Micro-Behavioral Analysis of Online Shopping Patterns for Blind Users

Yash Prakash
Old Dominion University
Department of Computer Science
Norfolk, Virginia, USA
yprak001@odu.edu

Akshay Kolgar Nayak
Old Dominion University
Department of Computer Science
Norfolk, Virginia, USA
anaya001@odu.edu

Nithiya Venkatraman
Old Dominion University
Department of Computer Science
Norfolk, Virginia, USA
nvenk001@odu.edu

Sampath Jayarathna
Old Dominion University
Department of Computer Science
Norfolk, Virginia, USA
ujayarat@odu.edu

Hae-Na Lee
Michigan State University
Department of Computer Science
East Lansing, Michigan, USA
leehaena@msu.edu

Vikas Ashok
Old Dominion University
Department of Computer Science
Norfolk, Virginia, USA
vganjigu@odu.edu

Abstract

While online shopping platforms provide convenience and autonomy to blind users, their non-visual interactions remain underexplored at a micro-behavioral level. Existing studies have primarily emphasized accessibility and usability challenges but have overlooked how fine-grained, screen reader-driven keystroke-level behaviors reflect users' cognitive strategies. In this paper, we present the findings of a longitudinal study with 25 blind participants to examine their micro-behavioral patterns, using keyboard activity and screen reader logs on both familiar and unfamiliar e-commerce websites. We complemented this study with semi-structured interviews to contextualize the uncovered micro-behavioral patterns. Our results revealed patterns in how blind users draw upon cognitive maps and well-established shortcut routines developed on familiar websites to streamline navigation on unfamiliar platforms. However, unfamiliar websites, even when structurally accessible, often introduced elevated navigation entropy, increased shortcut failures, and induced more exploratory behavior, as users worked to reconstruct new mental models. Additionally, we also identified a strong preferential structure in keyboard shortcut use, where users maintain a personalized and often chronologically-ranked sequence of keystrokes. Furthermore, most users approached shopping with pre-planned objectives, relying on targeted search queries rather than broad ad-hoc product exploration for securing the 'best deals'. Based on the study insights, we discuss design considerations for assistive technology developers and e-commerce websites to further improve the online shopping experience for blind users.

CCS Concepts

• **Human-centered computing → Accessibility technologies**; *Empirical study*.

ACM ISBN 979-8-4007-2414-5/2026/03
https://doi.org/10.1145/3786304.3788841

Keywords

Web accessibility, Usability, Web Browsing, Blind, Visual impairment, Screen reader, User Behavior

ACM Reference Format:
Yash Prakash, Akshay Kolgar Nayak, Nithiya Venkatraman, Sampath Jayarathna, Hae-Na Lee, and Vikas Ashok. 2026. Micro-Behavioral Analysis of Online Shopping Patterns for Blind Users. In *2026 ACM SIGIR Conference on Human Information Interaction and Retrieval (CHIIR '26), March 22–26, 2026, Seattle, WA, USA*. ACM, New York, NY, USA, 11 pages. https://doi.org/10.1145/3786304.3788841

1 Introduction

Online shopping refers to purchasing goods or services through the Internet, where users browse products on websites or apps, make selections, and complete transactions electronically [3, 50]. The global eCommerce market is projected to generate revenues of approximately $4.32 trillion in 2025. With a compound annual growth rate of 8.02% forecasted for 2025-2029, the market is expected to reach a valuation of $5.89 trillion by 2029 [52].

Although online shopping offers unparalleled convenience, it also introduces an overwhelming volume of information and a vast array of purchasing channels that can complicate the decision-making process. In such a dynamic environment, gaining a comprehensive understanding of customer behavior becomes increasingly important [31, 37]. Customer behavior encompasses the full sequence of decisions and interactions that occur throughout the shopping journey, including how consumers discover, evaluate, and ultimately choose products [51]. By analyzing these behavioral patterns, designers and developers can craft more intuitive website structures, engaging visual cues, and responsive interactive features that not only enhance user satisfaction but also reduce cognitive overload and improve conversion rates [19].

This has led to significant research into understanding the online shopping behaviors of sighted users [21, 22, 28, 34, 39]. Much of this work has traditionally focused on "macro-level behaviors", which capture high-level interaction patterns such as purchase histories, category-level browsing trajectories, and revisitation tendencies. Recent literature has investigated "micro-level behaviors" [4, 8, 61]. "Micro-behavior" refers to small, detailed units of interaction during web browsing, such as scrolling patterns, hovering activity, mouse inactivity, and episodic breakdowns in user sessions. For instance, as users become more familiar with a webpage, their scrolling typically becomes more efficient, and increased periods of mouse inactivity may signal reduced exploratory needs [4].

However, for blind users, the absence of visual cues necessitates reliance on screen reader assistive technologies, which are primarily operated via keyboard shortcuts [15, 44]. For instance, users may press H to jump between headings, TAB to navigate through links, L to list items, and use the arrow keys to traverse web elements sequentially. This interaction paradigm enables screen readers to present web content in a one-dimensional, linear manner, allowing blind users to navigate and interact with online shopping platforms [32]. As a result, "micro-behaviors" manifest differently in this context, through patterns of keyboard-based interactions such as the preference for specific shortcuts, variations in the sequence of shortcut usage, and adaptive keystroke strategies that evolve with increasing familiarity with a webpage. Despite their potential to reveal meaningful insights regarding non-visual shopping patterns, micro-behavioral interactions of blind users remain unexplored.

We fill this gap by collecting and analyzing micro-behavioral temporal units of interaction derived from keyboard shortcut usage and webpage DOM traversal logs of blind users. Specifically, we conducted a user study with 25 volunteering blind participants over a period of three months, organized into three phases. In the first phase, we selectively logged participants' interaction data as they navigated shopping websites they were already familiar with while ensuring that private information, such as form field entries, was excluded. In the second phase, we collected similar interaction data while participants explored unfamiliar online shopping platforms they had not previously used. The data from both phases were then analyzed to identify and compare micro-behavioral patterns. In the final phase, we conducted semi-structured interviews with the participants to gather qualitative feedback and validate the findings derived from the analysis of interaction logs.

From our studies, we uncovered several behavioral patterns that we organized into 3 primary themes: *Familiarity-based navigation strategies*, *Unfamiliarity-driven navigation entropy*, and *Preferential keyboard tactics.* Notably, we observed that blind users heavily rely on mental models formed through repeated interactions with familiar websites to guide their choice of keyboard shortcuts for navigation. However, on an unfamiliar website whose layout does not align with these established shortcut patterns, they tend to drastically reduce the diversity of shortcuts and shift toward slow exploratory behavior with a handful of basic shortcuts. This, in turn, leads to an increased number of key presses and longer interaction times, as users work to construct a new mental model that supports effective navigation on the unfamiliar webpage. Informed by our findings, we provide design suggestions for addressing the known interaction challenges faced by screen reader users in online shopping websites [1, 36, 48, 58]. In sum, our contributions are:

- The findings of a longitudinal study with 25 blind participants uncovering their micro-interaction behaviors in online shopping websites.
- Design suggestions for developers and researchers for improving the usability of e-commerce websites, based on the uncovered micro-behavioral interaction patterns.

2 Related Work

Our study expands the existing body of research in the following areas : (i) Online shopping experiences of blind users, and (ii) Micro-behavioral analysis of web interaction.

2.1 Online Shopping Experiences of Blind Users

Online shopping websites offer greater accessibility to visually impaired shoppers than physical stores, granting them a sense of reliability and independence by minimizing the necessity for physical navigation [26]. Studies show that blind individuals spend roughly twice the time of sighted users seeking information on online shopping websites [7]. Numerous research efforts have previously uncovered various accessibility and usability challenges of e-commerce platforms [9, 17, 26, 47, 59]. The accessibility challenges faced by visually impaired users in navigating shopping platforms are multifaceted and significant, especially due to the complex structures that include various data formats such as images, graphs, and tables. For instance, inadequate image descriptions make it difficult for visually impaired users to assess product relevance. While the implementation of 'alt-text' tags offers a partial resolution, a more precise and efficient method for product description is imperative [9]. Additionally, comprehension of web data tables requires significant memory, as the lack of visual cues exacerbates their inaccessibility [59, 62].

In terms of usability, web designers are encouraged to create simpler interfaces that alleviate cognitive and memory burdens for blind users [26, 53, 55]. However, companies often prioritize visual aesthetics of their platforms over adhering to accessibility guidelines. This leads to a convoluted structure and unclear organization, negatively impacting user orientation [17, 42, 43]. Dynamic features like pop-ups, automatic refresh, and flash plugins further diminish accessibility and hinder the shopping efficiency of blind users [17, 36, 47]. Additionally, issues with security and payment processes further degrade the user experience [17].

Most design recommendations and assistive technology solutions for enhancing the interaction of blind users with shopping websites focus on addressing these aforementioned accessibility and usability challenges. However, there has been no prior research that explores user interaction from a micro-behavioral perspective, which could lead to novel design implications. We aim to address this gap in our paper, providing new insights into designing more effective systems for visually impaired users.

2.2 Micro-Behavioral Analysis on Websites

In recent years, there has been a growing interest in the micro-behavior-based analysis of user interactions with systems [38, 60, 61]. The study of these interactions offers insights into users' underlying intentions, which could be exploited for the development of advanced recommendation systems in e-commerce platforms. For instance, Zhou et al. [61] proposed the 'RIB' framework, emphasizing the pivotal role of micro-behaviors in recommendation systems. Meng et al [38] integrated micro-behavioral patterns and item knowledge simultaneously to propose a novel session-based recommendation model, namely 'MKM-S.' More recent research by Yuan et al. [60] presents 'SR-EMBSR' model, capitalizing on the relational patterns of micro-behaviors within each session for making session-based recommendations.

'Micro-behavior' refers to small, detailed units of user interaction captured during Web browsing, such as mouse scrolling and hovering patterns, mouse inactivity, and the episodic breakdown of user sessions. For example, as users grow more familiar with a webpage, their scrolling tends to become faster and more concise. Also, periods of mouse inactivity increase with familiarity, possibly signifying a decreased need to explore actively [4]. These behaviors represent specific actions within a user's broader 'macro-behavioral' interaction pattern. By studying these micro-behaviors, researchers can uncover how users' engagement and navigation evolve, highlighting shifts in their proficiency and familiarity, which can then inform the development of personalized recommendation systems for shopping platforms [61].

Current research into the online shopping experiences of visually impaired individuals, however, remains limited, primarily addressing the accessibility and usability issues of online shopping sites as explained previously [9, 17, 26, 36]. There is a significant gap in research addressing "unconscious biases" or "micro-behaviors" of visually-impaired consumers during online shopping. For instance, there is a need to explore how the habitual use of keyboard shortcuts by blind users influences their navigation paths across various web pages, and how their familiarity with a website can significantly improve their experience when browsing multiple pages, compared to their experience on a website they have not visited before. In our work, we seek answers to these questions.

3 Micro-Behavioral Patterns

To capture the micro-behavioral patterns of screen reader users' interaction on online shopping websites, we conducted an IRB-approved longitudinal user study with blind screen-reader users, as explained next.

3.1 Participants

We recruited 25 blind participants [1] with a nearly balanced representation of male and female participants (12 female, 13 male) through email lists and word-of-mouth. The average age of the participants was 25.8 (Median = 25, Max = 40, Min = 18). Our inclusion criteria required that all participants were: (a) exclusively users of screen readers, thus including participants with severely limited visual acuity; (b) proficient in one of the screen readers - JAWS, NVDA, or VoiceOver; and (c) experienced with web navigation and online shopping. The demographics of the participants are detailed in Table 1, which encompasses self-reported data regarding their visual condition, their preferred assistive technology, and their familiarity with e-commerce platforms.

Category	Subcategory	Count
Sample	Total participants	25
	Median age (years)	24
	Male / Female	13 / 12
Age Range	18-25 years	13
	26-35 years	9
	>35 years	3
Visual Diagnosis	Glaucoma	5
	Optic atrophy	4
	Cataracts	3
	Leber congenital amaurosis	2
	Other conditions	4
	Not reported (N/A)	7
Occupation	Student	7
	Self-employed	8
	Consultant	3
	Teacher	2
	Other	5
Screen Reader	NVDA	13
	JAWS	12
Shopping Experience	1 year	5
	2-3 years	12
	4-5 years	6
	>5 years	2
Shopping Freq./Week	0-1 times	2
	1-2 times	9
	2-3 times	10
	>3 times	4

Table 1: Summary demographics of blind participants (N=25) in the online shopping evaluation study. All information was self-reported.

3.2 Materials and Methods

The study was conducted as a three-month longitudinal investigation into participants' online shopping behaviors in naturalistic environments. The study proceeded in three phases: In the initial phase, participants were invited to the laboratory for onboarding, during which the study's objectives, protocols, and expectations were explained. Participants were then briefed on the data collection procedures, provided informed consent, and were guided through the installation and configuration of lightweight logging tools on their personal computers. These tools enabled monitoring of shopping-related interactions, and participants were shown how to activate and deactivate the tools as needed to maintain control over their privacy.

In the second phase, participants met with the research team virtually via Zoom. Participants were presented with a curated list of 15 online shopping platforms, all of which were pre-screened for baseline accessibility using the WAVE evaluation tool [23]. From this list, they selected one platform they were highly familiar with (i.e., a site they regularly use and feel confident navigating) and five platforms they were unfamiliar with or had limited prior experience using. This design lets us examine how navigation routines and shortcut strategies developed on a well-known site transfer to new interfaces. We asked participants to select multiple unfamiliar platforms, rather than only one, to reduce the chance that any observed effects are driven by idiosyncrasies of a single website; instead, we

[1]The typical sample size for studies involving individuals with visual disabilities ranges from 8 to 20, reflecting the challenges associated with recruiting such participants.

assess whether the same micro-behavioral patterns persist across a diverse set of unfamiliar pages.

To verify the accuracy of participants' self-reported familiarity levels with selected platforms, we first collected responses on their frequency of online shopping using a seven-point Likert scale (1 = Rarely ever, 2 = Once a month, 3 = Once every two weeks, 4 = Once a week, 5 = 2–4 times a week, 6 = More than 5 times a week, and 7 = Every day). In addition, we cross-referenced these responses with participants' historical browsing logs collected during the study, focusing on the number of sessions, visit frequency, and duration of interactions with each platform. Platforms that showed consistent engagement in both self-reports and log data were categorized as 'familiar,' while those with limited or no prior interaction were classified as 'unfamiliar.'

Following this, participants were instructed to complete a *Free Task* on each of the six selected platforms, wherein they were hypothetically allotted a total of $500 for making purchases. They were given autonomy on how to split this budget, resulting in a wide variety of product searches.

Analysis of the session logs indicated that participants primarily looked for high-value electronics (e.g., mobile phones, laptops, and smart glasses), as well as daily-use items (e.g., clothes and perfumes). This task was designed to emulate realistic shopping behavior while allowing us to examine behavioral variations across platforms with differing levels of user familiarity.

Notably, our analyses focused on navigation micro-behaviors that are primarily shaped by page structure and interaction affordances, and we observed broadly similar product-category choices across familiar and unfamiliar sessions. To reduce potential cognitive constraints associated with time pressure [35], no time limits were imposed.

During the initial Zoom session, participants received detailed instructions on how to conduct the shopping tasks and were asked to integrate these activities into their regular online shopping routines over the subsequent three-month period. Participants were encouraged to shop naturally and at their own pace, treating the study platforms as they would in their everyday online shopping activities. They were instructed to activate the logging tools at the beginning of each shopping session and deactivate them upon completion, ensuring continuous yet privacy-conscious data collection throughout the study duration.

This longitudinal approach allowed us to capture authentic interaction patterns as participants progressively developed familiarity with initially unfamiliar platforms while maintaining their established behaviors on familiar ones. Throughout the three-month period, participants engaged in multiple shopping sessions across the six platforms, with the frequency determined by their natural shopping needs and preferences. Upon study completion, we collected the full set of interaction log data from all participants for subsequent analysis.

The final phase involved semi-structured interviews conducted after the log analysis. These interviews were designed to validate and further contextualize the findings from the logs and to explore participants' subjective experiences, shopping strategies, and preferences across both familiar and unfamiliar e-commerce platforms.

3.2.1 *Data Collection Sources*.

In this study, we collected data from distinct sources:

1. **AutoHotkeys:** AutoHotkey[2] scripts were employed to capture keystrokes and their respective timestamps. This data allowed us to discern patterns in keyboard navigation and the details of shortcuts employed by the participants during the study.
2. **NVDA Logs:** We developed a specialized add-on for the NVDA screen reader[3], enabling us to track users' interactions with the Document Object Model (DOM) elements. We capture the details of the DOM data element, which includes the node type, the inner text it encapsulates, assigned class names of web elements, time of interaction, duration, and the vocalized text sequences through the screen reader.
3. **Chrome Extension:** Our web Chrome extension [4], equipped with content scripts, was designed to both read and alter the DOM structure of the webpage. On every page load, it downloaded and stored all of the DOM data onto the disk file system. Additionally, it augmented each DOM element with a unique identifier, which could be cross-referenced with NVDA log data for thorough analysis.
4. **Screen Recording:** With formal consent from the participants, we screen-record the entire session to establish ground truth. This served as a reference point for data analysis, allowing us to consolidate information gathered from diverse sources.

All data from the tools above were logged locally on the users' computers and subsequently shared voluntarily with the researchers upon completion of the study. No personal data was collected, and participant confidentiality was maintained. We compensated the participants with a $30 Amazon e-gift card for their time. We utilized NVDA's open-source framework for logging as it allows custom add-on development; however, all participants were proficient with both NVDA and JAWS, and the core navigation shortcuts (e.g., H, B, TAB, ARROW keys) are consistent across both screen readers, ensuring the generalizability of our findings.

3.2.2 *Data Pre-Processing*.

For data pre-processing, we first began organizing our data by categorizing it according to the web pages visited, such as Amazon, eBay, Walmart, etc. For this, we used the data collected from the Chrome extension, which automatically downloaded and annotated each web element in the DOM as and when the webpage was loaded in the browser by the user to perform the task.

We categorized each webpage into two types: the *'Query-Results'* page, which displays a summary of data items, and the *'Details'* page, which presents comprehensive information about the items. We used the publicly available InSupport system [15] to further divide the Query-Results page into segments like filter, search data, and record segments, and the Details page into sections such as product description, specifications, and reviews.

Once the webpages were identified and segmented, the subsequent step involved segregating the NVDA log data collected according to these segments. Following this, we utilized timestamps from the log data and correlated the use of keyboard shortcuts recorded

[2] https://www.autohotkey.com/docs/v2/
[3] https://www.nvaccess.org/files/nvda/documentation/developerGuide.html
[4] https://developer.chrome.com/docs/extensions

through AutoHotkeys, to detail user interactions within each segmented part of the webpage. To ensure accuracy, the dataset was cleansed of errors and validated against screen recordings made during the study.

3.2.3 ***Log-Data Analysis***. Once we had organized the dataset from participants' log files, we began identifying microbehavioral patterns using a finite state machine (FSM) framework [30]. We defined states that represented user interactions for each participant across various segments of online shopping platforms, including search, filter, product summary, description, specifications, and reviews. Each sequence of log events was mapped to these predefined states, allowing us to systematically track and analyze user interactions. We analyzed various features from the log data, including the time spent on each web element, transitions between elements, the diversity of keyboard shortcuts used, and the relationships between keyboard shortcuts and transitions.

Afterward, we conducted three levels of clustering to uncover patterns: The first level focused on clustering pattern relationships of individual participants across different segments of the same webpage. The second level involved clustering similar segments across multiple websites for each participant. The third level of clustering looked at common interaction patterns among all participants. Interactions were assigned to clusters based on the sequence of keyboard shortcuts and element transitions, ensuring distinct categorization of strategies. This layered clustering approach allowed us to comprehensively analyze and draw final inferences from the data, revealing intricate behaviors in online shopping interactions.

3.2.4 Follow-up study interview. Following the log analysis, we conducted semi-structured interviews to understand the cognitive rationale behind the micro-behaviors observed in the logs. To avoid confirmation bias, we did not present our preliminary themes for simple agreement. Instead, we used specific interaction sequences identified in the logs as discussion probes. We provided verbal descriptions of specific emergent patterns observed during their sessions (e.g., instances of repetitive navigation loops, sudden shifts in shortcut usage, or high-frequency key presses). For each identified pattern, we asked open-ended seed questions such as *"You revisited the same three headings multiple times. Could you explain your objective at that moment?"* This approach allowed participants to articulate their strategies and intentions (e.g., building a mental map or feeling lost) in their own words, ensuring that the final qualitative themes were grounded in user-reported experiences rather than our assumptions. The interviews spanned from 30 to 45 minutes and were audio-recorded and subsequently transcribed for detailed analysis. The semi-structured nature of the interviews provided participants the opportunity to freely discuss their preferences and experiences with shopping platforms. Note: All conversations were conducted in English.

3.2.5 Follow up-Interview Studies Analysis. We adopted a grounded theory approach to analyze interview data [10, 16, 27]. Two researchers independently performed open coding on the data to identify emergent patterns. The initial coding phase produced a diverse set of codes grounded in the participants' explicit descriptions, focusing on types of shortcuts utilized, perceived navigation difficulties, and specific inaccessible webpage segments. To ensure reliability, the researchers held weekly meetings to resolve discrepancies and refine the code definitions. We did not use an a priori codebook; instead, the codebook was developed inductively and underwent iterative revisions as new codes emerged from subsequent transcripts. Through axial coding [57]., these codes were synthesized into higher-level themes , which were finally categorized into the three primary findings: familiarity-based strategies, unfamiliarity-driven entropy, and preferential tactics.

3.3 Log Data Results

We examined how blind users develop familiarity with previously unfamiliar e-commerce platforms. A statistical analysis of the log data collected during the user study revealed significant variation in the time participants spent across both familiar and unfamiliar webpages. On average, users spent approximately 3.5 minutes (Median = 3, Minimum = 2.0, Maximum = 6.6) navigating webpages they were familiar with. In contrast, the time increased to an average of 10.9 minutes (Median = 11.4, Minimum = 6.6, Maximum = 17.1) on unfamiliar webpages. A Wilcoxon signed-rank test confirmed that this difference was statistically significant ($W = 0.0$, $p < 0.001$). Additionally, the familiarity of a user with a webpage influenced the diversity of keyboard shortcut keys used and the number of web elements they interacted with. On familiar webpages, users employed a more diverse set of keyboard shortcuts, averaging 9 (Median = 7, Min = 4, Max = 12), and interacted with an average of 41 web elements (Median = 38, Min = 28, Max = 64). In stark contrast, on unfamiliar webpages, they relied on a less diverse set of keyboard shortcuts, averaging 6 (Median = 6, Min = 4, Max = 11), but engaged with a significantly larger array of web elements, with average interactions increasing to 99 (Median = 110, Min = 61, Max = 135). Wilcoxon signed-rank tests indicated that the number of web elements navigated differed significantly between familiar and unfamiliar webpages ($W = 38.5$, $p < 0.001$), whereas differences in shortcut diversity were not statistically significant.

Furthermore, a majority of the participants adopted an exploratory approach to navigating unfamiliar web pages, resulting in significant variation in the time spent on these pages and the keyboard shortcuts employed. On average, they spent 13.5 minutes (Median = 14.6, Minimum = 7.7, Maximum = 14.8) and employed an average of 3 keyboard shortcuts (Median = 2, Min = 2, Max = 6) to traverse the webpage. In most cases(70%), participants relied on the 'TAB' and 'ARROW' keys to sequentially navigate web elements and comprehensively understand the structure of the webpage. Additionally, they interacted with an average of 133 web elements (Median = 120, Min = 98, Max = 217).

Moreover, in our study, we leveraged concepts from information theory [5] to deepen our analysis of navigation strategies, specifically examining how website familiarity influences patterns of keyboard shortcut usage during interaction. We adopt an information-theoretic formulation because screen reader navigation can be modeled as a sequence of action selections under structural uncertainty. Entropy provides a principled measure of how concentrated or dispersed these action choices are, allowing us to distinguish routinized, familiarity-driven navigation from exploratory behavior induced by unfamiliar webpage layouts. For each category of webpage (familiar and unfamiliar), we first began by computing the probabilities of specific keyboard shortcuts being utilized in various webpage segments (e.g., search, filter, data record, description, etc.). For example, the set of keyboard shortcuts used within a segment was denoted by $X = \{x_1, x_2, \ldots, x_n\}$, where each x_i represents the number of times shortcut i was used. The probability of using a specific shortcut x_i within a segment is calculated using the formula:

$$p(x_i) = \frac{x_i}{\sum_{i=1}^{n} x_i} \tag{1}$$

Subsequently, we quantified the entropy of keyboard shortcuts, which was expressed as:

$$H(X) = -\sum_{i=1}^{n} p(x_i) \log_2 p(x_i) \tag{2}$$

This entropy was computed for each webpage segment and captured in a vector, represented as $H(X_i)$. This vector indicates the degree of randomness in the usage of keyboard shortcuts across different segments, highlighting the variability in user interactions within each part of the webpage.

The increase in entropy on unfamiliar webpages ($M = 2.51$, $SD = 0.48$), compared to familiar ones ($M = 1.21$, $SD = 0.36$), reflects a greater degree of randomness in keyboard shortcut usage, indicating that users employed more varied and less predictable navigation strategies. This heightened entropy is supported by the rise in navigation loops, where users revisited the same web elements more frequently on unfamiliar pages ($M = 12.6$) than on familiar ones ($M = 4.2$), suggesting difficulty in locating targets and a need for repeated scanning. Furthermore, shortcut failures, instances where keyboard commands did not yield expected outcomes, were significantly more common on unfamiliar websites (3.7 failures per session) compared to familiar ones (0.8 failures per session), contributing to irregular interaction patterns.

3.4 Follow-up study Results

Our qualitative analysis revealed three interrelated themes that characterize how blind users navigate and adapt in e-commerce settings: *Familiarity-based navigation strategies*, *Unfamiliarity drives navigation entropy*, and *Preferential keyboard tactics*.

3.4.1 *Familiarity-Based Navigation Strategies*.

Preference for Familiar Platforms. The majority of participants (14) expressed a strong tendency to rely on familiar e-commerce platforms, citing that established navigation routines reduce cognitive load and enhance efficiency. Participants noted that deviations from these known layouts often caused confusion or disorientation, making unfamiliar sites less appealing. Participant 15 described, *"Yes, I tend to stick to websites I'm familiar with because I have a specific approach for navigating through products on those sites. I avoid unfamiliar websites because when I try to navigate them the same way I do with the sites I know, I often get lost, which is quite frustrating."* Similarly, Participant 10 reinforced how habitual navigation behaviors fail to generalize across platforms: *"I have developed a routine for navigating familiar shopping sites like Amazon; it is almost automatic. So when I visit a new site, I instinctively try the same shortcuts, expecting a similar layout. But when things do not work the way I expect, it completely throws me off."* Together, these accounts underscore that *familiarity reduces navigational friction*, allowing blind users to perform tasks with confidence and fluency, while unfamiliar structures introduce disorientation and slow adaptation.

Building Mental Maps on Unfamiliar Sites. Several participants (19) described adaptive strategies developed to mitigate challenges encountered on new websites. These participants reported intentionally exploring unfamiliar interfaces to construct mental models of their structure. Such mental mapping enables more efficient navigation in subsequent interactions, reflecting an iterative learning process grounded in exploration and spatial reasoning. Participant 4 illustrated this adaptive pattern: *"I use a method of 'judge and see,' and 'see and judge.' If I've used the webpage before, I judge where information is likely to be and then confirm it using the screen reader. If it's a new site, I first explore it extensively to understand the layout. Once I've formed a mental map of where various elements are, I use that knowledge to navigate more effectively."* This strategy highlights that *blind users actively engage in cognitive mapping*—a process akin to spatial learning in physical navigation—to develop familiarity with digital environments over time.

Reliance on Predictability and Memorized Shortcuts. Many participants (12) emphasized that predictability and memorized keyboard shortcuts form the core of their navigation strategies. These shortcuts, once internalized on familiar sites, become procedural habits that support rapid and efficient browsing. However, when interface design diverges from expected structures, these routines can become barriers rather than aids. As Participant 6 articulated: *"I consistently shop on a set of familiar websites where I have memorized the necessary shortcuts to retrieve information. When required to use an unfamiliar platform, I often struggle to adapt and, in some cases, rely on others to complete the task for me."* Such reliance indicates that *interface consistency across platforms can substantially lower cognitive barriers* and foster independence, whereas unpredictability can increase reliance on external assistance.

Intrinsic Motivation to Explore. A minority of participants (14) expressed that exploration itself can be rewarding, viewing unfamiliar websites as opportunities for discovery and cognitive engagement. Unlike those who preferred predictability, these participants framed navigation as a challenge, describing satisfaction in decoding and adapting to novel layouts. Participant 17 described this mindset: *"Exploring websites is sometimes just out of personal interest. It feels like a challenge to me, and I actually enjoy doing it—it's like a learning path."* Similarly, Participant 12 likened the process to problem-solving: *"New websites are like puzzles (pause) I have to explore them section by section with the screen reader. After a few rounds of inspection, I start recognizing patterns, and then I adjust my strategy."* These narratives reveal an *overlap between exploration and learning*, where navigation challenges become opportunities for competence building and self-efficacy, reflecting intrinsic motivation rather than avoidance.

Cautious Engagement and Shortcut Evolution. Several participants (18) described adopting cautious navigation behaviors when initially engaging with new websites, prioritizing accuracy and comprehension over speed. This often involved limiting shortcut use to the most basic commands until sufficient familiarity was achieved. Participant 18 explained: *"In unfamiliar digital terrains, I gravitate towards basic navigation, predominantly using the down* *arrow key. When searching for a product on Amazon, I restrict myself to this key, ensuring a thorough yet controlled browsing experience. While this method is time-intensive, it instills confidence."* This illustrates a *phased navigation approach* starting with systematic, linear exploration and gradually evolving into shortcut-based strategies as users build trust in the site's structure. Such behavioral adaptation bridges the gap between exploration and efficiency, reinforcing how familiarity shapes confidence and control.

Avoidance of Unfamiliar Platforms. Finally, some participants (6) reported a complete avoidance of unfamiliar platforms, linking such decisions to time constraints, effort, and frustration. These participants prioritized comfort, predictability, and efficiency, even at the cost of reduced variety or missed opportunities. Participant 20 reflected: *"I never look at websites I have not used before because it becomes hard most of the time to navigate, and it's very time-consuming. If I need something online, I either ask someone else to find me the best deal, or I prefer to spend time on a webpage I know well and browse through products comfortably."* This finding highlights a *behavioral trade-off between autonomy and convenience*, while exploration may foster independence, it also demands significant cognitive effort. Consequently, avoidance emerges as a rational choice grounded in efficiency and predictability.

3.4.2 *Unfamiliarity drives navigation entropy*.

Cognitive overload from unfamiliar layouts. Many participants (13) reported that navigating unfamiliar websites led to increased cognitive effort and disorientation. They described how the absence of predictable layout structures forced them to make frequent corrections, revisit elements, and expend significant mental energy. One participant explained: *"When I do not know the structure of the page, I end up jumping all over the place to seek information. I revisit the same buttons or headings multiple times because I am unsure if I missed something. It definitely takes more mental effort, and I use way more commands than I would on a site I am used to."* This behavior aligns with heightened navigation entropy, where users rely on trial-and-error strategies, increasing both task time and interaction complexity, and often shifting toward slower, more linear commands (e.g., Arrow and TAB) to rebuild a reliable mental map of the page.

Inconsistencies amplifying unpredictability. Few participants (6) highlighted that inconsistent screen reader support across websites introduces unpredictability in navigation flow. Even when users develop stable mental models, these break down when commands behave differently across platforms. As one participant noted: *"I tend to use F7 to get the element list on websites, but the problem is it does not work reliably across all platforms anymore. On some sites, it shows everything clearly, and on others, it misses key elements. That inconsistency makes navigation feel random and harder to manage."* Such variation undermines efficiency and leads to fragmented mental representations of page structure.

Familiarity as a confidence scaffold. Few participants (10) emphasized that familiarity, rather than accessibility compliance alone, drives confidence and comfort during navigation. Even technically accessible websites were perceived as cognitively demanding when users lacked prior exposure. One participant summarized this by saying: *"Accessibility is definitely important, but even if a website is well-designed and technically accessible, I still feel uncomfortable if I have not used it much before. It's not just about whether the site works with my screen reader–it is about knowing how to move around, where things usually are, and what shortcuts will get me there. When that familiarity is missing, I hesitate more, try different keys, and it takes much longer to get things done."* These findings reveal that navigational fluency arises from habitual interaction patterns, not only design compliance.

Strategic and goal-oriented browsing. Many participants (18) demonstrated a premeditated approach to online shopping, focusing primarily on products that lend themselves to textual evaluation, such as electronics, while avoiding categories such as clothing that require tactile evaluation. They preferred to gather information offline or through product reviews before initiating a purchase. As one participant remarked: *"Yeah, I generally know what I want to buy beforehand. I do not explore shopping platforms very much. If I want to buy clothes, I will go to a nearby store, as I need to check what fits, which is not possible online. Online, I mainly shop for electronic items, and for these, I already gather information about the product, like a watch or mobile, so I directly check if it is available."* This illustrates a pragmatic decision-making process shaped by sensory limitations and prior product knowledge.

Desire for semantically rich search tools. The majority of participants (15) expressed enthusiasm for search features that could support semantic or attribute-based queries. One participant discussed using Amazon's review search to isolate battery-related feedback when evaluating smartwatches: *"While browsing for a smartwatch, I was particularly interested in reviews regarding the product's battery life. Amazon facilitates this with a feature that lets me search within reviews for battery life."* When probed about the absence of such functionality on other platforms, the same participant responded, *"Such a feature would be immensely beneficial, significantly reducing the time I spend seeking the precise information I need for decision-making."* These perspectives underscore the demand for search and filtering mechanisms that extend beyond keyword-based navigation.

3.4.3 *Preferential keyboard tactics*.

Individualized shortcut preferences. The majority of participants (14) demonstrated distinct keyboard shortcut preferences, reflecting personalized adaptation strategies shaped by familiarity and efficiency. These variations underscore that screen reader navigation is not uniform but rather influenced by users' individual learning and expectations of interface structures. As one participant explained, *"Individuals often develop expertise in specific shortcuts based on their preferences. For instance, some users are adept at leveraging 'H,' anticipating that the web interface categorizes most information under headings. Alternatively, they might expect functionalities to be primarily accessible as buttons via the 'B' shortcut."* This observation highlights the cognitive principle of preference transitivity [46], that users form consistent shortcut hierarchies that balance effort, predictability, and context relevance.

Resetting rather than retracing. The majority of participants (17) expressed a preference for restarting navigation from the top of a webpage rather than retracing previous steps when disoriented. This behavior reflects a cognitive reset strategy aimed at regaining control and ensuring completeness. As one participant elaborated, *"In situations where options vary, such as selecting a smartwatch versus a TV—where the latter presents more attributes like size and color—an inadvertent keystroke can displace the screen reader's position on the webpage. If I sense that I've missed vital information, I employ the 'Ctrl + HOME' command to restart the navigation process."* Such strategies reduce uncertainty in complex interfaces but come at the cost of increased time and cognitive repetition.

Emotional and physical strain of shortcut usage. Several participants (13) described a connection between shortcut use and emotional as well as physical fatigue. Frequent key activations, though efficient for control, were associated with discomfort and frustration over time. As one participant poignantly stated, *"The constancy of keyboard shortcuts is not the issue over time; my primary concern is the frequency with which these shortcuts must be activated, which is painful."* This underscores that accessibility design must not only account for cognitive workload but also for the embodied effort of repeated command-based interaction, a dimension often neglected in usability evaluations.

Cautious navigation in unfamiliar contexts. Many participants (15) reported adopting conservative shortcut use when first engaging with unfamiliar digital environments. They often defaulted to linear navigation through the down arrow key to ensure thorough comprehension before expanding their command repertoire. As one participant described, *"In unfamiliar digital terrains, I gravitate towards basic navigation, predominantly using the down arrow key. For instance, when searching for a product on Amazon, I restrict myself to this key, ensuring a thorough yet controlled browsing experience. While this method is time-intensive, it instills confidence. However, once I've gained familiarity, I diversify my shortcut usage."* This illustrates a strategic trade-off between speed and confidence. Blind users initially prioritize spatial mapping and trust-building over efficiency until familiarity enables broader command utilization.

4 Discussion

This research revealed micro-behavioral patterns that shape how blind users navigate online shopping platforms. We first summarize key study limitations, and then present design suggestions informed by prior work on micro-behavior [18, 61] and our findings.

4.1 Study Limitations.

In our study, we did not include a non-blind baseline, and unfamiliarity likely increases navigation time for sighted users as well. Our contribution is therefore not the direction of the effect, but the distinct, measurable screen-reader–specific micro-behavioral signature of unfamiliarity (e.g., increased shortcut entropy, revisitation loops, and command failures) and how these relate to mental model construction. Future work should include a sighted baseline (mouse/scroll micro-behaviors) and a controlled comparison under matched tasks and page structures.

Another limitation is that, although we captured detailed interaction logs and conducted follow-up interviews, our analysis and reporting placed primary emphasis on interview narratives to identify and explain patterns. Future work will adopt a log-first reporting structure that visualizes interaction traces (e.g., shortcut-sequence timelines and transition diagrams across page segments) and generates complementary visual summaries such as heat maps [13], segment maps [2], and saliency maps [49] to surface high-effort regions and potential navigation breakdowns. Beyond reporting, prior work shows that incorporating micro-behavioral signals can improve recommender systems and support explainable inferences [61]; extending our log dataset could enable accessibility-aware recommendation support for blind shoppers, who often rely on such systems for efficient and accessible online shopping [6].

4.2 Design Suggestions

4.2.1 ***Modeling Shortcut Selection through Utility Maximization:*** Blind screen reader users demonstrate a wide range of keyboard shortcut patterns while navigating web pages. Although, in theory, it might be possible to mathematically identify the most efficient combination of shortcuts to reduce navigation time, the reality is more complex. The sheer variety of tasks that users perform online results in an extensive array of possible shortcut combinations. This multitude of activities, ranging from simple browsing to complex interactions, means that there is not a one-size-fits-all optimal set of shortcuts. Each user's unique preferences, habits, and the specific context of their web activities play a significant role in determining their choice of shortcuts.

We introduce this decision-theoretic framing as an explanatory abstraction rather than a predictive model. Qualitative findings motivate the terms of the model by revealing how users balance efficiency, effort, uncertainty, and recovery when selecting shortcuts, while the formulation provides a compact way to reason about these trade-offs in assistive system design (section 3.4.2). Our observations suggest that blind users implicitly operate within a *utility maximization framework*, a well-established concept in decision theory [41]. In this framework, a user selects the shortcut combination $x \in X$ that maximizes their overall utility $U(x)$, subject to the constraints $C(x)$ imposed by the environment (e.g., webpage structure) and bounded by available cognitive or temporal resources B. Formally:

$$\max_{x \in X} U(x) \quad \text{subject to} \quad C(x) \leq B \tag{3}$$

Here, $U(x)$ denotes the perceived benefit (e.g., efficiency or familiarity) of using shortcut x, $C(x)$ represents the associated cost (e.g., effort, uncertainty, or failure risk), and B captures cognitive or temporal thresholds. For instance, in a search section lacking structural markup, commands like `H` (headings) may become ineffective, increasing $C(x)$ and prompting users to rely on alternatives like `Tab` or arrow keys, even if they are slower. Future work could formalize these functions through user modeling or adaptive interaction logging. Such insights could inform interface designs that minimize user burden, personalize shortcut recommendations, and promote more accessible digital environments for blind users.

4.2.2 ***Incorporating Emotional Feedback in Shortcut Design***. Keyboard interactions for blind users are not merely functional; they carry emotional and physical implications (section 3.4.3). Frequent key activations, particularly during moments of uncertainty or disorientation, can indicate stress or frustration. Building on insights from keystroke dynamics research [14], we propose that future accessibility designs incorporate *emotional feedback mechanisms* that respond to patterns of shortcut usage.

For instance, web interfaces could integrate adaptive feedback systems that detect erratic or high-frequency keystrokes as indicators of confusion. When such patterns arise, an assistive module, possibly powered by AI, could provide contextual cues, for example, "You seem lost, would you like to return to the top" or simplify the page temporarily. Over time, aggregated shortcut rhythm data could inform design revisions that reduce cognitive strain and improve flow. By acknowledging the affective dimension of keyboard navigation, developers can create emotionally adaptive interfaces that go beyond compliance to foster comfort, confidence, and well-being among blind users.

4.2.3 *Familiarity vs. Unfamiliarity: Customizable keyboard shortcuts.*

In our study, we observed that blind users are generally more comfortable on familiar web pages, where they have a sense of orientation and control, as opposed to feeling lost on unfamiliar ones (section 3.4.1). For example, a blind user might have memorized a sequence of shortcut keys to quickly navigate to the 'Add to Cart' button on Amazon. However, this memorized sequence might not work on a different site like Apple or Target, leading to confusion and inefficiency. To address this challenge, we recommend that web designers should enable blind users to customize accessibility options for key webpage elements on shopping platforms. This could involve creating a personalized 'dictionary' of special shortcut keys, where each key is designated for specific content or actions - like one for adding items to the cart, another for accessing product descriptions, and yet another for reviews [33]. Designers should then develop an interface that allows blind users to apply these shortcut keys across different web pages. By implementing such a system, unfamiliar web pages could become more accessible and user-friendly for blind users. This approach would standardize navigation across various sites, making even new and unfamiliar web pages feel more familiar and easily navigable [6].

4.2.4 *Supporting Cognitive Reset Through Navigation Anchors.*

While retracing prior navigation paths may seem efficient in theory, our findings show that many blind users prefer restarting from the top of a webpage when disoriented (section 3.4.3). This behavior represents a form of cognitive reset where users regain orientation by returning to a familiar anchor point rather than navigating backward through an uncertain path. To support this natural coping mechanism, we recommend that web developers embed structured *navigation anchors* across pages.

Such anchors could include persistent keyboard shortcuts that jump to major content sections, such as the top of the page, main product list, or filter menu, or quick navigation commands tied to logical page landmarks. Maintaining these consistent anchors across the entire site helps users re-establish context quickly after confusion, preventing frustration associated with retracing lost positions. This approach aligns with prior work on shelters and retracing strategies [56] and reimagines them as proactive design features that enable efficient recovery and reinforce spatial consistency in user experience.

4.2.5 *Optimizing Accessibility using Shortcuts.*

In our analysis, we recognize that blind users have diverse preferences [29] for using keyboard shortcuts while navigating web pages [15]. Some prefer navigating via headers, while others might opt for lists or other elements. However, the challenge arises due to the varying structures of web pages, which can make it difficult for users to consistently employ their preferred mode of navigation (section 3.4.1). We recommend that web designers integrate a feature enabling blind users to customize their web navigation based on personal preferences [40]. This would allow blind users to effectively 'design' the webpage layout themselves, choosing which content to display and in what format it should be structured [20]. For instance, upon entering a search query and reaching the query results page, a user could opt to view only product names and prices, formatted as headers in the HTML page. Alternatively, they might prefer to see product names as links and reviews presented in a table format. This level of personalization ensures that blind users can access web content in a way that best suits their navigation style [11] and information needs, making the web more accessible and user-friendly for them. Such a feature would represent a significant advancement in web design, prioritizing Accessibility and user preference in the digital experience [24].

4.2.6 *Immediate Content Access on online shopping platforms .*

Many prior research works highlight the evolving role of AI-powered chat assistants, especially with the advancement of Large Language Models (LLMs) [12], in enhancing user interaction on web platforms [45]. In the realm of online shopping, integrating these AI assistants with screen readers can revolutionize the experience for visually impaired users. Such integration would enable the chat system to not only provide instant access to content on the web pages but also guide the screen reader's cursor directly to specific webpage content [25] (section 3.4.2). This synergy offers a dual benefit: Users can swiftly navigate to the desired content, and the AI assistant can facilitate a more personalized interaction by understanding and adapting to individual user queries [54]. The result is a significantly improved and accessible browsing experience, where the complexity of web page navigation is greatly reduced.

5 Conclusion

This study presents a comprehensive micro-behavioral analysis of blind users navigating online shopping platforms using screen readers. Through a mixed-methods approach combining longitudinal log data and qualitative interviews, we identified three key patterns shaping non-visual shopping behavior: *Familiarity-based navigation strategies*, *Unfamiliarity drives navigation entropy*, and *Preferential keyboard tactics*. Our findings show that screen reader users rely heavily on structured mental models and personalized shortcut routines when navigating familiar interfaces, whereas unfamiliar platforms introduce higher entropy, increased navigation loops, and greater cognitive load. Importantly, our work highlights that accessibility is not merely a technical or structural attribute, but a cognitive and experiential phenomenon influenced by familiarity, personalization, and task intent. Informed by our results, we proposed design suggestions to aid web accessibility developers in accommodating these considerations in online shopping platforms.

References

[1] Amnah Alluqmani, Morgan A Harvey, and Ziqi Zhang. 2023. The barriers to online clothing websites for visually impaired people: an interview and observation approach to understanding needs. In *Proceedings of the 2023 ACM designing interactive systems conference*. 753–764.

[2] Judith Jeyafreeda Andrew. 2020. *Task Oriented Web Page Segmentation*. Ph. D. Dissertation. Normandie Université.

[3] N Anitha. 2015. Consumer preference towards online retailing. *ICTACT Journal on Management Studies* 1, 02 (2015), 74–80.

[4] Aitor Apaolaza, Simon Harper, and Caroline Jay. 2015. Longitudinal analysis of low-level web interaction through micro behaviours. In *Proceedings of the 26th ACM Conference on Hypertext & Social Media*. 337–340.

[5] Robert B Ash. 2012. *Information theory*. Courier Corporation.

[6] Vikas Ashok, Syed Masum Billah, Yevgen Borodin, and IV Ramakrishnan. 2019. Auto-suggesting browsing actions for personalized web screen reading. In *Proceedings of the 27th ACM Conference on User Modeling, Adaptation and Personalization*. 252–260.

[7] Jeffrey P Bigham, Irene Lin, and Saiph Savage. 2017. The Effects of" Not Knowing What You Don't Know" on Web Accessibility for Blind Web Users. In *Proceedings of the 19th international ACM SIGACCESS conference on computers and accessibility*. 101–109.

[8] Jonathan Carlton, Andy Brown, John Keane, and Caroline Jay. 2018. Using low-level interaction data to explore user behaviour in interactive-media experiences. *Measuring Behavior 2018* (2018).

[9] Terry L Childers and Carol Kaufman-Scarborough. 2009. Expanding opportunities for online shoppers with disabilities. *Journal of Business Research* 62, 5 (2009), 572–578.

[10] Juliet Corbin et al. 1990. Basics of qualitative research grounded theory procedures and techniques. (1990).

[11] Luiz Felipe da Paixão Silva, Antônio Armando de O. Barbosa, Evelise Roman Corbalan Góis Freire, Paula Christina Figueira Cardoso, Rafael Serapilha Durelli, and André Pimenta Freire. 2018. Content-based navigation within mathematical formulae on the web for blind users and its impact on expected user effort. In *Proceedings of the 8th International Conference on Software Development and Technologies for Enhancing Accessibility and Fighting Info-exclusion*. 23–32.

[12] Luigi De Angelis, Francesco Baglivo, Guglielmo Arzilli, Gaetano Pierpaolo Privitera, Paolo Ferragina, Alberto Eugenio Tozzi, and Caterina Rizzo. 2023. ChatGPT and the rise of large language models: the new AI-driven infodemic threat in public health. *Frontiers in Public Health* 11 (2023), 1166120.

[13] Mike DeBoer. 2015. Understanding the heat map. *Cartographic perspectives* 80 (2015), 39–43.

[14] Clayton Epp, Michael Lippold, and Regan L Mandryk. 2011. Identifying emotional states using keystroke dynamics. In *Proceedings of the sigchi conference on human factors in computing systems*. 715–724.

[15] Javedul Ferdous, Hae-Na Lee, Sampath Jayarathna, and Vikas Ashok. 2022. InSupport: Proxy Interface for Enabling Efficient Non-Visual Interaction with Web Data Records. In *27th International Conference on Intelligent User Interfaces*. 49–62.

[16] Md Javedul Ferdous, Akshay Kolgar Nayak, Yash Prakash, Nithiya Venkatraman, Sampath Jayarathna, Hae-Na Lee, and Vikas Ashok. 2025. Understanding Online Discussion Experiences of Blind Screen Reader Users. *International Journal of Human–Computer Interaction* (2025), 1–31.

[17] Elisabeth Fuchs and Christine Strauss. 2012. Online shopping involving consumers with visual impairments–a qualitative study. In *Computers Helping People with Special Needs: 13th International Conference, ICCHP 2012, Linz, Austria, July 11-13, 2012, Proceedings, Part I 13*. Springer, 378–385.

[18] Yulong Gu, Zhuoye Ding, Shuaiqiang Wang, and Dawei Yin. 2020. Hierarchical user profiling for e-commerce recommender systems. In *Proceedings of the 13th International Conference on Web Search and Data Mining*. 223–231.

[19] J Guo, W Zhang, and T Xia. 2023. Impact of shopping website design on customer satisfaction and loyalty: The mediating role of usability and the moderating role of trust. Sustainability, 15 (8), 6347.

[20] Djamel HADJADJ, Robert AGRO, and Dominique BURGER. [n. d.]. CUSTOMIZING HTML BY FILTERING: techniques for making the Internet accessible to the visually handicapped. ([n. d.]).

[21] Hong Huang, Bo Zhao, Hao Zhao, Zhou Zhuang, Zhenxuan Wang, Xiaoming Yao, Xinggang Wang, Hai Jin, and Xiaoming Fu. 2018. A cross-platform consumer behavior analysis of large-scale mobile shopping data. In *Proceedings of the 2018 World Wide Web Conference*. 1785–1794.

[22] Farid Huseynov and Sevgi Özkan Yıldırım. 2016. Internet users' attitudes toward business-to-consumer online shopping: A survey. *Information Development* 32, 3 (2016), 452–465.

[23] Shubhi Jain. 2025. *Automated Detection of Web Application Navigation Barriers for Screen Reader Users*. Master's thesis. University of California, Irvine.

[24] Aditi Kalangutkar, Radha Yadav, Priya S Hadapad, Vinisha V Naik, Valerie Menezes, and Shreedatta Sawant. 2023. Voice Controlled Operations and Navigations for e-Commerce. In *2023 International Conference on Network, Multimedia and Information Technology (NMITCON)*. IEEE, 1–7.

[25] Elise Karinshak, Sunny Xun Liu, Joon Sung Park, and Jeffrey T Hancock. 2023. Working with AI to persuade: Examining a large language model's ability to generate pro-vaccination messages. *Proceedings of the ACM on Human-Computer Interaction* 7, CSCW1 (2023), 1–29.

[26] Carol Kaufman-Scarborough and Terry L Childers. 2009. Understanding markets as online public places: Insights from consumers with visual impairments. *Journal of Public Policy & Marketing* 28, 1 (2009), 16–28.

[27] Akshay Kolgar Nayak, Yash Prakash, Sampath Jayarathna, Hae-Na Lee, and Vikas Ashok. 2025. Insights in Adaptation: Examining Self-reflection Strategies of Job Seekers with Visual Impairments in India. *Proceedings of the ACM on Human-Computer Interaction* 9, 7 (2025), 1–30.

[28] Farshad Kooti, Kristina Lerman, Luca Maria Aiello, Mihajlo Grbovic, Nemanja Djuric, and Vladan Radosavljevic. 2016. Portrait of an online shopper: Understanding and predicting consumer behavior. In *Proceedings of the ninth ACM international conference on web search and data mining*. 205–214.

[29] Christos Kouroupetroglou, Michail Salampasis, and Athanasios Manitsaris. 2008. Analysis of navigation behaviour of blind users using Browsing Shortcuts. *New Review of Hypermedia and Multimedia* 14, 2 (2008), 199–228.

[30] Ulf Kroehne and Frank Goldhammer. 2018. How to conceptualize, represent, and analyze log data from technology-based assessments? A generic framework and an application to questionnaire items. *Behaviormetrika* 45, 2 (2018), 527–563.

[31] Gideon Appiah Kusi, Mst Zannatul Azmira Rumki, Fiona Hammond Quarcoo, Esther Otchere, and Guanhui Fu. 2022. The role of information overload on consumers' online shopping behavior. *Journal of Business and Management Studies* 4, 4 (2022), 162–178.

[32] Jonathan Lazar, Aaron Allen, Jason Kleinman, and Chris Malarkey. 2007. What frustrates screen reader users on the web: A study of 100 blind users. *International Journal of human-computer interaction* 22, 3 (2007), 247–269.

[33] Hae-Na Lee and Vikas Ashok. 2020. Towards Personalized Annotation of Webpages for Efficient Screen-Reader Interaction. In *Proceedings of the 31st ACM Conference on Hypertext and Social Media*. 111–116.

[34] Munyoung Lee, Taehoon Ha, Jinyoung Han, Jong-Youn Rha, and Ted Taekyoung Kwon. 2015. Online footsteps to purchase: Exploring consumer behaviors on online shopping sites. In *Proceedings of the ACM web science conference*. 1–10.

[35] Chang Liu and Yiming Wei. 2016. The impacts of time constraint on users' search strategy during search process. *Proceedings of the Association for Information Science and Technology* 53, 1 (2016), 1–9.

[36] Guanhong Liu, Xianghua Ding, Chun Yu, Lan Gao, Xingyu Chi, and Yuanchun Shi. 2019. " I Bought This for Me to Look More Ordinary" A Study of Blind People Doing Online Shopping. In *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems*. 1–11.

[37] Jun Lv and Xuan Liu. 2022. The impact of information overload of e-commerce platform on consumer return intention: Considering the moderating role of perceived environmental effectiveness. *International Journal of Environmental Research and Public Health* 19, 13 (2022), 8060.

[38] Wenjing Meng, Deqing Yang, and Yanghua Xiao. 2020. Incorporating user micro-behaviors and item knowledge into multi-task learning for session-based recommendation. In *Proceedings of the 43rd international ACM SIGIR conference on research and development in Information Retrieval*. 1091–1100.

[39] Arjun Mittal. 2013. E-commerce: It's Impact on consumer Behavior. *Global Journal of Management and Business Studies* 3, 2 (2013), 131–138.

[40] Olfa Nasraoui and Carlos Rojas. 2003. From static to dynamic web usage mining: Towards scalable profiling and personalization with evolutionary computation. In *Workshop on Information Technology Rabat, Morocco*. 1–16.

[41] D Warner North. 1968. A tutorial introduction to decision theory. *IEEE transactions on systems science and cybernetics* 4, 3 (1968), 200–210.

[42] Yash Prakash. 2025. *Enhancing Data Usability for People with Visual Impairments*. Ph. D. Dissertation. Old Dominion University.

[43] Yash Prakash, Akshay Kolgar Nayak, Mohan Sunkara, Sampath Jayarathna, Hae-Na Lee, and Vikas Ashok. 2024. All in One Place: Ensuring Usable Access to Online Shopping Items for Blind Users. *Proceedings of the ACM on Human-Computer Interaction* 8, EICS (2024), 1–25.

[44] Yash Prakash, Mohan Sunkara, Hae-Na Lee, Sampath Jayarathna, and Vikas Ashok. 2023. AutoDesc: Facilitating Convenient Perusal of Web Data Items for Blind Users. In *Proceedings of the 28th International Conference on Intelligent User Interfaces*. 32–45.

[45] Emanuele Pucci, Isabella Possaghi, Claudia Maria Cutrupi, Marcos Baez, Cinzia Cappiello, and Maristella Matera. 2023. Defining Patterns for a Conversational Web. In *Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems*. 1–17.

[46] Michel Regenwetter, Jason Dana, and Clintin P Davis-Stober. 2011. Transitivity of preferences. *Psychological review* 118, 1 (2011), 42.

[47] PJ Rhodesa, NA Smallb, H Ismaila, and JP Wright. 2008. What really annoys me is people take it like it'sa disability', epilepsy, disability and identity among people of Pakistani origin living in the UK. *Ethnicity & Health* 13, 1 (2008), 1–21.

[48] Nuzhat Jahan Samreen. 2022. Online Shopping and Web-Accessibility: Strategies to Ensure Equal Access to Blind Users in E-commerce Platforms. (2022).

[49] Chengyao Shen and Qi Zhao. 2014. Webpage saliency. In *Computer Vision–ECCV 2014: 13th European Conference, Zurich, Switzerland, September 6-12, 2014, Proceedings, Part VII 13*. Springer, 33–46.

[50] R Sivanesan. 2017. A study on problems faced by customers in online shopping with special reference to Kanyakumari District. *International Journal of Research in Management & Business Studies* 4, 3 (2017), 22–25.

[51] StartupNation. n.d.. *Understanding Customer Behavior in E-Commerce*. https://startupnation.com/grow-your-business/get-more-sales/understanding-customer-behavior-in-e-commerce/ Accessed: 2025-03-31.

[52] Statista. 2025. eCommerce - Worldwide. https://www.statista.com/outlook/emo/ecommerce/worldwide Accessed: March 30, 2025.

[53] Mohan Sunkara, Akshay Kolgar Nayak, Sandeep Kalari, Yash Prakash, Sampath Jayarathna, Hae-Na Lee, and Vikas Ashok. 2025. Adapting Online Customer Reviews for Blind Users: A Case Study of Restaurant Reviews. In *Proceedings of the 22nd International Web for All Conference*. 135–146.

[54] Stephanie Valencia, Richard Cave, Krystal Kallarackal, Katie Seaver, Michael Terry, and Shaun K Kane. 2023. "The less I type, the better": How AI Language Models can Enhance or Impede Communication for AAC Users. In *Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems*. 1–14.

[55] Nithiya Venkatraman, Akshay Kolgar Nayak, Suyog Dahal, Yash Prakash, Hae-Na Lee, and Vikas Ashok. 2025. AccessMenu: Enhancing Usability of Online Restaurant Menus for Screen Reader Users. In *Proceedings of the 22nd International Web for All Conference*. 36–47.

[56] Markel Vigo and Simon Harper. 2013. Challenging information foraging theory: Screen reader users are not always driven by information scent. In *Proceedings of the 24th acm conference on hypertext and social media*. 60–68.

[57] Maike Vollstedt and Sebastian Rezat. 2019. An introduction to grounded theory with a special focus on axial coding and the coding paradigm. *Compendium for early career researchers in mathematics education* 13, 1 (2019), 81–100.

[58] Ruolin Wang, Zixuan Chen, Mingrui Ray Zhang, Zhaoheng Li, Zhixiu Liu, Zihan Dang, Chun Yu, and Xiang'Anthony' Chen. 2021. Revamp: Enhancing accessible information seeking experience of online shopping for blind or low vision users. In *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems*. 1–14.

[59] Michael Whitney. 2020. Teaching Accessible Design: Integrating Accessibility Principles and Practices into an Introductory Web Design Course. *Information Systems Education Journal* 18, 1 (2020), 4–13.

[60] Jiahao Yuan, Wendi Ji, Dell Zhang, Jinwei Pan, and Xiaoling Wang. 2022. Micro-behavior encoding for session-based recommendation. In *2022 IEEE 38th International Conference on Data Engineering (ICDE)*. IEEE, 2886–2899.

[61] Meizi Zhou, Zhuoye Ding, Jiliang Tang, and Dawei Yin. 2018. Micro behaviors: A new perspective in e-commerce recommender systems. In *Proceedings of the eleventh ACM international conference on web search and data mining*. 727–735.

[62] John Zimmerman, Aaron Steinfeld, Anthony Tomasic, and Oscar J. Romero. 2022. Recentering Reframing as an RtD Contribution: The Case of Pivoting from Accessible Web Tables to a Conversational Internet. In *Proceedings of the 2022 CHI Conference on Human Factors in Computing Systems*. 1–14.