A Mapping Review to Understand Web and Mobile Apps Accessibility for Adults with Autism

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ABSTRACT

Context: With the rise of the neurodiversity topic, there is a need to investigate the demands of autistic individuals for Information Systems, ensuring a more accessible and user-friendly experience.Problem: Despite existing guidelines for autistic individuals, there is a limited synthesis of findings to identify gaps and best practices, particularly for adults. Solution: This article reviews key guides, frameworks, evaluation tools, recommendations, and design standards that support the development and usability assessment of mobile and web applications for autistic users. Method: This research follows a mapping study approach with a narrative synthesis of 23 research articles. IS theory: This study applies Cognitive Load Theory to analyze usability challenges and evaluate the effectiveness of accessibility guidelines. Results: 23 papers were found within the Guideline for the Accessibility of Web Interfaces with a Focus on Autism (GAIA), covering visual/textual vocabulary, customization, redundant representations, participation, multimedia, and navigability. However, no studies were found in state visibility, recognition, predictability, response to actions, and touchscreen interactions. Barriers were analyzed across cognitive overload, processing, distinguishability, and breaking expectations.Contributions in the Field: We identified nine frameworks for designing and evaluating Information Systems for autistic users, improving usability and accessibility. However, further investigation is needed to assess the effectiveness of these guidelines, as some remain unvalidated.

KEYWORDS

Neurodiversity, Autism, Accessibility, Mobile Application

1 INTRODUCTION

Information Systems encompass a systemic view of a set of elements used to solve real-world problems by facilitating the flow of information. To be effective, information system design must prioritize user expectations, needs, and universal views, ensuring seamless integration with processes and people [7]. According to the Brazilian Institute of Geography and Statistics (IBGE) [28], in 2022, Brazil had approximately 18 million people with disabilities. A significant part of their challenge involves finding accessible environments, including digital spaces they rely on [31].

The need for inclusive systems is particularly relevant for individuals with autism. Autism, or Autism Spectrum Disorder (ASD), is a neurodevelopmental condition that affects how a person perceives, interacts, and communicates with the world around them [12]. Autism is characterized by distinct behavioral patterns, social skills, and communication, as well as restricted and repetitive interests and activities [12]. Given the wide range of abilities and social characteristics an autistic individual may manifest, technology offers an opportunity to support and improve the quality of life for these individuals. In this context, creating inclusive information systems provides a pleasant user experience for autistic people. However, app accessibility remains a substantial challenge for many of these individuals [1].

It is recognized that individuals with Autism Spectrum Disorder (ASD) can experience sensory and cognitive overload in various situations, including the use of digital technologies[46]. Sensory overload occurs when there is excessive exposure to stimuli such as lights, sounds, or visual information, which can be particularly challenging for individuals with ASD. Moreover, the complexity of certain applications may require intense cognitive processing, potentially resulting in overload. Therefore, it is crucial for applications designed for individuals with ASD to feature simple, intuitive, and customizable interfaces, aiming to minimize potential overload and facilitate interaction[46].

Several studies address accessibility for people with ASD, mainly investigating children [10, 13]. However, only a few studies investigate accessibility for autistic adults [3, 60]. The growing scientific understanding of ASD and awareness of the condition has naturally led to an increase in adult diagnoses [32]. Many of these individuals have lived with ASD-related challenges throughout

their lives without understanding the cause. Due to the late diagnosis, many autistic adults have not benefited from tailored support in their early life, missing the opportunity to develop effective coping strategies and adaptive behaviors that could help them navigate daily challenges[30]. Additionally, functional differences may exist between the brains of autistic children and adults, resulting from factors like treatment, maturation, and strategies developed over time to deal with ASD-related challenges [55]. Therefore, research on accessibility for autistic users should address the unique needs of adults on the spectrum.

The present study aims to provide a deeper understanding of the state-of-the-art research on accessibility in web and mobile system information for autistic users, particularly focusing on adults. This study is looking to compile key research involving autistic adults and information systems, providing a comprehensive perspective on the main areas, activities, barriers, and challenges currently being investigated in this field. To achieve this, we formulated the following research question: *To what extent does the current computing literature provide guidance for the design and evaluation of accessible information systems (both web and mobile) tailored to the needs of autistic adults?*

We conducted a systematic mapping study to identify research that proposes, evaluates, or uses frameworks, guidelines, or other technologies to design and assess the accessibility of web and mobile applications. We identified 23 studies addressing the accessibility of applications for autistic adults, including nine frameworks recommended for developing applications for the target population. Most of the studies focused on understanding how autistic individuals process information.

This article covers areas of psychology, design, and computing to balance technological and social aspects, emphasizing the harmony needed for equitable solutions. In the context of the Grand research challenges in Information Systems in Brazil [9], this study aligns with Challenge 4, which highlights the need for interdisciplinary methods to address real-world information system issues, integrating technology (machines, software) with social factors (people, culture). Additionally, it aligns with Challenge 12, which establishes that information systems must be socially responsible, accessed by everyone without discriminating. This paper contributes to Challenge 12 by identifying frameworks to support inclusive design and communicating research gaps that must be addressed to empower neurodiverse users.

2 BACKGROUND

2.1 Autism Spectrum Disorder

Autism Spectrum Disorder (ASD) is classified as a neurodevelopmental disorder that affects how individuals interact socially, communicate, and engage with their interests and behaviors [24]. Early diagnosis, particularly in childhood, ensures that individuals receive the necessary support to improve their quality of life [6]. Although ASD is a lifelong condition, most studies on accessibility for autistic individuals primarily focus on children [3]. The World Health Organization (WHO) has emphasized the need for solutions that enhance the quality of life for autistic individuals of all ages [41], as the neurological differences between autistic adults and children [55] must be considered when designing solutions to accommodate their needs. According to Valencia et al. [50], one way to improve the quality of life for autistic individuals is by providing technological solutions that follow accessibility guidelines tailored to this population, making them more accessible to these users. The following sections will present more details on accessibility recommendations for autistic individuals.

2.2 Cognitive Load Theory

The Cognitive Load Theory aims to elucidate the role of memory in the learning process [47]. The theory emphasizes that working memory, responsible for processing real-time information, has limited capacity for handling large amounts of information [4]. When a task demands excessive cognitive resources, the memory may become overloaded, impairing the learning process [47]. Sweller categorizes cognitive load into two distinct components [48]: *Intrinsic Cognitive Load (ICL)* refers to the inherent cognitive demand of a task, determined by the complexity of the task itself. *Extraneous Cognitive Load (ECL)* represents the additional cognitive load imposed by how the task is presented, influenced by the organization of information and the presence of distractions in the environment.

Sweller suggests an ideal balance between these two cognitive loads, advocating for higher intrinsic load and lower extraneous load [48]. This approach creates a favorable condition for efficient information processing, allowing for a more effective learning experience by reducing unnecessary distractions and maximizing cognitive engagement with the core task.

Neurodiverse users may experience the cognitive load of a user interface differently than a neurotypical user as the neurodiverse user may require extra mental effort to process information, perform complex tasks, and deal with varying levels of stimuli [59]. An autistic user may find it challenging to process information and perform complex tasks in a web or mobile application.

2.3 Accessibility Recommendations for Autism

The *Web Content Accessibility Guidelines* (WCAG) provides recommendations and evaluation criteria for web accessibility. These guidelines were developed by the *Accessibility Guidelines Working Group* (AG WG), part of the *World Wide Web Consortium* (W3C) *Web Accessibility Initiative* (WAI) [54]. However, WCAG does not offer specific recommendations tailored to the needs of autistic individuals, though its guidelines have served as a theoretical foundation for various works in the field.

In 2015, the AG WG published the *Cognitive Accessibility User Research* report [52], describing the primary challenges faced by individuals with cognitive disabilities when using web technologies. The follow-up work, released in 2017 *Cognitive Accessibility Issue Papers* [53], presented 76 recommendations across 10 categories. However, these recommendations remain broad and lack detail, such as: (a) Use contextually relevant images to enhance content, (b) Use white space for separation, and (c) Avoid distractions [29].

In 2018, Britto and Pizzolato [13] introduced the *Guideline for Web Interface Accessibility with a Focus on Autism* (GAIA). This guide was developed through a review of existing literature to create accessibility guidelines specifically for autistic users. However, the guide's evaluation only involved children, highlighting the

need for further research on other age groups, as emphasized by the WHO [13, 41]. GAIA includes 10 categories with 28 subcategories and 98 recommendations. The categories (with subcategories in parentheses) are: (I) Visual and Textual Vocabulary (Colors, texts, readability, and real-world compatibility); (II) Customization (informational, visual, flexible interfaces, and reading modes); (III) Engagement (eliminate distractions, minimalist interfaces, visual organization, and provide instructions); (IV) Redundant Representations (multiple formats, captions, and textual equivalents); (V) Multimedia (multiple media, avoid disruptive sounds, image enlargement); (VI) System Status Visibility (interaction instructions, action reversal, number of attempts); (VII) Recognition and Predictability (consistency, clickable appearance, and interaction feedback); (VIII) Navigability (simple navigation and avoid redirects); (IX) Action Response (action confirmation); (X) Touchscreen Interaction (appropriate sensitivity).

An important aspect of the GAIA framework is that it incorporates cognitive load theory into its design, addressing various elements such as excessive exposure to stimuli like lights and sounds, as well as emphasizing minimalist design and the management of visual information.

GAIA will be used in this research to categorize the studies identified. Its use is justified by its application in accessibility research for autistic individuals and its inclusion of a category for multitouch devices, which are a focus of this research, distinguishing it from the other guidelines presented.

2.4 Related Work

This section outlines studies following the same thematic approach adopted in our study and focusing on identifying accessibility recommendations for autistic individuals.

Aguiar et al. [3] conducted a systematic literature review to analyze recommendations for developing accessible applications for autistic users. As a result, the authors proposed the *AutismGuide*, a set of 69 design recommendations, divided into categories such as general usability, non-functional requirements, functional requirements, adaptability, direction, visual load, compatibility, explicit control, explicit codes, error management, and consistency. The study also presents a comparative analysis of three autism-focused guides—AutismGuide, GAIA, and COGA—aiming to standardize recommendations for professionals and researchers.

Dattolo and Luccio [18] compiled accessibility guidelines for autistic individuals based on a review of ten articles, resulting in 14 evaluation points for interfaces. These guidelines were used to evaluate 21 websites and seven applications designed for children on the spectrum. The study concluded that the primary barrier to technology use is the lack of adaptable interfaces.

de Souza et al. [20] conducted a literature review on accessibility for individuals with ASD, highlighting several gaps. The first is that accessibility guidelines for autistic users remain in the early stages of development. Furthermore, many guidelines lack sufficient empirical evidence to prove their effectiveness, as most have not been rigorously tested. Finally, there is a critical lack of studies that investigate accessibility from the perspective of autistic adults.

This work builds upon previous studies by incorporating more recent research in the field. Unlike earlier studies [3, 18, 20], this review focuses explicitly on accessibility for autistic adults, excluding research centered on children. Understanding the accessibility needs of autistic adults has often been overlooked in the literature, yet it is essential to consider the needs of all age groups, especially high-functioning autistic adults who live autonomously with minimal support [59]. Unlike other studies, this research aims to provide a detailed overview of the field rather than integrating existing recommendations.

3 SYSTEMATIC MAPPING PROTOCOL

This section presents the systematic mapping protocol used to conduct this research. According to Petersen et al. [42], the result of a mapping study is an inventory of documents on the thematic area mapped for classification. This process provides an overview of the scope of the area and highlights research gaps and emerging trends.

This research aims to thoroughly investigate the current literature to provide a comprehensive view of the field and identify gaps and emerging trends on accessibility in web and mobile applications for autistic adults. The methodology follows best practices for conducting such studies, as established in the literature [34, 42, 57]. The study was conducted in six stages: (i) Definition of Research Questions, (ii) Search Strategy, (iii) Selection Procedure, (iv) Data Extraction, (v) Data Synthesis, and (vi) Reporting of Results. The following subsections provide details for each of these stages.

3.1 Research Questions

The first stage of this study involved defining the research questions, which are listed below along with their justifications.

RQ1: *To what extent does the current computing literature provide guidance for the design and evaluation of accessible information systems (both web and mobile) tailored to the needs of autistic adults?*

Rationale: To achieve the primary goal, this work aimed to collect and synthesize the findings from studies addressing the development and evaluation of web and mobile applications for autistic adults. Regarding the software industry, this synthesis provides insights into recurring challenges and existing solutions that facilitate the development of more inclusive applications. For academia, this mapping can aid in developing new studies by presenting the main approaches, limitations, and challenges in the field, contributing to advancing the state of the art.

To answer this question, the following subquestions are addressed in this study:

RQ1.1: *What accessibility frameworks are used in the literature on accessible web and mobile applications for autistic adults?*

Rationale: In this study, frameworks is a generic term that encompasses theoretical or practical frameworks, questionnaires, guidelines, recommendations, guides, and heuristics for the development and evaluation of interfaces focusing on users in the autism spectrum. This question aims to compile and compare a set of best practice guides to assist in developing accessible applications for autistic adults. The results provide organizations with a list of best practice guides that can be fully or partially implemented to reduce the cognitive load autistic users experience when interacting with web and mobile applications.

RQ1.2: *How do existing studies evaluate the accessibility of web and mobile applications for autistic adults?*

Rationale: after identifying the existing frameworks for building accessible web and mobile applications for autistic individuals, this mapping seeks to determine how these technologies are evaluated. The results contribute to industry and academia by critically analyzing the methodologies primarily used to evaluate accessibility in the context of inclusive technologies.

RQ1.3: *What are the challenges and limitations in researching the accessibility of web and mobile applications for autistic individuals?*

Rationale: This question aims to identify the challenges faced by researchers when developing studies related to accessibility for autistic individuals. The results of this question inform the software industry about potential limitations in applying accessibility guides to software development and highlight areas for attention within the research community.

RQ1.4: *What accessibility barriers for autistic adults have been primarily investigated in the literature?*

Rationale: This question seeks to identify the main accessibility demands addressed in the literature. The goal is to understand what is being investigated in the field and, more importantly, to highlight which accessibility needs are being overlooked in current research, guiding future studies in this domain.

3.2 Search String

Based on the main research question (RQ1), the following search string was developed, inspired by the works of Costa et al. [16] and Aguiar et al. [3]:

"autism OR autistic OR Aspergers" AND "framework OR guidelines OR architecture OR protocols OR directives OR recommendations OR principles OR rules OR patterns OR questionnaire" AND "accessibility OR usability OR accessible" NOT "children" NOT "child"

The terms "autism OR autistic OR Aspergers" were used to define the target audience of the research. Initially, terms indicating adults (e.g., "adult") were also included; however, the results were unsatisfactory, as these terms are common in articles focusing on children. Additionally, limiting the search to abstracts resulted in excluding relevant articles, as many studies do not explicitly define their target audience in the title or abstract. Therefore, we opted to exclude articles that specifically mention children ("children", "child") and manually exclude irrelevant articles during the selection phase based on exclusion criteria.

We used the terms "framework OR guidelines OR architecture OR protocols OR directives OR recommendations OR principles OR rules OR patterns OR questionnaire" to define the study's objects of interest, while "accessibility OR usability OR accessible" delimits the scope of the application.

It is worth noting that although the search string includes only English terms, full-text articles in Brazilian Portuguese with English titles or abstracts were also considered. The inclusion and exclusion criteria are detailed later in this section.

3.3 Search Strategy

This research combined automated and manual search strategies. First, we conducted an automated search in the ACM, IEEE, and Elsevier digital libraries, as these are the primary computing-related publications in digital libraries up until December 2023. We adapted the search string to meet each library's requirements while retaining the terms and structure defined in the previous section. We tabulated the returned articles and removed duplicates.

Next, we used a *snowball* technique to find relevant articles that did not return but cited the studies identified in the automated search. The *snowball* technique is a manual process designed to increase the coverage of the automated search and improve the quality of the results [57].

3.4 Selection Procedure

The first step in the selection procedure was to perform the automated search, as described in Section 3.3. This search initially returned 143 articles from ACM, 28 from IEEE, and 225 from Elsevier. After removing duplicates (9), the first selection stage began with 387 articles.

The next step consisted of selecting the primary studies from the list of studies obtained in the first step. In the first selection cycle, two researchers reviewed together the articles based on title, abstract, and keywords. In cases of disagreement, a third researcher resolved the conflicts. In the event of uncertainty regarding the inclusion criteria, we adopted a conservative approach, moving the article to the next stage for further inspection. At the end of this stage, we selected 53 articles for the next phase. The second selection cycle involved a full-text review of the selected articles.

Finally, we applied the *snowball* technique by searching for citations to primary studies. In this process, we identified an additional 4 studies from 294 articles.

3.4.1 Inclusion and Exclusion Criteria. The inclusion criteria (IC) used to select the primary studies are as follows: IC1 - The study investigates usability or accessibility issues for autistic adults; IC2 - The study proposes usability or accessibility solutions for autistic adults; IC3 - The study investigates or develops guides, tutorials, frameworks, evaluation tools, recommendations, rules, patterns, or protocols that support the development or evaluation of usability for autistic adults;

We excluded the studies from our primary studies list when they met one of the following criteria: EC1 - The study is a version of a more recent or complete study that was also identified; EC2 - The study mentions autism without presenting targeted results; EC3 - The study was exclusively conducted with children; EC4 - The manuscript is written in a language other than English or Brazilian Portuguese; EC5 - The study falls under gray literature, such as theses, dissertations, or technical reports; EC6 - The study did not report results involving autistic adults; EC7 - The full text is not openly accessible.

3.5 Data Extraction

A data extraction form was developed to gather the information necessary to answer the research questions. The form includes the following fields to address this: (I) Year, (II) Title, (III) Author, (IV)

Research Location, (V) Application Area, (VI) Study Type, (VII) Application Domain, (VIII) Investigated Problem, (IX) Research Question, (X) Sample Size, (XI) Challenges Faced, (XII) Solutions, (XIII) Results, and (XIV) Instruments Used.

4 RESULTS

4.1 General Overview

The list of selected primary studies includes 23 articles, as listed in Table 1.

Table 1: Primary studies with corresponding identifiers

ID	Title
ID001	A survey on accessibility guidelines for users with autism [16]
ID002	"Keep it simple!": an eye-tracking study for exploring complexity and distinguishability of web pages for people with autism[23]
ID003	Do web users with autism experience barriers when searching for information within web pages?[21]
ID004	Developing a Set of Design Patterns Specific for the Design of User Interfaces for Autistic Users[27]
ID005	A review of websites and mobile applications for people with autism spectrum disorders: Towards shared guidelines[18]
ID006	A survey of the perceived text adaptation needs of adults with autism [60]
ID007	Towards co-design with users who have autism spectrum disorders[25]
ID008	Accessible texts for autism: An eye-tracking study[61]
ID009	Towards accessibility for users with autism: a comparative analysis of guidelines [2]
ID010	Holistic Approach for Sustainable Adaptable User Interfaces for People with Autism Spectrum Disorder [19]
ID011	Combining Trending Scan Paths with Arousal to Model Visual Behaviour on the Web: A Case Study of Neurotypical People vs People with Autism [38]
ID012	Impact of animated objects on autistic and non-autistic users [5]
ID013	Algorithmic Evaluation: Accessibility of Assistive Technology Webpage Content [8]
ID014	Puzzle Walk: A Gamified Mobile App to Increase Physical Activity in Adults with Autism Spectrum Disorder [37]
ID015	Web users with autism: eye tracking evidence for differences [22]
ID016	The evaluation of a mobile user interface for people on the autism spectrum: An eye movement study [45]
ID017	Adults with high-functioning autism process web pages with similar accuracy but higher cognitive effort compared to controls [59]
ID018	Autism and the web: using web-searching tasks to detect autism and improve web accessibility [58]
ID019	Web-based Search: How Do Animated User Interface Elements Affect Autistic and Non-Autistic Users? [49]
ID020	Crowdsourcing in the prioritization of accessibility and usability criteria for autism [15]
ID021	Designing for Common Ground: Visually Representing Conversation Dynamics of Neurodiverse Dyads [63]
ID022	Cyborg Assemblages: How autistic adults construct sociotechnical networks to support cognitive function [56]
ID023	Banal Autistic Social Media: A Found Footage Autoethnography [33]

Table 2 presents the alignment of the articles found in the mapping with the categories proposed by GAIA. It is worth noting that we utilized the GAIA framework because it is an established guide widely accepted by the community, which also examines aspects of cognitive load theory within its scope. The two categories with the most items are visual and textual vocabulary, and engagement. It was also observed that there were no studies in three categories: state visibility, recognition and predictability, and response to actions.

Table 2: Classification of primary studies according to the GAIA

GAIA Category	IDs
Visual and Textual Vocabulary	ID006, ID008, ID012, and ID017
Customization	ID006, ID010, ID022, and ID023
Redundant Representations	ID008 and ID023
Engagement	ID002, ID003, and ID015
Multimedia	ID012, ID014
Navigability	ID020
Recognition and Predictability	-
State Visibility	-
Response to Actions	-
Touchscreen	-

4.2 What accessibility frameworks are used in the literature on accessible web and mobile applications for autistic adults?

We found nine frameworks in the surveyed literature that are used to develop and evaluate the accessibility of web and mobile applications for autistic users, including AustimGuide (F001), GAIA (F002), WCAG (F003), and COGA (F008). Table 3 lists the identified frameworks with their identification code (ID) and a reference to the study where they are presented.

As presented in Table 4, the first identified framework was published in 2007, but the majority (six out of nine works) were published in the last eight years, suggesting a growing need for frameworks in the investigated context. Three of the frameworks are specifically designed for children, while the others do not specify the target age group, indicating that these frameworks could be used for developing and evaluating tools aimed at adults.

The number of guidelines per framework ranges from 12 (F003) to 28 (F002). For example, WCAG (F003) is a document that sets digital accessibility standards (not specifically focused on autism) to be followed by websites. It includes information, for instance, on how to create non-textual content, use audio or video, captions, audio descriptions, animations, and error prevention. In contrast, GAIA (F002) provides a set of accessibility recommendations for web development focused on autism aspects, including visual and textual vocabulary, recognition and predictability, and customization. The number of guidelines per framework is available in Table 4.

The most common methodology used to develop the frameworks is a literature review (LR), employed in five studies. The remaining frameworks were built based on interviews (F006) or the W3C process [51] (F003 and F008). This process involves several stages, including community review of the initial document, implementation of the recommendations for evaluating their applicability, and submission of the recommendations for W3C approval and publication. F007 does not explicitly describe the methodology applied to the framework's development and evaluation.

Only one of the analyzed works (F002) provides specific guidelines or recommendations for developing mobile applications. Research studies [35, 36, 43] show that the user experience with mobile applications can differ from web and desktop applications due to smaller screens and smaller button areas, for instance. Therefore, it

is important to understand if these generic guidelines are the most appropriate for the mobile device context.

Table 3: List of frameworks to develop and evaluate accessible identified

ID	Title	Ref.
F001	AutismGuide: A usability guidelines to design software solutions for users with autism spectrum disorder	[3]
F002	GAIA: uma proposta de um guia de recomendações de acessibilidade de interfaces Web com foco em aspectos do Autismo	[13]
F003	Web content accessibility guidelines (WCAG) 2.0	[14]
F004	Development of the AASPIRE web accessibility guidelines for autistic web users	[44]
F005	Accessible and Usable Websites and Mobile Applications for People with Autism Spectrum Disorders: a Comparative Study	[17]
F006	Designing Accessible Visual Programming Tools for Children with Autism Spectrum Condition	[64]
F007	Making written information easier to understand for people with learning disabilities: Guidance for people who commission or produce Easy Read information	[40]
F008	Cognitive accessibility user research	[52]
F009	Web accessibility design recommendations for people with cognitive disabilities	[26]
F010	Diversity for design: a framework for involving neurodiverse children in the technology design process	[11]

Another noteworthy point is that four of the frameworks focus on general accessibility, which may benefit autistic individuals (F003, F007, F008, and F009), while five of them focus entirely on autistic individuals (F001, F002, F004, F005, and F006).

4.3 How Do Existing Studies Evaluate the Accessibility of Web and Mobile Applications for Autistic Adults?

The findings of this study highlight the use of *eye-tracking* tools to identify the areas that autistic individuals focus on while using applications, and to compare these with the focus areas of neurotypical individuals. The primary aim is to understand reading patterns and engagement differences (ID002, ID003, ID008, ID011, ID012, ID015, ID016, ID017, and ID018).

Eye-tracking tools are commonly used in combination with a tool called ViCRAM [39], which analyzes the visual complexity of a page to assess the cognitive load required for information processing (ID002, ID003, ID011, ID016, ID017, and ID018). However, a subset of these studies (ID002, ID003, ID017, and ID018) originate from the same research project and share co-authors. The combined use of these two tools helps researchers understand the reading pattern tendencies of autistic individuals compared to neurotypical users.

Two studies utilize existing frameworks to evaluate interfaces via online questionnaires. ID004 validates recommendations proposed within the study itself with software development professionals, some of whom have experience with autistic individuals, while others do not. Article ID006 creates a survey for both autistic and neurotypical individuals, aiming to understand the challenges they face when reading product reviews in e-commerce settings. AutismGuide is employed in ID001 and ID020 for theoretical validation with family members and professionals, such as therapists and psychologists, but no practical interface testing is conducted.

The primary objective of ID013 is to develop an algorithm that identifies accessibility issues on web pages for individuals with ASD. The proposed algorithm can detect accessibility issues related to page language, internal and external links, image tags/alt text, and content text. For this purpose, a web scraping tool was used. In ID018, autistic individuals completed predetermined tasks via Skype, followed by qualitative interviews.

In ID021, researchers conduct participatory design sessions involving an autistic person and a trusted companion to better understand how to address communication within web design. In ID022, participants completed asynchronous interviews about using assistive technologies in daily life, aiming to discover solutions that this group has found in existing tools. A unique approach is seen in ID023, where the author, an autistic individual, documents their use of social media and derives results from a methodological analysis of this documentation.

4.4 What Are the Challenges and Limitations in Researching Accessibility for Web and Mobile Applications for Autistic Individuals?

The majority of challenges or limitations reported by researchers in the selected articles relate to sample size and diversity. This issue was cited nine times across articles ID002, ID003, ID012, ID013, ID015, ID016, ID017, ID018, and ID019. In all cases, this is noted as a limitation on the generalizability of results; however, it is important to mention that four of these studies—ID002, ID003, ID017, and ID018—stem from the same experiment and therefore share the same limitation. Additionally, 11 articles did not report direct issues at any stage of their research, with limitations instead relating to methodological aspects that were not specific to autistic individuals.

Among the remaining articles, ID001 faced challenges in grouping guidelines by relevance due to participant evaluations and addressed this issue through network analysis. Article ID020 focuses on resolving this difficulty. In ID007, the sample issue was associated with the inability to test with autistic participants due to the potential stress caused by expectation, so the study was conducted with specialized healthcare professionals. In ID011, a potential threat to the validity of the study was the accuracy of *eye-tracking* tools, which was mitigated through group analysis of results.

4.5 What Are the Primary Accessibility Barriers Investigated in These Studies?

Six of the reviewed articles do not specifically investigate accessibility barriers; three of these—ID001, ID004, and ID020—focus on refining frameworks, while article ID009 conducts a comparative analysis of three specific frameworks, and ID010 proposes the creation of a new framework without detailing specific barriers to be addressed. The accessibility barriers identified in the remaining 17 articles can be grouped into four main types:

- **Overload** - Relates to cognitive or sensory overload (e.g., unnecessary sounds, images, animations that may cause user discomfort). It also includes the visual complexity of a page.
- **Processing** - Involves the user's ability to comprehend the images, text, or page being presented.

Table 4: Metadata summary of identified frameworks

Criteria	F001	F002	F003	F004	F005	F006	F007	F008	F009
Year of Publication	2020	2016	2008	2019	2017	2021	2010	2015-2017	2007
Number of Guidelines	81	28	12	20	18	16	41	76	22
User Profile	General	Children	General	General	General	Children	General	General	General
Mobile Guidelines?	No	Yes	No	No	No	No	No	No	No
Evaluation Conducted?	No	Yes	No	Yes	Yes	Yes	No	No	No
Methodology	LR	LR	W3C	LR	LR	Interview	ND	W3C	LR
Objective	Recommend	Recommend	Recommend	Recommend	Recommend	Recommend	Recommend	Recommend	Recommend
Focus	Autistic Users	Autistic Users	General	Autistic Users	Autistic Users	Autistic Users	General	General	General

- **Distinguishability** - Refers to the ability to differentiate specific elements, such as icons or images, within the interface.
- **Expectation Mismatch** - Pertains to graphical changes between pages, frustration with icons that do not match user expectations, and general disruptions to routine.

The most commonly reported barrier is processing, identified in 17 articles. The distribution of other barriers across each article can be found in Table 5, which shows that multiple barriers were consistently addressed within each article, except for ID006, which focuses exclusively on information processing in e-commerce websites for autistic users.

Table 5: Distribution of Accessibility Barriers Encountered

Barrier	Article ID
Overload	ID002, ID003, ID005, ID008, ID012, ID014, ID015, ID017, ID018, ID022, ID023
Processing	ID002, ID003, ID005, ID006, ID007, ID008, ID011, ID012, ID013, ID014, ID015, ID016, ID017, ID018, ID021, ID022, ID023
Distinguishability	ID002, ID003, ID005, ID011, ID012, ID016, ID017, ID021
Expectation Mismatch	ID005, ID007, ID013, ID014

4.6 What Are the Primary Accessibility Barriers for Autistic Adults Addressed in the Literature?

ID006 addresses accessibility in texts, specifically examining the processing barrier in the context of online product reviews. Based on survey responses from users, the study concluded that one way to address this barrier would be to create summaries highlighting key points from all reviews. Users also expressed a need for a tool that could identify false reviews.

In ID007, the focus is on barriers in group work with autistic individuals for interface design projects. The primary barriers are processing, expectation mismatch, and overload. Solutions included transparent, direct communication, presenting the entire project, allowing the individual to process information, and minimizing expectation mismatch. Additionally, it is recommended to give autistic individuals control over situations, and withdraw if they experience stimuli overload.

A similar focus is seen in article ID021, which investigates communication between autistic and neurotypical individuals using participatory design. The study's findings address barriers related to processing and distinguishability, suggesting that analogies and comparisons in dialogue are tools used by both neurotypical and autistic participants. In addition, the authors highlight the need for assistive technology to support equitable social interactions in communication.

Both ID022 and ID023 identify autonomy as a critical factor in application accessibility for autistic individuals. Autonomy plays a significant role in overcoming overload and processing barriers. Both studies suggest that increased customization allows users to create personalized usage modes, enhancing accessibility without requiring increased cognitive load. Additionally, ID023 advocates for effective labeling and granular content filtering to help users manage social media content and avoid potential stress triggers.

ID018 examines findings similar to those discussed in *eye-tracking* studies, focusing on how non-essential elements affect autistic users' processing, overload, and distinguishability barriers. The study evaluates the impact of screen animations on autistic and neurotypical users' ability to complete specific tasks. While no significant time difference was observed, differences in strategies and reports of mental fatigue suggest that cognitive overload occurred in these cases.

This conclusion is supported by *eye-tracking* studies ID002, ID003, ID011, ID012, ID015, ID016, ID017, and ID018. All of these studies reach similar conclusions that, although processing time does not differ greatly, the cognitive load and processing difficulty are significantly higher on visually complex pages. The primary recommendation from these studies is to eliminate non-essential visual and auditory elements when designing accessible interfaces.

The only *eye-tracking* study presenting a different perspective is ID008, which proposes guidelines for creating more accessible texts by incorporating images, symbols, and photographs to help overcome processing barriers. It also includes text structure recommendations to facilitate readability.

Articles ID001, ID004, ID009, ID010, and ID020 do not seek solutions to specific barriers. ID001 and ID004 refine the F001 framework, while ID020 aims to prioritize categories within F001 based on the application context. ID009 focuses on comparing the recommendations of F001, F002, F004, and F009. ID010 proposes a structure to bridge current gaps by integrating an ontology with semantic user interfaces for autistic individuals.

Two articles that evaluated websites or applications, ID005 and ID014, did not present significant solutions or results. Article ID013 proposes an algorithm to evaluate the accessibility of the website. This algorithm extracts website information, processes it through multiple stages to identify potential issues with text, links, and

images, and reports deviations from a standard. Although this provides a method for accessibility evaluation, it does not directly address specific barriers.

5 DISCUSSION

The analysis reveals at least nine frameworks used by the academic community to establish best practices for accessibility for individuals with ASD. A notable point is that only one of these frameworks includes items specifically for the mobile context (i.e., GAIA). For classification purposes, we considered GAIA as a guide that provides recommendations for mobile devices, as it has a category titled "touchscreen." However, it is important to note that Britto and Pizzolato [13] briefly mention multi-touch devices, which may include tables and monitors that are not necessarily mobile.

The variation in the number of guidelines in each framework also stands out, ranging from 12 to 81. This suggests a lack of consensus on what is truly important for accessibility for autistic individuals. This variability can make it challenging to choose and implement one of the frameworks in projects.

As previously noted by Williams et al. [55], there are differences between autistic children and adults. Most frameworks are general and child-focused. Although many recommendations may apply to both children and adults, it is necessary to clarify their effectiveness for each group. This emphasizes the need for studies to investigate whether recommendations for children can be generalized to adults and whether general frameworks suit both groups.

In line with Souza et al. [20], we observed the absence of empirical studies demonstrating the impact of using this frameworks, particularly in the context of autistic adults. This highlights the need for empirical evidence to assess the effectiveness of research-based development standards when applied in industry. Although we recognize the value of proposed standards such as GAIA and AutismGuide–both of which incorporate some extent of empirical evaluation–we also acknowledge the need for further validation to ensure a meaningful impact on society. Furthermore, research is needed to empirically evaluate the existing frameworks, increasing their reliability and consequently fostering application in the industry contexts.

The use of eye-tracking tools appears to be a current research trend. Findings from these studies contradict the widely used frameworks, which often recommend using images and extra elements [3, 13, 52, 53]. Studies show that these elements can complicate page processing for autistic users, indicating a need for further investigation into the effectiveness of these frameworks.

The eye-tracking studies revolve around visual information. However, user interaction involves a combination of sensory and cognitive elements. For example, appropriate sound usage ensures a positive interaction experience by sensitive users [13]. Another example is the cognitive overload caused by the absence of specific elements, such as feedback, confirmation, or error messages. Although these aspects are included in a few frameworks (e.g., COGA, GAIA, and AutismGuide), the literature lacks studies dedicated to non-visual aspects.

One challenge identified in the reviewed literature is to achieve a sufficiently large and diverse sample for generalization. Autism is recognized as a spectrum, reflecting the wide range of experiences and characteristics among individuals. Therefore, sample diversity becomes essential to identify diverse user abilities and address different needs. This heterogeneity imposes challenges in generalizing results, with no satisfactory solution proposed in the current literature. While the issue with sample diversity persists, we propose that customization could be the alternative to provide a universal design, respecting the uniqueness of individuals.

When analyzing cognitive load theory, this study highlights that the category of visual and textual vocabularies is the most researched. These studies aim to provide customization options to reduce intrinsic load and enhance usability. Additionally, it was observed that external elements, such as unnecessary animations and visually complex interfaces, increase extraneous load. The findings emphasize that minimalist interfaces with simplified navigation contribute to reducing this load, fostering more effective interaction. However, few studies addressing this topic were identified.

This study provides researchers in the field with an updated overview of developments to date, as well as identifying potential gaps for future research. By identifying research patterns and trends, developers in the field gain a theoretical foundation for what can be done to enhance accessibility in this area.

6 LIMITATIONS AND THREATS TO VALIDITY

According to Zhou et al. [62], various limitations and threats to validity may arise when conducting a systematic mapping. To mitigate issues related to incomplete or incorrect search terms, we based our search string on two relevant studies in the literature [3, 16]. Another common issue in research is publication bias, which refers to the tendency for positive results to be published more often than negative ones [62]. This study aimed to identify studies regardless of their biases; however, we recognize that publication bias may exist in primary studies, which we cannot mitigate. To reduce extraction bias, the extraction process was conducted in pairs.

To minimize selection bias, two researchers independently conducted both automated and manual searches, with a third researcher responsible for resolving conflicts. The manual search process also helps identify relevant studies that may not have been found in the automated search [57].

A significant limitation of our study is its focus on computing-related research; our review does not consider studies in fields such as medicine and psychology that could have addressed the same topics.

Based on the guideline coverage and goals, we selected the framework GAIA as a reference to categorize the primary studies. This choice provided structure to the analysis and facilitated the identification of research gaps. We acknowledge that fitting the analysis into a single framework can limit the scope of our findings. A meta-analysis of established frameworks such as GAIA, AutismGuide, and COGA could provide a more comprehensive set of accessibility guidelines. However, we couldn't find such an analysis in the current literature, and conducting one is beyond the scope of this research.

7 CONCLUSION

This study aimed to increase the understanding of the state of research on accessibility in web and mobile applications for autistic adults. To this end, we identified and categorized a set of relevant articles. We believe that the results of this study provide a broad view of the field, as well as identifying gaps and emerging research trends. Through a systematic mapping, 23 articles were identified in the field of computing with a focus on Information Systems (web and mobile) accessibility for autistic adults. The studies were found within GAIA categories: visual and textual vocabulary, customization, redundant representations, navigability, engagement, and multimedia. However, no studies were found in the categories of system state visibility, recognition and predictability, action response, and touchscreen. Accessibility barriers affecting users were categorized into four primary areas: overload, processing, distinguishability, and expectation mismatch.

The main challenges and limitations in researching information systems for autistic adults are related to sample size and the use of applications on native devices. Additionally, nine frameworks were identified in the primary studies. Two frameworks focus on children (F002 and F006), while others are more general, not specifically targeting adults. Only one framework includes a guideline for multitouch devices, hence it was classified as mobile. Four frameworks included empirical validation at some level, yet none were tested with autistic adults to validate their guidelines.

Based on this study, we conclude that there are gaps the computing and human-computer interaction communities need to consider to improve the technological and social aspects of the information systems they build to be more inclusive. Key findings include: (1) A limited number of guidelines and studies investigate accessibility specifically in mobile applications; (2) widely recognized guidelines contradict findings from eye-tracking studies; (3) there remains a substantial gap in empirical studies on the effectiveness of these frameworks; and (4) there is a need for further understanding in the context of autistic adults.

For **Future Work**, aligned with our results and discussions, it is important to empirically evaluate the existing frameworks to increase reliability and delimit their scope of application. In addition, a deeper understanding of which guidelines are effective in mobile applications is recommended. A straightforward starting point would be to examine which of the presented frameworks best fit the mobile context and to test them with autistic users. We also propose investigating the impact of mobile platforms on individuals with ASD and compare this with findings from web platforms to understand potential differences. Finally, a possible path for future studies is a comparative analysis of findings from eye-tracking studies and the existing guidelines to determine which solutions are more effective in the overlapping fields. Finally, it would be beneficial to test guidelines with autistic adults on real devices to evaluate their effectiveness.

We used ChatGPT as a support tool for translating and rewriting this article.

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