Towards Web Accessibility Guidelines of Interaction and Interface Design for People with Autism Spectrum Disorder

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Abstract— **In this paper, we describe a proposal set of Web accessibility guidelines of interaction and interface design for people with Autism Spectrum Disorder (ASD) to help Web professionals to design accessible Web interfaces for these users. The guidelines were extracted from an exploratory bibliographic survey of 17 works published between 2005 and 2015 including international recommendations, commercial or academic software and peer-reviewed papers. We identified 107 guidelines that were grouped in 10 categories using the affinity diagram technique. Then, we systematized the guidelines in each group according to similarities and duplicated statements, generating a set of 28 guidelines. As a result, we evidenced best practices to design accessible Web interfaces for people with ASD based on well succeeded solutions presented in works of different contexts. With those results, we aim to contribute to the state of the art of cognitive Web accessibility. Therefore, we intend to make the set of guidelines available in a repository on GitHub.**

Keywords- Web Accessibility; Autism; Guidelines; Universal Access; Interface Design for People with Autism.

I. INTRODUCTION

Autism Spectrum Disorder (ASD) is a syndrome which affects three developmental abilities: social, communication and interest skills [1]–[3]. People with ASD usually present difficulties regarding social interaction, verbal and non-verbal communication and imagination, as well as a restricted repertoire of interests and activities [3][4]. As a spectrum, ASD has a myriad of characteristics and severity degrees related to the level of impairment of skills, from mild (high-functional autism) to severe. As soon as it is diagnosed, ASD has effective treatments to minimize the impact of the impairment of skills and improve life quality of people with the syndrome and their families [1]–[3][5].

In the past 20 years, computer technology has been used as a support tool for parents, therapists, educators and people with ASD [5]–[8]. Previous works showed that people with ASD are interested in technology [7] and that is beneficial to a) develop their abilities [6][9]–[11]; b) facilitate their lives [12]; and c) be a helpful tool for pedagogical, therapeutic and everyday life activities [11][13][14], independent of age. Nowadays, devices exploring natural interactions and direct manipulation with touch screens, such as tablets, increase the acceptance of technology by these users [9][15]–[17].

However, even having some successful solutions available for this audience, software developers still have a limited knowledge on how to develop native or Web-based applications suitable for people with ASD. Other cognitive disabilities are also challenging for developers. This happens mainly because they still do not know how technology is used in these users' life [7]. When we analyze the Web context, Web developers and designers have a lack of experience working with accessibility [18] and, when they have it, it is usually only about people with visual disabilities.

Another bias is that we have few Human-Computer Interaction (HCI) guidelines to help Web developers design for people with ASD [6][19]. Although specific literature provides some clues [7][12][20]–[24], the state of art regarding cognitive Web accessibility contains fewer works than expected [21]. HCI guidelines provide an understandable knowledge about needs and preferences of people with ASD and can help Web developers understand how technology is used by these users [25], also allowing Web access equity [21].

Thus, researches are needed to investigate which design features are critical in providing therapeutic and pedagogical support for people with ASD in order to understand the potential impact of technology in their change of behavior [14][26] and provide a formalization of this knowledge for Web developers and designers.

In this paper, we describe a proposal set of Web accessibility guidelines for people with ASD to help Web developers to design accessible Web interfaces for these users. These guidelines systematize and formalize recommendations and best practices extracted from literature and reviewed software.

This paper is organized as follow: in Section II, we present previous works related to the development of interface and interaction design guidelines for people with ASD, including exclusive and non-exclusive guidelines. In Section III, we describe our methodological approach to identify, extract and systematize the guidelines presented in this work. Section IV presents the proposed set of guidelines and describes each category, while in Section V we discuss their potential effectiveness for people with ASD. Finally, we present our conclusions in Section VI.

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II. BACKGROUND

Friedman and Bryan [21] were two of the first to formally propose Web accessibility guidelines for people with cognitive or neuronal disabilities. Through an extensive literature review of 20 studies involving guidelines from experts, governments and institutions, the authors established the 22 most frequent recommendations on selected works. Similarly, Darejeh and Singh [12] investigated usability principles for people with low digital literacy, including people with cognitive disabilities and ASD. Putnam and Chong [8] conducted a survey with parents and educators of children and adolescents with autism and adults with autism through an online questionnaire to identify software solutions that cater to people with ASD. The study does not define design recommendations, but highlights aspects that can help in building technology products for people with ASD considering the objectives, interests and abilities of the public. Web Accessibility Initiative (WAI), a W3C (World Wide Web Consortium) group to delimit Web accessibility guidelines, published in 2012 a draft of principles of Web accessibility for people with cognitive or neuronal disabilities and potential barriers to this group [24]. As these recommendations were a draft, the W3C created a task force group called Cognitive and Learning Disabilities Accessibility Task Force (COGA) focusing on the area now called Cognitive Web Accessibility. In January of 2015, COGA published the results of a user research conducted to address problems and solutions concerning Web accessibility for people with cognitive, neuronal or learning disabilities [22].

In general, most of the works presented preliminary results and need further details about their proposed solutions, although they have significant contributions. An observed bias is that these works aim to focus on technology professional and tend to have more technical content. Recommendations considering the skills of a person with ASD that can be used by professionals from different areas may have a potentially greater adoption and allow multidisciplinary works to develop affordable solutions.

III. METHODS

The process to identify, extract and systematize the guidelines presented in this work was conducted in three phases:

A. Phase 1 – Studies selection

We conducted an exploratory bibliographic survey to selected works about accessibility for people with ASD and other cognitive or neuronal disabilities published or developed between 2005 and 2015. We analyzed international recommendations, mobile and desktop applications, universal design approaches for educational purposed and peer-reviewed papers published in conferences and journals. The process of the survey involved an extensive search in databases, such as Association of Computer Machinery (ACM), IEEE, PubMed and Google Scholar. We also performed manual searches to find solutions that were not restricted to scientific papers. Table I presents the inclusion and exclusion criteria considered to select the works. Only the last inclusion criteria were mandatory to select or exclude works.

TABLE I. INCLUSION AND EXCLUSION CRITERIA TO SELECT THE WORKS TO BE ANALYZED IN PHASE 2

Inclusion criteria	Exclusion criteria
Peer-reviewed papers published in conference proceedings or scientific journals.	Unpublished papers, blog posts and other materials that did not presented verified empirical evidences and results.
Computational solutions for people with ASD, specially children.	Computational solutions focused on parents, therapists or educators of people with ASD.
Works approaching accessibility recommendations for computing systems and/or Web acessibility for people with cognitive, neuronal or learning disabilities.	Papers that didn't described clearly the design decisions taken to develop the solution regarding the needs of people with ASD.
Works approaching mainly interaction models based on touch screens or Web interfaces.	Works focused on robotics.
Works and solutions publised or developed between 2005 and March of 2015.	Works out of the inclusion criteria.

B. Phase 2 – Extraction

In this phase, we performed a triage to extract recommendations from selected works, where we identified 107 potential recommendations and best practices. Subsequently, we executed a process to group them using a process similar to the affinity diagram technique, in order to arrange the extracted statements in logical sets according to the patterns we could identify in each statement. This process resulted in ten categories of guidelines.

C. Phase 3 – Consolidation

Upon grouping the recommendations by affinity diagram, we could perceive similarities between recommendations within a group that was not noticed during the analysis of the raw material of the 107 recommendations. Thus, we did a second grouping process to combine analogue recommendations contained in each category, refine the statements and systematize the final set of guidelines. We also wrote a detailed description of each guideline, including how to implement them and their respective importance for people with ASD, a gap we identified in the selected works.

IV. RESULTS

Through an exploratory review of literature and available software, we selected 17 works according to the criteria of Phase 1, divided into international recommendations (3), software accessible for people with ASD (3), universal design guidelines for learning (1) and peer-reviewed papers (10). The selected works came from nine countries (United States, Brazil, Italy, England, Israel, India, Malaysia, Chile and Hong Kong), except the international recommendations, which can be considered global. Although contributions from United States correspond to 47% of works, it was still possible to bring cultural diversity from different countries.

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Regarding the platform, this work is focused on Web-based interfaces, but we selected works exploring distinct platforms and applications, such as Virtual Reality, Multitouch Table and native (desktop or mobile) due to the possibility of generalizing recommendations and interaction patterns that can be platform-independent. Most of the works are technology specific or accessible for people with ASD, although all works from International Recommendations are not exclusively focused on ASD.

In Phase 2, after extracting the potential guidelines, we grouped all 107 recommendations, organizing them based on a similarity criterion. This process resulted in ten categories carefully labeled to represent common elements in Web interfaces. The categories are: (G1) Visual and Textual Vocabulary; (G2) Customization; (G3) Engagement; (G4) Redundant Representation; (G5) Multimedia; (G6) Feedback; (G7) Affordance; (G8) Navigability; (G9) System Status; (G10) Interaction with Touch Screen.

In Table II, we present a summary of recommendations extracted from the first triage, where it is observed that the most critical interface design aspects are related to *Visual and textual vocabulary*, *Customization, Engagement* and *Redundant Representation*, according to the number of extracted recommendation and number of works from which we extracted these recommendations. At first, we had a hypothesis that *Customization* guidelines would be critical due to the diversity of characteristics of people with ASD as customization allows them to be in control and to tailor the interface according to their preferences. However, one of the biggest challenges for people with ASD when using the Web are: a) to focus or comprehend lengthy sections of text [23]; and b) to understand visual/textual information due to inaccurate visual and textual communication [12][22]. It is worth mentioning that *Visual and textual vocabulary* is recommended to be the first concern for developers and should be complemented with *Redundant representation* in order to increase the potential of being understood. As people with ASD, especially children, may be uncomfortable with certain distractive elements and also present some difficulties regarding focus and attention, *Engagement* guidelines are important to work memory, attention and reading skills on the Web interface.

TABLE II. DISTRIBUTION OF EXTRACTED RECOMMENDATIONS BETWEEN CATEGORIES AND QUANTITY OF WORKS REFERENCED IN EACH CATEGORY

Category	Extracted recommendations	Referenced works
G1	26	9
G2	14	10
G3	12	9
G4	12	7
G5	10	9
G6	8	8
G7	8	6
G8	7	4
G9	6	4
G10	4	4

The final step in Phase 2 was a second arrangement process to generate unique guidelines and reduce ambiguity and redundancy, since several recommendations in each category, from different authors, presented similar statements. As a result, we would formalize a set of 28 guidelines distributed in the ten categories, as presented in Figure 1. The guidelines from *Visual and textual vocabulary*, *Customization* and *Engagement* represent about 43% of all guidelines, reinforcing their importance when designing interfaces for people with ASD.

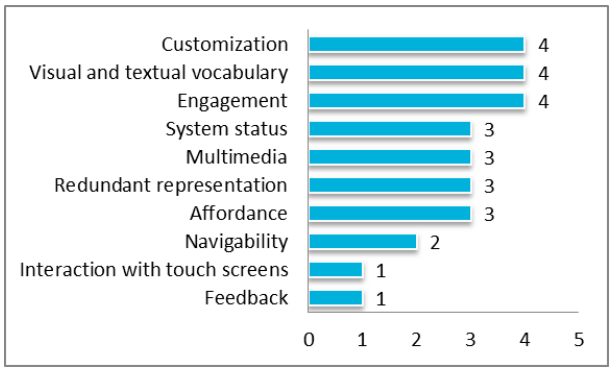

Figure 1. Number of unique guidelines generated for each category after systematization and summarization.

A. *Description of the guidelines' categories*

The consolidated guidelines compound a set of 28 Web accessibility recommendations to design and develop Websites and Web applications more suitable for people with ASD. As mentioned previously, the guidelines are distributed in ten categories and each one has a strategic scope regarding interface and interaction aspects of a Web interface. We describe in the following sections the scope of each category. The full set of guidelines ordered by category is presented in Table III.

1) G1 – Visual and textual vocabulary: This category presents the most important recommendations, according to the works we analyzed. They address the proper use of text and images considering particularities of people with ASD. About 50% of the works present concerns about text structure, language, verbal and pictorial communication, reading flow and color contrast. In guideline 1.2 we consolidated contributions from four works [12][22]–[24] and eight recommendations about the use of proper language. Guideline 1.4 summarizes five similar recommendations extracted from three works [15][27][28] related to real world representation of icons and interaction patterns. As people with ASD may face barriers to understand information and decode language, the guidelines of this category can improve the aspect of engaging in communication [29] and approach social and communication skills.

2) G2 – Customization: Guidelines from Customization category address recommendation to enable users to tailor interfaces according to their needs. It is the second most

important category and it addresses how users with ASD can adjust the interface in a more comfortably way to them, considering that the syndrome presents a myriad of characteristics and it is often risky to identify patterns between people with ASD, such as colors preferences.

3) G3 – Engagement: The guidelines of Engagement present recommendations regarding focus, attention and strategies to help users interact with the system. These guidelines address interface design issues and intersect with recommendation of "G1- Visual and textual vocabulary" and "G6 -Feedback".

4) G4 – Redundant representation: Redundant representation, along with G5 - Multimedia, refers to guidelines reinforcing that information should not be linked exclusively to a format (text, image or audio). Multiple representations (specially graphical) work as a supplementary content [30] and contribute with enrichment of the repertory of user's vocabulary [5][9].

5) G5 – Multimedia: Complementing guidelines from Redundant Representation, Multimedia's guidelines detail the proper use of multimedia in Web interfaces to work memory, attention, visual and textual understanding and sensorial integration of people with ASD.

6) G6 – Feedback: Providing feedback for actions performed in interfaces is a common usability recommendation independent of the characteristic of users. However, incomplete feedbacks or their absence are critical for people with ASD, particularly children, due to their potential difficulties to pay attention, deal with changes and understand verbal instructions. Thus, feedbacks are important for people with ASD to guide them in performing tasks, understanding the application behavior and predicting the behavior of similar features or elements. The recommendations we extracted were very similar to each other, evidencing how this aspect is important and is consistently established in different works. As a result, we could summarize them into a single guideline.

7) G7 – Affordance: Guidelines in this category address issues to design interface elements that clearly identify how they work without a deep investigation or a high cognitive effort. Reducing cognitive workload is an important accessibility concern when designing interfaces for people with ASD. Consequently, interface designers and Web developers should pay attention to the Web page element which may not specify clearly if they are clickable, draggable, pushable, etc.

8) G8 – Navigability: The guidelines of Navigability present recommendation about the navigational structure between Web pages. A large amount of information and number of links contribute to a bad user experience for people with ASD. Therefore, it is recommended to provide to the interface: a) a simplified navigation; b) consistent location indicators; and c) sequential navigation, when applicable. Also, it is important not to prevent users to be in control of the navigation flow.

9) G9 – System status: The System status' guidelines address recommendations about progress among tasks (clearly information about errors, help instructions and information related to changes in state of elements).

10) G10 – Interaction with touch screen: The last category presents a recommendation on the use of touch screen. We consider this recommendation important since Websites and Web applications are increasingly being accessed through mobile devices with touch screens. Those devices present direct manipulation of interface elements, people with ASD tend to interact better to such devices [9][15][20] and their interaction model is considered to be more natural. Interfaces with direct manipulation require less physical efforts and present interaction patterns compatible with the real world.

V. BRIEF DISCUSSION

It is possible to find some software, games and applications aimed at teaching and learning of people with ASD, both in scientific works and business solutions. However, for each of these applications, designers and developers may need to thoroughly investigate the most suitable design solution for the proposed application or may follow generic design guidelines that may not be appropriate in the context of software for people with ASD [6][27].

By proposing recommendations and guiding principles for the development of interfaces accessible to people with autism, it is possible to mitigate the lack of knowledge of developers and enable the development of more inclusive technologies. In addition to allowing the developers to know what they should consider when developing appropriate solutions for people with ASD, design recommendations can contribute to raise awareness of these professionals about the characteristics of the person with ASD and how technology can be valuable to them. Following recommended guidelines for proper software design, designers and developers can support the educational goals defined for the application.

Systematizing contributions from 17 works and selected solutions generated a consolidation of contributions that, to date, have been dispersed in different types of publications or were a tacit knowledge in the design of software solutions.

Some recommendations may not seem new regarding Web accessibility and interface design, e.g., "*provide clear error messages*" and "*provide feedback*". The difference is how the fulfillment of these factors has a different impact for people with ASD. When we suggest, for example, avoiding using metaphorical expressions in the interface content and icons, we can consider this as an important guidance for neurologically typical children in literacy age, because they often don't understand some non-literal expressions. But this recommendation is even more critical for people with ASD, considering that people with autism, in different age range, may have difficulty understanding and interpreting metaphors. The proposed guidelines can be used by interface designers, Web developers and other professionals involved in the design of applications for people with ASD as a

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support for decision-making to suggest information and resources more consistent with the context of children with autism and, potentially, a variety of users.

TABLE III. SET OF PROPOSED GUIDELINES

ID	Summary Description	Authors
	G1 – Visual and Textual Vocabulary	
1.1	Colors shouldn't be the only way to deliver content and the contrast between background and objects in foreground must be appropriate to distinguish items and distinct content or relate similar information	[20][21][23][30]
1.2	Use a simple visual and textual language, avoid jargons, spelling errors, metaphors, abbreviations and acronyms, using terms, expressions, names and symbols familiar to users' context	[12][22]–[24]
1.3	Be succinct, avoid writing long paragraphs and use markups that facilitate the reading flow such as lists and heading titles	[21][23]
1.4	Icons, images and label of menus and actions should be compatible to real world, representing concrete actions and everyday life activities in order to be easily recognized	[15][27][28]
	G2 – Customization	
2.1	Allow color, text size and font customization for interface elements	[12][16][21]–[23]
2.2	Provide options to customize information visualization with images, sound and text according to individual user's preferences	[6][7][16][21][31]
2.3	Provide options to customize the amount of element in the interface, their arrangement and enable features personalization	[6][9][16][17]
2.4	Enable a reading or printing mode for activities involving reading and concentration	[21][22]
	G3 – Engagement	
3.1	Avoid using elements that distract or interfere in focus and attention. In case you use it, provide options to suppress those elements on screen.	[9][23][24][31]
3.2	Design simple interfaces, with few elements and which present only the features and content need for the current task to be performed by the user	[12][15][28]
3.3	Use blank spaces between Web page elements to separate different contents or focus the user attention on a specific content	[21][23]
3.4	Provide clear instructions and orientation about tasks to ease the user understanding of the content and the content language, in order to stimulate, motivate and engage the user	[7][9][24]
	G4 – Redundant Representation	
4.1	The Website or Web application must not rely only in text to present content. Provide alternative representations through image, audio or video and ensure that they will be close to the corresponding text	[5][6][21][23][31]
4.2	Symbols, pictograms and icons should present a textual equivalent near to facilitate symbol understanding and contribute to enrich user's vocabulary	[9][21][31]
4.3	Provide audio instructions and subtitles for texts, but ensure that this is not the only alternate content representation	[21][28]
	G5 – Multimedia	
5.1	Provide information in multiple representation, such as text, video, audio and image for better content and vocabulary understand, also helping users focus on content	[5][12][16][23] [24][28][31]
5.2	Allow images magnification for better visualization and ensure they continue to be understandable when enlarged	[23]
5.3	Avoid the use of disturbing and explosive sounds, like sirens or fireworks	[20]
	G6 – Feedback	
6.1	Provide feedback confirm correct actions or alerting about potential mistakes and use audio, text and images to represent the message, avoiding icons with emotions or facial expressions	[8][9][15][17][20] [21][23][27]
	G7 – Affordance	
7.1	Similar elements and interaction must produce similar, consistent and predictable results	[12][23][24]
7.2	Use bigger icons, buttons and form controls that provide appropriate click/tap area and ensure that the elements look clickable	[9][12][21][23]
7.3	Provide immediate instructions and feedback over a interaction restriction with the system or a certain interface element	[8]
	G8 – Navigability	
8.1	Provide a simplified and consistent navigation between pages, use location and progress indicators and present global navigation buttons (Exit, Back to home page, help) on every page	[21][23][24][28]
8.2	Avoid automatic page redirects or expiration time for tasks. The user is who should control navigation and time to perform a task	[21][23]
	G9 – System status	
9.1	Present appropriate instructions to interact with interface elements, provide clear messages about errors and provide mechanisms to solve the errors	[9][23]
9.2	Allow critical actions to be reverted, cancelled, undone or confirmed	[21][23]
9.3	In interactive lessons and educational activities, it is recommended allow up to five attempts before showing the correct answer	[20]
	G10 – Interaction with touch screen	
10.1	Touch screen interactions should have the appropriate sensibility and prevent errors in selections and accidental touch in interface elements	[8][15][16][27]

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VI. CONCLUSIONS AND FUTURE WORK

In this work, we investigated and systematized Web accessibility recommendations and best practices to design Web interfaces suitable for people with ASD. While the works we selected usually presented the recommendations in a format of single sentence, we decided to develop an extended description for each guideline in order to help people to implement the guidelines properly and understand the rationale of the proposed approach. Some guidelines may present technical details, however, our intention is that the guidelines can be applied by multidisciplinary teams and educational professionals involved with use of digital resources for people with ASD.

Although the focus of the project is Web interfaces, we carefully propose generalized descriptions for most guidelines in order to not link them with a specific platform. The idea is to enable their application to different interaction contexts.

The full set of guidelines is available at an open-source repository on GitHub. Therefore, we hope this content may be complemented, distributed, derived and easily accessible to professionals and researches from different areas.

Finally, the proposed guidelines should provide advances in the state of the art of cognitive Web accessibility as: (1) support material to develop Websites and Web applications adapted to the needs of people with ASD, especially children; (2) a guidance documentation about best practices and potential challenges about interaction of people with ASD with interactive systems; (3) an open source repository of recommendations in constant update; (4) a complement to literature regarding the biases of Web accessibility for people with cognitive or neuronal disabilities, adding techniques related to ASD.

A. Next steps

In order to see if the proposed guidelines are effective in providing a better interaction for people with ASD, the next step of this work involves the development of an educational Web application using the guidelines to support the interaction design, followed by an experimental evaluation with children with ASD. The evaluation aims to observe how children react and interact with the application and collect a feedback to validate and improve the guidelines.

Alongside, we intend to: (1) interview parents and teacher of children with ASD to understand their perspective about using technology as an educational and therapeutic resource in order to contemplate their viewpoint into the guidelines; (2) perform technical evaluation of the guidelines with Web developers, accessibility experts and digital educational teachers involved with special education.

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