# Accessible Icons for Deaf: An UX Approach

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**Abstract.** Considering that deaf people have their own culture based upon their unique manners and characteristics this paper investigates the criteria for development of accessible icons, which are easily recognized by deaf. Thus, this paper starts with a brief description of the deaf culture and reviews related research. Finally, a systematic review of literature was carried out in order to describe the state of the art on the criteria to develop icons.

**Keywords:** Criteria · Icon design · Deft

## 1 Introduction

Technology is intended to enhance or facilitate human actions, as well as improve communication, leveraging the economy, politics, culture and dissemination and absorption of knowledge. In this respect, all technology is considered a social device, because it is about products, techniques and methods developed to benefit society [1, 2]. Castells [3] argued that: "… society shapes technology according to the needs, values and interests of persons who use these technologies […] technologies of information and communications are particularly sensitive to the effects of the social use of the technology itself. […]".

Cerezo [4] added that people must also have conditions to assess the impacts of information brought by the technologies, which tend to influence their surroundings. Castells [3] corroborates with Cerezo [4] by arguing that the knowledge generated by these technologies, is directly connected to the ability of organization of the society, capturing the benefits and excluding irrelevant information. Thus, all individuals of this society should have access to information, which leads to the problem of enhancing accessibility of technology.

Accessibility aims to make digital systems accessible to all people, with or without disabilities [5]. According to the W3C [6], Web accessibility means that people with disabilities "can perceive, understand, navigate, interact and contribute to the web". Pupo et al. [7] corroborate with ABRA [5] stating that the accessibility also benefits those who do not have disabilities, because a digital accessible system is designed to facilitate learning and use to improve the overall user experience.

Despite many Information and Communication Technologies (ICT) assist people with disabilities these technologies can also introduce limitation. That might happen because the information is designed focusing on satisfy the senses of vision and hearing. Therefore, those users with vision or hearing loss may have difficulty in perceiving information.

Perception results from what individuals capture with their senses. Senses can be divided into introspective and non-introspective senses. The former refers to the perception of the body, such as pain and movement of internal organs. The later is what we apprehend from the surroundings, captured by the senses of sight, sound, smell, taste and touch [8]. But, it's in the mind that occurs the perception from the information collected by the senses. According to Santaella [9] the perception results of referencing prior knowledge, which is necessary to an understanding of the facts presented [10]. In addition, the perception differs from one individual to another and from one culture to another, because each person has a singular experience of life. Therefore, each person has a unique perception of an artifact observed [8]. Then, designing for all is the topic of many researches. This paper discusses the user experience design approach that might ensure that most users experience the object as intended. This approach aims to design artifacts qualities that are recognized by most people, which means design for experience.

This means to create conditions so that people with a similar cultural perspective like deaf people who share a sociocultural background, will perceive and interpret a product in an intended way. Ribeiro [11] puts that there is little production of accessible material, and there is too much text in written form and with low production of images, icons, pictures, or videos to this public.

Considering that deaf people have their own culture based upon their unique manners and characteristics this paper investigate the criteria for development of accessible icons, which are easily recognized by deaf. Therefore, this papers starts with a brief description of the deaf culture and reviews related research. Finally, a systematic review of literature was carried out in order to describe the state of the art on the criteria to develop icons.

## 2 Deaf Culture

The history of deaf education presents a continuous evolution despite several significant impacts [12]. One of the most outstanding and impactful crises in the history of the deaf was in education. Deaf people "were subdued to non-deaf practices, having to abandon their culture, their identity as deaf and have undergone a 'ethnocentric hearing', having to imitate them for over 100 years" [12]. According to Quadros [12] this crises occurred after 1880 when the International Conference of Teachers of the Deaf in Milan discussed and analyzed the importance of the three rival methods of teaching: sign language, oral and mixed (sign language and oral). Most of the countries of Europe quickly adopted the oral method in schools for deaf, forbidding sign language. That was the beginning of the fight for deaf people's cultural linguistic right [12]. Perlin [13] affirms that this prejudice against the deaf culture still occurs today. Many countries allow sign language only if students fail with the oralization of spoken and written language.

Sá [14] argues that the deaf culture wants to be recognized as culture in a social context. But being minority it is dominated by the dominant culture (culture of listeners). For this reason, deaf culture is recreated almost every day. Therefore, Sá [14] understands that deaf people do not have a culture of their own. They interact among each other but tend to turn away from listeners by lack of understanding, which creates the illusion of a real culture of their own. Even though, they insist on demonstrating that they have their culture and that will not change because of the prejudice of the listeners.

Deaf culture is constructed by society as a subculture, as it aims to make the deaf accepted in society. This subculture is not formed by a minority, but by the minority of the minority [15]. And, according to Jeff McWhinney, Executive Director of the British Association of the Deaf in the year 2001, deaf community is a community proud of itself. They are proud of their culture, proud of its history and proud of its language.

Perlin [13] argues that deaf children should have, from an early age, contact with deaf adults, because at the same time that they learn sign language, they also create a psychosocial and cultural identity with the deaf community. Another important part of the deaf culture consists in writing-signal or Signwriting. This is the result of the search for a system of sign language representation. The development of this writing system was interrupted for several years due to foreclosure and the non-recognition of deaf culture. The Signwriting was created in the 90's by Valerie Sutton of the Deaf Action Committee (DAC), California, USA. It is based on a system that Sutton created to write down the dancers moves. The Signwriting is composed of symbols that represent the sign language both schematic and graphically. It works as an alphabetic writing system, in which the fundamental graphic units represent fundamental gestures units, their properties and relationships. The author states that the Signwriting can register any sign language in the world without passing through the translation of the spoken language. Each language of signs needs to adapt it to their own spelling system [16].

There are also institutions that are helping deaf culture with technology. The Board of Directors of the National Education Development Fund (FNDE) is one of them, and since September 8 2003, by resolution nº 26, is investing financial resources for the development of software to translate texts from Portuguese to LIBRAS.

## 3   Related Research

Deaf develop their own culture based primarily on the visual channel to acquire information because they have unique manners and characteristics. However, as stated by Moura [17], it is through language that people give meaning to the world in which they live. Thus, not only the understanding of each word influences the simple act of browsing at a web page for example, but also the shape of cognitive organization regarding the information in the long-term memory [18]. According to Fajardo [18] listeners and deaf adopt different forms of scanning information available on an interface. The former seek semantic hypertext standards, which means that they seek meaningful words. While the latter almost never use semantic patterns but they perform a random search of all visual information on the screen. The deaf has a more accurate visual language and they read images as listeners read a text o [9, 19]. Fajardo [18] had experimented using images as hyperlinks in order to verify how navigation for deaf

users would be like on the Web. They concluded that these users found more easily the information and took less time scanning the pages than on verbal interfaces. In addition, they concluded that if a page has many subpages (which might increase the semantic process) the performance on graphic interface was compromised. This happened because images with similar features have similar meanings, which makes it difficult to distinguish between the two, hindering navigation.

For this reason Reitsma, Galen [20] and Fajardo [18] point out that icons can be used to represent certain actions, because an icon is likely to be easier understood by a deaf. However, icons may be misunderstood when they portrait words with abstract meaning. In this case signs are usually a better choice. A sign is an image that does not have any semblance with the real object or information, such as transit signs.

In addition, iconic signs based on metaphor, which are icons that represent real objects, are usually pertinent for the deaf. These icons are meaningful to the user because they represent an object with quality. But this representation can be subjective, because the icons are designed to a specific culture or users. That is to say that icons are created based on real elements, which are part of the culture of the selected users, but also depend on the perception of the user and the representativeness of the icon design.

In this sense, the designers of visual elements (designers, painters, sculptors and others), in many cases, are unaware of the characteristics and culture of the deaf, not taking into consideration many aspects, which are only perceived by the deaf. For this reason the UX approach highlights the importance to involve the user in order to develop or evaluate a visual element in accessibility issues. Formiga [21] and Fekete [22] argue that a graphic symbol used in the Web, has advantage over texts, because the signs have free language and a single sign is enough to present information accessible to most people because it does not require the knowledge of the written language.

Next section discusses the findings of a systematic literature review on criteria to develop icons accessible to deaf.

## 4   Accessible Icons for Deaf

The systematic literature review was conducted based on Scopus (www.scopus.com), CAPES journals and Web of Science (webofknowledge.com). The papers analyzed bring relevant information about deaf accessibility and deafness, but none include the topic icon + deaf. The search was restricted to full papers, published in the last five years that had in the title one of the following keywords: information visualization, deaf, visual perception, icons, information display and visual sense. These keywords were chosen prioritizing those with a higher frequency on a preliminary search. These keywords were combined to perform the search, such as: "Information visualization and deaf"; "visual perception of the deaf"; "visual perception of deaf" and icons; "deaf information display" and icons e "visual sense" and deaf.

Table 1 shows the final combination of keywords and the number of documents found on Scopus, CAPES and Web of science.

After the selection of all 64 papers, their abstracts were analysed. The analysis chose 5 papers from Scopus, 5 papers from Capes and 3 from Web of science.

**Table 1.** Keywords and number of documents found on Scopus, CAPES and Web of Science data base.

| Keywords | Scopus | CAPES | Web of science |
|---|---|---|---|
| "Information visualization" + deaf | 2 | 0 | 3 |
| "visual perception" + deaf | 2 | 46 | 2 |
| "visual perception of deaf" + icons | 0 | 0 | 0 |
| "Deaf information display" + icons | 0 | 0 | 0 |
| "Visual sense" + deaf | 3 | 1 | 4 |
| Final selected papers | 5 | 3 | 3 |

This final selection was based on the pertinence of the content and excluded all repetitions. The analysis of the 11 papers follows.

The paper "Universal Use of Information Delivery and Display System using Ad hoc Network for Deaf People in Times of Disaster" [23] discuss visual messages to alert deaf people about risk activity, such as earthquake, flood and storm. The authors concluded that the system is useful to support both the elderly and hearing impaired in disaster. However, it would be important to make some changes in the size of the characters and its brightness.

The paper "Visual impairment in the hearing impaired students" [24], discusses occurrences of vision problems in children with hearing disabilities. The author concluded that there is no difference when compared with children without disabilities. These deficiencies, if detected belatedly, could aggravate the educational and social disability.

The other paper analyzed was "The study of the tactual and visual reception of fingerspelling" [25]. The author demonstrates the interaction and communication of deaf-blind student, which uses the reception of tactile fingerspelling (also knowledge as the finger alphabet or hand alphabet) to communicate and acquire knowledge. In this method, the hands of people who are deaf-blind are placed on the sender's side to monitor the hand shapes and movements associated with the letters of the hand alphabet.

The paper "The exchangeability of speech by cognitive metaphors" [26] deals with issues such as information visualization of deaf people using symbolic systems. Burmeister used metaphors as the background for the semantic of symbol systems, which is based on Piaget's work. The author states that metaphor represents a type of prelingual thinking.

In another paper Burmeister [27] intends to generalize given techniques in modeling semantic content. The paper "A semantic approach for user depending information visualization" Burmeister [27] discusses these techniques to the purpose of transferring them from industrial application scenarios and apply into projects for everyone's needs. The author found that deaf people assimilate information differently than hearing ones and he seeks for methods to map semantic roles with their situation dependent usage to proper metaphors. He explains that the sign language of deaf people may be a rich field to extract such metaphors, because gestures encode not only intentional aspects of information but are situation dependent visualizations of content. Thus, Burmeister proposes to rely on linguistic research concerning the decomposition of sign language in basic semantic units.

Another relevant work is a dissertation entitled the "Visuality of the deaf in the context of audio-visual education" [28]. In this work the author addressed themes focusing on audio-visual narratives for deaf people who are beginning on academia. One aspect that drew attention was the lack of importance the deaf community give to produce audio-visual products. Most productions are adapted for subtitles or windows with LIBRAS interpreter.

The paper "Perception of temporal patterns by deaf and hearing adults" [29] compared performance of under-graduate deaf students and listeners. Both had the same performance when it comes to simple activities, but when activities were more complex the deaf student had a disadvantage over the listener, because the temporal perception model of the deaf is different. This was already evident in the work written by Templin [30] entitled "A comparison of the spelling achievement of normal and defective hearing subjects". Templin [30] analyzed errors of spelling among three groups: 78 participants were deaf, 78 had hearing disabilities (listen something) and 78 children whose hearing was normal. Templin concluded that deaf students have more difficulty in writing and misspelled more than students with hearing impairments. In addition, those with hearing disabilities misspelled more than the non-disabled. This might happened because the perception of groups differs with respect to their culture (American Psychological Association).

The paper "Making Sense of an Unexpected Detrimental Effect of Sign Language Use in a Visual Task" [31] discusses a survey conducted in Italy to check the deaf visuospatial performance. They compared performance between those use sign language to those who do not use (nonsigners). They concluded that students who use sign language have a higher spatial information visualization compared to nonsigners students.

The paper entitled "Requirements of deaf user of information visualization an interdisciplinary approach" [32] deals with matters of avatar and viewing knowledge. Burmeister [32] highlights the importance of a good visualization of information in order to obtain a correct mental model. The author believes that the union of the gestural movements of the avatars to visually complement information considered abstract to the deaf user helps in the understanding of past information.

Another important work about accessible icons is a master dissertation [33] that discusses a learning environment prototype where all hypertexts are icons. The author states, "The icons were created by a deaf designer, who accepted to volunteer in this research. He used his creativity and then applied the technique of creativity Icon Sorting[1]". But no further research about icon design was carried out.

## 5  Conclusion

Considering that designers have few principles to guide icon design [34] designing accessible icons becomes a challenging task. In addition, Zender [34] reports depressingly results about icon understanding and highlights the need for researches about how visual symbols work or how they might be made to work better. Hence, this

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[1] Icon Sorting a technique for development of icons using correlated systems to everyday life.

paper is a first step toward understanding accessible icons that might contribute to create accessible interfaces. In addition, the knowledge involved in this task might benefit designing accessible visual-based elements. Therefore, this paper investigated criteria for development of accessible icons, which are easily recognized by deaf. A systematic review of literature was carried out in order to describe the state of the art on the criteria to develop icons.

The systematic literature review used six keywords to select 30 articles from three databases. The analysis of the abstracts resulted on eleven papers selected. None of these papers describes criteria, guidelines or recommendations for the development of icons, which are accessible to the deaf. Nonetheless, the papers analyzed bring relevant information about accessibility for deaf.

Zender argues that the interaction of the right number of symbols and a more apt combination of individual symbols for the referent, can improve the construction of an icon that communicates what was intended. Zender sees icon as a combination of symbols. In fact the icon "Paste" in Microsoft Word, for example, is a combination of paper sheet and a clipboard. Burmeister supports the quality part of this argument when he states that the importance of a good visualization of information in order to obtain a correct mental model.

In a previous work Zender [35] argued that context is the key concept for decoding the meaning of symbols. Once more, Burmeister findings may enrich this statement because he suggests that gestures encode not only intentional aspects of information but are situation dependent visualizations of content. Zender envisions three levels of context for a given icon: the Immediate, the Proximate and the Environment Context. Environment Context refers to the environment in which the images function, such as an airport. Proximate Context is an icon combination in a system relating to another to clarify meaning. For example, elevator icon next to escalator icon helps to clarify meaning of each. The Immediate Context refers to icons combined in the same space to clarify meaning. For example, man + bed = hotel. Therefore, the Proximate Context perception for deaf people might differ from hearing ones because deaf almost never use semantic patterns but they perform a random search of all visual information on the screen [18]. In addition, the Immediate Context might have a strong influence on the understanding of an icon by the deaf because images with similar features have similar meanings, which makes it difficult to distinguish between the two [18].

Kosslyn et al. [36] explored how the brain uses, stores, manipulates and processes mental visual representations to think and solve problems. They found that the brain holds simple representations of familiar objects in a specific region, which can be recalled into visual working memory to think and solve problems. This opens the possibility that people share a similar image for common objects.

Based on his studies Zender [34] proposes 3 rules of thumb for icon design:

1. Match symbols to definition: individual symbols should match to definitions of the referents. This means that the designers need to understand how deaf people define the referent
2. Add symbols to narrow focus: a symbol for each referent concept is necessary
3. Create symbol hierarchy: in some icons a sequence of concepts is an important feature of the referent definition

In addition to these rules Zender calls attention for the importance of study failure to improve success. Further studies will be carried out to investigate how influence of the context and these three rules on accessible icon design.

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