



# Accessibility in Chatbots: The State of the Art in Favor of Users with Visual Impairment

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**Abstract.** Society has been experiencing a great technological advance in the most diverse areas and, clearly, the development of accessibility for software and applications does not seem to follow this speed. In fact, systems sometimes do not embrace people with some kind of disability, and this is a problem that should be on the agenda of every designer and system designer when thinking about user experience. Chatbots are conversational interfaces on which users communicate with a robotic entity through text, either designed with artificial intelligence or not. However, how does a blind user interact with Chatbots? How should this interaction be carried on? What to expect when users' needs are challenged by physical barriers worse than what affects the common user? This article aims to present a systematic review of the existing literature on Chatbots, conversational interfaces and the inclusion of accessibility in these interfaces.

**Keywords:** Accessibility · Chatbots · Conversational interface  
Visual impairment · Smartphones · User centered design  
Rapid systematic review

## 1 Introduction

### 1.1 Accessibility and Smartphone Uses

In the widely diversified world where we live today, where each person is in a very specific context, we should not assume that everybody interacts with digital products in the same way. When we think about inclusion and diversity, accessibility should be the keyword. A product considered affordable is a product that can be used by all kinds of users. However, in most cases, there is little effort being made to design products that work well for everybody: from the common user to a range of disabled persons.

It is estimated that there are around 40 to 45 million blind people in the world today, according to the World Health Organization. By 2020, it is expected that those numbers will rise to 75 million of blind people and 225 million with low-vision.

“According to data from the 2010 Demographic Census, there were in Brazil 45,606,048 people with at least one of the investigated deficiencies, which makes up 23.9% of the Brazilian population. The visual impairment was the one that most affected the population, where 35,774,392 people reported having difficulty seeing, even with the use of glasses or contact lenses, which is equivalent to 18.8% of the

Brazilian population. Of this amount, 6,562,910 people had severe visual impairment, 506,337 of whom were blind (0.3% of the population), and 6,056,533 had great difficulty in seeing (3.2%)” [7].

The visually impaired are a significant part of the population, who also are users of all the available technologies, especially mobile devices and smartphones. Thinking of ways to make the use of these devices easier is essential in an inclusive world. Designers play a role of crucial importance in the development process of inclusive and accessible interfaces. To understand those users’ difficulties, to sympathize with them and, especially, to know how they interact with those devices are the first steps to succeed in the making of an accessible interface.

The increase in the quantity and variety of mobile devices available on the market comes with a huge range of applications designed to make life easier for people. These include users who are blind, deaf or otherwise disabled. Although there are no statistics on the adoption of mobile devices by people with disabilities, it is known that more than 100,000 people who are either blind or suffer from low-vision have used iPhone since the introduction of VoiceOver (iOS screen reader) and zoom options in 2008 (U. B. of Engraving and Printing, 2011). Despite this huge growth in the number of devices, applications and users, accessibility has not yet become a priority in the technology development.

“Being accessible means making your system, with all data and resources, available for anyone, notwithstanding the way they use it or the difficulties they may face.” [3]. Cunningham [3] also adds that, once accessibility becomes a goal within development, the project can be developed without data overload and the resulting system can become even better for the common users. To include accessibility in design development should be a goal for any designer who projects solutions for current problems.

## 1.2 Design Process

Design process is a human activity that goes back to primordial times and has evolved throughout the centuries. Whereas our ancestors built stone tools, we are in the present able to project intangible artifacts such as software and applications for mobile phones. The development of artifacts projected by human beings, from the stone tools to the complex interfaces that we project these days, has walked in tandem with the evolution of interaction design.

Preece et al. [16, p. 8] define interaction design as “to project interactive products to support the way people communicate and interact on a daily basis, either at home or at work”. Interaction design also allows “to create experiences to better and widen the way people work, interact and communicate to each other”. Winogard [19], in turn, describes interaction design as “projecting spaces for human communication and interaction.”

Design process, according to Löbach [11], is both a creative and troubleshooting process. There is a well-defined problem; information about the problem is gathered together, analyzed and its parts are creatively related to each other; alternatives for the solution are brought about and, at last, the alternative judged the most adequate is developed.

This cycle is iterative, as it is possible to reach back or forward to any stage during the project. To put the user at the center of the project is also to include them in the process. The user-centered design is “a philosophy based on their needs and interests, which gives special attention to the question of making products that are within their grasp and are easy to use” [14]. There are several theories regarding design principles. A sizable part of these studies deals with determining what designers should take into consideration when creating an interactive system.

Norman [14] defined design principles as “to make it sure that (1) the user is able to find out what to do and (2) that they have the conditions to know “what is happening”, and proceeds to describe them as such:

- **Visibility:** the more visible the functions are, the more able users will be to proceed;
- **Feedback:** related to the visibility concept, it refers to making information feed back to the user as to what action was made and what was achieved;
- **Restrictions:** it is about determining the ways to delimit the kind of interaction that may happen at any time;
- **Charting:** it is about the relation between controls and their effects;
- **Consistence:** it is about interfaces that have similar operations, with similar elements for the performance of similar tasks;
- **Affordance:** term applied to refer to an object’s attribute that allows for people to understand how to use it. It is about elements that are self-explanatory as to how the user is supposed to interact with them.

The aim of methods and techniques directed towards evaluation is to verify the experience of using a system, product or service and their interaction with people. Thus, according to Nielsen [13], “usability is a quality attribute that gauges how easy to use is a given interface” and “the measure of a user’s experience quality when interacting with a product or system.” That is to say that usability is associated with the employment of methods that help facilitate the use during the process of conception of a system, product or service.

As per Nielsen [13], usability is linked to the following factors:

- **Efficacy:** being able to accomplish what is expected from the product.
- **Efficiency:** the way by which the system eases users into completing their tasks by using as few steps as needed in order to reach their goal.
- **Security:** to protect the user from dangerous conditions and undesired situations.
- **Utility:** it has to do with how the system provides the right kind of functionality, in such a way that the users may be able to do what is needed or wanted.
- **Learning capability:** how easy is to learn to use the system.
- **Memorization capability:** being easy to remember how to use the system once one already has learnt it.

The use of design principles applied to accessibility influences directly the development of interfaces both easier to interact and more efficient to use, which ensues more benefits for the user.

### 1.3 Conversational Interfaces

A conversational interface is any one that works in the manner of a conversation between a human and a machine. These interfaces allow for the user to interact with intelligent devices (which may range from chatting with a robot to even objects that answer questions asked by users) through spoken language. Instead of communication by means of non-human terms with syntax controlled by specific command lines, it flows like a real conversation between two persons.

For a long time, conversational interfaces were only a sight into the future thought up by researchers in fields such as speech technology and artificial intelligence, but until not long ago those intellectual forays were rather based on science fiction's books and movies.

“Since the mid-1950s, artificial intelligence (AI) researchers have struggled to conquer the challenge to build computers capable of intelligent behavior. AI has gone through cycles of euphory and rejection, having had some initial accomplishments followed by some dramatic failures” [12, p. 16].

Many technological advances have contributed towards the increase in number of conversational interfaces, besides the users' increasing approval to make use of such interfaces. There are currently two such interfaces: Voice Assistants, by which the user speaks and the interface gives answers (like, for instance, Siri and Ok Google, which operate, respectively, on the iOS and Android platforms) and Chatbots, interfaces where the user interacts through texting.

Chatbots (“bot” standing for a shortened form of “robot”), also known as chatterbots, simulate real talk, wherein the user inputs some text and the Chatbot outputs an answer. Even though some Chatbots are developed with the aim of deceiving the user into thinking there is an actual chat between two persons taking place, this is not considered sound practice within a Chatbot project.

Most Chatbots interact through texting with users, though it has been common practice the implementation of buttons and menus that anticipate the users' decisions and make the conversation run faster. It is also possible to include avatars and empathetic answers so that the Chatbot appears to have something of a human personality.

According to Mc Teal et al. [12], Chatbots had their start with a system developed by Weizenbaum (1966) called ELIZA, which simulates convincingly the type of conversation a therapist would carry on. ELIZA inspired a whole generation of Chatbots developers since then.

“Chatbots have been increasingly used in such areas as education, data recovery, business and e-commerce, for instance, as automatized online assistants to complement or even replace call centers' human-based services” [12 p. 16].

Chatbots are conversational interfaces whose functioning is dictated by rules or generated through artificial intelligence. The difference between both kinds of interface is as follows:

Rule-based:

- Narrower output, responses are given only to specific commands;
- Follow well-defined navigation charts;
- If the user makes a mistake, the system won't be able to interpret the input;
- Their intelligence goes only so far as the code allows for.

Artificial Intelligence:

- Those systems have an “artificial mind”, that is, there is no need for the user to be the most precise in what they say because the bot learns and understands natural language, not only command lines;
- Chatbots learn and become more intelligent the longer they have conversations with users.

However, how can blind users interact with those interfaces? Do designers and developers have accessibility in mind in their projects? The importance of this kind of research resides in investigating how accessible those conversational interfaces are. Besides, this line of inquiry focused on the research's social impact into the future not only improves the systems' usability and consequent accessibility, but also makes them better for the general public.

## 2 Justification and Relevance

Previous bibliographic research shows that guidelines for accessible projects are still insufficiently explored and little known; interfaces projected specially for a public with specific needs are almost non-existent. For blind and low-vision users, the most used solutions are the TTS (Text to Speech), a system that converts written text into voice, and the screen readers, which describe through sound one interface's content and its interactions.

ISO 9241 defines usability and deals with requisites and recommendations for user-centered design principles and activities related to the cycle of interactive systems, such as: definition of use context, creation of requisites and solutions, tests and software evaluations.

The benefits of a system following those recommendations include increased productivity, a rise in the well-being of users, less stress, better accessibility and decreased margin for mistakes.

ISO 9241 describes six key principles that make it sure that a given project is user-centered:

- Project based on an explicit understanding about the users, tasks and use context;
- Users involved in all the development process;
- The project is conducted and improved by means of a user-centered evaluation;
- The project is iterative;
- The design tackles the whole of the user experience;
- The team is multidisciplinary, composed of people with different abilities and perspectives in relation to the project.

Usability and a good user experience are much more than the simplification of an interface. The ISO 9241 defines user experience as the perception and the responses of the user that come about from the use of a product, system or service, which include their beliefs, emotions, preferences, behavior, physical and psychological responses that happen during and after the use.

Preece et al. [16] list as desirable aspects in a user's experience systems that are: satisfying, pleasant, attractive, comfortable, exciting/thrilling, interesting, helpful, funny, provoking, surprising, rewarding, stimulating, challenging, that promote sociability, reward creativity, be emotionally fulfilling and cognitively challenging. On the other hand, the authoresses empathize that systems cannot be: boring, frustrating, irritating, infantile, unpleasant, patronizing, that make the user feel stupid or that be too glossy and artificial.

The main goal in developing products and systems with those desirable features lies in the experience the user will have while interacting with the system. Usability is the key factor in improving efficacy, efficiency and satisfaction during the use of a given interface. Accessible interfaces improve the user experience because they make the product easy to use, better their efficiency and efficacy and, lastly, keep the user satisfied with their use. In short, they widen the totality of users who benefit from their use experience.

“Good design is good citizenship” [5]. Only by being conscious of their duties, rights and their role in society, is the designer able to contribute with their work in an actual improvement in people's lives, most of all those who are handicapped somehow. If a fourth of the world population have some kind of disability, this number is too high to be simply put aside.

With such context within sight, it is paramount for designers to be active citizens, interested and engaged in society. That means they should be able to change the world around them. To have accessibility as a goal is not charity, it is an investment. The cost to include accessibility in a project after it has been finished is much bigger than it would be if it had been thought of since its inception. It is crucial for the designer to take part in this context as an agent of change, that they become able to perceive their role in society and their work's strength to make people's lives better.

### 3 Goals

The general goal of this research is to analyze the accessibility of Chatbots in the context of smartphones by means of criteria of accessibility and heuristics of usability with a focus on blind users, understanding what are the main aspects of use that make the best of experiences and what aspects can be re-studied and improved.

The specific goals are:

- To identify and analyze the studies and guidelines concerning accessibility in the context of mobile devices, with focus on the Android and iOS systems;
- To identify and analyze interactions and interfaces of Chatbots with focus on accessibility, by means of guidelines and heuristics found during a systematic review;

- To investigate what are the challenges that blind users meet when using Chatbots;
- To check aspects that can be utilized in a universal way in accessible interfaces;
- To suggest a guide of good practices involving guidelines and patterns for interactions and interfaces to be used during the development of Chatbots that have accessibility as a goal.

## 4 Rapid Systematic Review of Literature

The systematic review is a type of investigation focused on a well-defined theme, which aims to identify, select, evaluate and synthesize the relevant evidences available for approaching the question or a specific problem. It is “the application of scientific strategies that allow to delineate the frame of reference for selection of articles, to evaluate them from a critical viewpoint and summarize all relevant studies about a specific topic” [2, p. 126].

A systematic review is a kind of research that takes as its data source the existent literature on a given theme. Contrarily to the non-systematic process, systematic review is done in a meticulous and formal way, through application of explicit and systematized methods for search, critical evaluation and synthesis of the selected information. In order to do so, it is necessary to establish a method for the reviewing protocol and to follow it rigorously.

In line with Sackett et al. [17], a research based on evidences leads to an unbiased evaluation and a synthesis of empirical outcomes relevant for a given research question by means of a process of systematic literature, reviewing and integration of the evidence into professional practice. Besides, once access to summaries of all studies on a given theme is achieved, the systematic reviews widen the range of relevant outcomes, consequently preventing the research to become restricted to only a part of the literature.

“Rapid reviews are a form of evidence synthesis that may provide more timely information for decision making compared with standard systematic reviews.” (AHRQ, 2013). This method of review varies in terms of the time needed to complete it and is typically done in less than 5 weeks. When there is not enough time to undertake a systematic review or when it is not practical to synthesize evidence, a rapid review speeds up the process by omitting some steps that are mandatory in the systematic review.

### 4.1 Differences Between A Rapid Review and A Systematic Review

The basic difference between a rapid review and a systematic review is relative to the execution time and the rigor of the methodology. A rapid review takes 5 weeks maximum. The amount of time needed “depends on many factors such as but not limited to: resources available, the quantity and quality of the literature, and the expertise or experience of reviewers” [4]. Sources are limited due to search time constraints, though transparent and reproducible search methods are still used. As it is done in the systematic review, the rapid review is based on inclusion and exclusion criteria, critical and rigorous appraisal but limited time.

## 4.2 Methodology

Are Chatbots accessible to blind users? How do these users interact with those interfaces? In the search of the state of the art to answer these research questions, a charting of the literature was initially made.

This stage aimed at exploring as freely as possible the available literature, so as to identify possible relevant work within the studied theme.

During the research through relevant articles and books, it became a necessity to define what searching strategy to adopt. In the exploring research, books and articles possibly relevant for the research's progress were found, but nothing specifically related to Chatbot accessibility came up.

The searching strategy was shaped by choosing search engines, by formulating search terms and by intersecting keywords and the whole of the retrieved results. The used terms had keywords such as "accessibility", "Chatbot", "chatterbot" and "conversational interface", generating the following search strings:

- Accessibility Chatbot
- Accessibility Chatterbot
- Accessibility "Conversational Interface"

Besides the English keywords, the same corresponding Portuguese keywords were used: "acessibilidade" and "interface conversacional". The words "Chatbot" e "chatterbot" do not have equivalents in Portuguese:

- Acessibilidade Chatbot
- Acessibilidade Chatterbot
- Acessibilidade "Interface Conversacional"

The used strings were the same along all search engines due to the way each one indexes their results.

## 4.3 Search for Primary Studies on the Search Engines

The first step was to do the research through the search engines considered the most important and relevant to the technology, design and computer science fields. The choice of research bases was decided having the extent of the scope taken in consideration. Therefore, Periódico Capes and Scopus were chosen for the charting's exploratory stage. This was followed by research done on the ACM Digital Library and IEEE Xplore Digital Library, since both are libraries equipped with specific material in the fields of computer science and system development.

Searching was done by previously defined keywords and the formulating of search strings, which consists of combining two or more keywords. These strings also must be made in a manner specific to each engine, as sidestepping this factor can lead to very different results. The used filters also narrow considerably the number of found articles.

Besides keywords, some searches used the release date as a filtering criterion, taking in consideration articles and books ranging from 2007 to 2017.



#### 4.4 Selection and Evaluation of the Publications

After the research steps, came the article selection stage. With the intention of further refining the researches, some criteria were established to help delimit the most relevant results.

The studies regarded as most important for reviewing the state of the art were chosen and then their titles and summaries were read to eliminate the irrelevant ones. In the case where the summary was insufficiently informative but there was still the perception it could be useful, both introduction and conclusion were read. After this first selection of relevant studies, each and every one must be read to determine whether they comply with both the exclusion and inclusion criteria in order to decide which ones will actually comprise the review's primary bases.

For it to be included, a publication should conform to all established criteria. After a publication fits the inclusion criteria, it is then compared to the exclusion criteria, whereby it would be excluded from the former selection in the case of having a positive response to at least one of the latter criteria. Thus, a collection of publications able to pass into the analyze and extraction stage would be comprised of all those that complied with the inclusion criteria while being entirely devoid of any positive response to the exclusion ones.

Inclusion criteria were:

- Publication period being the one from 2007 to 2017;
- Used language being either English or Portuguese;
- Researches dealing with interaction with conversational interfaces;
- Researches about accessibility in conversational interfaces.

Exclusion criteria were:

- Publications that are just extended summaries;
- Publications that are posters;
- Publications unavailable for free.

To be able to evaluate studies through criteria of exclusion and inclusion, it is important to verify each publication's quality as well as the quality and relevance of the analyzed text.

#### 4.5 Extraction of Information from Publications

This stage intended to identify and choose the relevant information from the selected material to analyze it. For this purpose, one can try to answer the research questions with information already present in the studies or to hold information that carries importance for the research's continuation.

#### 4.6 Results

Through keywords and search strings, 95 articles were chosen. After analyzing titles and summaries, a number of publications were identified as capable of adherence and relevance to the research following inclusion and exclusion criteria. So, after extracting

information from every publication, a total of 25 publications were arrived at, which will be used in the research's development:

- 06 Articles related to the use of conversational interfaces in the health area;
- 05 Articles related to the use of conversational interfaces as an aiding tool in the educational area;
- 04 Articles related exclusively to accessibility or assistance to persons with disabilities.

The remaining articles refer to frameworks, patterns and innovations in the area of artificial intelligence applied to conversational interfaces. These may be useful for future research.

No publications about Chatbot accessibility were found. The theme is so much in its beginning that academic studies on it are still non-existent.

Based on the strings, series of searches were made complying with the criteria already mentioned in the methodology part. Some bases have different search operations, which demands applying some filters so that satisfying results are reached (Table 1).

**Table 1.** Results on search engines such as obtained by applying inclusion and exclusion criteria.

Base	Keywords/Strings	Filters	Partial result	Post-selection results
Periódicos Capes	Accessibility AND Chatbot	2007–2017	33	5
Periódicos Capes	Accessibility AND Chatterbot	2007–2017	19	2
Periódicos Capes	Accessibility AND “Conversational Interface”	2007–2017	28	6
Periódicos Capes	Acessibilidade AND Chatbot	2007–2017	0	0
Periódicos Capes	Acessibilidade AND Chatterbot	2007–2017	0	0
Periódicos Capes	Acessibilidade AND Chatterbot	2007–2017	0	0
Periódicos Capes	Acessibilidade AND “Interface Conversacional”	2007–2017	0	0
Scopus	Accessibility AND Chatbot	2007–2017 Title, Keywords, Abstract	3	2
Scopus	Accessibility AND Chatterbot	–	0	0
Scopus	Accessibility AND “Conversational Interface”	2007–2017 Title, Keywords, Abstract	4	2
Scopus	Acessibilidade AND Chatbot	2007–2017	0	0

(continued)

**Table 1.** (continued)

Base	Keywords/Strings	Filters	Partial result	Post-selection results
Scopus	Accessibilidade AND Chatterbot	2007–2017	0	0
Scopus	Accessibilidade AND “Interface Conversacional”	2007–2017	0	0
ACM	Accessibility Chatbot	2007–2017 Full Text	143	–
ACM	Accessibility Chatbot	2007–2017 Abstract	5	5
ACM	Accessibility Chatterbot	2007–2017 Full Text	41	–
ACM	Accessibility Chatterbot	2007–2017 Abstract	1	1
ACM	Accessibility “Conversational Interface”	2007–2017 Full Text	127	–
ACM	Accessibility “Conversational Interface”	2007–2017 Abstract	2	2
IEEE	Accessibility Chatbot		0	0
IEEE	Accessibility Chatterbot		0	0
IEEE	Accessibility “Conversational Interface”		0	0
<b>TOTAL</b>			95	25

## 5 Conclusions

Smartphones are increasingly present in people’s daily life, which include those with disabilities, who comprise about one fourth of the world population. Of those, about 45 million are blind, which makes them an important public to focus on during development of products and services. To make applications and smartphones accessible has become a prerequisite for most companies these days, since the cost to include accessibility in the development of applications as soon as the project’s inception is quite low. It is also already known that including accessibility in digital products improves usability even for those not disabled.

In this context, companies are progressively including virtual assistants to help their clients solve problems. They are called Chatbots, conversational interfaces with which users interact by texting. The question, though, is whether those interfaces are being projected with accessibility in sight. How do users interact with them? What are the biggest difficulties? These are questions to be answered as the research progresses.

In the review of the state of the art, no specific article or book were found on Chatbot accessibility. As it is an extremely new and almost uncharted theme, there is no academic studies on it, which reinforces the necessity of starting a general research on accessibility in conversational interfaces. What was found of literature on Chatbots and conversational interfaces was included in the review by the force of its relevance to future studies.

In order to fill the void in researches on accessibility and as a means to foster future research routes, there will be deeper assessments of the maturity level in the users' interaction with those interfaces and how much accessible they are, through the utilization of accessibility analyzing and tests with blind users.

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