International Journal of Recent Engineering Science
ISSN: 2349-7157/ https://doi.org/10.14445/23497157/IJRES-V11I6P122

Volume 11 Issue 6, 260-274, December 2024

Review Article

Assistive Technologies for Internet Navigation: A Review of Screen Reader Solutions for the Blind and Visually Impaired

Juan Nino[1], Sherezada Ochoa[2], Jocelyne Kiss[3], Geoffreyjen Edwards[4], Ernesto Morales[5], James Hutson[6], Frédérique Poncet[7], Walter Wittich[8]

[1]*Juan Nino, School of Design, Université Laval, Quebec, Canada, CIRRIS.*
[2]*Sherezada Ochoa, Université Laval, Quebec, Canada.*
[3]*Jocelyne Kiss, Design School, Université Laval, Quebec, Canada, CIRRIS.*
[4]*Geoffreyjen Edwards, Geomatic Sciences, Université Laval, Quebec, Canada, CIRRIS.*
[5]*Ernesto Morales, School of Rehabilitation , Université Laval, Quebec, Canada, CIRRIS.*
[6]*James Hutson, Lindenwood University, MO, USA.*
[7]*Frédérique Poncet, École de physiothérapie et d'ergothérapie, Université McGill, Canada.*
[8]*Walter Wittich, School of Optometry, Université de Montréal, Canada.*

[1]*Corresponding Author : 1juan-ricardo.nino-falcon.1@ulaval.ca*

Received: 26 October 2024 Revised: 29 November 2024 Accepted: 18 December 2024 Published: 30 December 2024

Abstract - *The internet is a critical resource for individuals with visual impairments (VI), including those with low vision or blindness, enabling access to information and fostering independent participation in society. However, despite advancements in screen reader software, challenges persist in navigating complex and dynamic web content. This narrative review evaluates Assistive Technologies (AT), which enhance internet navigation for VI screen reader users, focusing on design strategies and usability outcomes. A systematic search across the ACM Digital Library, IEEE Xplore, JSTOR, and ScienceDirect identified 698 studies, of which 33 met the inclusion criteria, encompassing 502 participants. Key themes were extracted from bibliographic data, technology descriptions, evaluation methods, and outcomes. The findings reveal that most software-based technologies, including browser extensions and web applications, have limited hardware integration. These solutions improve navigation by providing alternative content representations, enhancing page structure understanding, and automating user tasks. Evaluations demonstrated increased task completion rates, reduced cognitive load, and enhanced efficiency, though variations in study designs and small sample sizes limit the generalizability of results. Despite their promise, these technologies face barriers, including a lack of commercial availability and rapid obsolescence. Addressing these challenges requires modular, user-centred designs employing intuitive multimodal interactions and robust information models tailored to navigation tasks. This review emphasizes the need for scalable, sustainable, and accessible AT innovations through open, collaborative development, ensuring equitable internet access for VI users.*

Keywords - *Visual Impairment (Blindness and Low Vision), Assistive technology, Screen reader, Internet navigation, Human computer interaction design.*

1. Introduction

The Internet serves as a transformative tool for communication, overcoming barriers of distance, time, and physical limitations [1-2]. For individuals with visual impairments (VI), encompassing those with low vision or blindness, the internet fosters community engagement, social support, and improved quality of life [3-5]. However, navigating the internet remains challenging for VI users, often requiring assistive technologies (AT) to facilitate interaction with digital content [6-8]. Screen readers are the most prevalent AT, providing auditory or braille-based textual representation of web content [9-11]. While these tools are indispensable, their one-dimensional approach to presenting information significantly limits access to dynamic web elements, such as tables, graphs, and interactive interfaces, increasing the cognitive burden on users who must manage complex navigational shortcuts across multiple systems [12-16].

To address these challenges, AT for internet navigation have begun to integrate advanced auditory and tactile stimuli aimed at conveying critical spatial, structural, and semantic

relationships inherent in web content [9], [17]. These multimodal approaches attempt to bridge the gap between the one-dimensional textual output of traditional screen readers and the rich, interactive visual environments of modern websites. Auditory enhancements may include spatialized audio, dual-voice interfaces, and non-speech auditory cues, such as tones and alerts, to help users identify hierarchical structures, navigate lengthy documents, or interpret contextual information. Similarly, tactile feedback technologies, such as haptic interfaces or vibrotactile stimuli, offer an additional interaction layer by representing spatial layouts, object boundaries, or even directional guidance for navigation tasks.

Despite these advancements, significant design deficiencies persist, undermining the usability and accessibility of such technologies. Inadequate sensory feedback often results in information overload or confusion as users struggle to discern essential cues from redundant or conflicting signals. Overly complex information models, which fail to align with the cognitive processes and needs of VI users, can exacerbate the difficulty of understanding and navigating web content. Furthermore, unfamiliar interaction modalities—such as non-intuitive gestures, unconventional input devices, or insufficient customization options—introduce steep learning curves, making the technologies less accessible to diverse users with varying technical proficiency and needs [18-20]. These limitations underscore the importance of user-centered design approaches that prioritize simplicity, intuitiveness, and adaptability to ensure that AT solutions effectively address the unique challenges of VI internet navigation without imposing additional burdens on users.

This study undertakes a narrative review of the existing literature to evaluate the design and effectiveness of AT aimed at improving internet navigation for VI screen reader users. A systematic search was conducted across major databases, including the ACM Digital Library, IEEE Xplore, JSTOR, and ScienceDirect, yielding 33 relevant studies that examined user experiences and technological outcomes. This review synthesizes findings to uncover emerging themes in AT design and evaluates their impact on navigation efficiency, user satisfaction, and accessibility. This study highlights the need for innovative, user-centered, and sustainable solutions by identifying successful strategies and persisting limitations. Such advancements are crucial for ensuring equitable access to the internet, a cornerstone of modern life, for VI users.

2. Methodology

This narrative literature review synthesizes existing research on assistive technologies (AT) to support internet navigation for visually impaired (VI) users relying on screen readers. The review adheres to the PRISMA-ScR (Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews) guidelines [21], ensuring methodological transparency, reproducibility, and rigor. Ethical approval was not required as the analysis was based solely on publicly available data and literature.

2.1. Search Strategy and Information Sources

A comprehensive database search was conducted to identify relevant studies evaluating AT for VI screen reader users. The search strategy was meticulously developed to capture a broad spectrum of relevant literature, using the following keywords and Boolean operators: "visually impaired," "blind," "screen reader," "assistive technology," and "internet navigation." The query syntax employed was: ('assistive technology') AND (internet OR web OR webpage OR website) AND navigation AND ('visually impaired' OR blind) AND 'screen reader'. This query was applied to four prominent technology-focused databases: the ACM Digital Library, IEEE Xplore Digital Library, ScienceDirect, and JSTOR.

The search was finalized in July 2024, with specific inclusion criteria to ensure the relevance and quality of selected studies. Only English-language peer-reviewed journal articles and conference papers were considered, while patents, book chapters, and review articles were excluded to maintain focus on primary research. The review prioritized articles presenting empirical evaluations of AT with direct involvement of VI users. The search was restricted to studies reporting design features, usability assessments, and user outcomes related to screen reader technologies to enhance specificity.

This systematic approach facilitated the identification of 698 potential articles. These articles underwent further screening and selection to determine their alignment with the objectives of this narrative review, ultimately narrowing the scope to 33 studies for detailed analysis. Through a structured and transparent search process, the review aimed to capture a comprehensive understanding of the current landscape in assistive technologies for internet navigation by VI screen reader users.

2.1.1. Eligibility Criteria

Eligibility for inclusion in this review was determined through a rigorous screening process that applied specific criteria to ensure relevance and quality. Studies were screened for inclusion based on the following criteria:

1. Type of publication: Peer-reviewed journal articles and conference papers.
2. Focus of research: Studies reporting the results of VI user experiments evaluating AT designed to improve screen reader internet navigation.
3. Publication date: Published before July 2024.
4. Language: English-language publications only.

Only peer-reviewed journal articles and conference papers were considered, as these publication types typically provide the most reliable and robust findings. The review focused exclusively on studies that reported empirical evaluations involving VI users testing AT designed to enhance screen reader-based internet navigation. To maintain currency and applicability, only studies published prior to July 2024 were included. Additionally, the review was restricted to English-language publications to ensure clarity and consistency in the analysis. These criteria were applied systematically to refine the initial pool of 698 articles, ensuring that the final selection of 33 studies provided comprehensive insights into AT design, usability, and effectiveness for VI screen reader users.

Study Selection

The study selection process was conducted in a structured, multi-phase approach to ensure the most relevant and high-quality research was included. This rigorous process consisted of three sequential phases, each designed to progressively refine the pool of articles identified during the initial search. Two reviewers (JN, SO) independently conducted each phase to minimize bias and enhance the reliability of the selection process. Results from each phase were recorded systematically on a standardized spreadsheet, providing a transparent and reproducible record of the decision-making process.

In the first phase, the reviewers screened article titles for relevance to the review's focus on AT for VI screen reader users navigating the internet. Titles that fell outside the scope, such as those addressing unrelated technologies or populations, were excluded. This preliminary step reduced the dataset, allowing the reviewers to focus on potentially applicable articles.

The second phase involved evaluating the abstracts of the remaining articles. Abstracts were carefully examined to determine whether the studies met the predefined eligibility criteria, including type of publication, focus on empirical evaluation involving VI users, and alignment with the study's objectives. Articles that did not provide sufficient detail in the abstract to confirm relevance or adherence to these criteria were excluded at this stage.

In the final phase, the full texts of the shortlisted articles were reviewed in detail. This comprehensive examination allowed the reviewers to confirm that the studies met all inclusion criteria, including methodological rigor and relevance to the design and evaluation of AT for VI screen reader users. Discrepancies in the reviewers' assessments at any stage were resolved through discussion and consensus, ensuring that the final selection represented a robust and focused dataset. This iterative and collaborative approach refined the initial pool of 698 articles to a final set of 33 studies for detailed analysis.

2.2. Data Extraction and Analysis

A comprehensive data extraction process was employed to ensure systematic collection and analysis of information from the selected studies. A data extraction grid, adapted from established methodologies [22], was developed to capture key categories relevant to this review.

These categories included bibliographical data, detailed descriptions of the assistive technologies (AT) under evaluation, the design of the evaluation studies, and the reported outcomes. The grid facilitated consistent and thorough documentation across all selected studies, ensuring no critical information was overlooked.

The first author conducted the data extraction, while a coauthor (SO) independently reviewed the entries for accuracy and completeness. This dual-review approach minimized the risk of errors and enhanced the reliability of the data collection process.

Following the data extraction, a thematic analysis was conducted using a six-step process [23]. This approach allowed for identifying recurring patterns and key insights into the design, functionality, and impact of the AT evaluated in the studies.

The categorization and synthesizing of the data provided a clearer understanding of emerging trends and gaps in the field. The findings were organized and presented using tables, enabling readers to easily compare and contrast the features and outcomes of the included technologies. This tabular presentation, informed by best practices in data visualization [24], [25], ensured that complex information was accessible and comprehensible to diverse audiences.

3. Findings

3.1. Study Selection and Characteristics

The initial search across four databases yielded 698 results, with individual database contributions ranging from 18 to 461 articles. After applying the systematic selection process described in earlier sections, the pool of articles was narrowed to 33 studies. These studies represented the most relevant and rigorous research addressing the review's focus. As summarized in Figure 1, the selection process involved meticulous screening at multiple levels to ensure alignment with the review's objectives.

Figure 1 provides a detailed breakdown of the design characteristics and evaluation outcomes of the 33 AT evaluated. Notably, more than half of these studies were published within the past five years, highlighting the growing interest and advancements in AT for VI screen reader users in recent years. This temporal distribution underscores the dynamic nature of the field and the increasing emphasis on improving accessibility and usability for this population.

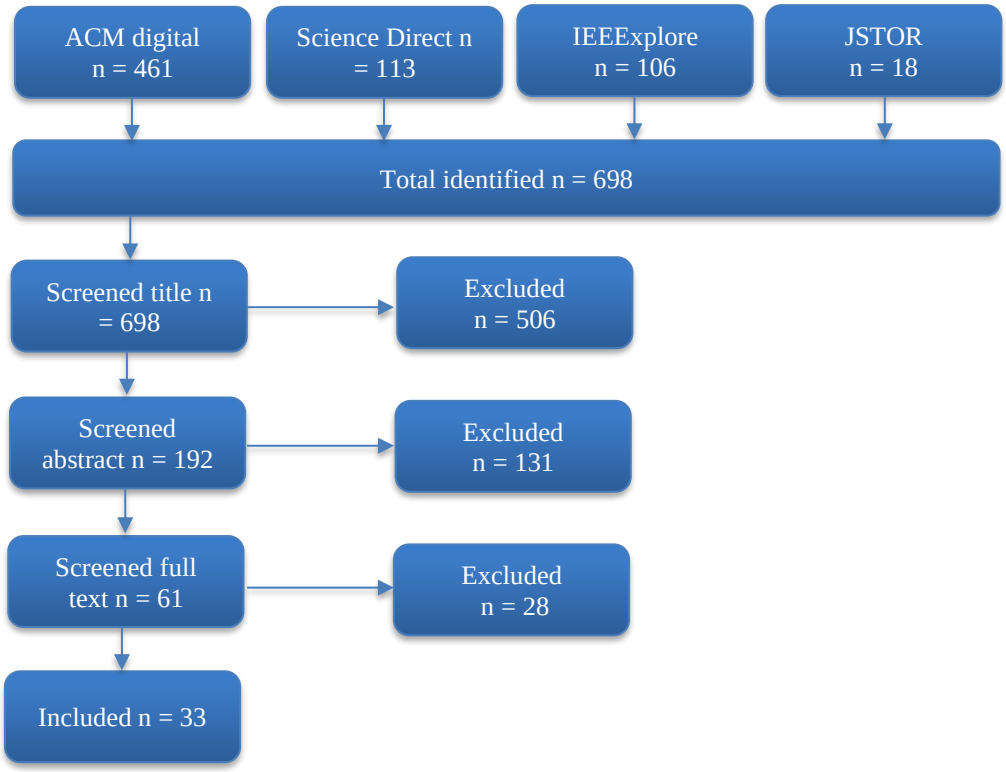

Fig. 1 Study selection and characteristics

3.1.1. Technology Design

The AT reviewed in this study exhibited a strong reliance on software components, with notable diversity in their implementation and functionality. The majority were browser extensions, accounting for 25 out of 33 technologies, while others included web applications (n=4), desktop applications (n=3), and a single screen reader extension (n=1). Though less common, hardware components were integrated into three technologies, leveraging devices such as the Wiimote, the Surface Dial, and a haptic feedback robot. These hardware elements primarily aimed to complement the software features by providing tactile interaction capabilities. However, only three technologies incorporated haptic feedback, highlighting its limited adoption within the current landscape. The most common functions of these technologies were:

- Providing alternative presentation (n=24): Simplify page layout, add descriptive text and hide website elements.
- Overviewing information (n=10): Aid information seeking and skimming through textual summaries, navigable tables of contents and accessible contextual cues.
- Interacting with data records (n=9): Annotate and restructure tables and search results with centralized filtering and sorting controls.
- Communicating visual semantics (n=7): Provide non-visual cues of graphs, styles and layouts.
- Automating common tasks (n=6): Simplify web navigation by predicting and automating user tasks or triggering natural language commands.

All the technologies reviewed sought to enhance standard screen reader outputs by introducing additional layers of information. Most commonly, these enhancements were based on semantic relationships (n=29), enabling the representation of contextual connections between web elements. A smaller subset utilized hierarchical structures (n=18) to clarify the organization of content, while others employed visuospatial cues (n=11) to convey the spatial layout and formatting of web elements in non-visual modalities.

The functions of these technologies varied widely, reflecting their attempts to address distinct challenges faced by visually impaired (VI) users. The most prevalent function was providing alternative content presentation (n=24), achieved by simplifying page layouts, adding descriptive text, and hiding non-essential website elements to improve clarity. Ten technologies focused on facilitating information seeking by enabling users to skim content through textual summaries, navigable tables, and accessible contextual cues. Nine technologies offered enhanced interaction with data records, allowing users to annotate, filter, and sort tables and search results. Seven technologies aimed to communicate visual semantics, offering non-visual representations of graphs, styles, and layouts. Finally, six technologies automated common navigation tasks by predicting user

intents and enabling natural language commands, streamlining the browsing experience for VI users. This array of functionalities underscores the diverse and evolving strategies employed in the design of AT to improve internet accessibility and usability for screen reader users.

Technology Evaluations

Evaluations of the technologies consistently demonstrated positive usability outcomes, highlighting their potential to enhance internet navigation for VI users. However, the significant variation in experimental designs, participant demographics, task goals, and data collection methods across studies limits the generalizability of these results. This diversity in methodology also hinders the establishment of clear correlations between specific design choices and their respective usability outcomes. For example, the evaluations collectively involved 502 participants, including 328 individuals who were blind, 26 with low vision, and 55 whose specific visual impairments were not detailed. Participants represented a broad range of sociodemographic backgrounds and varying levels of screen reader experience. Despite this diversity, the majority of studies (n=23) were conducted with small sample sizes, often ranging from just 1 to 15 participants, which may constrain the applicability of the findings.

The types of tasks evaluated in these studies varied but could be grouped into three primary categories: information retrieval tasks (n=19), such as locating specific data or content; website exploration tasks (n=12), which assessed general navigation and discovery; and transactional tasks (n=9), including activities like purchasing products or booking services. Most studies (n=30) employed comparative experimental designs, collecting data under at least two conditions: one involving using a standard screen reader alone and the other incorporating the evaluated AT.

Quantitative metrics were widely used to measure usability and efficiency. These metrics included reductions in task completion time (n=20), the number of commands required (n=10), and cognitive effort (n=12), as well as improvements in task completion rates (n=11). In addition to quantitative measures, qualitative feedback was collected in 29 studies. This feedback emphasized improvements in usability, accessibility, and user satisfaction, providing valuable insights into the technologies' impact on the overall web navigation experience. Together, these evaluations underscore the significant advancements in AT design while also highlighting areas where further refinement is needed to ensure broad accessibility and effectiveness.

4. Discussion

The technologies reviewed demonstrate significant potential to enhance web navigation for visually impaired screen reader users through a combination of innovative strategies. These approaches can be broadly categorized into three primary mechanisms: supplementing non-linear information, providing overviews or descriptions of content, and optimizing common navigation tasks, such as locating and synthesizing information, completing forms, and enabling natural language interactions. Empirical evidence suggests that these strategies contribute to more accessible and user-friendly technologies by reducing cognitive load and improving navigation efficiency for VI users.

4.1. Non-linear Information

4.1.1. Semantic Relationships

Assistive technologies often leverage semantic relationships embedded in web content, utilizing contextual and interconnected elements to deliver features such as semantic annotation, which clarifies relationships between webpage elements, natural language interfaces for intuitive interaction, concept clustering to streamline information retrieval, and topic segmentation to navigate lengthy texts [26]. Examples like chatbot-based systems [27-28] and Speed-dial [29] illustrate how semantic relationships can facilitate web navigation. However, these relationships alone are insufficient for deep content engagement [30]. Effective designs must empower users with granular control over cursor movement, screen representation, and task execution [31]. Limitations, such as the need for domain-specific knowledge and the absence of automated annotation tools, hinder the scalability of this approach. However, advancements in artificial intelligence (AI) show promise for overcoming these barriers [32].

Hierarchical Relationships

Hierarchical relationships, which organize information structures within web pages, are fundamental to effective screen reader use and critical for orientation and navigation [15], [33], [34]. These relationships have been integral to assistive web technologies since the early days of the internet [35], [36], [37], [38], enabling non-visual access to tables, spreadsheets, diagrams, audiobooks, and structured documents [39], [40], [41], [42]. For instance, navigating hierarchies provides VI users with a conceptual overview [28] and allows selective reading of sections, which is particularly beneficial on unfamiliar web pages [43], [44]. Hierarchical models also enable users to adopt physical navigation strategies, such as identifying "landmarks" within frequently visited sites [45]. However, the effectiveness of hierarchical designs depends on adherence to W3C accessibility standards and logical organization of webpage content [43].

Visuospatial Relationships

Visuospatial relationships convey meaning through attributes like spatial positioning, color, size, and shape. These relationships are particularly valuable when accessibility standards are lacking or hierarchical structures are unclear, and they assist VI users in creating content for

visual and non-visual audiences [46]. The reviewed technologies addressed these relationships by converting visuospatial cues into auditory or tactile stimuli and mapping page layouts to keyboard regions, enabling spatially corresponding interactions. However, presenting complex visuospatial relationships non-visually remains challenging, requiring significant cognitive and spatial ability [33], [47]. Moreover, spatial representations may not always be the most efficient method for conveying structural information or supporting information retrieval [48], [49].

Interaction Modalities

All reviewed technologies relied on auditory feedback from screen readers, though only one [20] incorporated additional auditory techniques. Effective auditory designs must balance enhanced functionality with avoiding user confusion from overlapping or continuous sounds [17]. Techniques such as concurrent speech [50], dual-voice and spatialized speech [51], auditory icons [52], and pitch or stereo-based spatialization [53] can enrich auditory navigation experiences when implemented thoughtfully.

Haptic feedback was leveraged in only three technologies, employing force feedback and vibrotactile stimulation to convey non-linear relationships. Combining auditory and haptic feedback can reduce cognitive effort and improve navigation efficiency [54]. Research on mobility aids demonstrates that cognitive maps formed through audio-tactile interaction are more effective than those based solely on verbal descriptions when navigating physical spaces [55]. However, hardware challenges—including high costs, limited availability, and obsolescence risks—pose barriers to widespread adoption.

Of the three technologies with hardware components, tools like haptic feedback robots, gaming console controllers (Wiimote), and computer dials (Surface Dial) expanded user interaction possibilities through intuitive gestures such as tapping, sliding, swiping, and turning. These gestures complemented traditional screen reader input methods, including voice commands and keyboard shortcuts, offering a more versatile and user-friendly navigation experience. The integration of tactile and auditory feedback ensured that these technologies provide a richer and more accessible interaction paradigm for VI users.

Design Considerations

The findings of this review underscore several essential design considerations for developing AT that effectively support impaired screen reader users. A foundational element of effective AT design is the implementation of appropriate information models. These models must strategically integrate hierarchical, spatial, and semantic webpage information to align with users' navigation goals and the intended contexts of use [56]. By combining these dimensions, AT can present information in ways that reflect the complexity of modern web environments while simplifying navigation for VI users. Ensuring this alignment between user needs and technology functionality is vital to enhancing accessibility and reducing cognitive burden. Additionally, thoughtful integration of these models can empower users to navigate websites with increased precision and confidence.

Equally important is the need for clear multimodal interactions which balance simplicity and functionality. By employing intuitive and familiar input gestures while minimizing redundant or excessive feedback, multimodal designs can significantly reduce user cognitive overload [19]. For instance, feedback mechanisms should be concise yet informative, providing enough guidance without overwhelming the user. This balance ensures that technologies are accessible to users with varying levels of technical proficiency. Furthermore, clear multimodal interactions improve the user experience by enabling smoother transitions between tasks and reducing the mental effort required to understand and use the technology. Such thoughtful design choices not only increase usability but also enhance user satisfaction.

AT must supplement rather than replace familiar screen reader strategies to preserve user autonomy. Alternative interaction methods should complement existing tools, ensuring VI users can retain control over their navigation processes while benefiting from additional functionalities [20]. This complementary approach respects the skills and preferences of experienced screen reader users, allowing them to integrate new technologies into their existing workflows seamlessly. Moreover, maintaining compatibility with familiar strategies minimizes the learning curve for users adopting these technologies. This balance between innovation and familiarity is key to ensuring AT solutions' long-term adoption and success. User-friendly design is another critical pillar of effective AT development. Interfaces should prioritize intuitiveness, customization, and learnability to accommodate users across a wide range of experience levels [57]. By creating designs that are easy to understand and adapt, developers can empower users to refine their skills and navigate the technology efficiently and independently. Customizable features, in particular, allow users to tailor the interface to their specific needs and preferences, further enhancing accessibility. This focus on user-centered design increases engagement and fosters a sense of ownership and competence among users.

A modular approach to AT design further enhances adaptability and scalability. By leveraging software and hardware modules based on standard protocols, developers

can reduce barriers to innovation while allowing users to easily integrate additional functionalities [58-59]. Modular implementation supports the use of off-the-shelf peripherals, such as USB Human Interface Devices, as well as custom-built components. This flexibility enables users to expand the capabilities of their AT as their needs evolve, ensuring that the technology remains relevant over time. Additionally, modularity simplifies maintenance and updates, promoting long-term usability and sustainability.

Finally, participatory and open development models are critical for creating truly inclusive AT solutions. Actively involving VI users throughout the design and evaluation process ensures that the resulting technologies address real-world needs and preferences, minimizing the risk of creating inaccessible or ineffective systems [58], [60]. Furthermore, open-source collaboration fosters innovation by leveraging multidisciplinary expertise and incorporating diverse perspectives [61-63]. This collaborative approach not only enhances the quality of the technology but also contributes to the development of equitable systems, policies, and communities. Together, these design considerations provide a comprehensive framework for creating AT that is user-centric, functional, and sustainable, paving the way for more accessible digital experiences for VI users.

Limitations

This review offers valuable insights into assistive technologies designed for screen reader-based internet navigation by visually impaired users. However, certain limitations should be acknowledged. The exclusion of 24 studies that lacked user evaluations by VI individuals may have omitted important design considerations that could contribute to a broader understanding. Furthermore, the relatively small number of technologies included in the review, coupled with generally small sample sizes and experimental design variations, limits the findings' generalizability. These constraints highlight the need for more comprehensive evaluations and larger participant cohorts to strengthen the reliability and applicability of future research in this area.

Future Research

While the evaluated technologies demonstrated promising outcomes in enhancing accessibility and usability, they also face notable challenges. These include limited evaluation by VI users, the lack of commercial availability, rapid obsolescence of components, and underrepresentation in human-computer interaction (HCI) research [64]. To address these barriers, adopting an open-source development model presents a viable pathway forward. Open-source frameworks could facilitate equitable, sustainable, and affordable innovation by distributing research, development, and distribution costs and benefits among a collaborative network. This approach encourages the co-creation of assistive tools, incorporating diverse expertise and perspectives while ensuring long-term support and adaptability [62], [65].

5. Conclusion

This narrative review examined 33 assistive technologies designed to support internet navigation for VI screen reader users, focusing on their design features and impact on user experience. Most of these technologies were software-based, primarily implemented as web browser extensions, with only a few incorporating hardware components. The reviewed technologies employed diverse strategies to enhance web accessibility, including alternative content presentations, page overviews, improved data record interactions, visual semantics annotation, and the automation of user intents. Key design considerations identified include using appropriate information models tailored to specific navigation tasks, implementing intuitive multimodal interactions, and leveraging modular and customizable components. Evaluations consistently demonstrated promising outcomes, such as reduced cognitive load, improved task efficiency, and enhanced navigation experiences. However, the absence of commercially available solutions highlights the need for sustainable development models that prioritize long-term viability and accessibility. This gap underscores an opportunity for future research and development to focus on co-creating modular, sustainable, and widely available assistive technologies that better serve the needs of VI internet users.

Funding Statement

This research was made possible through funding provided by Société Inclusive, the Office des personnes handicapées du Québec (OPHQ), and the Centre interdisciplinaire de recherche en réadaptation et intégration sociale (CIRRIS).

Acknowledgments

The authors extend their sincere gratitude to Université Laval, the Institut Nazareth et Louis-Braille of the CIUSSS de la Montérégie-Centre, the Lethbridge-Layton-Mackay Rehabilitation Centre of the CIUSSS Centre-Ouest-de-l'île-de-Montréal, and the Regroupement des aveugles et amblyopes du Montréal Métropolitain (RAAMM) for their invaluable support. Dr. Poncet’s contribution was supported by a Junior 1 chercheur boursier career award from the Fonds de recherche Québec-Santé, the Unité de soutien Système de Santé apprenant Québec, and by the Habilitas Foundation.

References

[1] James Slevin, "Internet," *The Blackwell Encyclopedia of Sociology*, pp. 1-5, 2017. [CrossRef] [Publisher Link]

[2] Frank Webster, *Theories of the Information Society*, 4th ed., Routledge, pp. 1-416, 2014. [CrossRef] [Google Scholar] [Publisher Link]

[3] Patricia Obst, and Jana Stafurik, "Online We are All Able Bodied: Online Psychological Sense of Community and Social Support Found through Membership of Disability-Specific Websites Promotes Well-Being for People Living with a Physical Disability," *Journal of Community Applied Social Psychology*, vol. 20, no. 6, pp. 525-531, 2010. [CrossRef] [Google Scholar] [Publisher Link]

[4] Steven A. Wall, and Stephen Brewster, "Sensory Substitution Using Tactile Pin Arrays: Human Factors, Technology and Applications," *Signal Processing*, vol. 86, no. 12, pp. 3674-3695, 2006. [CrossRef] [Google Scholar] [Publisher Link]

[5] Susan Miller Smedema, and Amy R. McKenzie, "The Relationship among Frequency and Type of Internet Use, Perceived Social Support, and Sense of Well-Being in Individuals with Visual Impairments," *Disability and Rehabilitation*, vol. 32, no. 4, pp. 317-325, 2010. [CrossRef] [Google Scholar] [Publisher Link]

[6] Simon Harper, Carole Goble, and Robert Stevens, "Augmenting the Mobility of Profoundly Blind Web Travellers," *New Review of Hypermedia and Multimedia*, vol. 11, no. 1, pp. 103-128, 2005. [CrossRef] [Google Scholar] [Publisher Link]

[7] Shikha Shethia, and Angsana A. Techatassanasoontorn, "Experiences of People with Visual Impairments in Accessing Online Information and Services: A Systematic Literature Review," *Pacific Asia Journal of the Association for Information Systems*, vol. 11, no. 2, pp. 39-66, 2019. [CrossRef] [Google Scholar] [Publisher Link]

[8] Shivang Tripathi, Chandrani Halder, and D. Vanusha, "A Survey on Assistive Technology for the Visually Impaired," *International Research Journal of Engineering and Technology*, vol. 5, no. 2, pp. 1152-1155, 2018. [Google Scholar] [Publisher Link]

[9] Guy Meyer et al., *Literature Review of Computer Tools for the Visually Impaired: A Focus on Search Engines*, 1st ed., Artificial Intelligence in Healthcare and Medicine, pp. 237-259, 2022. [Google Scholar] [Publisher Link]

[10] Prabhat Verma, Raghuraj Singh, and Avinash Kumar Singh, "A Framework for the Next Generation Screen Readers for Visually Impaired," *International Journal of Computer Applications*, vol. 47, no. 10, pp. 31-38, 2012. [CrossRef] [Google Scholar] [Publisher Link]

[11] Screen Reader User Survey #10 Results, WebAIM, 2024. [Online]. Available: https://webaim.org/projects/screenreadersurvey10/

[12] Jan Charvat, "*Development of a Mobile Web Browser User Interface for the Blind*," Master Thesis, Czech Technical University in Prague, pp. 1-75, 2019. [Publisher Link]

[13] Yevgen Borodin et al., "More than Meets the Eye: A Survey of Screen-Reader Browsing Strategies," *International Cross Disciplinary Conference on Web Accessibility Raleigh*, pp. 1-10, 2010. [CrossRef] [Google Scholar] [Publisher Link]

[14] Marion A. Hersh, and Michael A. Johnson, *Assistive Technology for Visually Impaired and Blind People*, 1st ed., 2008. [CrossRef] [Google Scholar] [Publisher Link]

[15] Robert Baumgartner, Ruslan R. Fayzrakhmanov, and Rafael Gattringer, "Web 2.0 Vision for the Blind," *Web Science Conference*, pp. 1-8, 2010. [Google Scholar] [Publisher Link]

[16] Emma Murphy et al., "An Empirical Investigation Into the Difficulties Experienced by Visually Impaired Internet Users," *Universal Access in the Information Society*, vol. 7, no. 1-2, pp. 79-91, 2008. [CrossRef] [Google Scholar] [Publisher Link]

[17] Elizabeth D. Mynatt, "Transforming Graphical Interfaces Into Auditory Interfaces for Blind Users," *Human–Computer Interaction*, vol. 12, no. 1-2, pp. 7-45, 1997. [Google Scholar] [Publisher Link]

[18] Jaka Sodnik, Grega Jakus, and Sašo Tomažič, 'Multiple Spatial Sounds in Hierarchical Menu Navigation for Visually Impaired Computer Users," *International Journal of Human Computer Studies*, vol. 69, no. 1-2, pp. 100-112, 2011. [CrossRef] [Google Scholar] [Publisher Link]

[19] Ravi Kuber, Wai Yu, and Graham McAllister, "Towards Developing Assistive Haptic Feedback for Visually Impaired Internet Users," *Conference on Human Factors in Computing Systems - Proceedings*, pp. 1525-1534, 2007. [CrossRef] [Google Scholar] [Publisher Link]

[20] Jaeyoon Song et al., "SoundGlance: Briefing the Glanceable Cues of Web Pages for Screen Reader Users," *Extended Abstracts of the CHI Conference on Human Factors in Computing Systems*, pp. 1-6, 2019. [CrossRef] [Google Scholar] [Publisher Link]

[21] Andrea C. Tricco et al., "PRISMA Extension for Scoping Reviews (PRISMA-ScR): Checklist and Explanation," *Annals of Internal Medicine*, vol. 169, no. 7, pp. 467-473, 2018. [CrossRef] [Google Scholar] [Publisher Link]

[22] Kirsten R. Butcher, "Learning from Text with Diagrams: Promoting Mental Model Development and Inference Generation," *Journal of Educational Psychology*, vol. 98, no. 1, pp. 182-197, 2006. [CrossRef] [Google Scholar] [Publisher Link]

[23] Virginia Braun, and Victoria Clarke, "Using Thematic Analysis in Psychology," *Qualitative Research in Psychology*, vol. 3, no. 2, pp. 77-101, 2006. [CrossRef] [Google Scholar] [Publisher Link]

[24] Karen Denard Goldman, and Kathleen Jahn Schmalz, "The Matrix Method of Literature Reviews," *Health Promotion Practice*, vol. 5, no. 1, pp. 5-7, 2004. [CrossRef] [Google Scholar] [Publisher Link]

[25] Abdullah Ramdhani, Muhammad Ali Ramdhani, and Abdusy Syakur Amin, "Writing a Literature Review Research Paper: A Step-by-Step Approach," *International Journal of Basic & Applied Science*, vol. 3, no. 1, pp. 47-56, 2014. [Google Scholar] [Publisher Link]

[26] Niki Gomez, Dale Lane, and Julian Dailly, "The Conversational Internet : Creating a Natural Language Interface for Visually Impaired People to Converse with the Web," *W4A2013 – Communications*, pp. 1-4, 2013. [Google Scholar] [Publisher Link]

[27] Marcos Baez, Florian Daniel, and Fabio Casati, "Conversational Web Interaction: Proposal of a Dialog-Based Natural Language Interaction Paradigm for the Web," *Chatbot Research and Design*, vol. 11970, pp. 94-110, 2020. [CrossRef] [Google Scholar] [Publisher Link]

[28] Michail Salampasis et al., "BrowserTree: A Specialized Voice Web Browser for Blind People Modelling Hierarchical Structure of Web Pages," *Proceedings WMSCI 2005 - The 9th World Multi-Conference on Systemics, Cybernetics and Informatics*, vol. 9, pp. 59-64, 2005. [Google Scholar]

[29] Syed Masum Billah et al., "Speed-Dial: A Surrogate Mouse for Non-Visual Web Browsing," *Proceedings of the 19th International ACM SIGACCESS Conference on Computers and Accessibility*, Baltimore Maryland USA, pp. 110-119, 2017. [CrossRef] [Google Scholar] [Publisher Link]

[30] Alexandra Vtyurina et al., "Verse: Bridging Screen Readers and Voice Assistants for Enhanced Eyes-Free Web Search," *21st International ACM SIGACCESS Conference on Computers and Accessibility*, Pittsburgh PA USA, pp. 414-426, 2019. [CrossRef] [Google Scholar] [Publisher Link]

[31] Mahika Phutane et al., "Speaking with My Screen Reader: Using Audio Fictions to Explore Conversational Access to Interfaces," *Proceedings of the 25th International ACM SIGACCESS Conference on Computers and Accessibility*, New York NY USA, pp. 1-18, 2023. [CrossRef] [Google Scholar] [Publisher Link]

[32] Jiaji Wang, Shuihua Wang, and Yudong Zhang, "Artificial Intelligence for Visually Impaired," *Displays*, vol. 77, pp. 1-17, 2023. [CrossRef] [Google Scholar] [Publisher Link]

[33] Ahmad Hisham Zainal Abidin, Hong Xie, and Kok Wai Wong, "'Blind Users' Mental Model of Web Page Using Touch Screen Augmented with Audio Feedback," *International Conference on Computer and Information Science*, Kuala Lumpeu, pp. 1046-1051, 2012. [CrossRef] [Google Scholar] [Publisher Link]

[34] Emilia Djonov, "Website Hierarchy and the Interaction between Content Organization, Webpage and Navigation Design: A Systemic Functional Hypermedia Discourse Analysis Perspective," *Information Design Journal*, vol. 15, no. 2, pp. 144-162, 2007. [CrossRef] [Google Scholar] [Publisher Link]

[35] I. Karshmer et al., "Software Technology and Computer Interfaces for the Disabled : Non-Visual Browsing of the World Wide Web," 1998. [Google Scholar]

[36] Andrea Kennel, Louis Perrochon, and Alireza Darvishi, "WAB: World Wide Web Access for Blind and Visually Impaired Computer Users," *ACM SIGCAPH Computers and the Physically Handicapped*, no. 55, pp. 10-15, 1996. [CrossRef] [Google Scholar] [Publisher Link]

[37] Louis Perrochon, and Andrea Kennel, "World Wide Web Access for Blind People," *IEEE Symposium on Data Highway*, 1995. [Google Scholar]

[38] E. Pontelli et al., "Intelligent Non-Visual Navigation of Complex HTML Structures," *Universal Access in the Information Society*, vol. 2, pp. 56-69, 2002. [CrossRef] [Google Scholar] [Publisher Link]

[39] Martin Lukas Dorigo et al., "Nonvisual Presentation, Navigation and Manipulation of Structured Documents on Mobile and Wearable Devices," *Computers Helping People with Special Needs*, pp. 383-390, 2014. [CrossRef] [Google Scholar] [Publisher Link]

[40] Iyad Abu Doush, and Enrico Pontelli, "Non-Visual Navigation of Spreadsheets: Enhancing Accessibility of Microsoft Excel™," *Universal Access in the Information Society*, vol. 12, no. 2, pp. 143-159, 2013. [CrossRef] [Google Scholar] [Publisher Link]

[41] Oussama Metatla, Nick Bryan-Kinns, and Tony Stockman, "Using Hierarchies to Support Non-Visual Access to Relational Diagrams," *Proceedings of HCI 2007: The 21st British HCI Group Annual Conference*, vol. 1, pp. 215-225, 2007. [CrossRef] [Google Scholar] [Publisher Link]

[42] Kazunori Minatani, "Development of a DAISY Player that Utilizes a Braille Display for Document Structure Presentation and Navigation," *Computers Helping People with Special Needs*, vol. 7382, pp. 515-522, 2012. [CrossRef] [Google Scholar] [Publisher Link]

[43] Atiwong Suchato, Jirasak Chirathivat, and Proadpran Punyabukkana, "Enhancing a Voice-Enabled Web Browser for the Visually Impaired," *Proceedings of the International Conference on Applied Science*, pp. 1-7, 2006. [Google Scholar]

[44] Jirasak Chirathivat et al., "Internet Explorer Smart Toolbar for the Blind," *Proceedings of the 1st International Convention on Rehabilitation Engineering and Assistive Technology in Conjunction with 1st Tan Tock Seng Hospital Neurorehabilitation Meeting*, Singapore, pp. 195-200, 2007. [CrossRef] [Google Scholar] [Publisher Link]

[45] Carole Goble, Simon Harper, and Robert Stevens, "The Travails of Visually Impaired Web Travellers," *Proceedings of the eleventh ACM on Hypertext and Hypermedia*, pp. 1-10, 2000. [CrossRef] [Google Scholar] [Publisher Link]

[46] Ashrith Shetty, Ebrima Jarjue, and Huaishu Peng, "Tangible Web Layout Design for Blind and Visually Impaired People: An Initial Investigation," *Adjunct Proceedings of the 33rd Annual ACM Symposium on User Interface Software and Technology*, Virtual Event USA, pp. 37-39, 2020. [CrossRef] [Google Scholar] [Publisher Link]

[47] Alexy Bhowmick, and Shyamanta M. Hazarika, "An Insight into Assistive Technology for the Visually Impaired and Blind People: State-of-the-Art and Future Trends," *Journal on Multimodal User Interfaces*, vol. 11, no. 2, pp. 149-172, 2017. [CrossRef] [Google Scholar] [Publisher Link]

[48] Ahmad Hisham Zainal Abidin, Hong Xie, and Kok Wai Wong, "Touch Screen with Audio Feedback: Content Analysis and the Effect of Spatial Ability on Blind People's Sense of Position of Web Pages," *International Conference on Research and Innovation in Information Systems*, Kuala Lumpur, Malaysia, pp. 548-553, 2013. [CrossRef] [Google Scholar] [Publisher Link]

[49] Shaojian Zhu et al., "Identifying the Effectiveness of Using Three Different Haptic Devices for Providing Non-Visual Access to the Web," *Interacting with Computers*, vol. 23, no. 6, pp. 565-581, 2011. [CrossRef] [Google Scholar] [Publisher Link]

[50] João Guerreiro, and Daniel Gonçalves, "Scanning for Digital Content: How Blind and Sighted People Perceive Concurrent Speech," *ACM Transactions on Accessible Computing*, vol. 8, no. 1, pp. 1-28, 2016. [CrossRef] [Google Scholar] [Publisher Link]

[51] Laurent Sorin et al., "Communicating Text Structure to Blind People with Text-to-Speech," *Computers Helping People with Special Needs*, pp. 61-68, 2014. [CrossRef] [Google Scholar] [Publisher Link]

[52] Rodrigo Prestes Machado et al., "Implementation of Sound Workspace Awareness to Visually Impaired Users in Synchronous and Cooperative Web Applications," *New Technologies in Education Magazine*, vol. 15, no. 2, pp. 1-10, 2017. [CrossRef] [Google Scholar] [Publisher Link]

[53] Jonathan Cofino et al., "Sonifying HTML Tables for Audio-Spatially Enhanced Non-Visual Navigation," *Proceedings of IEEE Southeastcon*, Jacksonville, FL, USA, pp. 1-5, 2013. [CrossRef] [Google Scholar] [Publisher Link]

[54] Jingyi Li et al., "Editing Spatial Layouts through Tactile Templates for People with Visual Impairments," *Conference on Human Factors in Computing Systems - Proceedings*, Glasgow Scotland Uk, pp. 1-11, 2019. [CrossRef] [Google Scholar] [Publisher Link]

[55] Konstantinos Papadopoulos, Eleni Koustriava, and Panagiotis Koukourikos, "Comparison of Three Orientation & Mobility Aids for Individuals with Blindness: Verbal Description, Audio-Tactile Map and Audio-Haptic Map," *Assistive Technology*, vol. 29, no. 1, pp. 1-7, 2016. [CrossRef] [Google Scholar] [Publisher Link]

[56] Justin R. Brown et al., "Comparing Natural Language and Vibro-Audio Modalities for Inclusive STEM Learning with Blind and Low Vision Users," *Proceedings of the 25th International ACM SIGACCESS Conference on Computers and Accessibility*, New York NY USA, pp. 1-17, 2023. [CrossRef] [Google Scholar] [Publisher Link]

[57] Mailson de Queiroz Proença et al., "Coping with Diversity-A System for End-users to Customize Web User Interfaces," *Proceedings of the ACM on Human-Computer Interaction*, vol. 5, pp. 1-27, 2021. [CrossRef] [Google Scholar] [Publisher Link]

[58] Jaylin Herskovitz et al., "Hacking, Switching, Combining: Understanding and Supporting DIY Assistive Technology Design by Blind People," *Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems*, Hamburg Germany, pp. 1-17, 2023. [CrossRef] [Google Scholar] [Publisher Link]

[59] Farhani Momotaz, Md Ehtesham-Ul-Haque, and Syed Masum Billah, "Understanding the Usages, Lifecycle, and Opportunities of Screen Readers' Plugins," *ACM Transactions on Accessible Computing*, vol. 16, no. 2, pp. 1-35, 2023. [CrossRef] [Google Scholar] [Publisher Link]

[60] Charlotte Magnusson, Per-Olof Hedvall, and Héctor Caltenco, *Co-Designing Together with Persons with Visual Impairments*, Mobility of Visually Impaired People, Springer, Cham, pp. 411-434, 2017. [CrossRef] [Google Scholar] [Publisher Link]

[61] Ali Abdolrahmani et al., "Blind Leading the Sighted: Drawing Design Insights from Blind Users Towards More Productivity-Oriented Voice Interfaces," *ACM Transactions on Accessible Computing*, vol. 12, no. 4, pp. 1-35, 2020. [CrossRef] [Google Scholar] [Publisher Link]

[62] Jonathan Álvarez Ariza, and Joshua M. Pearce, "Low-Cost Assistive Technologies for Disabled People Using Open-Source Hardware and Software: A Systematic Literature Review," *IEEE Access*, vol. 10, pp. 124894-124927, 2022. [CrossRef] [Google Scholar] [Publisher Link]

[63] Catherine M. Baker, "*Understanding and Improving Blind Students' Access to Visual Information in Computer Science Education*," Thesis, University of Washington, pp. 1-169, 2017. [Google Scholar] [Publisher Link]

[64] Fatih Gurcan, Nergiz Ercil Cagiltay, and Kursat Cagiltay, "Mapping Human–Computer Interaction Research Themes and Trends from its Existence to Today: A Topic Modeling-Based Review of past 60 Years," *International Journal of Human–Computer Interaction*, vol. 37, no. 3, pp. 267-280, 2021. [CrossRef] [Google Scholar] [Publisher Link]

[65] Maria Angela Ferrario et al., "Software Engineering for "Social Good": Integrating Action Research, Participatory Design, and Agile Development," *Companion Proceedings of the 36th International Conference on Software Engineering*, Hyderabad India, pp. 520-523, 2014. [CrossRef] [Google Scholar] [Publisher Link]

[66] S. Elzer et al., "Accessible Bar Charts for Visually Impaired Users," *Proceedings of the 4th IASTED International Conference on Telehealth and Assistive Technologies*, pp. 55-60, 2008. [Google Scholar] [Publisher Link]

[67] Darren Lunn, Simon Harper, and Sean Bechhofer, "Combining SADIe and AxsJAX to Improve the Accessibility of Web Content," *Proceedings of the 2009 International Cross-Disciplinary Conference on Web Accessibililty (W4A)*, Madrid Spain, pp. 75-78, 2009. [CrossRef] [Google Scholar] [Publisher Link]

[68] K. Selçuk Candan et al., "SEA: Segment-Enrich-Annotate Paradigm for Adapting Dialog-Based Content for Improved Accessibility," *ACM Transactions on Information Systems*, vol. 27, no. 3, pp. 1-45, 2009. [CrossRef] [Google Scholar] [Publisher Link]

[69] Andy Brown, Caroline Jay, and Simon Harper, "Tailored Presentation of Dynamic Web Content for Audio Browsers," *International Journal of Human Computer Studies*, vol. 70, no. 3, pp. 179-196, 2012. [CrossRef] [Google Scholar] [Publisher Link]

[70] Yury Puzis et al., "An Intuitive Accessible Web Automation User Interface," *Proceedings of the International Cross-Disciplinary Conference on Web Accessibility*, Lyon France, pp. 1-4, 2012. [CrossRef] [Google Scholar] [Publisher Link]

[71] Worasa Limpanadusadee et al., "Chula-FungPloen: Assistive Software for Listening to Online Contents," *Proceedings of the 6th International Convention on Rehabilitation Engineering and Assistive Technology*, Tampines Singapore, pp. 1-4, 2012. [Google Scholar] [Publisher Link]

[72] Faisal Ahmed, "Accessible Skimming: Faster Screen Reading of Web Pages," *Proceedings of the 14th International ACM SIGACCESS Conference on Computers and Accessibility*, Boulder Colorado USA, pp. 289-290, 2012. [CrossRef] [Google Scholar] [Publisher Link]

[73] Romisa Rohani Ghahari et al., "Back Navigation Shortcuts for Screen Reader Users," *Proceedings of the 14th International ACM SIGACCESS Conference on Computers and Accessibility*, Boulder Colorado USA, pp. 1-8, 2012. [CrossRef] [Google Scholar] [Publisher Link]

[74] Najd A. Al-Mouh et al., "Proxy Service to Contextualize Web Browsing for the Visually Impaired," *Proceedings of International Conference on Information Integration and Web-Based Applications & Services*, Vienna Austria, pp. 634-638, 2013. [CrossRef] [Google Scholar] [Publisher Link]

[75] Eu Jin Wong et al., "HABOS: Towards a Platform of Haptic-Audio Based Online Shopping for the Visually Impaired," *IEEE Conference on Open Systems*, Melaka, Malaysia, pp. 62-67, 2015. [CrossRef] [Google Scholar] [Publisher Link]

[76] Petra Gröber, and Julia Köster, "An Analysis to Overcome Shortcomings to Improve the Accessibility for the Blind: A Case Study on Facebook's Homepage," *Proceedings - 12th International Conference on Signal Image Technology and Internet-Based Systems*, Naples, Italy, pp. 442-449, 2016. [CrossRef] [Google Scholar] [Publisher Link]

[77] Vikas Ashok et al., "Web Screen Reading Automation Assistance Using Semantic Abstraction," *Proceedings IUI International Conference on Intelligent User Interfaces*, Limassol Cyprus, pp. 407-418, 2017. [CrossRef] [Google Scholar] [Publisher Link]

[78] Rushil Khurana et al., "Nonvisual Interaction Techniques at the Keyboard Surface," *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems*, Montreal QC Canada, pp. 1-12, 2018. [CrossRef] [Google Scholar] [Publisher Link]

[79] Stéphanie Giraud, Pierre Thérouanne, and Dirk D. Steiner, "Web Accessibility: Filtering Redundant and Irrelevant Information Improves Website Usability for Blind Users," *International Journal of Human Computer Studies*, vol. 111, pp. 23-35, 2018. [CrossRef] [Google Scholar] [Publisher Link]

[80] Vikas Ashok et al., "Auto-Suggesting Browsing Actions for Personalized Web Screen Reading," *Proceedings of the 27th ACM Conference on User Modeling, Adaptation and Personalization*, Larnaca Cyprus, pp. 252-260, 2019. [CrossRef] [Google Scholar] [Publisher Link]

[81] Kristin Williams et al., "Find and Seek: Assessing the Impact of Table Navigation on Information Look-Up with a Screen Reader," *ACM Transactions on Accessible Computing*, vol. 12, no. 3, pp. 1-23, 2019. [CrossRef] [Google Scholar] [Publisher Link]

[82] Hae-Na Lee, and Vikas Ashok, "Towards Personalized Annotation of Webpages for Efficient Screen-Reader Interaction," *Proceedings of the 31st ACM Conference on Hypertext and Social Media*, Virtual Event USA, pp. 111-116, 2020. [CrossRef] [Google Scholar] [Publisher Link]

[83] Iris Xie et al., "Using Digital Libraries Non-Visually: Understanding the Help-Seeking Situations of Blind Users," *Information Research: An International Electronic Journal*, vol. 20, no. 2, pp. 1-35, 2015. [Google Scholar] [Publisher Link]

[84] Hae-Na Lee, Sami Uddin, and Vikas Ashok, "iTOC: Enabling Efficient Non-Visual Interaction with Long Web Documents," *IEEE International Conference on Systems, Man, and Cybernetics (SMC)*, Toronto, ON, Canada, pp. 3799-3806, 2020. [CrossRef] [Google Scholar] [Publisher Link]

[85] Javedul Ferdous, Sami Uddin, and Vikas Ashok, "Semantic Table-of-Contents for Efficient Web Screen Reading," *Proceedings of the ACM Symposium on Applied Computing*, Virtual Event Republic of Korea, pp. 1941-1949, 2021. [CrossRef] [Google Scholar] [Publisher Link]

[86] Yanan Wang et al., "What Makes Web Data Tables Accessible? Insights and a Tool For Rendering Accessible Tables for People with Visual Impairments," *Proceedings of the Conference on Human Factors in Computing Systems*, New Orleans LA USA, pp. 1-20, 2022. [CrossRef] [Google Scholar] [Publisher Link]

[87] Natã M. Barbosa et al., ""Every Website Is a Puzzle!": Facilitating Access to Common Website Features for People with Visual Impairments," *ACM Transactions on Accessible Computing*, vol. 15, no. 3, pp. 1-35, 2022. [CrossRef] [Google Scholar] [Publisher Link]

[88] Aboubakr Aqle, Dena Al-Thani, and Ali Jaoua, "Can Search Result Summaries Enhance the Web Search Efficiency and Experiences of the Visually Impaired Users?," *Universal Access in the Information Society*, vol. 21, pp. 171-192, 2022. [CrossRef] [Google Scholar] [Publisher Link]

[89] Anand Ravi Aiyer, IV Ramakrishnan, and Vikas Ashok, "Taming Entangled Accessibility Forum Threads for Efficient Screen Reading," *Proceedings of the 28th International Conference on Intelligent User Interfaces*, Sydney NSW Australia, pp. 65-76, 2023. [CrossRef] [Google Scholar] [Publisher Link]

[90] Yash Prakash et al., "AutoDesc: Facilitating Convenient Perusal of Web Data Items for Blind Users," *Proceedings of the 28th International Conference on Intelligent User Interfaces*, Sydney NSW Australia, pp. 32-45, 2023. [CrossRef] [Google Scholar] [Publisher Link]

[91] Mohan Sunkara et al., "Enabling Customization of Discussion Forums for Blind Users," *Proceedings of the ACM on Human-Computer Interaction*, vol. 7, pp. 1-20, 2023. [CrossRef] [Google Scholar] [Publisher Link]

[92] Javedul Ferdous et al., "Enabling Efficient Web Data-record Interaction for People with Visual Impairments via Proxy Interfaces," *ACM Transactions on Interactive Intelligent Systems*, vol. 13, no. 3, pp. 1-27, 2023. [CrossRef] [Google Scholar] [Publisher Link]

[93] Dena Al-Thani, and Aboubakr Aqle, "Evaluating Search Results Overviews and Previews with Visually Impaired Users," *Proceedings of the 16th International Conference on PErvasive Technologies Related to Assistive Environments*, Corfu Greece, pp. 680-685, 2023. [CrossRef] [Google Scholar] [Publisher Link]

[94] Mengxi Zhang et al., "Enhancing Accessibility of Web-Based SVG Buttons: An Optimization Method and Best Practices," *Expert Systems with Applications*, vol. 238, 2024. [CrossRef] [Google Scholar] [Publisher Link]

[95] Jorge Sassaki Resende Silva et al., "In-Page Navigation Aids for Screen-Reader Users with Automatic Topicalisation and Labelling," *ACM Transactions on Accessible Computing*, vol. 17, no. 2, pp. 1-45, 2024. [CrossRef] [Google Scholar] [Publisher Link]

[96] Yash Prakash et al., "All in One Place: Ensuring Usable Access to Online Shopping Items for Blind Users," *Proceedings of the ACM on Human-Computer Interaction*, vol. 8, pp. 1-25, 2024. [CrossRef] [Google Scholar] [Publisher Link]

Appendix 1 Design characteristics and evaluation outcomes of included studies

	Technology description													Participants			Evaluation scenario		Experimental task			Reported outcomes				
Bibliographical reference	Browser extension	SR extension	App	HW	Haptic feedback	Alternative presentation	Page overview	Data Records	Visual semantics	Automate intent	Semantic info.	Hierarchical info.	Spatial/visual info.	Low vision	Both	Blind	Only SR vs. AT	Only AT	Information retrieval	Website exploration	Transaction	Reduced time	Reduced shortcut number	Reduced cognitive effort	Increased completion rate	Positive user feedback
Elzer et al., 2008 [66]	✓								✓		✓		✓			10		✓		✓					✓	✓
Lunn et al., 2008 [67]	✓					✓			✓			✓	✓	1		3	✓		✓			✓			✓	✓
Candan et al., 2009 [68]	✓					✓					✓	✓		1		3	✓		✓			✓	✓		✓	✓
A. Brown et al., 2012 [69]	✓					✓	✓				✓	✓		2		10	✓				✓					✓
Abidin et al.,		✓			✓		✓		✓				✓			11	✓			✓					✓	

2012 [33]																									
Puzis et al., 2012 [70]	✓									✓	✓					17	✓				✓	✓		✓		✓
Limpanuadusadee et al., 2012 [71]			✓*pc	✓		✓						✓				1	✓		✓			✓				
Ahmed, 2012 [72]	✓					✓	✓				✓					23	✓		✓			✓		✓		✓
Ghahari et al., 2012 [73]			✓*web				✓				✓					10	✓			✓		✓	✓	✓	✓	✓
Al-Mouh et al., 2013 [74]			✓*web			✓			✓		✓	✓	✓			5		✓		✓						✓
Wong et al., 2016 [75]			✓*web	✓	✓			✓		✓	✓		✓		15			✓			✓				✓	✓
Grober & Koster, 2017 [76]	✓					✓	✓				✓	✓	✓			1	✓		✓							✓
Ashok et al., 2017 [77]	✓									✓	✓					18	✓		✓		✓	✓	✓			✓
Khurana et al., 2018 [78]	✓					✓	✓		✓			✓	✓	2		8	✓		✓	✓					✓	✓
Giraud et al., 2018 [79]			✓*pc			✓					✓	✓				76	✓		✓		✓	✓		✓		✓
Song et al., 2019 [20]			✓*pc				✓		✓		✓		✓			14	✓			✓						✓
Ashok et al.,	✓			✓	✓	✓				✓	✓	✓				12	✓				✓	✓				✓

2019 [80]																									
Williams et al., 2019 [81]	✓+human					✓		✓			✓		✓			21	✓		✓	✓		✓		✓	✓	✓
Lee & Ashok, 2020 [82]	✓					✓	✓				✓	✓				5	✓		✓	✓			✓			
Xie et al., 2020 [83]			✓*web			✓		✓			✓	✓			40		✓		✓	✓				✓		✓
Hae-Na Lee et al., 2020 [84]	✓						✓				✓	✓				15	✓			✓		✓	✓			✓
Ferdous et al., 2021 [85]	✓					✓					✓	✓				15	✓				✓	✓	✓	✓		✓
Y. Wang et al., 2022 [86]	✓					✓		✓			✓	✓	✓			5	✓			✓						✓
Barbosa et al., 2022 [87]	✓+human									✓	✓					9	✓		✓			✓				✓
Aqle et al., 2022 [88]	✓					✓		✓			✓	✓				16	✓		✓			✓			✓	✓
Aiyer et al., 2023 [89]	✓					✓		✓			✓	✓				11	✓		✓			✓	✓	✓		✓
Prakash et al., 2023 [90]	✓					✓					✓					11	✓		✓		✓	✓	✓		✓	✓
Sunkara et al., 2023 [91]	✓					✓					✓					14	✓			✓				✓		✓
Ferdous et al., 2023 [92]	✓					✓		✓			✓	✓		16		14	✓		✓			✓	✓	✓		✓

Al-Thani & Aqle, 2023 [93]	✓					✓		✓			✓	✓				35	✓		✓			✓			
Zhang et al., 2024 [94]	✓					✓					✓		✓	4		6	✓								✓
Silva et al., 2024 [95]	✓					✓	✓				✓					8	✓		✓			✓		✓	✓
Prakash et al., 2024 [96]	✓					✓		✓	✓	✓	✓					14	✓		✓		✓	✓	✓	✓	✓	✓