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Accessibility Evaluation of E-Government Mobile Applications in Brazil

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Abstract

The provision of e-government services using mobile applications (known as m-government) has had a significant growth in recent years. However, it is very important that such applications be accessible to people with disabilities in order to ensure inclusive access. Using appropriate accessibility auditing methods is very important to help identify accessibility problems in interactive systems during their development. However, there has been little support in terms of formal standard accessibility guidelines to help develop and evaluate mobile applications. In this paper, we present a case study with the evaluation of four e-government mobile applications in Brazil using the Web Content Accessibility Guidelines (WCAG) 2.0. The paper discusses the methodological adaptations of WCAG 2.0 for the context of mobile applications and its current limitations. The results of the evaluations performed in the four applications in the case study showed that many elementary accessibility problems widely known by HCI researchers were encountered extensively in the applications evaluated. This highlights the importance of furthering research in accessibility design and evaluation of mobile applications, in order to provide more inclusive access to essential applications used by all citizens, such as e-government services.

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Keywords: Mobile applications, Accessibility, e-government, m-government

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1. Introduction

The use of Information and Communication Technology (ICT) by government agencies has brought important improvements in the offer of public services available by different levels of governments to their citizens. E-government corresponds to the use of ICTs, particularly the Internet, as a tool to promote better governance to answer to citizens' needs[18]. In this sense, the adoption of citizen-centred e-government strategies[3] also impacts on other societal issues, such as: improvement in information access, reduction of corruption, improvements in government efficiency, as well as improvements in citizen participation in societal matters.

The trend to use mobile applications in e-government services has been called "m-government", and is directly linked to the popularization of mobile devices. The use of such services open numerous opportunities for governments to make more services available to their citizens. By means of using m-government services, more citizens can be reached by these services, collaborating to a more democratic access to government services.

However, it is very important that such services be developed under an inclusive perspective in order to guarantee access to all citizens. According to the World Report on Disability from the World Health Organization and the World Bank[25], more than 1 billion people have some kind of disability worldwide, with around 200 million of them having a considerable functional difficulty.

Although making content and services more available to citizens when the required infrastructure is properly implemented[13], e-government and m-government services are not always accessible to disabled people. It is very important that such services be made accessible to guarantee inclusive access for people to benefit from the advantages of such technologies with equal access[9, 10], creating a perception of value[26], by means of characteristics of usability, ease-of-use, security, as well as acceptance by the citizens who use such services[6].

Evaluating the accessibility of mobile applications in e-government and m-government is crucial to help developers identify accessibility problems that need to be addressed. In order to perform evaluations of accessibility, well-established methods of evaluations in the field of Human-Computer Interaction can be employed, such as tests with target users or accessibility audits performed by experts using heuristics or guidelines. Although accessibility audits with guidelines only cover a portion of problems that disabled users would encounter[23], such methods are still valuable to help find common problems that can be avoided.

While guidelines for Web accessibility, such as the Web Content Accessibility Guidelines (WCAG 2.0)[5], have provided well-established means to audit the accessibility of websites, no such official and well-established set of guidelines has been defined for auditing the accessibility of mobile applications[19]. Although having been originally developed for the Web context, the Web Accessibility Initiative[27] states that WCAG 2.0 was developed with the aim to accommodate new developments of technologies in the future.

In this paper, we present a case study involving the adaptation of the WCAG 2.0 to evaluate four e-government mobile applications in Brazil. The paper discusses the methodological approaches and adaptations made in the guidelines in WCAG 2.0 to accommodate issues related to mobile applications, and presents the main results and characterization of the types of problems encountered in the four applications evaluated.

This paper is organized as follows. Section 2 presents a literature review on mobile accessibility. Section 3 details the method used for the evaluation of the applications. Section 4 presents results and discussion. Finally, Section 5 discusses conclusions and future work.

2. Mobile Accessibility

The use of computational systems available with several types of interfaces, such as the Web or mobile devices, has become one of the most widely used means to provide access to news, services, and all kinds of information used by people in their daily lives. It is of utmost importance that all people can use such services, include people with disabilities.

People with disabilities can be even more benefited from being able to use such services, as online services can provide them with more opportunities to lead independent lives than they would have otherwise[11]. In order for online services to be accessible to everyone, they should include not only "mainstream users", but people with disabilities, such as people with hearing, visual, physical, cognitive disabilities or specific learning disabilities, such as dyslexia.

The ability to use computational systems is related to the attribute of *usability* of systems. The concept of accessibility, as defined by the ISO 9241-Part 171[15] brings it closer to that of usability. According to ISO 9241 – Part 11[14], the concept of usability is defined as "The extent to which a product [service or environment] can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use". In part 171 of ISO 9241[15], software accessibility is defined as: "the usability of a product, service, environment or facility by people with the widest range of capabilities", including people with disabilities.

Many studies have investigated the accessibility of Websites[23], mostly by performing audits using technical guidelines such as the Web Content Accessibility Guidelines (WCAG)[5], which help encounter elementary problems that can affect disabled users. It is important, however, to emphasize that effective accessibility evaluations need to include evaluations involving people with disabilities to help uncover real problems only real users can reveal. Nevertheless, accessibility audits performed by experts throughout the development process of interactive systems can have an important role in avoiding elementary accessibility problems early in the design process.

If compared with studies involving audits of the accessibility of Websites, there are comparatively fewer studies and well-established techniques and guidelines to help audit the accessibility of mobile applications, despite the significant growth such systems have had in recent years[19]. Vendors of mobile phones have developed specific guidelines that help include accessibility features in mobile applications for platforms such as the Apple iOS[2] and Android[1]. However, such guidelines are limited to more specific technical issues related to accessibility, but they do not involve wider interaction issues. The BBC (British Broadcasting Corporation) has defined a set of guidelines to be used in the design of their mobile applications[4], making it available under the Open Government License.

Recent studies have begun to further investigate accessibility issues in mobile applications, although being still in smaller number than the studies that evaluated the accessibility of Websites. An early study in 2006 conducted by Plos and Buisine[22] proposed design guidelines for the accessibility of mobile devices, mainly based on key-based smartphones available at the time, not involving gesture-based interactions. In a study conducted by Kane *et al.* [16], design guidelines for improving the accessibility of touch screen interfaces was proposed, focusing on the appropriate use of gestures to help people with visual disabilities. The study compared how visually disabled and sighted people used such gestures. Piccolo *et al.* [21] also developed a set of general accessibility guidelines for mobile devices based on experiences in the development of mobile applications, focused on blind and partially sighted users. The guidelines included recommendations to provide autonomy, real-world metaphors and privacy in the content shown in the screen.

Leporini *et al.*[17] conducted a study involving an online questionnaire with 55 blind users about the accessibility and usability of mobile devices with iOS and the VoiceOver screen reader. The study pointed out that the use of VoiceOver presents a significant improvement in the accessibility for those users, but that they still encounter several difficulties in issues such as data entry of long texts and performing more complex operations.

In another study, Chiti and Leporini[8] performed a preliminary study involving four users with visual disabilities using a prototype of an Android system to collect their initial impressions. The study revealed several problems related to the accessibility of the system and indicated the need of more studies to improve the accessibility of Android applications used by means of the TalkBack screen reader.

Sánchez *et al.*[24] proposed an API to allow developers to adapt the content of mobile applications to low-vision users, with specifically-designed features.

Although not specifically related to the accessibility of applications, Harrison *et al.*[12] also showed in their review of methods to evaluate the usability of mobile applications that other measures of effectiveness, efficiency and satisfaction should be included in such methods. In their paper, they proposed the framework PACMAD – People at the Centre of Mobile Application Development.

Clegg-Vinell *et al.*[7] performed a study with the analysis of accessibility problems encountered by people with different disabilities using Websites in mobile devices, encountered in tests performed by the consultancy firm AbilityNet, in the UK. The data were compared with Web accessibility guidelines and guidelines for developing mobile Websites from the World Wide Web Consortium (W3C). The results pointed out that several types of problems encountered by users were not covered by the guidelines. Even in cases when problems were covered, the severity of problems as indicated by the impact on users did not correspond to the priority level of the correspondent guidelines.

Park *et al.*[19] conducted a study with four blind participants in interviews about their usage of mobile applications and observation of use. Based on this study, the authors proposed a set of 10 heuristics to be used in heuristic walkthrough methods to audit the accessibility of mobile applications. The authors argue in their paper about the need to define standard guidelines and recommendations for the accessibility of mobile applications.

3. Evaluation Method

3.1. Sample of Evaluated Apps

The applications evaluated in this paper were sampled from the Guide of E-government applications of the Brazilian Government†. The guide provides a list of several applications in the categories involving citizenship and justice, science and technology, culture, defense and security, economy and employment, education, government, infrastructure, environment, health and tourism.

In order to perform a first round of evaluations and to establish the method to audit such applications, four applications were sampled for evaluation. The applications were selected considering different categories and applications available for both Android™ and iOS™ platforms. The applications selected included:

- Banking – **Caixa Economica Federal** (Fig. 1) – Main bank from the Federal Government, in charge of managing large social benefits programmes;
- Economy – **Receita Federal Pessoa Física** (Fig. 2) – App with functionalities related to income tax and national registration with the ministry of finance;
- Security – **SINESP Cidadão** (Fig. 3) – National Information System about public security;
- Tourism – **Infraero voos online** (Fig. 4) – Central Information System about flights in airports maintained by the federal government.

Fig. 1. Home screen (left) and account functionalities (right) of the Caixa Economica Federal app for the iOS platform. Source: Caixa Economica Federal app.

† Available at www.aplicativos.gov.br

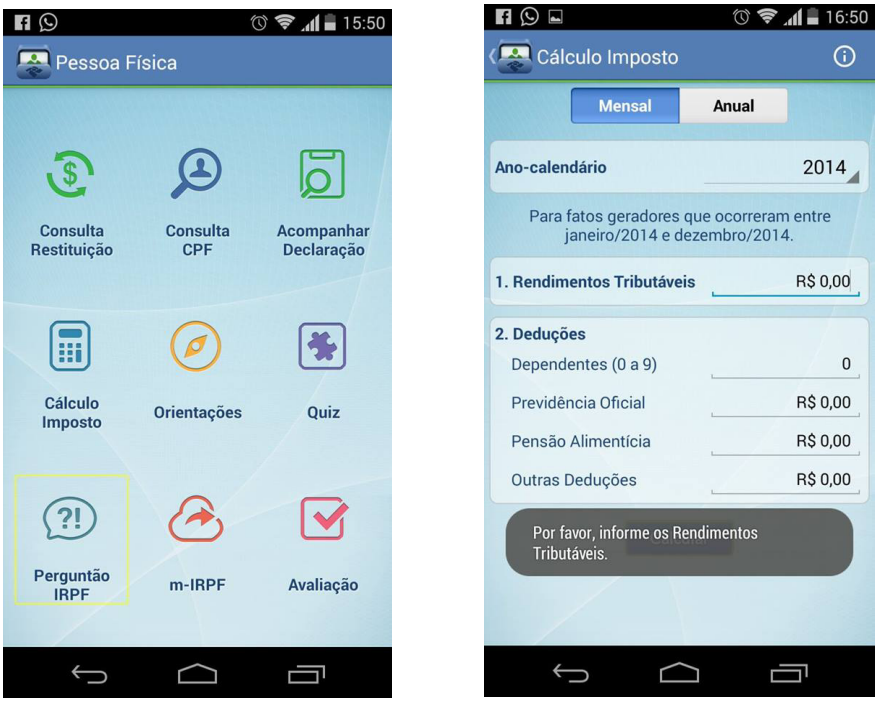

Fig. 2. Home screen (left) and tax calculation screen of the Receita Federal's Pessoa Física app for the Android platform. Source: Receita Federal's Pessoa Física app.

Fig. 3. Home screen (left) and information about stolen vehicles (right) of the SINESP Cidadão's app for the iOS platform. Source: SINESP Cidadão's app.

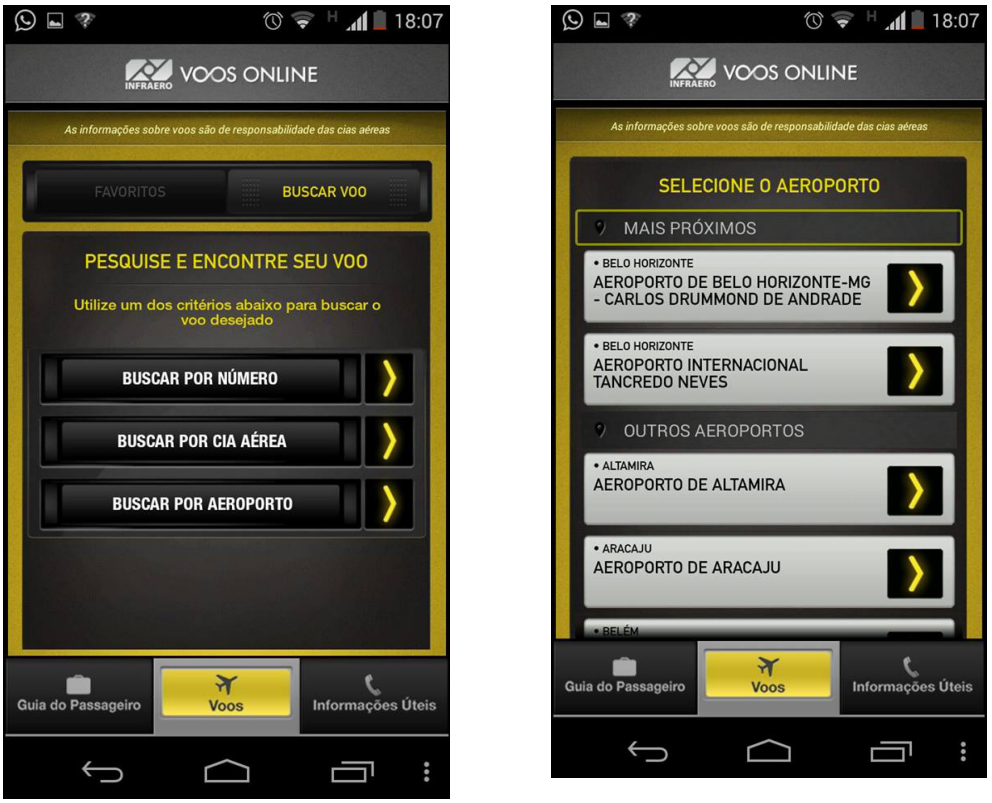

Fig. 4. Home screen (left) and airport selection in flight search (right) of the Infraero's app for the Android platform. Source: Infraero's app.

3.2. Accessibility Audit Procedure

For the accessibility audits, we considered different approaches that could be taken to evaluate the accessibility of the sampled applications. The chosen method was a review of guidelines, and for this reason other options that considered broader heuristics such as those proposed by Park *et al.*[19] were not considered.

The main options analysed were existing well-established sets of accessibility guidelines, such as the ISO 9241-171[15] for software accessibility and WCAG 2.0[5] for Web accessibility. By analyzing those options, we concluded that neither offered specific recommendations for mobile applications.

Considering the indications from the Web Accessibility Initiative[27] about the need to make WCAG 2.0 less dependent on technology, and on the widespread use of the guidelines to evaluate Web accessibility, we decided to use those guidelines in this case study, after making adaptations for the mobile applications context.

We analysed the 61 success criteria available at WCAG 2.0, which are divided into levels A, AA and AAA. Then, we verified which success criteria had to be adapted to the context of mobile applications accessibility. The main issues were concerned with references to "keyboard accessibility", such as in success criteria 2.1.1 - "Keyboard: All functionality of the content is operable through a keyboard interface without requiring specific timings for individual keystrokes, except where the underlying function requires input that depends on the path of the user's movement and not just the endpoints.", 2.1.3 (similar to 2.1.1, but with no exceptions) and 2.1.2 – "No Keyboard trap". Many of the adaptions were in line with the recent working draft started by the Web Accessibility Initiative[20] to map WCAG 2.0 and other WAI recommendations to mobile accessibility.

The keyboard-related success criteria were adapted in order to reflect the interaction mode used in most smartphones and tablets, by allowing users to be free to use the features in the interface by using gestures available

in their assistive technologies, such as swipe right and swipe left as a simulation of the "TAB" key used by screen reader users.

Other adaptations included success criterion 4.1.1 – "Parsing: In content implemented using markup languages, elements have complete start and end tags, elements are nested according to their specifications, elements do not contain duplicate attributes, and any IDs are unique, except where the specifications allow these features.". Many of the techniques provided for this technique in WCAG 2.0 assume that interfaces are implemented using Web technologies such as HTML (HyperText Markup Language). When auditing mobile applications developed for iOS and Android, evaluators have to consider the use of such features in the context of the technologies used and verify programming flaws in the interface that can cause confusion to assistive technology users.

After adapting the success criteria to the context of mobile applications, three evaluators performed audits using the 61 criteria in WCAG 2.0 on three screens of each of the four sampled applications, both in the iOS and Android platforms. For each success criterion, evaluators made notes about the main problems encountered and recorded the number of instances of violations (e.g. number of times they encountered images without alternative text for success criterion 1.1.1).

The evaluations were performed manually using a Samsung S4 running Android 4.4 with the TalkBack screen reader and an iPhone 5 with iOS and the VoiceOver screen reader.

4. Results and Discussion

The evaluation of the mobile applications sampled in this study helped uncover many important problems to know the status of the accessibility of e-government applications used in Brazil. This evaluation helped perform an initial analysis on the problems present in such applications and to verify the use of an adapted version of the Web Content Accessibility Guidelines 2.0[5] to evaluate mobile applications.

After conducting the audits on 3 screens of each of the sampled applications, the first analysis proceeded to verify the number of instances of violations of WCAG 2.0 success criteria and the number of different success criteria violated in each screen. In order to provide indicators for each application, we calculated the average number of violations and number of different success criteria violated at each conformance level (A, AA and AAA) in WCAG 2.0 in the 3 screens of each application. Table 1 shows the average number of violations and number of different success criteria violated for the iOS versions of the applications, whilst Table 2 shows the same information for the Android versions of the applications.

It is possible to observe in both tables that none of the applications would be considered conformant to WCAG 2.0 at any level. Considering that since the Decree Law 5.296/2004 Brazil has stated that government services should be accessible to people with disabilities, the large number of problems encountered in the mobile applications developed by governmental agencies is not a good indicator that such consideration is being made for those apps. One possible reason for that is the lack of explicit mention to the need to consider accessibility in mobile applications in the official documents and policies from the government. Most documents only mention explicitly the need for accessible Websites and portals. However, such documents have not yet followed the technological advances and the uptake of mobile technologies in e-government services.

The data of the audits shown in Table 1 and Table 2 provide indications that, despite having similar functionalities, the Android versions of the apps tended to violate more WCAG 2.0 success criteria than their iOS counterparts (with the exception of the Receita Federal's app).

Android versions of the evaluated applications also violated a larger number of different success criteria than their iOS counterparts (with the exception of the Receita Federal's app). This also means that the Android versions presented more different types of problems that can be encountered by users with disabilities.

More research is needed to verify whether such trend holds for other applications developed as e-government services, and whether this could be caused by the availability of more accessibility features in Apple's iOS or by the development tools used to develop either version. The process for including applications in iTunes can also be a possible explanation, given that developers of iOS applications have to follow more strict interface guidelines and standards than those required to include Android applications in Google's Play store.

In terms of the functionalities of assistive technologies – namely the Android's TalkBack and Apple's VoiceOver, it is important to highlight that VoiceOver presents a much wider range of functionalities than

TalkBack. When this study was carried out, VoiceOver presented a series of features to allow users to navigate by jumping through paragraphs, figures, headings, links, buttonts and others, while TalkBack had a much more limited set of possibilities for navigation.

Table 1. Summary of the accessibility audit of e-government applications in the iOS platform

Application	Average Instances of violations				Average number of different success criteria violated				Conformance level
	Level A	Level AA	Level AAA	Total	Level A	Level AA	Level AAA	Total	
Caixa Economica Federal	7,3	4,0	8,3	19,7	4,3	2,0	5,7	12,0	None
Receita Federal Pessoa Física	12,3	7,0	10,7	30,0	3,7	1,7	3,0	8,3	None
SINESP Cidadão	10,7	6,3	5,3	22,3	4,0	2,3	4,0	10,3	None
Infraero Voos Online	18,7	6,3	16,3	41,3	4,7	4,7	6,0	15,3	None

Table 2. Summary of the accessibility audit of e-government applications in the Android platform

Application	Average Instances of violations				Average number of different success criteria violated				Conformance level
	Level A	Level AA	Level AAA	Total	Level A	Level AA	Level AAA	Total	
Caixa Economica Federal	15,7	7,7	11,0	34,3	6,3	2,7	6,7	15,7	None
Receita Federal Pessoa Física	3,7	6,3	8,7	18,7	1,7	2,0	3,0	6,7	None
SINESP Cidadão	14,0	7,7	6,7	28,3	6,0	2,7	4,3	13,0	None
Infraero Voos Online	24,3	8,3	18,0	50,7	6,7	4,0	7,0	24,3	None

In the following paragraphs, we present the main types of problems encountered in the audits.

Lack of accessible labels and descriptions

When analyzing the main types of problems encountered, it was possible to observe that mobile e-government applications need to observe basic features that have long been targeted in Web accessibility. Almost all screens violated success criterion 1.1.1 – "All non-text content that is presented to the user has a text alternative that serves the equivalent purpose". There was a substantial number of images (many that served as buttons) that were not labeled or had labels such as "button 1" when read out by screen readers.

Meaningful sequence

Success criterion 1.3.2 – "Meaningful Sequence: When the sequence in which content is presented affects its meaning, a correct reading sequence can be programmatically determined" was also violated in several applications. In many cases, the reading sequence of content also made sense visually. Users who use gestures to browser through the options would have severe difficulties to understand the content in the sequence it was presented by screen readers.

Colour contrast

Success criteria 1.4.3 and 1.4.6, regarding the minimum levels of colour contrast were also violated in several applications. Many colour combinations with low contrast were used, making it difficult for users with low vision and other difficulties to read. This is particularly concerning as many people can use such applications in mobile devices in different places with different lighting and seeing conditions.

Navigation

Many applications presented problems with the navigation, mainly related to not presenting more than one way of reaching content in certain screens (related to success criterion 2.4.5 – "Multiple ways").

Help

Another important finding of the study was the lack of help features in most applications for data entry in mobile applications (related to success criterion 3.3.5 – "Help: Context-sensitive help is available"). It would be worth investigating how such feature could be better implemented in mobile applications, considering the limitations in screen size and how it could be integrated with assistive technologies.

Links and buttons

Success criteria 2.4.4 and 2.4.9 (link purpose and destination) also had a number of violations, as many links and buttons did not clearly indicate to users (on their own) what feature they would lead to. In many such cases, problems were related to poorly labeled images used as representations of links and buttons, which was also reflected by many violations of success criteria 1.4.5 and 1.4.9 (avoiding using images of text). This seemed to be a trend in the applications, with many interactive elements laid out as images taken from graphical editors instead of using standard interface components.

5. Conclusions and Future Work

This study presented a case study of evaluation of e-government mobile applications in Brazil in the iOS and Android platforms. Evaluations were performed using an adapted version of the Web Content Accessibility Guidelines[5], constructed to be less dependent on technology.

The use of this adapted version showed that many important accessibility issues can be uncovered by using such guidelines after the adaptions, considering specific issues such as the use of gestures instead of keyboard interaction. However, more research is needed to define more specific sets of guidelines for mobile accessibility and procedures to help practitioners perform effective audits to improve the accessibility of mobile applications, especially in the case of e-government services. Such procedures should be incorporated in user-centred design processes that need to include intensive involvement of users with disabilities in the design and evaluation of mobile applications.

The results of the evaluations performed in the four applications in the case study showed that many elementary accessibility problems widely known by HCI researchers are found extensively in the applications evaluated. This highlights the importance of furthering research in accessibility design and evaluation of mobile applications, in order to provide more inclusive access to essential applications used by all citizens, such as e-government services.

Whilst governments in several countries have defined specific guidelines and policies for the accessibility of e-government services available on the Web, little has been done to provide such guidance and policies for the provision of "m-government". It is very important that governmental agencies include mobile accessibility in their agendas, as mobile applications have grown in importance and use as a means to provide services and opportunities for participation for their citizens.

As future work, we intend to perform evaluations on a wider range of e-government applications to perform quantitative analysis of the status of the accessibility of such services in Brazil. We also aim to conduct studies with people with disabilities to analyse the main problems they encounter when using mobile applications, in order to help define recommendations for mobile accessibility based on empirical evidence.

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