Association for Information Systems
AIS Electronic Library (AISeL)

AMCIS 2020 Proceedings
Human-Computer Interaction (SIGHCI)

Aug 10th, 12:00 AM

Interaction Strategies of Blind Web Users – A Qualitative Study

Shrirang Sahasrabudhe
EDUCATIONAL TESTING SERVICE, shrirang.s@gmail.com

Rahul Singh
University of North Carolina at Greensboro, r_singh2@uncg.edu

Interaction Strategies of Blind Web Users – A Qualitative Study

Completed Research

Dr. Shrirang Sahasrabudhe
Educational Testing Service
ssahasrabudhe@ets.org

Dr. Rahul Singh
University of North Carolina at Greensboro
rahul@uncg.edu

Abstract

Blind and visually impaired (BVI) individuals face significant accessibility problems while interacting with the web. BVI individuals engage in non-visual interactions with the web using screen readers. Accessibility problems hinder user interactions and generate frustration. Current approaches to solve those problems are predominantly techno-centric and tend to improve the screen reading capabilities. They, however, overlook the role of BVI individual's interaction strategies.

We define the "interaction strategy" as a coordinated sequence of user interactions with online resources that is intended to achieve an interaction goal. Interaction strategy is a larger term which includes browsing as well as coping strategies used in web-interactions. We collect qualitative observations of five BVI users' web-interactions. Using the inductive analysis, we produce a web-interaction strategy framework.

Keywords

Interaction strategies, accessibility, usability, blind and visually impaired, screen readers.

Introduction

Blind and visually impaired (BVI) individuals face significant accessibility problems while interacting with web applications (Babu and Singh, 2010; Sahasrabudhe and Lockley, 2013). They engage in non-visual interactions with web applications using screen readers. Screen readers read aloud the textual screen-content in a sequential manner and provide numerous keystrokes to interact with the application interface (Harper et al., 2005) to access various functions offered by that interface (Leuthold et al., 2008). Yet, the interactions using screen readers are plagued by numerous accessibility problems.

Accessibility problems hinder user interactions and generate frustration (Lazar et al., 2007). Current approaches to solve those problems are predominantly techno-centric and tend to improve the screen reading capabilities. They, however, overlook the role of BVI web-users' interaction strategies. We define the "interaction strategy" as a coordinated sequence of user interactions with online resources that is intended to achieve an interaction goal. Interaction strategy is a larger term which includes browsing as well as coping strategies used in interacting with applications.

Furthermore, an access to electronic health(eHealth) applications is of paramount importance to BVI individuals as it is to the sighted. It is because, BVI adults are more likely to have serious health issues such as diabetes (Thylefors et al., 1995). An access to eHealth can enable BVI individuals to manage their personal health information independently and effectively, however, accessibility problems in eHealth prevents them to do so. Therefore, we situate this study in the context of BVI individuals' interactions with eHealth to manage blood sugar information. We collect qualitative observations of five BVI web users' interactions with eHealth. Using the inductive analysis, we produce a web-interaction strategy framework.

Literature Review

The literature seems to be grappling with various accessibility problems from the technical accessibility perspective. Majority of the research identifies BVI users' web accessibility problems and attempts to explain or resolve them. However, very few studies discuss the web-browsing strategies of BVI. The literature is also scattered across two decades and there are no prominent studies regarding BVI user browsing and coping strategies after Power et al. (2013). Consequently, the information regarding how BVI users interact with the Web, as opposed to what problems they encounter, is surprisingly thin (Power et al., 2013). Moreover, the term interaction strategy as not been conceptualized yet. It is a significant research gap which we aim to bridge.

In this section, we discuss the key studies which identified various browsing and coping strategies of BVI web-users. Francisco-Revilla & Crow (2010) studied how BVI web-users interpret and navigate the webpage layouts. Specifically, they identified two strategies to scan a webpage (1) sequential scanning and (2) skim reading. Initially, BVI participants used top-down and bottom-up sequential scanning in quick succession until they got some idea about the content. However, this strategy often resulted in missing the middle portion of the page which was the main content. They also noted that the participants jumped to successive links or headings to expediate the scanning process. However, the strategy resulted into missing the information between the consecutive links and/or headings. Power et al. (2013) identified seven browsing strategies of BVI Web users. Those were (1) navigation, (2) discovery, (3) exploration, (4) anchoring, (5) help seeking, (6) reset, and (7) task acceleration. Takagi et al. (2007) identified (1)exhaustive scanning (a scanning tactic by listening to content in a sequential fashion) and (2)gambling scanning (by jumping forward and skipping a determined amount of lines until bumping into content that draws user's attention) as two key browsing strategies of BVI web users. Saqr (2016) explored the web-browsing patterns and respective adaptive behaviors of BVI. They identified (1)probing/backtracking, (2)using hot keys, (3)search functions, and (4)avoidance as the browsing strategies.

Lunn, et al., (2011) Vigo & Harper, (2013, 2014), identified coping tactics like (1)impulsive clicking, (2)exploration tactics, (3)redoing, and (4)giving up. These studies used coping theories and considered the BVI adaptive strategies as coping mechanisms. Bigham et al. (2007) identified (1)use of simulated mouse like the JAWS cursor in JAWS screen reader to read text when faced with accessibility problems, and (2)avoidance, for example, avoiding visiting the pages that contained either dynamic content or which issued AJAX requests as the coping strategies of BVI users. Similarly, Borodin, et al. (2010) identified (1)increasing the speech rate of the screen reader, (2)exploring the visual interface with a keyboard-driven mouse, and (3)falling back to external help as the coping strategies used by BVI users.

Research Question

Extant research inconsistently classifies the browsing and coping strategies. For example, strategies like "navigation" and "discovery" (Power et al., 2013) are not the strategies but interaction goals. Similarly, strategies like "help-seeking" and "giving up" are not interaction strategies as they execute when the interaction is impossible. The inconsistent definition of the term strategy prevents us from comparing the strategies used to achieve a common goal.

Moreover, extant research focuses on specific accessibility problems and respective work-arounds but not on the entire interaction which begins with goal-formation and ends with goal-achievement or the interaction- termination. The extant research views the browsing, coping and adaptive strategies of BVI web-users as independent units scattered throughout the problem-solving process. "Problem-solving," in the context of this research denotes the entire interaction of a web-user to achieve an overall goal. Thus, the extant research fails to comprehend the entire interaction as a single unit. It confines us to improve the parts of interaction independent of the context of the entire interaction. Such improvements, agnostic of the context, can lead to an accessible but not usable webpage. Thus, it is important to clearly define the term interaction strategy to distinguish it from the interaction goals and broaden its scope to encompass the entire interaction.

Furthermore, all interaction strategies do not execute at the same level of interaction. They execute at the level of overall problem solving, or at the level of task-completion on a webpage, or at the level of operating a webpage component. However, extant research does not classify the strategies according to the levels of execution. It prevents us from meaningfully organizing the interaction strategies to compare the competing interaction strategies and identify the effective strategies for the given context. Therefore, we ask

"What are the BVI users' interaction strategies to interact with web applications?"

Methods

Tasks and Electronic Health

As previously mentioned, we situated this study in the context of BVI web-user's interactions with eHealth to manage blood sugar information. Moreover, we chose the tasks which represented common tasks performed by web-users. We did so to ensure that the outcomes of this research are generalizable and applicable beyond eHealth. In this section, we describe those tasks and their alignment to the common tasks performed by web-users.

According to the American Association of Diabetes Educators (2019), the seven essential self-care behaviors which predict good outcomes in diabetes patients are 1. monitoring of blood sugar, 2. risk-reduction behaviors, 3. compliance with medications, 4. healthy eating, 5. being physically active, 6. good problem-solving skills, and 7. healthy coping skills. Behaviors 1, 2, and 3 were directly relevant to the context of blood sugar management. So, we chose five tasks related to those three behaviors. Subsequently, through a systematic web search, we chose the eHealth to perform those tasks. Table1 shows those tasks and respective eHealth.

Moreover, the chosen tasks represent the common web-user tasks. Learning about the normal blood sugar levels involves information search task. Viewing and understanding the blood sugar trends involves information comprehension task. These are common essential web-user tasks. Similarly, setting the blood sugar targets, logging blood sugar information, and adding a medication reminder involve form-filling task which is also a common essential web-user task. Therefore, the outcomes of this study are generalizable beyond the health information management context.

Task	Task Details	eHealth
Task1	Learn about normal blood sugar levels	WebMD.com
Task2	Set blood sugar target levels	gomeals.com
Task3	Log blood sugar levels	mydiabeteshome.com
Task4	View and understand the trends in blood sugar levels	sugarstats.com
Task5	Add a medication reminder	mymedschedule.com

Table1. Tasks and Electronic Health

Participants

Five adult, English-speaking blind computer JAWS screen reader web-users were the participants. Five participants are necessary to uncover usability issues of technology interfaces (Nielsen, 2000). The JAWS screen reader is one of the popular screen reader among BVI computer users (WebAim, 2019). To control the variability among the participants in terms of their familiarity with that screen reader, we ensured that every participant used the web with JAWS for at least three years. Participant selection was gender-agnostic. We used snow-ball sampling to recruit the participants. The participants came from the Industries of the Blind-USA, the Industries for the Blind-USA, and the Blind Technology Center at the University of Pune-India. We informed every participant about the study and gave $10 as an incentive.

Procedure

Participants performed the five tasks using respective eHealth. Using semi-ethnographic method of observation, we had a conversation with them while they performed the tasks. To control the learning effects of the order in which the tasks were performed, we ensured that no two participants perform the tasks in the same order. We observed the participants separately. Two participants preferred the face-to-face setting and three participants preferred the remote setting. Approximately, every participant observation took around four hours. It was tiring for the participants to perform all five tasks in a single session. So, we scheduled three-four sessions with each participant to finish five tasks.

We collected participants' concurrent and retrospective verbal protocols by audio-recording (a) the conversation between us and the respective participant, and (b) the respective screen reader announcements. The concurrent verbal protocols contain evidence of the information that participants process to perform a task (Ericsson & Simon, 1984) and concurrent verbalizations are non-reactive and do not alter participants' behavior in tasks (Ericsson & Simon, 1993). This technique is effective for developing an in-depth understanding of human problem-solving (Newell & Simon, 1972) and is a feasible method to trace usability problems in human computer interactions (Cotton & Gresty, 2006).

Concurrent Protocol Questions

- What objective are you trying to achieve?
- What is your strategy to achieve the objective?
- Why do you choose that strategy?
- Do you know any alternative strategies to achieve the objective?
- Are you facing any challenges in executing the strategy?
- How will you overcome the challenge?

Retrospective Protocol Questions

- What aspects of the interface were helpful for using your interaction strategies?
- What aspects of the interface were not helpful for using your interaction strategies?
- What were the most critical accessibility and usability problems for you?
- Could you have used any alternative interaction strategy to achieve better interaction?
- Can you suggest any improvements to the interface to make the interaction better?
- How soon do you generally give-up an interaction?

Analysis

We transcribed the audio recordings and decomposed the transcripts into key-commands, screen reader announcements, participant verbalizations, and researcher verbalizations. We then identified the strategic action sequences. A strategic action sequence (SAS) is a series of operations in an application that a user applies to achieve a goal. We identified the generic and specific objectives of every SAS. A specific objective is the intended user goal of a SAS. We grouped the specific objectives according to the respective unit of user interface under operation. We assigned generic objectives according to the intended higher-level function and the class of the UI unit under operation. For example, specific objectives "enter the username" and "enter the password" were assigned the generic objective "edit a text-field." For every SAS, we identified participant rationale for choosing that SAS, corresponding accessibility problems faced, workarounds used to overcome those problems, and the alternative SAS to achieve the respective specific objective. This analysis produced the web-interaction strategy framework shown in Table2.

Findings and Discussion

Objective	Strategy	Accessibility/Usability Problems
Locate the target control or information	Use of screen-reader specific navigation functions	None

Objective	Strategy	Accessibility/Usability Problems
	Use of links list	Unavailability of the contextual information
Navigate within a table	Use the up and down arrow keys	Difficulty in understanding the associated labels
	Use the "table layer"	None
Scan the web page	Using arrow keys	None
	Use of the tab key	Propensity to miss the important information which is not focusable
	Use of screen-find function	None
Open a form field	Hit the enter key	Accidental form submission, unexpected shift of the focus
	Hit the spacebar	None
Probe the control under focus	Tab and shift + tab in succession	None
	Up and down arrow keys in succession	None
	Use screen-reader function such as insert + tab in JAWS	None
Work-around the gulf of evaluation	Re-doing the component-level operation	Information re-submission
	Restarting the browser and re-doing the entire task-flow	None
Work-around the gulf of execution	Trial and error	Accidental form submission

Table 2. Web Interaction Strategy Framework

Locate the Control or Information

To explore an unfamiliar web page, the participants sequentially scanned the webpage using up and down arrow keys or the tab key. They could always successfully locate the desired information/control using the arrow keys. They preferred the arrow keys over the tab key because, in their experience, (a) often, the custom controls such as “My Preferences” seen in Figure1 do not receive the keyboard focus, and (b) often the tab sequence is not logical which reduces their speed of interaction.

They used the JAWS screen-find function to locate the control label when they were unsure of the type of the target control. For example, they used the screen-find function to find “My Preferences” which was a custom control. The strategy was effective to locate the target control only when the participant knew the respective text label.

They also used the screen-reader-specific navigation quick-keys to rapidly locate the target control when they knew the type of the target control. For example, they used the quick-key “e” to locate the edit fields, the quick-key “b” to locate the buttons, etc. The strategy was effective when the design exposed the respective role of controls to the screen-reader. Screen-reader could recognize the role of the standard HTML elements such as, input buttons, checkboxes, edit fields. However, the strategy did not work with the custom controls for which no ARIA role was specified. “My Preferences” in Figure1 was an expandable/collapsible menu without the associated “role” attribute. Participant 4 used the quick-key “b,” JAWS list of links, and list of buttons to locate “My Preferences.” However, none of the functions worked as “My Preferences” did not have the role specified. When the quick-keys did not yield expected outcomes, the participants scanned the entire webpage using the arrow keys as the alternative strategy. The following interaction demonstrates it.

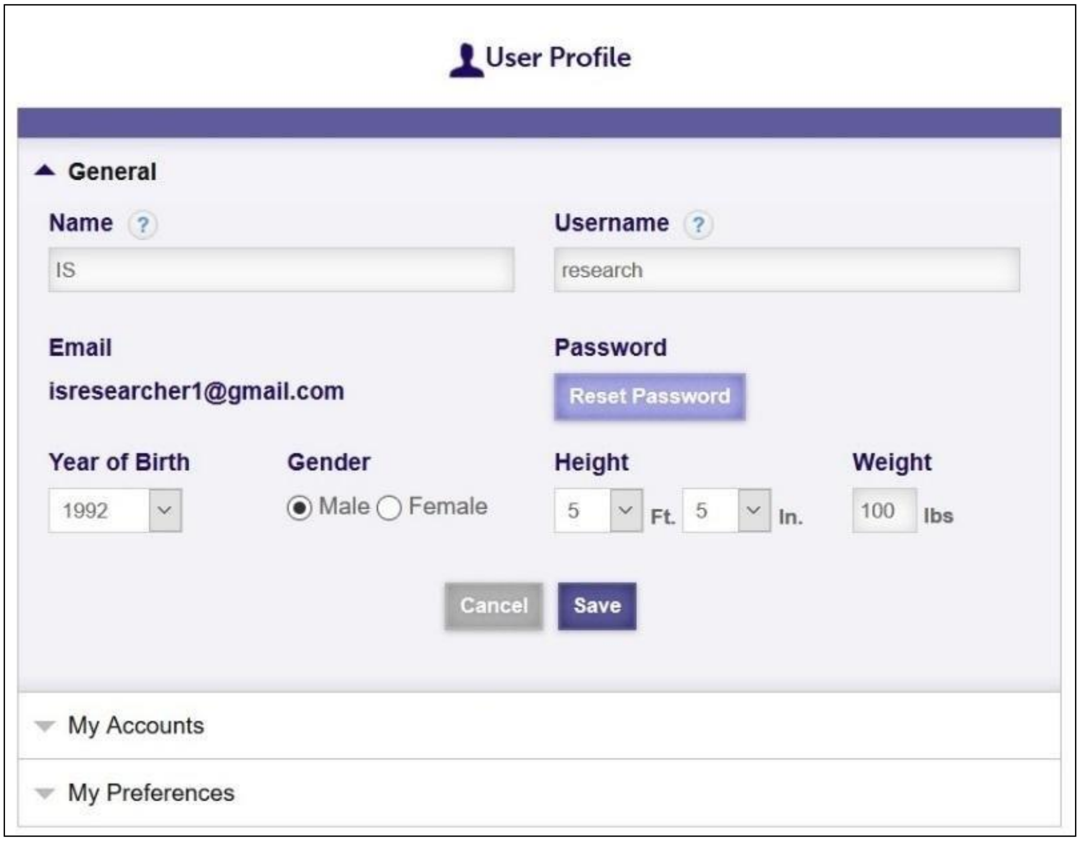

Figure 1. My Preferences – Menu Collapsed

User goal	User action	SR announcement	User's interpretation of the announcement
To find “my preferences” link.	insert+f7	links list dialogue. links list view.	list of links has appeared.
to move to the link “my preferences.”	M	tung	There is no link starting with the letter "m."
to close the list	Escape	escape	the list of links is closed.
To open the button list	ctrl+insert+b	list of buttons dialogue.	list of buttons has appeared.
to move to the button “my preferences.”	M	tung	There is no button starting with the letter "m."
to close the list	Escape	escape	the list of buttons is closed.

Table 3. BVI User Interaction

Participants used the JAWS links list to quickly locate the desired link on a page. The strategy was effective; however, they could not understand the contextual information for the links while using the links list. Also, JAWS did not distinguish the links from the anchors (same page links) in the links list. Consequently, the participants expected a new page to open when they activated the anchors. However, they got confused as the new page did not open.

Navigate Within a Table

Participants used two strategies to navigate within tables, (1) use the “table layer” in JAWS, and (2) use the up/down arrow keys. Using the “table layer” was an effective strategy and it always worked. However, only one of the five participants used the strategy. Two other participants knew about the strategy, but they mentioned that they never use it. The remaining two did not know about the "JAWS table layer" functionality. Use of the up and down arrow keys was effective to navigate the tables containing information, for example, Figure2.

Figure 2. Screen to Add Medication

However, the strategy was not effective in case of tables containing form-fields like in Figure3. The first two rows of that complex table were the header rows. Every following row contained eight edit-field and two buttons. The first row of the table contained the time-slots namely, breakfast, lunch, supper, bedtime, and night. The second row contained the time-points around the time-slots namely, "before," and "after." Also, the time-slots "bedtime," and "night" have only one blood sugar reading associated with each of them; whereas the remaining time-slots namely, breakfast, lunch, and supper had two associated readings, one reading before the respective time-slot and another reading after the time-slot. The first row contained the first label and the second row contained the second label for the respective edit-field.

Figure 3. Screen to Add Blood Sugar Data

However, the labels were not programmatically associated with those fields. Consequently, JAWS screen reader couldn't associate the appropriate labels with those fields. As the participants navigated the table using the down arrow key, the focus moved to the edit fields one by one. As there was no text/graphic between those fields, JAWS announced "edit" on every press of the down arrow key. It was confusing and annoying for the participants. One participant wrongly interpreted the screen-reader response and inferred that he was trapped inside an edit field.

Open a Form Field

Participants used two strategies to open the form-fields for editing namely. (1) hit the enter key on the form-field and (2) hit the spacebar on the form-field. The strategy to hit the enter key was not a reliable strategy. It yielded inconsistent outcomes when used with two form-fields on a same webpage. In one case, the strategy resulted in an unexpected shift of the focus. Participants also noted that hitting the enter key sometimes results into an accidental form submission.

Probe the Control Under Focus

Participants used three strategies to probe the control under focus, namely, (a) press the tab and shift + tab successively, (b) press the up and down arrow keys successively, and (c) use the JAWS keystroke "insert tab." All three strategies always worked across all eHealth used in this study.

Work-around the Gulf of Execution

When participant could not perceive if an element could be activated they faced the gulf of execution. As a work-around, participants often used the trial-error strategy and tried activating the respective element. However, the strategy sometimes led to unwanted information submission.

Work-around the Gulf of Evaluation

When there was no system response on participants' action such as, hitting the enter key, they faced the gulf of evaluation. To work-around the situation, they either (a) re-did the component level action such as hitting the enter key, or (b) restarted the entire task. However, re-doing the component-level operation can result into unwanted information re-submission.

Limitations and Future Directions

The limitation of this study is that all the participants had more than three years' experience of using the web and JAWS screen reader. It limits the generalizability of the findings. The interaction strategies employed by the novice users of screen readers could be different than those revealed by this study. To overcome this limitation, we plan to replicate this research with the novice users of screen readers. Also, using the knowledge of BVI users' interaction strategies, we are developing principles to inform both the web-design and the BVI users' browsing behavior to improve the interaction outcomes.

Conclusion

BVI web-users face significant accessibility and usability problems while interacting with the web using screen readers (Babu and Singh, 2010; Sahasrabudhe and Lockley, 2013). Current approaches to solve those problems tend to overlook the role of BVI user interaction strategies while resolving those problems. BVI users' interaction strategies is an understudied topic in Information Systems research. Therefore, using an observation study of five BVI web-users, we produced a comprehensive framework of their interaction strategies and respective accessibility and usability problems.

BVI users develop multiple strategy to achieve every interaction goal. However, many of those strategies are prone to accessibility problems. BVI users can overcome most of those problems, however, some problems cannot be overcome just by using different strategies.

REFERENCES

Babu, R., Singh, R., and Ganesh, J. 2010. "Understanding Blind Users' Web Accessibility and Usability Problems," *AIS Transactions on Human Computer Interaction* (2:3), pp. 78-91.

Sahasrabudhe, S., and Lockley, M. 2014. "Understanding Blind User's Accessibility and Usability Problems in The Context of MyITLab Simulated Environment," in *Proceedings of Americas Conference on Information Systems in 2014*.

Power, C., Petrie, H., Swallow, D., Murphy, E., Gallagher, B., and Velasco, C. A. 2013. "Navigating, Discovering and Exploring the Web: Strategies Used by People With Print Disabilities on Interactive Websites," in *IFIP Conference on Human-Computer Interaction*. Springer, Berlin, Heidelberg, pp. 667-684.

Newell, A., and Simon, H. A. 1959. "The Simulation of Human Thought," *RAND Corporation Paper*, pp. 1734.

Newell, A., and Simon, H. A. 1972. "Human Problem Solving," *Upper Saddle River, NJ: Prentice-Hall* (104:9).

Norman, D. A. 1988. "The Design of Everyday Things," *New York, NY: Basic Books*.

Leuthold, S., Bargas-Avila, J.A., and Opwis, K. 2008. "Beyond Web Content Accessibility Guidelines: De-Sign of Enhanced Text User Interfaces for Blind Internet Users," International *Journal of Human-Computer Studies* (66:4), pp. 257-270.

Loiacono, E. T., McCoy, S., and Chin, W. 2005. "Federal Web Site Accessibility for People with Disabilities," *IT Professional* (7:1), pp. 27-31.

Harper, S., Goble, C., and Stevens, R. 2005. "Augmenting the Mobility of Profoundly Blind Web Travellers," *New Review of Hypermedia and Multimedia* (11:1), pp. 103-128.

Lazar, J., Allen, A., Kleinman, J., and Malarkey, C. 2007. "What Frustrates Screen Reader Users on the Web: A Study Of 100 Blind Users," *International Journal of Human-Computer Interaction* (22:3), pp. 247-269.

Saqr, R. 2016. "Blind and Visually Impaired Users' Adaptation To Web Environments: A Qualitative Study," *Doctoral dissertation, University of South Florida*.

Lunn, D., Harper, S., and Bechhofer, S. 2011. "Identifying Behavioral Strategies of Visually Impaired Users to Improve Access to Web Content," *ACM Transactions on Accessible Computing (TACCESS)* (3:4), pp. 1-35.

Thylefors, B., Negrel, A.D., Pararajasegaram, R. and Dadzie, K.Y. 1995. "Global Data on Blindness," *Bulletin of the world health organization* (73:1), pp. 118-119.

Association of Diabetes Care & Education Specialists. 2019. "AADE7 Self-Care Behaviors," *retrieved from https://www.diabeteseducator.org/living-with-diabetes/aade7-self-care-behaviors*.

Nielsen J. 2019. "Why You Only Need to Test with 5 Users," Nielsen Norman Group, *retrieved from https://www.nngroup.com/articles/why-you-only-need-to-test-with-5-users/*.

WebAIM. 2019. "Screen Reader User Survey #8 Results," WebAIM, *retrieved from https://webaim.org/blog/screen-reader-survey8-results/*.

Takagi, H., Saito, S., Fukuda, K., and Asakawa, C. 2007. "Analysis of Navigability of Web Applications for Improving Blind Usability," *ACM Transactions on Computer-Human Interaction (TOCHI)* (14:3), pp. 13-es.

Vigo, M., and Harper, S. 2013. "Coping Tactics Employed by Visually Disabled Users on the Web," *International Journal of Human-Computer Studies* (71:11), pp. 1013-1025.

Vigo, M., and Harper, S. 2014. "A Snapshot of the First Encounters of Visually Disabled Users With the Web," *Computers in Human Behavior* 34, pp. 203-212.

Ericsson, K. A., and Simon, H. A. 1984. "Protocol Analysis: Using Verbal Reports as Data," *Cambridge, MA: The MIT Press*.

Cotton, D. and Gresty, K., 2006. "Reflecting on the Think- Aloud Method for Evaluating e- Learning," British Journal of Educational Technology (37:1), pp. 45-54.

Bigham, J. P., Cavender, A. C., Brudvik, J. T., Wobbrock, J. O., and Lander, R. E. 2007. "Webinsitu: a Comparative Analysis of Blind and Sighted Browsing Behavior," in *Proceedings of the 9th International ACM SIGACCESS Conference on Computers and Accessibility,* pp. 51-58.

Borodin, Y., Bigham, J. P., Dausch, G., and Ramakrishnan, I. V. 2010. "More Than Meets the Eye: A Survey of Screen-Reader Browsing Strategies," in *Proceedings of the 2010 International Cross Disciplinary Conference on Web Accessibility (W4A),* pp. 1-10.

American Diabetes Association. 2018. "Statistics About Diabetes," *retrieved from http://www.diabetes.org/diabetes-basics/statistics/*

Francisco-Revilla, L., & Crow, J. (2010, June). Interpretation of web page layouts by blind users. In *Proceedings of the 10th annual joint conference on Digital libraries* (pp. 173-176).