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Designing Heuristics for Accessible Online Text Production

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Abstract. Governments and public organisations provide digital services and share information on websites, so web content needs to be accessible to all citizens. Text remains the main form of providing information, and reading is the primary way to interact with digital services. However, existing guidelines are not adequate for content creators in public organisations. The wide scope and technicality of these guidelines make them confusing, difficult to understand and challenging to implement. To respond to this emerging need, in this paper, we contribute improvements to the guidance of accessible text production by proposing heuristics with a design science approach. Specifically, we (1) review accessibility guidelines and determine improvement factors related to text accessibility, (2) establish a design and evaluation workshop with 38 students, and (3) verify the feasibility of the proposal with content creators. Our evidence shows that the proposed accessibility heuristics are clear and easy to understand, and they are useful for content creators.

Key words: accessibility heuristics, text accessibility, web accessibility, design science.

1 Introduction

The number of users of digital public services is constantly increasing, as more and more services are becoming available only through websites or mobile applications (European Commission, 2015). For example, in Finland, where the use of digital public services is highest in EU countries (year 2019) (European Commission, 2015), the digitalisation

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of public services has been one of the government's flagship projects since 2015 (Ministry of Finance [Finland], n.d.). The provision of digital services is enshrined in law; in Europe, an EU directive (Directive (EU) 2016/2102) on the accessibility of public sector bodies' websites and mobile applications requires these public entities to develop their online services (Directive 2016/2102 (2016) of the European Parliament and of the Council of 26 October 2016, 2016; European Telecommunications Standards Institute, 2015).

Because of the heterogeneous user communities of digital services, websites, mobile applications, and their content need to be accessible and understandable. In digital services, texts and linguistic elements convey meaning (Isohella & Nuopponen, 2016). Despite the increasing amount of audiovisual content, a significant proportion of online content remains in textual form (Kalender et al., 2018), so reading is one of the primary ways to interact with digital services (Rello et al., 2016). In this regard, knowledge of the factors serving as barriers to screen reading is urgently needed (Dyson & Haselgrove, 2001)there is an urgent need to increase our knowledge of factors influencing reading from screen. We investigate the effects of two reading speeds (normal and fast. However, studies that develop guidelines for accessible texts often focus on certain groups, such as people with dyslexia (Li et al., 2019; Miniukovich et al., 2017; Rello et al., 2012), thus excluding individuals with other needs.

Although accessibility guidelines, such as the Web Content Accessibility Guidelines (WCAG), offer great help for web practitioners, webmasters and web developers, websites often remain inaccessible (Lazar et al., 2004; Vollenwyder et al., 2019). One reason for this is confusing guidelines (Lazar et al., 2004; Minin et al., 2015; Vollenwyder et al., 2019). The majority of web practitioners who have technical expertise have at least a basic awareness of web accessibility that individuals in non-technical roles do not necessarily possess (Vollenwyder et al., 2019). Content creators are one of the groups of practitioners who are struggling with the question of how to create accessible content for websites. A content creator is a practitioner often without web technological expertise. Their responsibility is to create and update the content of an organisation's website. This content may consist of any digital media format, such as images, videos or audio, but it is mostly text. Even though some content creators may have an understanding of web technologies, existing guidelines are relatively technical, as they consist of techniques to improve the programming of a website (Leuthold et al., 2008; Martins et al., 2017). The scope of existing accessibility guidelines is too wide and technically specified for the use of content creators in public services. There is a need for clear guidance on how accessible text can be produced for websites.

Our research question is as follows:

What design heuristics can support content creators in producing accessible online texts?

To answer this research question, using the design science approach, we first investigated available accessibility guidelines and identified practices related to producing accessible text. Second, from these findings, we provided a list of heuristics that were evaluated and improved in a workshop. Third, the heuristics were revised again. Finally, the practical feasibility of the revised version was discussed in interviews with online content creators from sampled organisations.

In this paper, we contribute improvements to the guidance of accessible text production. Our goal is to design a proposal for accessibility heuristics (i.e., general principles that are easy to use and understand for content creators in public services for creating accessible textual web content). This paper makes the following contributions. First, the factors that improve text accessibility are categorised and summarised in a literature synthesis. Second, the proposed heuristics for online text production for content creators in the public sector are presented. These heuristics are the outcomes of the literature review, two design and evaluation iterations (i.e., a workshop with students [N = 38]) and interviews with three content creators.

The rest of the paper is organised as follows. The next chapter presents the background. Chapter 3 describes the design science methodology. Chapter 4 presents the results of design and development, including the literature review, the results of the design iterations and the proposed heuristics. Chapter 5 presents the discussion and concluding remarks.

2 Background

Accessibility requirements for web and mobile services in the EU directive are based on the European Standard "Accessibility requirements suitable for public procurement of ICT products and services in Europe" (EN 301 549 V1.1.2 2015-04). The foundation of accessibility requirements is the WCAG, developed by the Web Accessibility Initiative of the World Wide Web Consortium (W3C). WCAG are structured into three levels of compliance: A (lowest), AA and AAA (highest) levels. In legislation, the EU directive recommends following the middle-level AA. Guidelines are organised into four principles: perceivable, operable, understandable and robust (W3C, 2018). Legal requirements consist of all documents and software that are embedded, rendered or

intended to be rendered with web pages (Directive 2016/2102 (2016) of the European Parliament and of the Council of 26 October 2016, 2016; European Telecommunications Standards institute, 2015).

In this paper, accessibility is defined as "appropriate measures to ensure to persons with disabilities access, on an equal basis with others, to the physical environment, to transportation, to information and communications, including information and communications technologies and systems, and to other facilities and services open or provided to the public, both in urban and in rural areas" (United Nations, 2006). This definition is from the United Nations Convention on the Rights of Person with Disabilities, and it also emphasises that state parties should promote the design, development, production and implementation of information accessibility at the early stage of information and communication technology processes. According to Petrie et al. (2015), accessible websites need to be designed and developed to support usability. One of the most cited theories of usability describes it based on five attributes that emphasise usefulness: (1) easy to learn, (2) efficient to use, (3) easy to remember, (4) contains few errors and (5) subjectively pleasing (Nielsen, 1993).

Previous studies contributing design guidelines to improve web page readability often have a certain focus group. For example, Miniukovich et al. (2017) provided design guidelines to improve web readability. They reviewed existing readability guidelines and obtained a set of 61 readability guidelines. However, as they addressed the issue of having existing guidelines that are too many, too generic and poorly worded or that lack cognitive grounding, they conducted a series of workshops with design and dyslexia experts and a user study with dyslexic and average users to compile a set of 12 core guidelines (Miniukovich et al., 2017). Rello et al. (2012) offered a set of dyslexic-friendly guidelines with the following parameters for the layout of web text to improve accessibility for people with dyslexia: grey scale in the font (10%), grey scale in the background (90%), colour pairs (creme/black), font size (26), character spacing (+7%), line spacing (1.4), paragraph spacing (2) and column width (77 characters/line). Despite the focus group, the authors argued that the use of web accessibility practices for dyslexic users is beneficial for all (Rello et al., 2012). These parameters are similar to web browser settings, such as Mozilla Firefox's *Reader View* for modifying the web page layout. Li et al. (2019) investigated the impact of web browser reader views on reading speed and user experience. The authors conducted an online study with 391 participants, of which 42 were self-diagnosed with dyslexia. They found that the reader view increases the reading speed of readers by 5%, on average, and there is a similar rate for readers self-diagnosed with dyslexia (Li et al., 2019). Moreover, the average

perceived readability and perceived classical aesthetic (e.g., clean, pleasant) increased significantly within both groups.

According to studies by Li et al. (2019), Miniukovich et al. (2017) and Rello et al. (2012), web text design practices for dyslexic users are beneficial for all.

However, a number of issues that require further examination can be highlighted to generalise existing guidelines:

- Existing text accessibility principles often provide guidelines on how to formalise text for faster reading speed or better readability. They ignore guidance for text content formalisation in order to have easier-to-understand text or guidance for content structure organisation in order to have easier-to-perceive text.

- Existing formulations of text accessibility guidelines do not provide explanations for achieving this aim, which may affect an individual's motivation to follow them.

- Existing guidelines are designed to cover instance problems with instance solutions for specified users (e.g., dyslexic). Little attention is given to the person implementing the design principles. This person can be, for example, a content creator who uses design principles in practice or a theoriser who uses them to capture knowledge (Gregor et al., 2020).

Next, we describe our method.

3 Method

Our research aims to deliver solutions to text accessibility for the use of practitioners. We adopted the design science research methodology process model by Peffers et al. (2007) presents, demonstrates in use, and evaluates a methodology for conducting design science (DS to achieve our research aims. We conducted our study in three conceptual phases: problem identification and objective definition (phase 1), artefact design (phase 2) and artefact demonstration and evaluation (phase 3).

In the first phase, we performed a literature review and content analysis of our selected primary studies (PSs) to identify the inadequacy of existing guidelines, and we made additions from other literature. In the second phase, we formulated the heuristics in the design cycle. In the third phase, we conducted two design iterations. In the first one, we established a design and evaluation workshop. In the second design iteration,

we conducted interviews. By design iteration, we mean the process of applying extracted data.

During our research process, we formulated three versions of the heuristics. The first version (VER1.) is based on the results of the first phase, the second version (VER2.) is based on the results of the first design iteration (workshop) in the third phase and the proposed heuristics (final version) are based on the results of the second design iteration in the third phase (see Figure 1). The evaluation of the heuristics was conducted during the workshop and interviews. Next, we describe the literature review, design iterations and evaluation in detail.

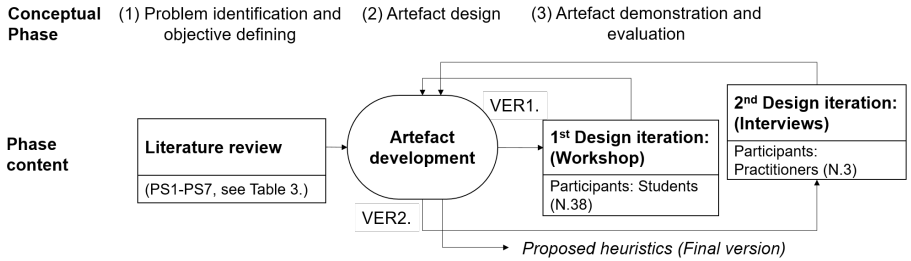

Figure 1. Research process overview (adopted and modified from Peffers et al. 2007)

3.1 Literature review

To collect prior knowledge on our research topic, we conducted a literature review. We aimed to summarise findings to identify any gaps (Gregor & Hevner, 2013; Okoli, 2015) in current guidance and obtain reusable items (Peffers et al., 2007)presents, demonstrates in use, and evaluates a methodology for conducting design science (DS for developing the first version of the accessibility heuristics scoped to online text. We focused on heuristics that provide guidance on how to formalise and produce text, considering linguistic elements to conform to accessibility.

This review process involved two steps. First, we developed a review plan for searching the literature. We formulated the search term 'accessibility heuristics' and the search string 'text' AND 'accessibility heuristics'. We performed the search on Google Scholar with a date range of 2000-2019. The first search term returned 387 papers, and the search string returned 189 papers. We then included only journals and conference papers with a search term/string stated in the title, abstract or keyword list. After the exclusion of papers with these criteria, 34 papers remained. Next, we analysed the content of the papers based on the full article and included only those studies that provided heuristics or guidance relating to text accessibility. At this point, we manually added

the WCAG and ICT for Information Accessibility in Learning (ICT4IAL) guidelines to our set. WCAG are amongst the major guidelines concerning web accessibility. ICT4IAL guidelines are a result of the Accessible Information Provision for Lifelong Learning project, co-funded by the European Commission's Lifelong Learning Transversal Programme (European Agency for Special Needs and Inclusive Education 2015). We chose the ICT4IAL guidelines because they are directed to non-expert actors for the creation of achievable knowledge in their work environment (European Agency for Special Need and Inclusive Education, 2015). Thus, they fit well for our purpose—the heuristics we create are meant to serve a wide range of users, especially non-experts. Finally, we included seven papers or guidelines for further analysis. The results of the literature review are presented later in Section 4.

3.2 Artefact development and design iterations

The key step in design science research is artefact design and development (Brown et al., 2011). The heuristics were built based on two design iterations: a workshop and interviews. We analysed the data obtained from the design iterations and formulated the heuristics in the artefact development phase. In the following, we describe the design iteration procedure.

First design iteration (workshop)

In the first design iteration, we demonstrated our first version of the heuristics as a candidate solution for accessible text production (Mettler et al., 2014) in a workshop to evaluate and enhance the heuristics. The workshop focused on contributing improvements to three areas: 1) the content and formulation of the heuristics, 2) their usability and 3) their utility.

The workshop was held with 31 university master's-level students, of which 22/31 (71%) were females and 9/31 (29%) were males. Their average age was 29 years, and their age range was 21-51 years. The majority of the students 23/31 (74%) were from the technical communication programme. They had some experience in website design and content creation, and almost everyone had work experience in companies or public sector organisations. Therefore, the students were regarded as intermediate content creators (on user types, see, e.g., Cooper et al. 2007). The workshop was held in February 2020 as part of a 5 ECTS web content accessibility course. The prerequisite for the course was an introductory course in human-computer interaction. The students par-

ticipated voluntarily. They were asked for permission to use their work in this research, and the decision not to participate had no impact on the students' grades.

The workshop lasted for 90 minutes. As the course was organised in a flexible way, allowing the students to participate synchronously on-site (N = 16) or via a Zoom video conference (N = 15), the workshop was organised in a similar way. To simulate real work conditions, we had the students participate in on-site work in pairs and via Zoom individually. They were already familiar with the heuristics, as we had presented these two days earlier in a lecture titled "Strategies for producing textual online content". The students were given the role of content creators in public organisations. They were asked to choose the website of a Finnish public organisation from a list given by their instructors. They first evaluated the web content heuristic by heuristic and took notes. They then summarised their findings in a questionnaire, were asked to look at the heuristics row by row and then commented on each of the heuristics in terms of understandability, clarity of content, flawlessness and anything that comes to mind that they consider important regarding content. At this point in the study, we concentrated on the content and not the layout of the heuristics, as organisations may want to use their own templates. This questionnaire was also used in the evaluation. Thematic content analysis (Zhang & Wildemuth, 2017) was used to examine the qualitative data (i.e., responses to the open-ended questions of the questionnaire regarding the content of the heuristics).

Second design iteration (interviews)

After revising the heuristics based on the results of the first iteration, we conducted the second design iteration with three content creators (P1-P3). The participants were invited to an interview to evaluate the feasibility of the heuristics and to contribute improvements to them. We sent invitations directly to individuals involved in content creation. They were invited purposively from different public organisations under the same accessibility legislation: a university, a government agency and an association dealing with special groups. Participation was voluntary.

The participants had different years of work experience in content creation—P1: 8 years, P2: 4 years and P3: 15 years. We sent the proposed heuristics to the participants a week before the interview so that they could familiarise themselves with the heuristics beforehand. To simulate real-life conditions, we did not give any instructions on how to use the heuristics when we sent these to them. Two face-to-face interviews were conducted in June 2020 in the participants' workplaces, and one was conducted in August 2020 on the phone. The data were gathered through semi-structured theme interviews

(Wengraf, 2001), which each lasted about two hours. The themes for the interviews were 1) the current situation regarding accessibility in the relevant organisation, 2) the content of the proposed heuristics and 3) the feasibility of the heuristics. The improvements suggested by the interviewees for the content are discussed in Chapter 4.

3.3 Evaluation

As evaluation is one of the key activities in design science (Venable et al., 2016), we developed an evaluation strategy for assessing the proposed heuristics. In the conceptual phase—artefact demonstration and evaluation—we performed the evaluation, first, during the workshop as an ex ante evaluation (Sonnenberg & vom Brocke, 2012; Venable et al., 2016) to confirm proof of concept (Gregor & Hevner, 2013). This evaluation included the following evaluation criteria: learnability, utility, memorability, flawlessness and consistency. Second, we conducted the evaluation during the interviews as an ex post evaluation (Sonnenberg & vom Brocke, 2012; Venable et al., 2016) to verify the expected value (Gregor & Hevner, 2013) for content creators, i.e., assessing with real users (Gregor & Hevner, 2013; Venable et al., 2016). This evaluation included criteria such as importance, feasibility and utility to practice (Sonnenberg & vom Brocke, 2012). The evaluation strategy involved a framework proposed by Venable et al. (2016) with the following components: why, when, how and what to evaluate (see Table 1). We conducted the assessment concerning the *validity*, *utility quality*, and *ef-*

Why evaluate? (Verification of…)	*When to evaluate? (Phase of the research)*	*How to evaluate? (Method)*	*What to evaluate? (Target)*
Validity	During the workshop, during the interview and after the workshop	Open-ended questions, interviews and reflection paper	Importance and feasibility
Utility	During the workshop and during the interview	Open-ended questions and interviews	Utility
Quality	During the workshop	Open-ended questions	Flawlessness and consistency
Efficacy	During the workshop and after the workshop	Open-ended questions and reflection paper	Learnability and memorability

Table 1. Evaluation framework adopted from Venable et al. (2016)

ficacy (Gregor & Hevner, 2013) of the heuristics as follows. To verify their *validity*, we evaluated *importance* and *feasibility* during the first iteration in the workshop. We used open-ended questions in a questionnaire filled out by the students during and after the, as well as during the second iteration in the interview. After the workshop, the students were given an individual assignment to complete outside the class. They were asked to create textual content for an organisation's website using heuristics and then to write a reflection paper on it. Specifically, they were advised to evaluate usability-related issues, such as learnability and memorability, but especially utility, as well as the validity of the workshop outcomes. By having the students work with heuristics, we prepared them to evaluate the validity, utility, quality and efficacy of the heuristics. The data consisted of 31 reflection papers ranging from one A4 to two sheets in length.

The evaluation of *utility* was conducted with open-ended questions in the questionnaire completed by the students during the workshop and the interviews. The *quality* of the heuristics was evaluated during the workshop with open-ended questions in the questionnaire related to the flawlessness and consistency of the heuristics. *Efficacy* was evaluated during the workshop with open-ended questions in the questionnaire related to the learnability and memorability of the heuristics and after the workshop in an assignment followed by a reflection paper.

4 Results

In this chapter, we report the results of the literature review and design iterations, including the evaluations, and present our proposal for the heuristics. In order to construct the heuristics, we extracted those factors improving text accessibility from the PSs as reusable items (Peffers et al., 2007) presents, demonstrates in use, and evaluates a methodology for conducting design science (DS to formalise our first version of the heuristics, which we supplemented with other literature. We then revised the heuristics based on the workshop findings in the first design iteration. Then, in the second design iteration with the revised version, we interviewed content creators from three different organisations and included the results in the final version. In the following sub-chapters, we describe the results of these steps.

4.1 Results of the literature review

We included seven papers or guidelines as PSs for further analysis (see Table 2).

ID	*Title*	*Name of the Heuristics/Guide-lines*	*Author(s)*	*Year*
PS1	Applying heuristics to accessibility inspections	IBM web accessibility heuristics: WCAG1.0, Nielsen Accessibility Guidelines (2001), IBM Web Accessibility Checklist 3.01, Guidelines for UK Government Web Sites (2004), Section 508 Web Standards (2004)	Paddison, Claire and Paul Englefield	2004
PS2	A study of web accessibility barriers for older adults, and heuristics evaluation of email websites based on web accessibility heuristics for older adults by AARP	WAI AGE guidelines (Web Accessibility Guidelines for older adults by W3C) and heuristics evaluation based on AARP heuristics	Ilyas, Mahanum	2012
PS3	Designing location-based learning experiences for people with intellectual disabilities and additional sensory impairments	Heuristics for good design (Accessibility part)	Brown, David J., David McHugh, Penny Standen, Lindsay Evett, Nick Shopland and Steven Battersby	2011
PS4	Toward accessible mobile application design: developing mobile application accessibility guidelines for people with visual impairment	Mobile Application Accessibility Heuristics for people with visual impairment	Park, Kyudong, Goh Taedong and So Hyo-Jeong	2015
PS5	Evaluation of the effectiveness of a tool to support novice auditors	Accessibility Evaluation Assistant (AEA) heuristics checks	Bailey, Christopher and Elaine Pearson	2012
PS6	Web Content Accessibility Guidelines (WCAG) 2.1	Web Content Accessibility Guidelines (WCAG) 2.1	World Wide Web Consortium (W3C) Web Accessibility Initiative (WAI)	2018
PS7	Guidelines for Accessible Information	Guidelines for Accessible Information. ICT for Information Accessibility in Learning (ICT4IAL) (Section 1: Making your text accessible)	The European Agency for Special Needs and Inclusive Education	2015

Table 2. List of primary studies

Next, we analysed the content of the PSs to categorise the guiding factors. We found that every recommendation on text accessibility was related to text format, structure or content (see Table 3).

Factors that Improve Text Accessibility	*Category*	*Instances (ID)*
Colours and the use of bold and italics are not the only methods for conveying meaning.	Formatting	PS1, PS5, PS6, PS7
The text size in documents is a minimum of 12 pt; the user interface should allow text resizing.	Formatting	PS1, PS2, PS5, PS7
Sans serif fonts, such as Arial, Verdana, Helvetica, Tahoma and Trebuchet MS, are used.	Formatting	PS7
Bullets are used.	Formatting	PS7
Text spacing (line spacing: 1.5 times the font size, paragraphs: two times the font size, letter spacing: 0.12 times the font size, word spacing: 0.16 times the font size)	Formatting	PS6
Left alignment is used.	Formatting	PS7
Alt text for non-text elements is used.	Structure	PS1, PS3, PS4, PS5, PS6, PS7
Consistent navigation and headings with a logical order	Structure	PS1, PS4, PS5, PS6, PS7
Links are highlighted differently from the text with an action word in the label.	Structure	PS2, PS4, PS5, PS6, PS7
Simple language is used.	Content	PS3, PS6, PS7
The full meanings of abbreviations and acronyms are provided the first time they are used.	Content	PS6, PS7
Important information is provided first.	Content	PS4
Short summaries of content are provided.	Content	PS7
Appropriate language for the audience is used.	Content	PS6

Table 3. Identified factors that improve text accessibility based on the PSs

In the following sub-chapters, we describe the findings on these categories in detail.

Text formatting

The guidelines in the PSs provided a relatively large number of precise instructions for text formatting. Text formatting refers to text style definitions, such as font, font size, bold and italics, and line spacing, to name a few. The use of formatting makes the text easier to perceive and interpret. ICT4IAL recommends using fonts such as Arial, Helvetica or Verdana, as well as Tahoma or Trebuchet MS, which are designed for reading on the screen (PS7). ICT4IAL recommends a font size of at least 12 pt (font size of Cascading Style Sheets, CSS) to be used in documents ignoring text size recommendations in titles or on a website (PS7). The website design should provide configuration for resizing text (PS1, PS2, PS5, PS6) and changing colours (PS6) by users. In addition, the WCAG instruct that the text size should be scalable without assistive technology (up to 200%) and without losing any information (PS6).

Both the WCAG and ICT4IAL consider line spacing, text spacing and letter and word spacing to be more important than font selection. The WCAG recommend the line spacing to be at least 1.5 times the font size, the text paragraph spacing at least two times the line spacing, the letter spacing at least 0.12 times the font size and the word spacing at least 0.16 times the font spacing (PS6). Such precise formatting definitions can rarely be made with a content management system's text editor tool, requiring either CSS-style definitions or other parts of the management system.

According to the PSs, colours, bolding or italics should not be used for conveying meaning (PS1, PS5, PS6, PS7). ICT4IAL states that text should be left aligned, in which case alignment on both edges should be avoided (PS7). Text should be written horizontally, and text written vertically should be avoided (PS7). The guidelines recommend using bullets for a list (PS7).

Text structure

The accessibility guidelines almost invariably recommend alternative text, the so-called alt text, to elements that are not text (PS1, PS3, PS4, PS5, PS6, PS7). The WCAG provide guidance on this matter even at the lowest A level. Alt text should be given, for example, to an image that represents information. This way, people who cannot perceive an image visually get the same information with a screen reader. However, the instructions do not specify in detail how to write, for example, the content of a verbose and informative image. The guidelines also emphasise that text should not be presented in image format.

The second extensive guidance refers to issues related to operability and navigability. Of these selected guidelines, the most common instruction refers to considering the

contribution of the logical use of a heading structure to support navigation (PS1, PS4, PS5, PS6, PS7).

Links in the text should be named in such a way that the user understands the purpose of the link and where it leads (PS5, PS6, PS7). Links should be highlighted differently from other texts to draw attention (PS4) and should be named with an action word (PS2). In addition, ICT4IAL recommends that the URL of the link must be presented in its entirety, for example, in a separate list, so that the same information is retained when printing.

Text content

The third principle of WCAG 2.1 is understandability. One A-level criterion, one AA-level criterion and three AAA-level criteria are given to achieve this. The A and AA level (legal requirements) guidance provides only some technical solutions. For example, the A-level criterion is the language of the page (i.e., the default natural language of each web page can be determined programmatically), and the AA-level criterion instructs specifying words or phrases with language tags if they are in a different language from that of the body text. In practice, this is done by marking the HTML language with a so-called lang-attribute or language tags, which tell search engines or user agents in which language the web page or particular word/phrase is.

However, the PSs provided some textual guidelines related to (1) language, 'Use the simplest possible language appropriate to your document' (PS3, PS6, PS7); (2) abbreviations and acronyms, 'When using abbreviations or acronyms, mention the full names when the abbreviations or acronyms are used for the first time' (PS6, PS7); (3) summaries, 'Add short summaries of the content or paragraph, where possible' (PS7); and (4) order, 'Provide important information first' (PS4). The PSs contained only a few general remarks related to text and linguistic elements.

As there were only a few recommendations concerning text production and linguistic elements in the PSs, we expanded our search and made supplements to strengthen the guidance that we will include in the first proposal of the heuristics. From the results of the literature review, we identified the lack of a detailed explanation for why proposed suggestions are necessary to implement. Therefore, we applied manual precision searching for text size, font type and simple language to have more detailed instructions.

In addition to the PSs, we found that Rello et al. (2016) recommended using a text size of at least 18 pt. up to 26 pt. to improve readability and comprehension when reading on the screen. The use of sans serif font types, such as Arial and Verdana, has a significant impact on readability, especially for people with dyslexia, whereas itali-

cisation of text, or the use of italics, has been found to slow down and make reading difficult regardless of the font used (Rello & Baeza-Yates, 2013). As the development of plain language has a long tradition (Mazur, 2000) in pursuing an understanding of the text (Redish et al., 2010), we extracted two of the most critical plain language guides to expand our first proposal of the heuristics: (1) write short sentences and (2) address readers directly with *you* or the imperative *do* (Redish et al., 2010).

Finally, we formulated the first version of the heuristics based on the factors presented in Table 2 and the supplements. The heuristics were presented in the form of an instruction. For example, the factor 'bullets are used' is expressed as 'use bullets'.

4.2 Findings from the first iteration (workshop)

The aim of the workshop was to evaluate the heuristics in terms of their content, usability and utility. As the crucial point in the first design iteration was to refine the content of the heuristics, in this chapter, we focus on describing improvements that were made to have a refined version of the content of the heuristics. The findings on the assessment of the usability and utility of the heuristics are described in detail in sub-chapter 4.4.

Regarding understandability and clarity of the content of the heuristics, three themes emerged from the students' answers: (1) removal of irrelevant words and information, (2) insertion of clarifications and (3) removal of repetition. The evaluation done by the students showed that the heuristics included words or phrases that were unnecessary and that lengthened the documents. For example, the phrase 'Remember that' in the description of the first heuristic was regarded as irrelevant: 'Remember that the reader may only focus on your written text […]'. As a result, the description became shorter: 'The reader may only focus on your written text […]' (See the first heuristic, H1, in Table 4). Another example of an irrelevant phrase is in H6, 'Align the text to the left', which, in the evaluation version, was followed by another sentence: 'Don't squeeze too much text in a small space'. Students considered the sentence irrelevant, so it was removed.

Although the heuristics were regarded as clear and easy to follow (see sub-chapter 4.4), the students suggested some clarification for some heuristics, such as H3, 'Favour sans serif fonts, such as Verdana or Arial'. The heuristic had an explanation ('Verdana is one of the most popular and aesthetically pleasing fonts designed for on-screen viewing. Arial is slightly faster to read'), but a clarification of why sans serif fonts are preferred was required. Another clarifying sentence was therefore added: 'Sans serif fonts are simple, so they are clear and easy to read online'.

The third theme in the students' responses dealt with repetition. For example, the explanation of H2, 'A larger font sizes improve online readability', contained information about font sizes in the evaluation version ('Larger font sizes, such as 18-26, […]'. It was considered repetition, as the heuristic was already informing about font sizes: 'Use font sizes 18-26 for online content and 22-26 for headings, depending on the heading level'. Regarding flawlessness, the students did not report any writing or factual errors. As stated above, their findings and suggestions were related to word choice.

Except for H11, all the proposed heuristics had some suggestions for improvements. Using the findings from the first iteration, we revised and updated the heuristics and moved on to the second design iteration, as described in the following sub-chapter.

4.3 Findings from the second iteration (interviews)

The first impression of all the participants regarding the proposed heuristics was positive

> 'clear and nice structure; if I need help in content, I just refer to points 11-15 (P1)
>
> It looks good; it's nice that you have instructions first and then an explanation of why they should be done (P2).
>
> Clear and simple! But there are a few things I hope to have more information on (P3).

In the interviews, we discussed each heuristic one by one and asked for the interviewees' opinions on each of them. We asked whether they were easy to understand and easy to implement. The interviewees were also asked to provide suggestions for improvements. In the case of H10, P1 suggested providing more concrete instructions on how to formalise a link in the text. Based on experience, P1 suggested underlining the text and using the blue colour in the links. In addition to H10, P3 suggested naming the link that indicated the name of the website. Related to H1, P3 suggested additions to the description to avoid the use of bolding in titles, which is a common mistake. To respond to the suggested additions, we modified the explanation of H1 by adding 'Do not use bolding to indicate titles…' to the instruction, and for H10, we verified this suggestion by referring to the guideline for visualising links by Nielsen (2004); it states that underlines and the blue colour are the strongest perceived affordance of clickability. Responding to requirements to provide concrete instruction, we decided to define

the heuristic more closely, adding 'with underlined blue colour' to the instruction and 'or the name of the website' to the explanation.

4.4 Results of the evaluations

We conducted the evaluation during the workshop, after it and during the interviews. The questionnaires in the workshop contained only open-ended questions because these were likely to elicit novel and unanticipated responses. In the evaluation after the workshop, we refer to the reflection papers written by the students after the workshop (see 3.3). In this chapter, we refer to them as post-workshop reflections.

In the following, we describe the evaluation in more detail. We present the results of the evaluation concerning the validity, utility, quality and efficacy of the heuristics. We illustrate the results by providing examples of the answers representing the majority of the responses.

Validity: In the questionnaire, we asked, 'How did it feel to use the list? Was it, for example, easy, nice, fun, difficult, complicated...? Justify your answer'. Thirty respondents (N = 31) felt positively about the heuristics. They described the list, for example, as easy and clear:

> The list was easy to use, and it controlled the viewing of the page well. It was clear, and the descriptions helped find concrete things in the text.

The respondents also described the list as nice and useful:

> [It's] nice, and the list makes the job easy. Definitely a good tool for those who do accessibility work. Without a list, the job can feel really big, and it can be hard to get a grip. [It's] a very useful list'.

One respondent reported that the list was difficult to use:

> The list was difficult to keep track of because of its layout; the use of colours could help structure different areas.

The third theme in the interviews with the three practitioners (P1-P3) considered the importance and feasibility of the heuristics. We asked, 'How would you rate the value

of the guidelines? Would they be an added benefit to your work? The practitioners answered the following:

> The list is good; we have one infographic about accessibility in our organisation, but it's too plain. This list is good and gives instructions for a certain level of accessibility (P1).'

> Yes, sure, it's good… It helps a lot. All the things that it contains are important (P2).

> Good checklist! The web is full of instructions, longer and shorter. Are they reliable? They're good to place on the wall of the office and check if I have now taken them into account. I could think of keeping the instructions in my office room. The good thing is that there are instructions on what to do and then descriptions, especially for people who may not be familiar with accessibility issues (P3).

In the post-workshop reflections, the students (N = 31) commented on the feasibility of the heuristics. All respondents considered the heuristic list useful. In their responses, the list was characterised as a *guiding principle* or *aid*. According to these responses, the heuristics also worked well in creating textual web content and not just in evaluating it.

Utility: To the question 'How well did the heuristic list help you in making the assessment? Would you have passed the evaluation without the list?', all the respondents (N = 31) said that the heuristics helped them in conducting the accessibility assessment:

> Very much. Assessing accessibility would have been much more challenging without it. I would probably have first searched Google for some sort of list/piled up ripped data so that I'd come close to the same result. So, it greatly speeded up and facilitated the process.

Most of the respondents (61%) said that without the heuristics, they could not have made the assessment, or the results would not have been so accurate:

> I wouldn't have performed without the list. It was a lot of help in breaking down the evaluation into details.

In the interviews, we also asked whether the practitioners would use the heuristics. As a sample, they answered the following:

> [When] in a hurry and when you have a lot to do, then such a guideline would be useful. Certain things go easily once you have done them before (e.g., font and line spacing). The instructions are specific enough that the user knows what to check (P1).

> It's good to have instructions in place, especially in organisations that produce a lot of content (P2).

> Yes, and I would share it with others (P3).

Quality: The assessment of quality (N = 30) of the heuristics was divided into flawlessness and consistency of the heuristics. As for flawlessness, we asked, 'Did you notice typos or factual errors in the text content? If so, what kinds?' Four respondents recommended different word choices for one heuristic, which was fixed.

As for consistency, we asked, 'When using the list, did you have to correct an assessment you had already made about the content of the website, for example, after noticing that an item you were evaluating only came up later in the list?' Sixteen respondents answered that they performed without any problems:

> There were no points in which I had to jump over them or go back.

Six respondents found contradictions in the guidance or heuristics that excluded others:

> Yes, heuristics 1 and 10 are a bit mutually exclusive if you think you'd like the listener to notice the links, as well. Heuristic 1 instructed avoiding all highlights, and heuristic 10 instructed taking advantage of them.

Therefore, we made additions to the description of H10 to provide more detailed information on how to highlight links. Four respondents commented on the order of the heuristics:

> I had to at one point; for example, when the font was being processed, I corrected an earlier point about highlights.

However, these corrections were made to the revised version, and because of their clarity, further assessment was not needed.

Efficacy: The assessment of the efficacy of the heuristics was divided into learnability (N = 31) and memorability (N = 30).

As for learnability, we asked, 'How quickly were you able to leverage the heuristic list to assess the accessibility of textual web content? For example, did you initially have to spend time perceiving and understanding the heuristic list, or did you use it to start the evaluation quickly?' Twenty-five respondents said that the heuristics were fast to use and easy to understand:

> I was able to start the evaluation immediately. Overall, there was a good level of understandability.

Two respondents said that the heuristics helped them learn about accessibility at the same time. Five respondents reported needing time to understand the heuristics before using them:

> It initially took some time to grasp the list of heuristics, but I got to the point well; after that, it was easy to use it to assess online content.

For memorability, we asked, 'Evaluate how the heuristic list supports memorability. Imagine you are working for an organisation in the summer. Your job is to improve the accessibility of online content, and you want to start the task by evaluating existing online content, although the heuristic list is not available. What things on the heuristic list could help bring things to mind? Is there something missing that could make it easier to remember?' Twelve respondents recommended visual additions to the heuristic list presentation (e.g., use of colour coding by theme, icons in the titles or a symmetric layout). No one suggested improvements to the content of the heuristics:

> I think the list is made easy to remember when things are broken down by theme. A more visual look could help with memorability.

These results are in line with those of the reflection papers, as all suggested improvements related to layout. In this study, we scoped the development to concern only the content of the heuristics, not the layout.

4.5 Proposed heuristics for accessible online text production

As a result of the two design iterations and as an answer to our research question, we proposed a total of 15 heuristics to improve accessible online text production. The heuristics are meant for content creators in public organisations to achieve or enable text accessibility for users with disabilities on a website and thus foster the principle of equal access for all.

The heuristics may also be used as a self-assessment tool for the same purpose. The heuristics are a combination of three categories: text formatting, text structure and text content. The instructions and explanations of the proposed heuristics are presented in Table 4.

Heur.	*Instructions*	*Explanation*	*Category*
H1	Emphasise verbally the important points you want to make. You may also use bolding or colours for emphasis, but do not use bolding to indicate titles.	The reader may only listen to your written text, in which case the emphasis or use of colours is ignored.	Formatting
H2	Use font sizes 18-26 pt. for online content and 22-26 pt. for headings, depending on the heading level.	Larger font sizes improve online readability.	Formatting
H3	Favour sans serif fonts, such as Verdana or Arial.	A sans serif font is simple, so it is clear and easy to read online. Verdana is one of the most popular and aesthetically pleasing fonts designed for on-screen viewing. Arial is slightly faster to read.	Formatting
H4	When you list things, use bullets or numbers. Try to avoid using multi-level lists.	By using bullets for main topics, you help readers scan your content and identify key areas. Multi-level lists can be confusing.	Formatting

Heur.	*Instructions*	*Explanation*	*Category*
H5	Make the text airy. Adjust the line and paragraph spacing.	Readability increases if the line spacing is 1.5 and the paragraph spacing is twice the font size.	Formatting
H6	Align text to the left.	Text aligned to the left margin makes it easier to find the start of the next line.	Formatting
H7	Pay attention to the contrast between the text and the background.	To improve readability, you may use light tones of warm colours for the background.	Formatting
H8	Use headings (H1, H2, etc.) consistently. Avoid sub-sub-headings (e.g., 1.1.1.1).	Do not use headings to increase just font size, as headings are meant to divide content into meaningful sections. Headings are important for screen reader users to navigate a page according to its headings.	Structuring
H9	When you add images using information, explain their message in the textual content. This way, the screen reader user gets the same information, too.	If the image is not described in the text content, you can describe it in about 100 character-long alt text (in image properties). When a screen reader finds an image, it reads out the content of the alt tag.	Structuring
H10	Separate links from other content with underlined blue colour, and use text that properly describes where the link will go.	Name links according to the action that will occur or the place or name of the website to which the user will be taken (e.g., 'Go to calendar').	Structuring
H11	Use clear and simple language.	Use common everyday words and avoid the use of jargon whenever possible.	Content

Heur.	*Instructions*	*Explanation*	*Category*
H12	Provide the full meanings of abbreviations and acronyms at their first use.	Abbreviations and acronyms should be defined in full. The exception is established abbreviations, which may not even be recognised when written out (e.g., DVD).	Content
H13	Provide the most relevant information first. For long texts, provide a short summary of the content at the beginning.	The content is easier to perceive when the most important information is placed on the top of the page.	Content
H14	Prefer short sentences and avoid complicated sentence constructions.	Short sentences help readers understand the content better. Express one idea in one sentence.	Content
H15	Use *you* when addressing the reader.	This way, readers feel that the text is speaking to them.	Content

Table 4. Online text accessibility heuristics

Formatting text

Our proposal contains seven heuristics (H1-H7) related to text formatting.

(H1)*:* It is important to consider that the reader may focus only on the written text, in which case emphasising with text bolding, using italics or using colours is irrelevant. It should also be noted that using only bolding to indicate a title does not make it a title structurally. Pointing out important information verbally benefits people with limited colour vision, people who use Braille or screen magnifiers and people who have difficulties understanding cues or messages between colour and text (W3C, 2018).

(H2): According to a study by Rello et al. (2016), larger font sizes, such as 18-26 pt, help improve readability, overall, when reading from the screen, and this is especially true for people with dyslexia or people with a lower level of visual impairments (W3C, 2018). It should also be noted that different fonts of the same size may look different in their actual size. **(H3):** Rello and Baeza-Yates (2013) showed in their study that different fonts have pros and cons, so recommending one is difficult. According to their

research, Arial, for example, is faster to read, but Verdana is more pleasant looking and popular (Rello & Baeza-Yates, 2013). As a general rule, it is recommended to use an endless font (i.e., sans serif or grotesque fonts, such as Verdana and Arial, which both significantly improve readability for people with dyslexia (Rello & Baeza-Yates, 2013).

(H4): Using bullets for main topics or for the main information helps readers scan the content and identify key areas. However, multi-level lists can be confusing and are therefore not recommended. Chen et al. (2015) reported that using bullets to present important information contributes to the perception of content and the comprehension of important information, thus supporting learning, especially for people with dyslexia.

(H5): Rello et al. (2012) considered the *airiness* of the text (i.e., line spacing, spacing of text paragraphs and spacing of letters and words) to be more important than the choice of fonts. As a solution, readability will improve if the line spacing is at least 1.5 and the paragraph spacing is twice the font size. Chisnell et al. (2006) recommended avoiding overcompressing content.

(H6): According to plain language printing instructions, instead of justified text, only left-aligned text should be used. Left-aligned text helps readers perceive the transition from one line to another (European Agency for Special Need and Inclusive Education, 2015; Plainlanguage.gov, 2011).

(H7): As a result of the first design iteration, guidance regarding the appropriate background colour was needed in addition to the proposed heuristics. According to Rello and Bigham (2017), the use of light tones of warm colours for the background improves readability for people with dyslexia.

Structuring the text

Our proposal contains three heuristics (H8-H10) related to text structure.

(H8): The PSs placed the major quantitative emphasis on issues related to navigation, as well as on the title structure of the text. Heading levels should be used sequentially and logically to facilitate navigation. Headings should not be used only to increase font size, as headings are meant to divide content into meaningful sections. Sequentially and logically used headings benefit people with cognitive disabilities, limited short-term

memory, visual disabilities and severe mobility impairments, as well as people who use audio for navigation (W3C, 2018).

(H9): The PSs placed the greatest quantitative emphasis on issues related to the alternative text. According to the WCAG, alt text should only be given to non-text elements, such as images, charts, videos and audios, if they are used to share particular information (W3C, 2018). In the HTML structure, the recommended length for alternative text is about 100 characters maximum (W3C, 2018). This poses a challenge for content creators if there is much information in an image. Therefore, we recommend that all information be written in the body text. If images or other elements are used alone without explanatory texts, they should be described with alternative texts using about 100 characters. Repeating the same information in the text and alt text is unnecessary. The information presented should be the same, with or without the capability to interpret images. The use of alternative text is identified to benefit people with difficulties in perceiving visual information, understanding the meaning of images or perceiving or understanding audio information, as well as people who use Braille (W3C, 2018).

(H10): The PSs strongly emphasise the importance of naming links in the text; links should be presented with an action word, such as 'Go to calendar', which tells readers where the link leads. We also recommend using the colour blue and underlining to separate the link from the text because these have the strongest perceived affordance of clickability (Nielsen, 2004).

Content of the text

Our proposal contains five heuristics (H11-H15) related to formulating content.

(H11): The choice of the appropriate language for the target group includes the idea that the author always keeps in mind who is reading their text (Union, 2012). The requirement for clear and simple language is also familiar in usability studies, in which clear and simple language has been found to promote comprehensibility, including in specialised fields (Richardson et al., 2017). Clear and simple language also means avoiding professional slang or jargon, as it is often difficult for outsiders and the public to understand (Union, 2012). The PSs encourage the use of the simplest possible language appropriate to the document. This means the use of familiar, everyday words and avoiding expressions whose meaning cannot be inferred from the meaning of individual words. For texts addressed to the public (i.e., wide heterogeneous groups), we suggest

using common everyday words and avoiding the use of jargon whenever possible to benefit especially those people who have difficulty comprehending and interpreting written language (Plainlanguage.gov, 2011; W3C, 2018).

(H12): Abbreviations and acronyms should be written in full. The exception is established abbreviations, which may not even be recognised when written out (e.g., DVD = digital video disk). Abbreviations should be used with caution and defined in full for at least their first mention (European Agency for Special Needs and Inclusive Education 2015; Union 2012). This benefits people who have difficulties decoding words or using context to aid understanding, people with limited memory and people who use screen magnifiers (W3C, 2018).

(H13): ICT4IAL recommends adding short summaries of the content or paragraph (European Agency for Special Needs and Inclusive Education 2015) but does not indicate the place of the summary. We suggest providing a summary at the beginning of the text, as it gives readers an idea of what the following text contains (Union, 2012).

(H14): Short sentences, in which one important thing is expressed per sentence, help ensure that the text does not become too complicated (Plainlanguage.gov, 2011). This is vital for online content, as short sentences make it easier to find the main points of the sentences. Short sentences help readers better understand the content.

(H15): Addressing text to the reader, the you-form or the active voice is one way to increase text comprehensibility (Plainlanguage.gov, 2011). As a result, readers feel that the text is speaking to them.

5 Discussion and concluding remarks

There is an urgent need for clearer and easier-to-use guidance for accessible text production in public organisations. Content creators do not have appropriate accessibility guidance in use for text production, despite reading remaining one of the most common ways to perceive information on the web (Rello et al., 2016). Existing accessibility guidelines are often scoped to web accessibility and thus provide appropriate guidance mainly to webmasters and web developers, whose main responsibility is the development and maintenance of websites. Content creators need to adopt these practices, which may be confusing or difficult. However, textual content is one of the most important channels for sharing information (Kalender et al., 2018). In this study, we

therefore provided improvements to accessibility guidance for textual online content by creating a proposal for accessibility heuristics for text production.

We extracted factors that improve text accessibility from the PSs (see Table 3). The PSs contained relatively few instructions related to text issues (PS1: four, PS2: two, PS3: two, PS4: four, PS5: five, PS6: eight, PS7: eleven). From this selected set, WCAG 2.1 (PS6) and ICT4IAL (PS7) provided the greatest number of instructions. Compared with the proposed heuristics, WCAG 2.1 does not provide detailed instructions relating to (1) font size (see H2), (2) font selection (see H3), (3) use of bullets (see H4), (4) text alignment (see H6), (5) order of content by importance (see H13) and (6) summary provision of content (see H13), but these factors significantly improve readability and support the learning of people with dyslexia or those with lower levels of visual impairments (Chen et al., 2015; Rello et al., 2016; Rello & Baeza-Yates, 2013). Some of the instructions in the PSs are repetitive, but many have been provided only once. As an example, WCAG 2.1 provides very detailed instructions for letter and word spacing in the system preferences, which are difficult to implement for content creators because of access to these preferences. In the workshop, the participants used the Moodle text editor with basic text editing features that are similar to those of other content management systems in public organisations. However, ICT4IAL does not provide any instructions for text spacing. We therefore ended up with a solution that is practicable for content creators in their context. The comparison of ICT4IAL with other PSs shows that it differs only in two instructions—the provision of precise line spacing and the instruction on information order. Based on the PSs, ICT4IAL is the most comprehensive, but it lacks detailed practical guidance on how and why to implement it, which emerged as a crucial need of the workshop participants to which the presented heuristics responded.

Our proposed heuristics differ from the PSs in their provided contributions. First, the result of the literature review divided the proposed heuristics into categories: *formatting*, *structure* and *content.* The workshop participants, as well as the content creators, reported that the categorisation helped them perceive and understand the structure of the heuristics. It also aided them in focusing on particular areas for which they needed help. Second, the proposed heuristics were derived and formulated based on the PSs, supplements, the results of the design and evaluation workshop, and the results of the evaluation made with content creators. Unlike the guidance provided by the PSs, the proposed heuristics were designed to solve the difficulties that content creators in the public sector may face when producing online text. Many of the related studies contributed guidelines for improving the readability or accessibility of online text reporting guidelines that considered the needs of dyslexics (Li et al., 2019; Miniukovich et al., 2017; Rello et al., 2012). The proposed heuristics aim to improve text accessibility for a

wide scope of users' needs. Therefore, beyond the needs of dyslexic heuristics, they also covered the needs of people with difficulties in understanding content or cues (cf., H15; H9; H1), people with limited memory (cf., H12) or those with difficulties in perceiving visual information (cf., H1; H9; H12).

The effects of the proposed heuristics are based on evidence from the literature. Implementing these heuristics makes text easier to perceive and written language easier to navigate, read, interpret and understand; heuristics help make the interaction more usable. However, the implementation of the heuristics and their effects on improved usability are not discussed in this paper and require further research.

In terms of significance to practice, existing guidelines are confusing, difficult to implement and too technical; they are inappropriate for most content creators. Based on the presented results, the proposed heuristics are clear, easy to understand and useful. When formulating the heuristics, we ensured that they are easy to use (i.e., they are clear and simple and thus immediately usable as such). Unlike using the WCAG, applying these heuristics does not require knowledge of HTML. The heuristics respond to the need that emerged as a result of the legal obligations imposed on the accessibility of websites in public sector bodies. It should be noted that the heuristics presented in this paper do not meet all legal obligations regarding accessibility, as only the accessibility of textual online content was addressed here. However, it should be noted that legislation, for example, the EU directive, recommends following the WCAG middle-level AA, ignoring all AAA-level guidance, even if it has a significant impact on understanding words and phrases and on decoding words (W3C, 2018). In the AAA level, the WCAG give guidance for unusual words, abbreviations and reading, which all are considered in the proposed heuristics as crucial points when creating accessible text content.

This study also has implications for design knowledge. In the development process, we involved possible users in two rounds: first, in the workshop for developing the heuristics and, second, in the ex ante evaluation (Sonnenberg & vom Brocke, 2012).We assessed and re-formulated the heuristics with university master's-level students who were *on the crest of a wave* of their studies in technical communication, meaning that they were recently introduced to the topic. They also had some experience in website design and content creation, and almost everyone had work experience in companies or public sector organisations. Therefore, the students were regarded as intermediate content creators. The focus in the workshop was on the content and formulation of the heuristics, their usability and their utility.

Second, we involved content creators to assess feasibility as an ex post evaluation (Sonnenberg & vom Brocke, 2012). The participants had different years of work ex-

perience in content creation, from 4 years to 15 years. Both sessions gained valuable contributions in tackling domain-specific concerns.

As a methodological contribution, involving possible users in the development and evaluation of the heuristics from two groups with different perspectives; students who evaluated learnability, utility, memorability, flawlessness and consistency of the heuristics; and content creators who evaluated importance, feasibility and utility to practice, can improve robustness because the formulation of the heuristics and domain-specific concerns are already considered in the development process. Moreover, we found it important that solutions should be evaluated not only by their means of effectiveness but also by their feasibility; they are formulated so that they respond to the problem in the problem's context.

5.1 Limitations and future research

This study has its limitations. Our PSs consisted only of research found via Google Scholar with a certain search term and string. The use of alternatives in search terms and various databases may provide a broader knowledge base. However, to supplement the search results, we added WCAG 2.1 and ICT4IAL guidelines to the PSs. Although the PSs contained only seven studies, we believe that they represented the best practices in the field, as these studies contained 10 separate sets of guidelines for web accessibility, including major guidelines, such as the WCAG, Section 508 Web Standards and IBM web accessibility heuristics, amongst others (see Table 2). We scoped voice and video content and mobile applications beyond the heuristics. However, it should be noted that the first means to improve the accessibility of audio and video formats is to provide text alternatives and captions that require text production (European Agency for Special Needs and Inclusive Education 2015; W3C 2018). The proposed heuristics are general in nature and do not consider different text genres. The heuristics are designed for Western writing systems, which means that they need to be modified for other writing systems.

We identified emerging problems from the iterations for future research. The workshop participants reported on the requirements for the presentation and layout of the heuristics that we scoped out from this study. As a preliminary solution, the workshop participants suggested features for the layout (e.g., icons, colours and mnemonics) to improve their learning, memorability and motivation to use the heuristics. How the implementation of the proposed heuristics affects usability also requires empirical research. This study serves as a starting point for the future development and testing of the proposed heuristics.

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