agentic Commerce Protocol*. <https://openai.com/index/buy-it-in-chatgpt/>
- [80] OpenAI. 2025. *Introducing Operator*. OpenAI. <https://openai.com/index/introducing-operator/>
- [81] Pilar Orero, Clara Delgado, and Anna Matamala. 2020. Easy to Read Standardisation: Some Steps towards an International Standard. In *Proceedings of the 9th International Conference on Software Development and Technologies for Enhancing Accessibility and Fighting Info-exclusion* (Online Portugal, 2020-12-02). ACM, 44–46. <https://doi.org/10.1145/3439231.3440605>
- [82] Organisation for Economic Co-operation and Development (OECD). 2024. *Do Adults Have the Skills They Need to Thrive in a Changing World?: Survey of Adult Skills 2023*. OECD, Paris France. <https://doi.org/10.1787/b263dc5d-en>
- [83] People First (Self Advocacy). [n. d.]. *Our history*. <https://www.peoplefirstltd.com/pages/our-history>
- [84] TheA11Y Project. 2013-2024. The A11Y Project is a community-driven effort to make digital accessibility easier. Retrieved November 19, 2025 from <https://www.a11yproject.com/>
- [85] Muhammad Moiz Riaz, C.M. Nadeem Faisal, Toqeer Mahmood, Daniel Fernandez-Lanvin, Martin Gonzalez-Rodriguez, and Javier De Andrés. 2023. *Navigation Patterns and Design Strategies to Minimize Mobile Usability Issues*. <https://doi.org/10.21203/rs.3.rs-3399474/v1>
- [86] John A. Rice. 2007. *Mathematical statistics and data analysis* (3rd ed ed.). Thomson/Brooks/Cole, Belmont, CA.
- [87] Sara Rosén. 2023. *Cognitive Accessibility and Ecommerce Evaluation of a Cognitive Criterion*. Bachelor Thesis. Linköping University.
- [88] Elizabeth B.-N. Sanders and Pieter Jan Stappers. 2008. Co-creation and the new landscapes of design. *CoDesign* 4, 1 (March 2008), 5–18. <https://doi.org/10.1080/15710880701875068>
- [89] Simone de Oliveira Santos, Robson de Moraes Alves, Francisco Carlos de Mattos Brito Oliveira, and Francisco Ivanilso Soares Araujo. 2025. Investigating LLM-based Tools to Support Usability, Accessibility, User Experience in HCI Activities: A Systematic Literature Mapping. In *Brazilian Symposium on Multimedia and the Web (WebMedia) (2025-11-10)*. SBC, 631–645. <https://doi.org/10.5753/webmedia.2025.16160>
- [90] Teresa M. Schubert. 2017. Why are digits easier to identify than letters? *Neuropsychologia* 95 (Jan. 2017), 136–155. <https://doi.org/10.1016/j.neuropsychologia.2016.12.016>
- [91] Lisa Seeman and Clayton Lewis. 2019. Cognitive and Learning Disabilities. In *Web Accessibility*, Yeliz Yesilada and Simon Harper (Eds.). Springer London, London, 49–58. [https://doi.org/10.1007/978-1-4471-7440-0\\_4](https://doi.org/10.1007/978-1-4471-7440-0_4) Series Title: Human–Computer Interaction Series.
- [92] Ather Sharif, Ployplin Pruekcharoen, Thrisha Ramesh, Ruoxi Shang, Spencer Williams, and Gary Hsieh. 2022. "What's going on in Accessibility Research?" Frequencies and Trends of Disability Categories and Research Domains in Publications at ASSETS. In *Proceedings of the 24th International ACM SIGACCESS Conference on Computers and Accessibility*. ACM, Athens Greece, 1–5. <https://doi.org/10.1145/3517428.3550359>
- [93] Sabina Sieghart. 2020. The Influence of Macrotypography on the Comprehensibility of Texts in Easy-to-Read Language. *Visible language* 54, 3 (2020), 48–95.
- [94] Sabina Sieghart. 2023. The Influence of Fonts on the Reading Performance in Easy-to-Read Texts: A Legibility Study with 145 Participants. *Design Issues* 39, 3 (July 2023), 30–44. [https://doi.org/10.1162/desi\\_a\\_00724](https://doi.org/10.1162/desi_a_00724)
- [95] Sabina Sieghart, Björn Rohles, and Ann Bessemans. 2024. Empowering Independence Through Design: Investigating Standard Digital Design Patterns For Easy-to-Read Users. In *Proceedings of the CHI Conference on Human Factors in Computing Systems*. ACM, Honolulu HI USA, 1–18. <https://doi.org/10.1145/3613904.3641911>
- [96] Laurianne Sitbon and Shanjana Farhin. 2017. Co-designing interactive applications with adults with intellectual disability: a case study. In *Proceedings of the 29th Australian Conference on Computer-Human Interaction*. ACM, Brisbane Queensland Australia, 487–491. <https://doi.org/10.1145/3152771.3156163>
- [97] David Sloan and Sarah Horton. 2019. Usability, Universal Usability, and Design Patterns. In *Web Accessibility*, Yeliz Yesilada and Simon Harper (Eds.). Springer London, London, 445–460. [https://doi.org/10.1007/978-1-4471-7440-0\\_24](https://doi.org/10.1007/978-1-4471-7440-0_24) Series Title: Human–Computer Interaction Series.
- [98] Jeon Small, Pamela Schallau, Karen Brown, and Richard Appleyard. 2005. Web accessibility for people with cognitive disabilities. In *CHI '05 Extended Abstracts on Human Factors in Computing Systems*. ACM, Portland OR USA, 1793–1796. <https://doi.org/10.1145/1056808.1057024>
- [99] Leandro Soares Guedes, Ryan Colin Gibson, Kirsten Ellis, Laurianne Sitbon, and Monica Landoni. 2022. Designing with and for People with Intellectual Disabilities. In *Proceedings of the 24th International ACM SIGACCESS Conference on Computers and Accessibility*. ACM, Athens Greece, 1–6. <https://doi.org/10.1145/3517428.3550406>
- [100] Katta Spiel, Kathrin Gerling, Cynthia L. Bennett, Emeline Brulé, Rua M. Williams, Jennifer Rode, and Jennifer Mankoff. 2020. Nothing About Us Without Us: Investigating the Role of Critical Disability Studies in HCI. In *Extended Abstracts of the 2020 CHI Conference on Human Factors in Computing Systems*. ACM, Honolulu HI USA, 1–8. <https://doi.org/10.1145/3334480.3375150>
- [101] Linda Squiers, Molly M. Lynch, Sidney L. Holt, Aileen Rivell, Kathleen Walker, Stacy Robison, Elizabeth W. Mitchell, and Alina L. Flores. 2023. Building Evidence for Principles to Guide the Development of Products for Adults with Intellectual and Developmental Disabilities and Extreme Low Literacy—A Product Development Tool. *Healthcare* 11, 12 (June 2023), 1742. <https://doi.org/10.3390/healthcare11121742> Publisher: MDPI AG.
- [102] A.L. Strauss and J.M. Corbin. 1996. *Grounded theory: Grundlagen qualitativer Sozialforschung [Fundamentals of qualitative social research]*. Beltz, Psychologie-Verlag-Union, Weinheim. <https://books.google.de/books?id=wr3QPQAACAAJ>
- [103] Andreas Säuberli, Silvia Hansen-Schirra, Franz Holzknecht, Silke Gutermuth, Silvana Deilen, Laura Schiffl, and Sarah Ebling. 2023. Enabling text comprehensibility assessment for people with intellectual disabilities using a mobile application. *Frontiers in Communication* 8 (Aug. 2023), 1175625. <https://doi.org/10.3389/fcomm.2023.1175625>
- [104] Darren Taljaard and Myra Thiessen. 2023. Show Me What You Mean: Inclusive Augmented Typography for Students with Dyslexia. 57 ([n. d.]), 53–74. <https://doi.org/10.34314/91m10w95>
- [105] Panayioti Tsatsou. 2020. Digital inclusion of people with disabilities: a qualitative study of intra-disability diversity in the digital realm. *Behaviour & Information Technology* 39, 9 (Sept. 2020), 995–1010. <https://doi.org/10.1080/0144929X.2019.1636136>
- [106] University of Cologne. 2022. *LeisAparti Project*. University of Cologne. Retrieved November, 29th, 2025 from <https://leisa-leichtesprache.uni-koeln.de/index.html>
- [107] W3C. 2024. *Web Content Accessibility Guidelines (WCAG) 2.2*. <https://www.w3.org/TR/WCAG22/>
- [108] Waller R and Delin J. 2010. Towards a pattern language approach to document description. Paper presented at Multidisciplinary Approaches to Discourse, Moissac, France. University of Reading. *Simplification Centre* 4, Technical paper (2010), 1–13.
- [109] WCAG. 2025. How WCAG benefits everyone: A focus on neurodiversity and accessibility. <https://www.wcag.com/blog/digital-accessibility-and-neurodiversity/>
- [110] Justin D. Weisz, Jessica He, Michael Muller, Gabriela Hofer, Rachel Miles, and Werner Geyer. 2024. Design Principles for Generative AI Applications. In *Proceedings of the 2024 CHI Conference on Human Factors in Computing Systems* (New York, NY, USA, 2024-05-11) (CHI '24). Association for Computing Machinery, 1–22. <https://doi.org/10.1145/3613904.3642466>
- [111] J. Yablonski. 2020. *Laws of UX: Using Psychology to Design Better Products & Services*. O'Reilly Media, Incorporated, Sebastopol. <https://books.google.be/books?id=fve3yQEACAAJ>
- [112] Sihang Zhao, Shoucong Carol Xiong, Bo Pang, Xiaoying Tang, and Pinjia He. 2025. Let AI Read First: Enhancing Reading Abilities for Individuals with Dyslexia through Artificial Intelligence. In *Proceedings of the Extended Abstracts of the CHI Conference on Human Factors in Computing Systems*. ACM, Yokohama Japan, 1–16. <https://doi.org/10.1145/3706599.3720113>

## A Appendix

### A.1 Full data of test persons

See detailed descriptions of the test participants in table 4 and table 6 on the next three pages. The full questionnaire is available as supplementary material.

Code	Age	Gender	Reading				Internet				
			Lea Reading level	Help Reading	Time Reading	Issues Reading	Access	Screen Time	Settings Changed	Getting Help	
A3	35	m	2	Sometimes	Every day	Yes	Yes	< 4 hours a day	No	Yes	
A4	36	w	4	No, I read alone	Every day	No	Yes	< 4 hours a day	No	No	
A5	20	m	3	No, I read alone	Once a week	No	Yes	1-2 hours a day	No	No	
A6	20	m	5	No, I read alone	Every day	No	Yes	1-2 hours a day	Font slightly larger	No	
A7	39	m	3	Yes, I always need help	As little as possible	Yes	Yes	> 1 hour per day	No	Yes	
A8	21	w	3	Sometimes	As little as possible	Yes	Yes	< 4 hours a day	No	Yes	
A9	40	m	3	No, I read alone	Every day	Yes	Yes	< 4 hours a day	Font much larger, bold and high contrast	No	
A10	58	m	2	Need help	Once a week	Yes	Yes	1-2 hours a day	No	Yes	
A11	21	m	3	Sometimes	As little as possible	Yes	Yes	< 4 hours a day	No	Yes	
A12	22	w	3	No longer read at all	Never	Yes	Yes	2-4 hours a day	No	No	
A13	19	w	3	Sometimes, No, I read alone	As little as possible	Yes	Yes	2-4 hours a day	Block letters	Yes	
A14	22	Neither	2	No, I read alone	Every day	No	Yes	< 4 hours a day	No	No	
L16	23	m	4	No, I read alone	Every day	Yes	Yes	2-4 hours a day	No	No	
L18	25	m	5	No, I read alone	Every day	No	Yes	1-2 hours a day	No	Yes	
L19	51	w	4	No, I read alone	Once a week	No	Yes	1-2 hours a day	The contrast is higher	Yes	
L20	31	w	3	No, I read alone	Every day	No	Yes	< 4 hours a day	The contrast is higher	No	
L21	29	m	3	Sometimes	Once a week	Yes	Yes	1-2 hours a day	Font larger	Yes	
L22	27	m	4	No, I read alone	never	No	Yes	> 1 hour per day	The contrast is higher	Yes	
L23	46	m	5	No, I read alone	As little as possible	Yes	Yes	Different	No	No	
L24	53	m	3	No, I read alone	Every day	No	Yes	Different	Font larger	Yes	
L25	39	m	4	No, I read alone	Once a week	No	Yes	< 4 hours a day	No	No	
L27	52	m	3	Sometimes	Every day	No	Yes	> 1 hour per day	No	Yes	
L28	23	m	4	No, I read alone	Never	No	Yes	< 4 hours a day	Font larger	No	
L29	55	m	4	No, I read alone	Every day	No	Yes	< 4 hours a day	No	No	
L30	27	w	5	Sometimes	As little as possible	No	Yes	< 4 hours a day	Font larger	Yes	
M31	18	m	2	Yes, I always need help	As little as possible	No	Yes	2-4 hours a day	No	No	
M32	17	w	2	Yes, I always need help	Once a week	Yes	Yes	> 1 hour per day	No	No	
M33	18	w	4	No, I read alone	Once a week	No	Yes	< 4 hours a day	No	No	
M34	16	w	4	No, I read alone	As little as possible	No	Yes	< 4 hours a day	Keyboard German/Macedonian	Yes	
M35	17	w	4	Sometimes	Every day	No	Yes	< 4 hours a day	No	Yes	
M36	17	w	4	Sometimes	Every day	No	Yes	< 4 hours a day	Font larger	Yes	
M37	19	w	4	Sometimes	Once a week	No	Yes	< 4 hours a day	my pin	No	
M38	16	m	4	No, I read alone	Every day	No	Yes	< 4 hours a day	Font larger	No	
M39	16	m	5	No, I read alone	Every day	No	Yes	< 4 hours a day	Time and language Romanian	No	
M40	18	Neither	4	No, I read alone	Once a week	No	Yes	> 1 hour per day	No	Yes	
M41	17	m	4	No, I read alone	Once a week	No	Yes	< 4 hours a day	Font larger	Yes	
M42	17	m	4	No, I read alone	As little as possible	No	Yes	< 4 hours a day	The contrast is higher	No	
M43	15	m	4	No, I read alone	As little as possible	No	Yes	< 4 hours a day	No	Yes	
O57	44	w	5	No, I read alone	Once a week	Yes	Yes	2-4 hours a day	No	No	
O58	74	w	4	No, I read alone	As little as possible	Yes	Yes	< 4 hours a day	Font larger	No	
O59	69	w	4	No, I read alone	Once a week	Yes	No	< 4 hours a day	Font slightly larger	No	
O60	24	w	4	No, I read alone	Every day	No	Yes	< 4 hours a day	No	Yes	
O61	29	m	2	Yes, I always need help	Every day	Yes	Yes	2-4 hours a day	The contrast is higher	No	
K44	28	m		No, I read alone	Every day	No	Yes	2-4 hours a day	No	No	
K45	21	w		No, I read alone	Every day	Yes	Yes	< 4 hours a day	No	No	
K48	20	w		No, I read alone	As little as possible	No	Yes	< 4 hours a day	No	No	
K49	30	w		No, I read alone	Every day	Yes	Yes	< 4 hours a day	Background black	No	
K50	21	m		No, I read alone	Every day	No	Yes	< 4 hours a day	No	No	
K51	19	m		No, I read alone	Every day	Yes	Yes	< 4 hours a day	Larger icons, everything on maximal size	No	
K52	22	m		No, I read alone	Every day	No	Yes	< 4 hours a day	No	No	
K53	24	m		No, I read alone	Every day	No	Yes	< 4 hours a day	Eye protection mode	No	
K54	20	m		No, I read alone	Every day	No	Yes	2-4 hours a day	No	No	
K55	31	m		No, I read alone	Every day	Yes	Yes	< 4 hours a day	No	No	
K56	60	m		No, I read alone	Every day	No	Yes	< 4 hours a day	No	No	
K57	49	w		No, I read alone	Every day	No	Yes	< 4 hours a day	No	No	

**Table 4: Age, Gender, Reading level, Reading Time, Issues Reading, Internet access, Screen time, Settings Changed, and Getting Help. (Test group A3 – O61, control group K 44-57)**

Code	Websites used	Apps used	Screen Reader	Online Shopping	Search Strategies (Google)
A3	N/A	WhatsApp, kicker, sports show	No	Yes	I type question or I speak question
A4	Weather, News, Latest news, DB	WhatsApp, Facebook, YouTube	No	No	I type a question
A5	FC Bayern	WhatsApp, phone calls	No	No	Yes
A6	Weather, WhatsApp	WhatsApp, ebay, YouTube, Netflix, manga games, dating apps, "sealed with a demon kiss", animal coins	No	Yes	Yes
A7	Nothing specific	WhatsApp	No	No	I type question or I speak question
A8	TikTok, Snapchat, Instagram (I'm not allowed to)	YouTube, Spotify, WhatsApp, calendar, weather	No	No	Unknown
A9		Facebook	No	Yes	I type a question
A10	News	Drawing (fantasy images)	No	Unknown	I speak question
A11	Disney+	Monopoly, poker, chess, sinking ships, Dome, Amazon news, YouTube, Netflix,	No	No	I type a question
A12	YouTube, Netflix	YouTube, Netflix, paint by numbers, minecraft, iron on beads, playstation	No	Yes	I type question or I speak question
A13	Instagram, TikTok, YouTube,	pinterest, tumblr, Snapchat	No	No	I type a question
A14	Soccer, basketball, if there is wifi	N/A	No	Yes	I type a question
L16	FC Wacker Munich, FC Ottobrunn	Holy, Bank, Amusement park	No	No	I type a question
L18	YouTube, games Tetris, Monopoly, Netflix, Instagram, TikTok	WhatsApp, car racing games, YouTube movies	No	No	I type a question
L19		WhatsApp, Games	No	No	I type a question
L20	Instagram, TSV Ismaning Handball	N/A	No	No	I type a question
L21	Edit photos, FCB Basketball, Magenta TV	MVG, Sky Sport, WhatsApp, Aldi Talk, Engelbert Strauss (online order done by father), Red Bull sports page	Yes	No	I type question or I speak question
L22	Radio Gong, google	Radio Gong	No	No	I type a question
L23	All	All	No	No	I type a question
L24			Yes	No	I need help
L25	Foosball (soccer), gaming, Ebay classifieds, Amazon	one Football, Instagram, WhatsApp, YouTube	No	No	I type a question
L27	Streetcar, workshop film	MVV, BVG	No	No	I speak a question
L28		TikTok, Instagram, YouTube, watching soccer, fifa, kicker	No	No	No
L29	Four pictures one word, Games, Painting by numbers	Slotpark, Genios and Games, Coinmaster, FC Bayern App	Yes	No	No
L30	N/A	Netflix, games (Roblox), YouTube, Instagram	No	No	No
M31	Paul Walker	WhatsApp, Snapchat, TikTok, Instagram	No	No	I speak a question
M32	Makeup tutorials, watch funny clips	Instagram, YouTube	No	No	I type question or I speak question
M33		Instagram Reals, TikTok	No	No	I type a question
M34	N/A	Snapchat, Netflix, YouTube, Shein app	No	No	I type a question
M35	YouTube for listening to music	sms messages and music	No	No	I type question or I speak question
M36	Fashion magazines, girls, top model, singer Nancy Ajram from Lebanon), dice game	Ice king, memory, fire department, YouTube, music, bluetooth, TikTok, singing	No	Yes	I type question or I speak question
M37	TikTok, Spotify, Snapchat	TikTok, WhatsApp, capcut	Yes	No	I type a question
M38	Fifa	Insta, TikTok	No	No	I type a question
M39	google translate, discord, twitch, Fifa mobile, FC 24	Instagram, TikTok, Telegram, Facebook, Snapchat rare	No	Yes	I type question or I speak question (rarely)
M40	Instagram, YouTube		No	No	I type question or I speak question
M41	Fifa	Instagram, TikTok, YouTube, Spotify	Yes	No	I type a question
M42	Netflix, Action Games (I'd like Call of Duty, GTA 5)	All, TikTok, FC24, Instagram, YouTube,	No	No	I type a question
M43	YouTube, Games: Subway Surfers, Fit Mobile, Football,	WhatsApp, Snapchat, Instagram, Threads, Score Hero, Card	No	No	I type a question
O57	actually everything: bingo, facebook, free games	WhatsApp, Google, Voice App	No	Yes	I type question or I speak question
O58	what there is	Google	No	No	I type a question, need help
O59	YouTube, news	Matching games (Tile stories, Match stories, Candy story)	No	No	I type a question google/YouTube
O60	YouTube	Instagram, MVG	No	Yes	I type question or I speak question
O61	Detective game, theater play, YouTube	Smartphone only for WhatsApp, iPad for games and YouTube, music and Spotify	No	No	I type question I need help

Table 5: Websites/Apps Used, Screen Reader, Online Shopping, and Search Strategies (Part 1: Test group)

Code	Websites used	Apps used	Screen Reader	Online Shopping	Search Strategies (Google)
K44	ChatGPT	Instagram, YouTube, WhatsApp	No	No	I type a question
K45	Design pages	Zeit Online, TikTok, WhatsApp, Instagram, Merge Mansion	No	Yes	I type a question
K48	YouTube, Online Shopping, Chat GPT, Online City Magazine	TikTok, WhatsApp	No	Yes	I type question or I speak question (rarely)
K49		Family calendar	No	Yes	I type question or I speak question
K50	YouTube, Pinterest, ChatGPT, deepl	Spotify, WhatsApp, Instagram	No	Yes	I type a question
K51	Behance, ChatGPT, vizom	YouTube, Instagram, Spotify, Discord	No	Yes	I type a question
K52	YouTube, sz.de, LinkedIn	Instagram, Spotify, ebay classifieds, Amie, DeepL, Shazam	No	Yes	I type a question
K53	ChatGPT	TikTok, Switch, YouTube	No	Yes	I type question or I speak question
K54	Design, Vehicles, YouTube	Pinterest, Adobe Cloud	No	Yes	I type question or I speak question
K55	LinkedIn	Time, SZ, News portals, research, Google	No	Yes	I type question YouTube
K56		Strava, Duolingo	No	Yes	I type question or I speak question
K57	News pages (SZ, Zeit), Research All	Heroic, LinkedIn, DKN, ChatGPT, WhatsApp, PayPal	Yes	Yes	I type question or I speak question

**Table 6: Websites/Apps Used, Screen Reader, Online Shopping, and Search Strategies (Part 2: Control Group)**

## A.2 Statistics

Statistics are available in supplementary material.