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Haze in the digital library: design issues hampering accessibility for blind users

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Abstract

Purpose – The purpose of this study is to explore design issues hampering the accessibility of digital libraries (DLs) for first-time blind users.

Design/methodology/approach – A combination of questionnaire, pre-interview, think-aloud and post-interview methods was used to collect data on non-visual interaction experiences with American Memory Digital Collection (AMDC) from 15 blind participants. Qualitative analysis via open coding revealed recurring themes on design problems and consequent difficulties for blind users in accessing DLs.

Findings – It was found that AMDC is not blind-friendly. Five categories of design problems were identified. Participants faced difficulty perceiving, operating and understanding content and controls needed for information retrieval.

Research limitations/implications – This paper does not offer a comprehensive set of design issues prevalent across DL design models, instead it focuses on design problems observed in a publicly available DL.

Practical implications – This paper raises awareness of design choices that can unintentionally bar blind information seekers from DL access, and further suggests solutions to reduce these design problems for blind users.

Originality/value – The paper's originality is its identification of unique design problems that prevent blind users from effectively interacting with DLs.

Keywords Digital libraries, Accessibility, Information retrieval, User studies, Web accessibility, Systems design, Problems, Adaptive technology, Visually handicapped

Paper type Research paper

Introduction

Digital libraries (DLs) have emerged as a new and complex information retrieval (IR) system affording easy access to a variety of digitized resources (Hariri and Norouzi, 2011). Consequently, public libraries, museums and other cultural institutions are increasingly offering digitized collections of images, books, audio-recordings and videos (Matusiak, 2012). DLs have particular significance for blind and visually challenged people, as these could potentially offset the disadvantage of visually encoded information. However, realizing this potential is contingent on DL accessibility. Here, *accessibility* represents the perceivability, operability and understandability of content and features of the DL interface by listening to the screen-reader (SR) renditions. Blind people predominantly rely on SRs for non-visual interaction with computers and smartphones. This research is concerned with DL accessibility for blind information seekers without DL experience. Universal access is



the objective for DLs (ARL, 1995). Approximately 285 million people around the world are blind (WHO, 2010). They comprise an atypical population that interacts with digital resources by listening to information verbalized by the SR. The sight-centred design of digital resources presents challenges in SR-mediated interaction (Babu and Singh, 2013). DLs are highly complex by nature, as content is heterogeneous in format and system dimensions (O'Day and Nardi, 2003). This complexity and sight-centeredness makes IR tasks significantly challenging for blind DL users (Xie *et al.*, 2015). With increasing digitization, it is imperative for designers and librarians to ensure accessibility of information resources for blind users (Kumar and Sanaman, 2015). Therefore, the question arises: How can a blind-friendly DL environment be provided?

The *Web Content Accessibility Guidelines* (WCAG) (W3C, 2005) addressed Web page interoperability with the SR. WCAG compliance is necessary but not sufficient to create a blind-friendly digital environment (Babu and Singh, 2013). A user-centred knowledge of blind information seekers' needs, abilities and challenges is needed. However, a dearth of research in this area creates a knowledge gap about blind-friendly DL environments. Exploratory research must investigate the design problems that hamper DL accessibility for novice blind users. The motivation for this research is to design more accessible DLs for blind users.

This paper investigates the following research question:

RQ1. What design problems hamper DL accessibility for novice blind users?

Here, *novice user* refers to blind users who have not accessed DLs before this study. It reports results of an exploratory study with 15 blind participants using the American Memory Digital Collection (AMDC) (<https://memory.loc.gov/ammem/index.html>). Qualitative analysis revealed five design problem types that reduced perceivability, operability and understandability of the AMDC's content and features and hampered participants' ability to retrieve information. The methodological approach is useful to conduct a more wider-scale investigation to generate a comprehensive set of design problems and their consequent impact on DL accessibility for blind users. This is necessary to create design guidelines on blind-friendly DL environments.

Literature review

Blind users and online information search

For the blind user, Web interaction is a listening activity made possible by the SR (Xie *et al.*, 2015). Arriving on a Web page, a user typically hears three announcements: the percentage of page content downloaded, title of the page and composition of the page in terms of interface objects (e.g. "Page has three frames, two headings, 20 links, etc."). The SR continues by verbalizing every bit of text information on the page serially from top left to bottom right. However, many users prefer listening to the page in chunks, rather than this continuous audio stream (Babu and Singh, 2013). A chunk could be a word, line or paragraph of text, or the label of an interface object (e.g. hyperlink, button, image). Arrows, either individually or in combination with Control, Insert or other keys, represent the most common keyboard shortcuts to read chunks of text (Babu and Fuller, 2015). Common page navigation shortcuts include H (to navigate by section headings), Tab (to navigate by hyperlinks) and CTRL + F (to move to specific words or phrases) (WebAIM, 2014). Numerous other commands are available for a multitude of operations, but blind users typically use just a handful of them (Leuthold *et al.*, 2008). Babu (2013) explains that the SR renders text content in audio, but is unable to effectively translate information embedded in

graphics or the layout. Therefore, blind users *see* only a part of the information conveyed by a Web page. This description of a non-visual Web experience is intended to help the reader understand how a blind user might engage with a digital resource.

Scant research has been done on the information-seeking behaviour of blind people on the Web. It has found that searching for information online without sight is quite challenging. Chandrashekar (2010) noted that this non-visual information search on the Web is very complex, demanding higher cognitive effort from blind users. Xie *et al.* (2014) further pointed out that cognitive overload results in trying to interpret the browser, the website and the SR simultaneously, all the while being forced to hear repetitive information across pages. Jones *et al.* (2005) found blind users are challenged to:

- perform actions (e.g. typing and executing key commands);
- recognize the website's state;
- perceive the website's response; and
- examine the page for relevant information.

Sahib *et al.* (2011) reported that, compared to their sighted counterparts, blind users are likely to enter fewer queries, use query and spelling suggestions less frequently and explore search results in a limited way. Only a few studies have examined the DL experiences of blind information seekers (Xie *et al.*, 2014, 2015). This body of literature explains that blind users seek help to:

- identify, understand or evaluate information;
- identify current location or path; and
- understand or use special DL features.

However, owing to a focus on help-seeking situations, this literature does not distinguish problems related to DL accessibility from those related to other design factors.

Accessibility problems of digital resources

It is widely believed that the Web is sight-centred by design and, thereby, it presents significant problems for blind users (Babu, 2013; Leuthold *et al.*, 2008). Bigham *et al.* (2007) described dynamic technologies including AJAX, JavaScript and Flash as problematic. Lazar *et al.* (2007) identified six design problems that can frustrate blind Web users:

- (1) complex page layout generating erratic SR feedback;
- (2) SR-incompatible Web applications;
- (3) unlabelled and unorganized forms;
- (4) visual items without alternative text descriptions;
- (5) misleading links; and
- (6) inaccessible PDFs.

Leuthold *et al.* (2008) pointed out four issues that hamper Web navigation:

- (1) visual orientation of navigation elements;
- (2) navigation and interpretation cues conveyed via colour, graphic or video;
- (3) navigation options repeated across pages; and
- (4) multiplicity of navigation options.

In addition to previously identified design problems, [Kumar and Sanaman \(2015\)](#) noted that extensive images, hyperlinking and advertising also have a negative impact on the accessibility of Web resources. Accessibility of digital resources also extends to online learning environments, as [Babu \(2011\)](#) highlighted the six design problems that hinder accessibility of online quizzes:

- (1) pages with frame-based structures;
- (2) link activations without feedback;
- (3) selection controls without keyboard navigation support;
- (4) pop-ups on alert dialogue boxes;
- (5) toolbars with multiple text formatting tools; and
- (6) input areas with inappropriate labels or cluttered surroundings.

While previous research discusses blind users' online search experience and preliminary understanding of potentially problematic Web design, there is still a lack of clarity on the perceivability, operability and understandability of DL content and controls needed to retrieve information for novice blind users. It does not clarify what design problems impede blind users' access to DL content and controls needed for IR.

Methodology

The unexplored and contextual nature of DL access for novice blind users and associated design problems calls for a qualitative approach to guide subsequent research in this stream ([Aizpurua *et al.*, 2015](#)). Accordingly, the present study adopted the qualitative approach to investigate the proposed research question. An exploratory study design was used with 15 blind participants without DL experience.

Participants, sites and tasks

For this study, an appropriate investigation required blind individuals, who had more than three years' experience in online information search, but absolutely no DL experience, to be reliant on the SR. Because there was some difficulty in recruiting this low-incidence population, vocational and rehabilitation (VR) centres for the blind in multiple cities were contacted. In total 15 blind individuals, comprising eight males and seven females (mean age = 32 years), suggested by the VRs, were recruited. Each reported having some college education. Ethnically, they consisted of nine Caucasians, four African Americans, one Hispanic and one Asian. While four reported congenital blindness, the rest had acquired blindness later in life. All of them had used the internet non-visually on a Windows PC with JAWS SR for more than 10 years at the time of the study. Each reported browsing the Web at least once a day, typically for e-mails, information search, current affairs and health and well-being. When asked to rate their information search skills, five reported an advanced level and nine reported an intermediate level, while only one reported a beginner level. None of them reported experience in DL use. They received \$100 as compensation and travel support. The site for the study was the usability lab at a state university.

The study computer has JAWS SR, Morae software and the Internet Explorer browser loaded on it. The AMDC was selected for the study because it contains American historical materials in which blind participants are interested. The three online search tasks enumerated below represent a variety of typical tasks that blind participants might perform in their daily life:

- Find the letter written by Alexander Graham Bell to Helen Keller dated 23 March 1907. Use two different search approaches – keyword search and browse.
- Find when President Abraham Lincoln and President James A. Garfield were assassinated and how they were assassinated.
- Identify at least two issues regarding immigration policy in the USA, using as many sources from the AMDC as you can. Each issue you identify should have a different source.

Data collection

Multiple data collection methods were used to collect data: pre-questionnaire, pre-interview, think-aloud and post-interview. This study focuses on the pre-questionnaire and think-aloud data. The pre-questionnaire included items on demographics, blindness, technical background (computers, SR, internet and DL), and level of information searching skill. The think-aloud data recorded participants' thoughts during their search process interacting with the AMDC. Each participant had an opportunity to practice thinking aloud while exploring the different AMDC pages for ten minutes. Each participant performed the three IR tasks using the AMDC. She was prompted to "keep talking" whenever pausing for more than 10 s. The typical length of a study session was 135 min. Each session was audio-recorded to capture participant utterances, JAWS announcements, system-generated audio cues and observer queries. Audio-recordings of all the search sessions were transcribed to generate 368 pages of text in Word format.

Data analysis

Transcripts were analysed for recurring patterns in the data (Miles and Huberman, 1994). Through an open-coding process, codes were derived inductively. Two independent coders reviewed the transcripts, decomposed them into segments (units of thoughts) and applied meaningful codes to each segment. A segment could be a word, sentence, paragraph or passage. Meaningful codes had direct relevance to a design problem that was seemingly counter-intuitive to SR accessibility and created difficulty for participants. The coders exchanged their codes with each other. Each purposefully raised alternate explanations to challenge the other's interpretations and disagreements were resolved through discussions. This continued until consensus was reached on the codes. Following Mayring (2002), the assigned codes were bundled with regard to content and summarized in a category system. This yielded five DL design problem types. To avoid overlapping, the definitions and examples for each design problem is presented in Results section.

Results

Analysis of the verbal evidence generated a category system comprising five themes on problematic DL designs:

- (1) Lack of meaningful text descriptions for multimedia content and format.
- (2) Lack of meaningful labels or instructions for DL features.
- (3) Lack of meaningful labels for hyperlinks.
- (4) Lack of descriptive section headers in organizing content.
- (5) Lack of an explanation mechanism for jargon.

The following presents results relevant to each theme describing the design errors, illustrative examples of their manifestations in the AMDC interface and consequent challenges for participants. Supportive evidence is provided using quotes that capture exemplar blind-user DL interactions. Quotes comprise participant utterances (enclosed with double quotes), SR announcements (enclosed within angular brackets), OS-generated sound effects (enclosed within square brackets) and observer utterances (enclosed within curly braces). Asterisks are used to point the reader to relevant parts of the quotes from the text.

Lack of meaningful text descriptions for multimedia content and format

Analysis revealed several instances where non-text content (e.g. broadside, scanned papers, images) lacked meaningful text descriptions. For example, broadsides were not described textually to be perceptible non-visually. Consequently, participants could not *see* what information they communicated. [Figure 1](#) includes quotes capturing the experience of Participant P1. The scenario is when P1 is surveying an area around a broadside with the arrow key.

[Figure 1](#) illustrates how lacking text descriptions made information conveyed by broadsides imperceptible. Another non-text content without meaningful description included a scanned historical document (letter or newspaper cutting). Such documents remained imperceptible and unreadable for participants. [Figure 2](#) presents evidence of this problem experienced by participant P12. The scenario is when P12 examines the page titled “George Washington Papers at the Library of Congress” looking for the transcript of a particular paper.

[Figure 2](#) illustrates how missing or hiding transcripts in text format makes the text in scanned letters simply invisible. These and other contexts of non-text content without meaningful descriptions represent problematic design choices for accessibility of images and scanned documents.

Another case of problematic instruction was cues on item format. Recognizing item format assumes significance for blind users who deem graphical items worth ignoring. Such imperceptible instruction compelled participants to spend additional time and effort trying to recognize the item format before determining if it merits further examination. [Figure 3](#) captures evidence of this problem experienced by Participant P9. The scenario is when P9 examines the content of a page presenting multiple graphical items.

```
"I am trying to find an accessible version of these broadsides."
<link text.>
"I'm clicking on text."
<Enter.>
<Text link. [New page loads]. How to view left paren American memory from the library of Congress right paren. . . . Blank. Table with 4
columns and 6 rows. Doc. About the format. Viewers. Samples. TIFF left parenth. Used for original page. Dash Windows TIFF viewers. Blank.
Link Alternatiff. Blank. Link InterneTIFF. Blank. Link Irfanview. Blank. Link Quick View Plus. Blank. Blank.>
"Some of these viewers are likely to be inaccessible to screen readers, but . . ."
<Dash Mac TIFF viewers OSX colon locate quote preview quote on your computer. Blank. Link graphic converter. Dash link sample TIFF.>
"See this seems irrelevant to me. I'm reading about how to view texts, I think. It's talking about things, some of which I don't know
about, and it's off. I just want to get to the information-the texts they're talking about in these broadsides. It's not that easy."
```

Figure 1.
Example 1 for lacking
of meaningful text
descriptions for
multimedia content
and format

```
"I have to see if there's an accessible part where I can access it."
<Visited link graphic ammem slash. Link prev. Link next. Link item list. Link new search. Blank. George
...
Separator. Blank. George.>
I don't believe I saw the word "transcription."
```

Figure 2.
Example 2 for lacking
of meaningful text
descriptions for
multimedia content
and format

Figure 3 illustrates how the absence of item format information prevented participants from discriminating ornate decorations (avoidable) from graphical links to articles (unavoidable). These and other contexts of sight-reliant instructions to understand and operate content represent design choices that hampered accessibility of DL items and resources.

Lack of text instruction for DL features

Analysis revealed several instances where DL features (e.g. edit field, button, checkbox) lacked meaningful labels or supplementary instruction. The context of search fields and submit buttons without proper labels or instruction is worth mentioning. Several search features for generic and specialized searches were provided without describing their specialties for non-visual cognition. The case of a search field designed for descriptive information is noteworthy. Figure 4 captures evidence of this problem experienced by Participant P7. The scenario is when P7 looks for a search field for a keyword search on the US immigration policy. While exploring a resource page, he arrives at an input field.

Figure 4 illustrates two challenges presented by the input field. First, the meaning of “bibliographic record” is not apparent in the context of a search function, thereby creating difficulty in recognizing its purpose (refer to the segment suffixed with {*}). Second, the absence of any instruction made difficult predicting the outcome of using the search function (refer to the segment suffixed with {**}).

The case of submit buttons without appropriate labelling or instruction for non-visual cognition is equally interesting. An example is the “GO” button of the search function affording suggestions that confused participants. Figure 5 captures evidence of this problem experienced by Participant P8. The scenario is that while exploring a resource page for a keyword search feature, P8 comes across the search function affording suggestions.

Figure 5 illustrates the difficulty in understanding the purpose and function of a poorly labelled search feature. Participants did not find the label “GO” descriptive enough of its purpose. And the text “Suggestion Enabled” was not perceived as instructive. These and

Figure 3.
Example 3 for lacking
of meaningful text
descriptions for
multimedia content
and format

```
<Visited link left bracket Louis F. Swift and Count James Minotto standing in front of the United States Immigration. Link Chicago Daily. 2.>
<It would be good if we knew that was a picture. It's not clear.>
<Link left bracket Mary A. Smith, standing at door of the United States Immigration Service General Offices right bracket. >
<That could be a picture right there. Or is it an article? You see, that doesn't tell us that.>
```

Figure 4.
Example 1 for lacking
of text instruction for
DL features

```
<Search descriptive information left paren bibliographic records right paren colon. Edit.>
<“Bibliographic records?” Who the heck knows. Well, I’m just going to put “policy” in. {*>
<Search button. [Bip.] Type a text. p o l i c y. >
<How horrible can it be? It can only bring me down the wrong path if it wants to. {**>
Q: Do you understand what this box is searching exactly?
No, I’m not.
```

Figure 5.
Example 2 for lacking
of text instruction for
DL features

```
<Search, edit. poetry digital format.> [boop] <Suggestions enabled. Go button.>
Suggestions enabled? What does that mean?
<Suggestions enabled. Go button. Search region end. Visited link Library of. Search go button. Suggestions enabled.>
Shall I go to [activate] “Suggestions” or “Go”? I’m not sure.
```


other contexts of using form controls without meaningful labels or instructions represent design choices that hampered accessibility of DL search forms.

In addition, the case of instruction for using browse categories to retrieve necessary information from a collection is worth noting. Several lists of browse categories spread across multiple DL pages were provided without text descriptions on browsing the collection by listening to the SR. This design choice hampered perceivability of directions on using the browse approach or a problem-solving strategy to overcoming roadblocks along the IR path. [Figure 6](#) shows evidence of this problem as experienced by participant P2. The scenario is when P2 spends considerable time and effort trying to browse a collection for a specific item without success.

[Figure 6](#) illustrates how the absence of text directions on using browse categories hampered the perceivability of instruction to effectively browse collections.

Lack of meaningful labels for hyperlinks

Analysis identified several instances where link labels did not convey the link purpose and function meaningfully for non-visual use. Such labels were either misrepresenting or ambiguous. Misrepresenting labels conveyed the wrong idea about the information resource the link pointed to. Consequently, participants were misled into exploring irrelevant pages in search of needed information. [Figure 7](#) captures evidence of this problem experienced by Participant P4. The scenario is when P4 peruses the bottom section of the “AG Bell Family Papers” page looking for cues to locate a specific letter and encounters a link labelled “Finding Aid”.

[Figure 7](#) illustrates how a poorly labelled link’s utility misled participants to examine an irrelevant page in search of needed information. They discovered the real purpose of the link only after reviewing the page content thoroughly. In contrast to a misrepresenting label, ambiguous labels presented an unclear picture of the link’s utility, sometimes obscuring it completely. Consequently, participants kept having to guess if the pointed-to information resource was relevant to the task at hand or not. [Figure 8](#) captures evidence of this problem

| “You know what would be good for this site? Something like “How to use this site”, maybe on the first page, and then it’ll say, “this is broken down to these different categories”. I think that might be good. Because, I’m not used to this and I’m frustrating myself going to... ending up in the same place and I’m not... it doesn’t seem like I’m progressing from where I need to be.

“Oh! “Finding aid”. I get it. Well that’s different way of saying “Help”, I guess. We’ll see how helpful it is.”
 <Enter> {Brings up destination page}
 <Collection summary heading level 2. Summary colon. Blank. Summary colon overview table. Blank. Table with 2 columns and 11 rows. Title. Span dates row 2. 1834 dash 1970. Column 2. Bulk dates row 3. I D no row 4.>
 “What is going on? It’s not giving what I want.”
 ↓
 <147,700 items semi colon 4 hun. Blank. Language. Collection material in English.>
 “This is not, I guess this “Finding Aid” is not what I’m wanting, it would appear.”

“Where is the home page?”
 <Visited link ammem slash index.>
 “Is that it? That’s confusing. Is that it-the home?”
 <Links list dialog. Links. Ammem slash index. Ammem slash index. Browse. About. Help. Contact. Guy slash bin slash. Ammem slash index. Ammem slash. Browse. Ammem slash index.>
 “I don’t like that, but I don’t know what to do.”

Figure 6.
Example 3 for lacking of text instruction for DL features

Figure 7.
Example 1 for lacking of meaningful labels for hyperlinks

Figure 8.
Example 2 for lacking of meaningful labels for hyperlinks

experienced by participant P11. The scenario is when P11 looks for a link to return to the home page.

Figure 8 illustrates how meaningless labels (such as Ammem slash index) made the link purpose ambiguous, creating confusion in operating them. Clearly, the two kinds of link labels – misrepresenting and ambiguous – created difficulty understanding the hierarchy of DL pages and determining their relevance. Consequently, operability of links to retrieve needed information became difficult. Links without meaningful labels represent design choices that hampered accessibility of DL resource pages and items.

Lack of descriptive section headers in organizing content

Analysis showed that content on most DL pages were organized without logical sections and descriptive section headers for non-visual use. Such poorly organized content erected barriers in performing two activities – quick verbal scan and section topic interpretation. Quick verbal scan is a non-visual practice to gain an overview of the content of a page. Blind users use the H key to jump from section header to section header when the content is organized by sections having titles marked for SR navigation. DL pages without logical sections and section headers prevented the participants from navigating by headings to take a *glance* at the page content. Figure 9 captures evidence of this problem experienced by participant P10. The scenario is when P10 activates a link labelled “View Text” expecting a text version of an image item. Hearing SR announcements, he believes the destination page has loaded. He decides to explore this new page through a quick verbal scan.

Figure 9 illustrates the frustration caused by the absence of navigable section headers on a resource page. Implicit in this frustration is the concern that examining the page for relevant information could be time-consuming and tedious. In contrast to the quick verbal scan, section topic interpretation is another non-visual practice to acquire the big picture of the information covered in a section of the page. Blind users do this by making sense of the assigned title of the section header. When sections of DL content were assigned section headers without descriptive titles, it prevented section topic interpretation. Consequently, participants could not acquire the big picture of that section to determine its relevance to the task at hand. Figure 10 captures evidence of this problem as experienced by P8. The scenario is when P8 navigates to the “Presidents” browse category page, page components summary verbalized “Two Headings”.

Figure 10 illustrates the challenge in acquiring an overview of the content of the two sections owing to the lack of descriptive titles. First, the label “Presidents” did not describe

Figure 9.
Example 1 for lacking of descriptive section headers in organizing content

```
"Let me check the headings on the page. Hit H"
<There are no headings on this page.>
"I expected headings on this page. But it told me there were none. That's not good."
```

Figure 10.
Example 2 for lacking of descriptive section headers in organizing content

```
"Two headings. I'm checking the two headings to see if one of them might be more useful than the other to avoid a search on the whole page.
Using h."
<Presidents. Heading level 1.>
"Heading 1 doesn't tell me anything." [*]
"Down Arrow"
<Link The Library of Congress. Greater. Link American Memory Home. Greater. Visited link Browse Collections.>
"This is odd. This is all up front. Header information that doesn't . . . I don't like that." [**]
"I'm hitting the header button again to see what else we have."
<Presidents colon 14 collections heading level 2.>
"Presidents. 14 collections. Uh . . ." [13 seconds silence] "That didn't reveal much. I give up."
```

the section header appropriately (refer to the segment suffixed with {*}). Hence, the participant tried finding additional cues from the surrounding. That still did not clarify the purpose of the section (refer to the segment suffixed with {**}). Finally, she skipped to the subsequent section header to see if that would make sense. Unfortunately, that wasn't helpful either (refer to the segment suffixed with {***}). Consequently, she gave up, concluding it was not possible to acquire the big picture of the page content. These and other contexts of organizing content without logical sections or descriptive section headers for keyboard navigation represent design choices that hampered accessibility of DL resource pages.

Lack of explanation mechanism for jargon

Analysis revealed several instances where jargon words and specialized terms had no mechanism for explanation. For example, browse categories were labelled as “Ephemera” and other specialized terms without defining them. Consequently, the utility of such browse categories remained unclear for non-visual cognition; participants had difficulty understanding their relevance for the task at hand. Figure 11 captures evidence of such a problem experienced by P5. The scenario is when P5 inspects the collections list under the category “Immigration, American Expansion”.

Figure 11 illustrates the meaning of ephemera that was not apparent. More importantly, a mechanism to define the term was unavailable. This and other contexts of jargon usage without definitions represent design choices that hampered accessibility of relevant DL features (e.g. browse category).

To summarize, the authors found that the American Memory Digital Collection was not blind-friendly to 15 novice users. Six design problems were identified that reduced the AMDC's accessibility for participants. These design problems hampered the ability of participants to access DL content and features for three assigned IR tasks. These design problems resulted in hundreds of interface elements that were difficult to perceive, operate, or understand by listening to the SR. They highlight the barriers erected by poorly designed interface elements that can adversely impact universal access to DL.

Discussion

Results explain that blind users perceive DL features and functions aurally by listening to their labels and other non-verbal sounds. They operate them via keyboard shortcuts. They understand them by interpreting the labels and text descriptions. When DLs are designed without consideration of these different abilities, blind users will have difficulty interacting with DLs. The following discusses how designers and librarians could address DL accessibility for novice blind users, starting with available design standards from WCAG and applying the interpretations from the present study.

Design problems, such as non-text content without meaningful descriptions and sight-dependent instruction to understand/operate content, hamper perceivability of DL features and functions. *WCAG Success Criterion 1.1.1* indicates the first perceivability problem might be addressed by supplementing non-text content with text alternatives that serve an equivalent purpose. This implies image items, such as pictures, broadsides and scanned

Figure 11.
Example 1 for lacking
of explanation
mechanism for jargon

<Broadsides and Printed Ephemera.>

“What is “ephemera?” I have no idea. Do you know if this {DL} has something like a dictionary? ”

documents, are described meaningfully for novice users. Such descriptions may be included either in Alt Attributes of items or as accompanying text so that the SR rendition conveys the embedded information effectively. This could help novice blind users *see* these items clearly when searching the DL for needed information.

Design problems in relation to the lack of meaningful labels or instruction for DL features raise the issue of how to enhance search and browsing features. *WCAG Success Criterion 3.3.2* indicates the problem of search input may be addressed by assigning input elements with labels or supplementary instruction to identify them, describing the nature of input expected, and clarifying the required input format. This implies search forms on DLs are designed such that each edit box, dropdown list, button or any other form control has a meaningful label and/or adjacent text and overall instructions that clarify purpose and function in the context of the search task at hand. *Meaningfulness* here is concerned with a novice user's ability to make sense of the information based on the SR's verbal rendition. Consequently, novice blind users could avoid undue confusion and navigation, and readily understand how to use the search feature to retrieve needed information. *WCAG Success Criterion 1.3.3* indicates the browsing feature problem might be addressed by supplementing sight-centred instruction to understand/operate content with text alternatives. It recommends not to rely exclusively on visual characteristics of content and controls, such as shape, size, location and orientation. This implies instructions on browsing the collection are described meaningfully for novice users. Such descriptions might be included either as metadata of items or as accompanying text so that the SR rendition conveys the visual information effectively. This could help novice blind DL users recognize these directions clearly when the task demands doing so.

Design problems, such as hyperlinks lacking meaningful labels, and page content organized lacking logical sections and descriptive section headers hamper operability of DLs. *WCAG Success Criterion 2.4.4* indicates the first operability problem may be addressed by clarifying the hyperlink's purpose through linked text either independently or in combination with the link's context. This implies each link's purpose and function is meaningfully described for novice users. This description may be included in the link label, and even in accompanying text as supplementary instruction. This could help novice blind users recognize the link's utility as a gateway to a given information resource, and the necessary action sequence to retrieve relevant information. Consequently, she could understand the DL page hierarchy and relevance of the linked resource and decide whether to follow it. *WCAG Success Criteria 2.4.6* and *2.4.10* may serve as good starting points for addressing the second operability problem. *SC 2.4.6* indicates that organizing page content into logical sections with headings and labels could be helpful. This implies a resource page has sections dedicated to individual topics under section headers that communicate what information is available and how that information is organized. This would help novice blind users understand how different sections of the page are related and quickly locate necessary information. *SC 2.4.10* explains that when page content is not organized using section headers, it becomes difficult for the blind user to navigate within the content and to acquire mental handles to comprehend the content effectively. In light of this, assigning meaningful and descriptive labels to section headers of a logically sectioned resource page will convey its relevance, coverage and navigability, thereby aiding in skim-reading the content. Consequently, novice blind users might determine its relevance effectively and locate needed information efficiently.

Design problems, such as jargon usage without an explanation mechanism, hinder the understandability of DL features and content. *WCAG Success Criterion 3.1.3*, *3.1.5* and *3.3.5* together may be good starting points to address the understandability problem. *SC*

3.1.3 calls for mechanisms to define ambiguous, unknown or specialized terms. Such mechanisms may include accompanying text, a definition list and a glossary. SC 3.3.5 recommends such mechanisms should be available in context. SC 3.1.5 recommends definitions adhere to a seventh-grade reading level. This implies whenever DL content and control understanding requires higher than a seventh-grade reading level, contextually situated mechanisms are available to define the jargon, idiom or specialized term that makes sense to a seventh-grader listening to the SR rendition. Consequently, novice blind users might readily understand the relevance of the content or control to their IR task.

Conclusion

This research was motivated by the belief that the sight-centred design and complex structures make DLs unfriendly to blind information seekers. A dearth of research in this area creates a knowledge gap about design strategies for blind-friendly DL environments. There is a critical need for research to examine how current design practices impact IR outcomes for blind users (Kumar and Sanaman, 2015). This paper attempts to address this research need and knowledge gap. It offers a feasible approach to develop user-centred design knowledge on DL accessibility for blind information seekers. It demonstrates the utility of this approach through an exploratory field study with 15 blind participants. Qualitative analysis of verbal evidence around their first encounter with the AMDC identified five types of design problems that made it an unfriendly DL. The problem types are lacking of meaningful text descriptions for multimedia content and format, lacking of meaningful labels or instruction for DL features, lacking of meaningful labels for hyperlinks, lacking of descriptive section headers in organizing content and lacking of an explanation mechanism for jargon. Thus, participants had difficulty perceiving, operating and understanding content and features needed to perform typical IR tasks.

Findings have implications for practice and theory. The identification of design problems will help designers and librarians better assess the accessibility, usability and utility of DLs for novice blind users. WCAG success criteria relevant to specific design problems have been identified and interpreted for DL users reliant on SR mediation for IR. Subject to experimental validation, these potential solutions should help designers and librarians better address the technical accessibility of a DL in line with ISO standards, comply with legal mandates on accessibility and, more importantly, provide an inclusive DL environment to millions of blind information seekers. The theoretical implications accrue from the mapping between problematic design problems and consequent impact on perceivability, operability and understandability of DL content and controls. This way, technical accessibility for the SR is linked to effective access for blind information seekers and, ultimately, to DL utility for this atypical user group. This accessibility to utility chain offers a useful framework to study social inclusion of blind people in the digital society.

This paper provides unique insights into design problems and their adverse impacts on DL accessibility for novice blind users. However, this study has limitations in terms of its sampling and site selection. It involved a single DL (representing a single DL design model), used by 15 blind volunteers from the Midwestern USA, performing three IR tasks, spread across 60 search sessions. The authors recognize other types of design problems may be observed in other design models from that of the AMDC. The need to identify remedial measures to address these design problems and further testing are also acknowledged.

Limitations of this study call for future research that involves multiple DLs with diverse design models, a larger sample of blind users with diverse demographic and technical

backgrounds to develop a comprehensive set of erroneous design choices and corresponding remedial measures to build a blind-friendly DL environment. Future research shall also design new and improved DL features, and further test these designs with blind users.

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