Are Mobile Apps Usable and Accessible for Senior Citizens in Smart Cities?

Elenia Carrasco Almao(✉) and Fatemeh Golpayegani

School of Computer Science and Statistics, Trinity College Dublin, Dublin, Ireland
{carrasce,fgolpaye}@tcd.ie

Abstract. The population in cities is expected to exponentially grow by 2050, and so is the world population aged 65 and over. This has increased the efforts to improve citizens' quality of life in urban areas by offering smarter and more efficient IT-based services in different domains such as health-care and transportation. Smart phones are key devices that provide a way for people to interact with the smart city services through their mobile applications (Apps). As the population is ageing and many services are now offered through mobile Apps, it is necessary to design accessible mobile interfaces that consider senior citizens' needs. These needs are related to cognitive, perceptual, and psycho-motor changes that occur while ageing, which affect the way older people interact with a smart phone. Although a comprehensive set of design guidelines are suggested, there is no evaluation on how and to what extent they are considered during the mobile App design process. This paper evaluates the implementation of these guidelines in several industry-built Apps, which are either targeted at older people or critical city services Apps that may benefit older people, but are targeted at a broader audience.

Keywords: Ageing population · Accessible App design · Smart cities

1 Introduction

Cities and the services offered in them are going towards being smarter in different domains such as mobility, health-care, and economy. Figures show that in 2007 half of the world population lived in cities and urban areas and this is expected to grow up to 70% by 2050 [1–3]. This is why major efforts have been put towards improving the citizen's life quality in urban areas, by offering smarter and more efficient IT-based services. Additionally, the growth rate of population aged 65 and over is likely to double by 2050 [4], and as cities expand, more older people will live in urban areas. This is why, it is essentially important for smart cities to offer services that are age-friendly to include more age demographic of cities.

Smart phones are key components that provide a way for people to interact with the smart city services through their mobile Apps. Smart phones have become indispensable devices in people's everyday life, facilitating many activities such as health-care, banking, transportation, or accessing information. The

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use of such technologies is rapidly increasing around the world. As reported in [5], in 2017 approximately 2.4 billion people were smart phone users. By 2020 it is forecast that there will be 2.9 million people using smart phones, a 20% growth. This figures include the increased number of older people who are using a smart phone [6,7], not only for communication purposes, but also for its help as assistive technology through mobile Apps. This assistive technology allows an ageing person to feel more secure and carry out a more autonomous life. However, many older adults still find interacting with a smart phone difficult. In [8,9], it is suggested that older people expect smart phones to be reliable means of communication, which can improve their safety and quality of life.

As the global population is rapidly ageing, and many services are now offered online through mobile Apps, it is necessary to design accessible mobile user interfaces (UI) that consider senior citizens' needs. These needs are related to cognitive, perceptual, and psycho-motor changes that occur in the ageing process, which affect the way older people interact with a mobile device. As a result, they often need support in carrying out tasks and activities [8]. For example, due to visual degrading, to be able to perceive a mobile interface they require larger UI elements than the average user. Also, due to cognitive loss, which causes a decline in memory and the speed at which older people process information, they prefer simplified menus. These are some of the reasons why accessibility should be part of the UI design process, putting a special emphasis on making an interface usable for older people. The issue is that there are still not as many accessible websites and Apps for them as there should be. Which is even more concerning in the context of smart phones, as they are rapidly growing and constantly changing, making it harder to properly address accessibility.

Smart phones can open new opportunities for people with different levels of impairment through the assistive technology in the phone's Apps. However, if interfaces are still not accessible for people with impairments, then they cannot take advantage of the technology in smart cities. By addressing accessibility during the mobile App design process, it is possible to improve older population's life quality in these cities. Several design standards and guidelines are suggested by both industry and research communities, to decrease the impact of older adults limited motor, cognitive, and visual skills when interacting with smart phones [8,10–12]. Guidelines solve the issue of recruiting, retaining, and working with older people during heuristic evaluation [12]. The inclusion of these guidelines also help to facilitate the interaction between older people and smart phones.

The work of Petrovčič et al. is a review of different published research-based guidelines and checklists for designing age-friendly mobile interfaces [12]. This work suggests a set of 38 age-friendly guidelines, that include aspects such as having big buttons with clear feedback to address visibility issue among older people. In addition to the research-based guidelines, the World Wide Web Consortium (W3C) is also putting a major effort into developing guidelines for designing usable and accessible mobile interfaces [10]. The W3C, based on [13], divides the guidelines into four principles related to barriers experienced by people with impairments.

Although a comprehensive set of design guidelines have been suggested, there is no evaluation on how and to what extent they are implemented during the mobile App design process. The aim of this paper is to evaluate the usability and accessibility of two groups of mobile Apps based on research-based and standards guidelines. These groups include Apps that are designed for older people, and Apps that are designed for critical city services that may benefit older people, but are targeted at a broader audience. The Apps are selected based on their popularity in the main domains of interest: health, mobility, socialising, entertainment, emergency, assistance, customization, finance and location.

The following section is a literature review of the available guidelines for designing age-friendly mobile interfaces. Sect. 3 describes the evaluation design. Section 4 presents the results, and finally, Sect. 5 provides the final discussion and conclusion of the results.

2 Literature Review

Smart phones through the Apps installed in them, allow citizens to interact with provided smart city services that improve people's life quality. An important group of citizens that may benefit from these smart services are the older population. Smart services face certain issues, especially in understanding the real needs of the people living in the city [14]. Older people's needs are associated to the age related changes they face. The main issue is that services targeted at older people do not seem to address these needs in the visual presentation of information. This represents a universal barrier to communicate with older people, which prevents an active ageing [1]. Major operative systems include built-in accessibility functionalities, such as Voice Over in iOS or TalkBack in Android. Both functionalities allow to turn the interface into text to speech for people with visual disabilities. Not only that, to address older people age-related needs, the industry and the academia has proposed age-specific design guidelines for mobile devices. Guidelines, enable the designers to create accessible interfaces without the need to hire older people for heuristic evaluation. This is why in this study the available guidelines are used as parameters to evaluate the Apps.

This section presents an overview of the available research, from both industry and academia, regarding accessible mobile UI design for older people.

2.1 Research-Based Guidelines

Research-based guidelines are the ones developed in the academic context, which are published in indexed conferences and journals. Based on eight different age-friendly mobile design guidelines and checklist [15–21], Petrovčič et al. suggested a set of 38 senior friendly usability guidelines [12]. Table 1 summarizes the list of 38 guidelines, grouped within seven different dimensions associated with various interaction elements of smart phones. These dimensions are: screen, touchscreen, keypad, text, menu, exterior, and content.

Table 1. Usability dimensions and categories for designing age-friendly mobile interfaces.

Dimension	Guideline	Source
Screen	Display size	[19]
	High contrast	[19]
	Colors	
	High resolution	[22,23]
	Slower dimming	[24]
	Zooming and magnification	[25–27]
Touchscreen	Touchscreen gestures	[28–30]
	Feedback	[31]
	Target/Icon properties	[32]
	Content layout	[12]
	Animation	[25]
Keypad	Button type	[12]
	Button shape	[25]
	Button size	[24,25,33]
	Button feedback	[34]
	Button responsiveness	[33]
	Labelled buttons	[35]
	Button positioning	[12,31,36]
	Number of buttons	[12]
Text	Ease of text entry	[29–31]
	Font size	
	Font type	
Menu	Simple menu	[30]
	Consistent menu	
	Minimized nesting	
	Ease of navigation	
	Current location in the menu	
Exterior	Device size	[25,26,32]
	Shape	
	Material	
	Battery charging	
	External volume buttons	
	Hearing aid compatible	
Content	Terminology	[12]
	Function labels	
	Additional languages	
	User help and/or manual	
	Error messages	

Screen. Older people favour a big display size, with a high resolution screen, and options to magnify the content. Colors in the screen should have a high contrast between the foreground and the background, and should be conservative. Since there is no agreed definition of conservative colors in the provided guidelines, the following definitions are considered: "marked by moderation or caution" [19], and "sober and conventional" [37]. Conservative colors are: black, white, grey, blue, beige, and various shades, tones, or tints of these colors. As well as, any color palette with a mix of neutral and highlight colors, where the neutral color appears in the biggest amount.

Touchscreen. The touch technology in mobile device creates difficulties for older people. They are not familiarized with tapping on the screen, so they need more time to comprehend and learn gestures [28–30]. Therefore, it is highly recommended to keep gestures simple. It is also suggested to include auditory and tactile signals that give distinctive feedback to the user [31].

Keypad. Buttons play an important role in age-specific UI design. Older people prefer large buttons with clear and immediate feedback (visual, tactile, and/or auditory) that helps them avoid mistakes when pressing a button [24,33,34]. It is suggested that older adult's pointing performance is better with: large buttons; a wider spacing between buttons; a target size between 14 and 17.5 mm; and by placing the buttons in the upper right direction from the centre point [31,36]. Buttons should not be too sensitive, and they should be visually differentiated from other actionable elements [25].

Text. Older people prefer a bigger font size that allows the to better perceive the screen. Also, it is recommended to provide easier ways for them to input data [29–31].

Menu. The increased number of features and services offered on a smart phone has resulted in more complex menus that are harder to understand by older people. That is why, a menu should be simple, consistent, have minimised nesting, and Show the current location in the menu [30].

Exterior. Several studies have revealed that phones for older people should: be big, facilitate an ergonomic grip, be lightweight, and have the shape of a bar [25,26,32]. Additionally, it is advisable to include audio adjustment, preferably from an external button, with a wide number of volume levels.

Content. Function labels have a fundamental role in UI design for older people who do not know what to do while navigating a menu [12]. Therefore, terminology used in a function label should be simple, consistent, self-explanatory, non-ambiguous, and should avoid foreign expressions, abbreviations, and technical terms. Instructions and error messages should be easy to understand and be always available.

2.2 Design Standards

Design standards are guidelines developed in standards organizations like ISO or W3C. The W3C is the main standard's organization for the web. They have published "Web Content Accessibility Guidelines" (WCAG) [13], where they categorize guidelines into four principles: perceivable, operable, understandable, and robust [38]. These principles are the required foundation to develop any accessible web and mobile content [38]. Table 2 shows the W3C's suggested guidelines for designing accessible mobile devices.

Table 2. W3C's mobile accessibility guidelines.

Principle	Category	Guideline
Perceivable	Small screen size	Minimize the amount of information displayed
		Provide a reasonable default size for text and touch controls
		Adapt the length of link text to the view-port width
		Position form fields below their labels.
	Magnification	Allow customization of default text size, preferably on page controls
		Allow for magnification of entire screen
		Allow for magnifying lens view under user's finger
	Contrast	Provide high contrast text
Operable	Keyboard control for touchscreen devices	Allow interfaces to be operated by external keyboards
	Touch target size and spacing	Touch targets should be at least 9 mm high by 9 mm wide and be surrounded by a small amount of inactive space
		Allow a reasonable spacing between buttons
	Touchscreen gestures	Gestures should be as easy
		Allow activating elements via the mouse up or touch end event
		To manipulate a device always provide touch and keyboard operability
	Buttons	Provide button positioning alternatives based on different scenarios
Understandable	Screen orientation	Support both portrait and landscape
	Layout	Repeated interaction elements should be displayed consistently across different pages, screen sizes and orientations
		Position important page elements before having to scroll
	Operable elements	Group operable elements that perform the same action
		Provide clear indication that elements are actionable
	Instructions	Provide instructions for custom touchscreen and device manipulation gestures
		Instructions should be easily discoverable and accessible at anytime
Robust	Data input	Set the virtual keyboard to the type of data entry required
		Provide easy methods for data entry
		Support the characteristic properties of the platform

Perceivable. Some of the W3C's recommendations to create perceivable UI components are:

- Reduce the amount of information displayed in a phone's viewport, through hierarchizing the information and only including what is necessary.
- Position form fields below their labels to increase the size of input elements, and improve visibility.
- Allow to customize the text size and magnification, through on page controls that are visible and recognizable.

Operable. An operable mobile device is when all UI elements and navigation can be easily controlled by the user without requesting to perform an unknown interaction. Some of the suggested guidelines to design operable UI are:

- Set the touch target to at least 9 mm high by 9 mm wide. If the elements are close to the minimum value then they should have an inactive space around them. This makes the touch target bigger and makes it easier to interact with the elements.
- Provide a prudent separation between the interaction elements.
- Avoid complex gestures like pinch and spread, which is a standard gesture for zooming in and out [27].

Understandable. An interface is understandable when everyone is able to comprehend all the information and operations in it. Some suggestions to turn a mobile interface understandable are:

- Support both screen orientations, landscape and portrait, and not to force the user to change their orientation if they do not want.
- Display repetitive elements across the interface consistently, even in different screen sizes and orientations.
- Provide visual hints that differentiate actionable from non-actionable elements through colour, shape, iconography, positioning, and text label.

Robust. An interface is robust if it remains accessible through the changes and adaptation of an App. Some recommendations for a robust interface are:

- Automatically trigger the type of keyboard that matches the kind of data entry required in a form. So for example, if only numbers are required, then enable only the numeric keyboard.
- Provide easy methods for data entry. A convenient way to do so is to include select menus, radio buttons, check boxes, and even auto-complete acquainted information.
- Support the characteristic properties of the platform, such as the accessibility feature in Android or iOS smart phones.

3 Evaluation Design

The aim of this research is to assess how and to what extent industry takes into account the usability and accessibility needs of the ageing population in the design of mobile Apps in smart cities. Two sets of mobile Apps are selected and evaluated based on the research-based guidelines and design standards. These sets include age-specific Apps and Apps that are critical city services that may benefit older people, but are targeted at a broader audience. This section describes the procedure and method applied to evaluate the Apps, including the Apps and checkpoint selection criteria.

3.1 Checkpoint Selection

In this section, the selected guidelines are grouped into two lists of checkpoints (Tables 3 and 4), which serve as metrics to evaluate the Apps. To facilitate the evaluation process, a code name is assigned to each checkpoint. RBG for research-based guidelines and DS for design standards.

Research-Based Checkpoints From Table 1, all the guidelines listed under exterior dimension, along with three out of six guidelines from the screen dimension are excluded. These guidelines are not in the scope of this study, as they address more physical characteristics of a mobile device, than the UI components. Also, content layout, number of buttons, font type, animation and additional languages are not considered in this study, as there is not clear explanation in the corresponding literature into what they mean. Finally, high contrast is also excluded, because there are not enough resources available to evaluate it. Therefore, from the original set of 38 guidelines in Table 1, only 23 are selected as the first set of checkpoints to evaluate the selected Apps (Table 3).

Design Standards Checkpoints. From the design standards on Table 2, contrast, touch target size and spacing are not considered in this study due to tools limitations. Additionally, keyboard control for touchscreen devices, device manipulation gestures, allowing for magnifying lens under user's finger, and adapting link text width to the view-port width are excluded as there is not enough clarification on their importance to older people. Hence, from the original 26 guidelines on Table 2, 20 of them are considered for the final evaluation (Table 4).

Table 3. Selected list of checkpoints from the research-based guidelines.

Dimension	Checkpoint	Code
Screen	Colors' conservativeness	RBG-01
	Zooming and magnification	RBG-02
Touchscreen	Touchscreen gestures	RBG-03
	Feedback	RBG-04
	Target/Icon properties	RBG-05
Keypad	Button type	RBG-06
	Button shape	RBG-07
	Button size	RBG-08
	Button feedback	RBG-09
	Button responsiveness	RBG-10
	Labelled buttons	RBG-11
	Button positioning	RBG-12
Text	Ease of text entry	RBG-13
	Font size	RBG-14
Menu	Simple menu	RBG-15
	Consistent menu	RBG-16
	Minimized nesting	RBG-17
	Ease of navigation	RBG-18
	Current location in the menu	RBG-19
Content	Terminology	RBG-20
	Function labels	RBG-21
	User help and/or manual	RBG-22
	Error messages	RBG-23

Table 4. Selected list of checkpoints from the design standards.

Principle	Dimension	Checkpoint	Code
Perceivable	Small screen size	Reduce information	SG-01
		Font size	SG-02
		Form field below label	SG-03
	Magnification	Text resizing	SG-04
		On-screen control to change text size	SG-05
		Zoom	SG-06
Operable	Touchscreen gestures	Easy	SG-07
		Touch-end event	SG-08
	Buttons	Accessible	SG-09

(*continued*)

Table 4. (*continued*)

Principle	Dimension	Checkpoint	Code
Understandable	Screen orientation	Support both	SG-10
	Consistent layout	Multiple pages	SG-11
		Screen orientations	
	Page elements	Important page elements before page scroll	SG-12
	Operable elements	Group operable elements performing same action	SG-13
		Visually differentiate actionable elements	SG-14
	Instructions	Available	SG-15
		Easily discoverable and accessible	SG-16
		Available anytime	SG-17
Robust	Data input	set virtual keyboard to the type of data entry required	SG-18
		Reduce amount of text entry required	SG-19
	Support characteristic properties of platform	Zoom	SG-20
		Font size	
		Captions	

3.2 App Selection and Evaluation Process

To find a set of suitable mobile Apps for the evaluation, a systematic review of the market was performed. The review was carried out using Google's browser, Apple App Store, and Google Play Store. Throughout the review, certain keywords were used to ensure that all the relevant Apps for the ageing population were detected: best, older, App, senior, elder, older people. Every hit was reviewed in terms of its relevance and based on the following selection criteria:

– The App must be targeted at older people and/or be an App designed for critical city services that may benefit older people, but targeted at a broader audience.
– The App should be up to date, meaning that it is still in use and developers still support it.
– The App should be for iOS and/or Android.
– The App should be free or at least should have a demo version.

Based on these criteria 22 Apps are selected and grouped by functionality to facilitate the evaluation process (see Table 6).

To assess the usability and accessibility of the selected Apps for older people, an expert-based usability evaluation has been performed. This method involved an expert review of the Apps in terms of usability and accessibility on the basis of the defined list of checkpoints. Throughout the evaluation, each individual checkpoint was tested manually for every App.

To grade each checkpoint, a scale system that goes from 0 to 2, in which 0 is given where the checkpoint is not addressed, 1 is given to a partially addressed checkpoint, and 2 is given to checkpoint fully addressed. To evaluate the Apps level of accessibility, a 5 level score system was designed (see Table 5). The 5 levels are high, high-moderate, moderate, low-moderate, and low, which are calculated based on the number of checkpoints each of the Apps have covered in each of the guidelines or standards. Each list of checkpoints obtained an individual preliminary score (Table 6). The final score was obtained by calculating the average between these preliminary scores. The final App score (Table 6) presents the most and least accessible Apps which shows how the industry is complying with older people's accessibility requirements in the design of mobile interfaces.

The Apps' evaluation was performed using two different devices: an iPhone 5s with iOS 11.3, and a Moto G 2014 with Android 7.1.1. In both cases, the platforms' built-in accessibility settings were disabled, unless necessary.

Table 5. Guideline/standard coverage scoring systems.

	High	High-mod.	Moderate	Low-mod	Low
RBG Score	37-46	33-36	28-32	23-27	0-22
DS Score	32-40	28-31	24-27	20-23	0-19
Total Score	34.9 - 43	30.6 - 34.8	26.3 - 30.5	21.6 - 26.2	0 - 21.5

4 Results

4.1 Apps Results per Set of Checkpoints

Research-Based Checkpoints. The results show that there is a high level of inclusion of the research-based checkpoints in more than half of the Apps. Figure 1 (left) shows that 17 out of 23 checkpoints are fully addressed in more than half of the Apps. While, Table 6 shows that 54% of the Apps (11 out of 22) reached high and high-moderate level of accessibility. However, Two checkpoints from this set of guidelines, Zooming and Magnification (RBG-02) and Feedback (RBG-04), are not included in more than 75% of the Apps (see Fig. 1 Left). These checkpoints impact how older people interact with a mobile interface, and have been recurrently mentioned in several guidelines since 2014 [12,16,25–27,31,33,61–66].

Design Standards Checkpoints. Unlike the results from the research-based guidelines, the evaluation of the Apps based on the design standards show a low level of addressing of the checkpoints. As reflected on Fig. 1 Right, only 9 out of 20 checkpoints were fully addressed in more than 50% of the Apps. While 8 out of the 20 checkpoints were not addressed in at least 50% of them. Among these checkpoints were aspects that allow to make an interface perceivable, understandable and robust for older people. The checkpoints with low level of inclusion are: Form field below label (DS-03), Text resizing (DS-04), On-screen control to change text size (DS-05), Zoom (DS-06), Support both Screen Orientations (DS-10), Instructions easily discoverable and accessible (DS-16), Instructions available anytime (DS-17), and Set virtual keyboard to the type of data entry required (DS-18). From these checkpoints DS-05 is not even part of any of the sample Apps. Furthermore, the design standards scores on Table 6 show that none of the Apps obtained a high level of accessibility, only 2 obtained a high-moderate level, 6 a moderate level, and 14 out of 22 Apps reached between low-moderate and low levels of accessibility.

In the evaluation it was observed that almost all the Apps support the zoom from the accessibility menu in the device, which means that even though an App does not include a zoom feature, the platform will allow to do so if activated from the phone's menu. However, asking an older person to interact with a complex menu like that represents a difficulty [12].

4.2 Apps Total Score

From the results on Table 6, it is clear that mobile Apps are still not accessible enough for older people. Out of the 22 evaluated Apps, none of them reached a high level of accessibility, and only 5 had a high-moderate level of accessibility. While the remaining 17 Apps are still not accessible enough for older people. Particularly, in most of the evaluated Apps, including the age-specific and non-age-specific Apps, there are problems with aspects that address visual degrading for older people such as zooming, text resizing and on-screen controllers to modify text. Additionally, most of the Apps lacked proper instructions and options to ease the data input process for users. These features decrease the impact of older adults' degrading cognitive skills when interacting with an interface. Thus, there are different guidelines that could be better addressed by the industry to design mobile Apps for older people. By making sure that these guidelines are applied during the design process of a mobile App, it is possible to contribute to senior citizens' inclusion and engagement in smart cities.

Table 6. Apps evaluation results

Domain	App	Score (RBG)	Score (DS)	Total Score
Emergency	Red Panic Button [39]	33	23	**28**
	Fade: fall detector [40]	29	17	**23**
Assistance	Magnifying Glass With Light [41]	26	21	**23.5**
	Magnifying Glass Flashlight [42]	32	22	**27**
	Usound (Hearing Assistant)[43]	42	26	**34**
	MyEarDroid - Sound Recognition [44]	22	18	**20**
	Live Caption [45]	36	29	**32.5**
Personalisation	Wiser – Simple Senior Launcher [46]	40	19	**29.5**
	Nova Launcher [47]	28	20	**24**
Health	MindMate - Healthy Aging [48]	32	23	**27.5**
	WebMD [49]	28	22	**25**
	Pocket Physio [50]	37	23	**30**
	Blood Pressure Monitor [51]	23	20	**21.5**
	Pill Reminder by Medisafe [52]	35	23	**29**
Enterteinment	Lumosity - Brain Training [53]	40	29	**34.5**
Social	Skype *[1] [54]	26	26	**26**
	Stitch Companionship [55]	34	24	**29**
Location	Find My Family, Friends, Phone Safe365 [56]	38	24	**31**
Finance	Bank of Ireland * [57]	31	19	**25**
	RevApp * [58]	36	26	**31**
Mobility	Dublin Bus * [59]	33	24	**28.5**
	Mytaxi * [60]	37	21	**29**

* Apps that are designed for critical city services that may benefit older people, but are targeted at a broad audience

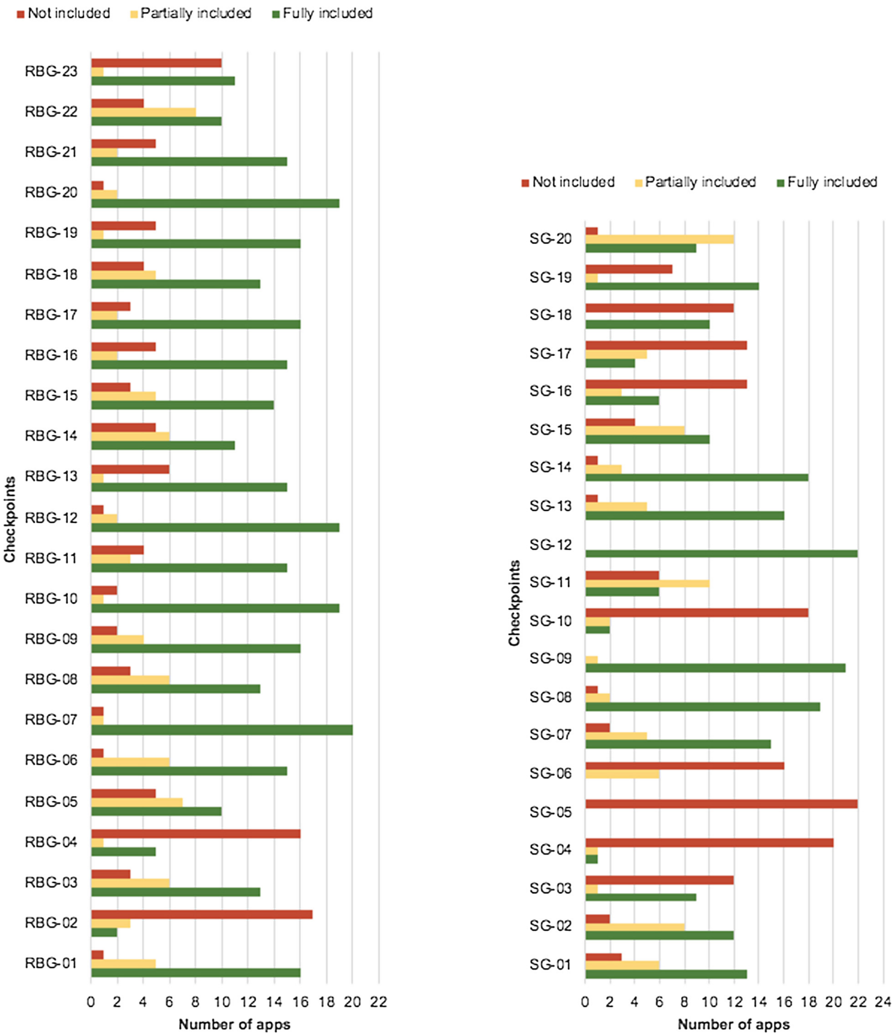

Fig. 1. Checkpoints level of inclusion in Apps. Left: research-based. Right: design standards

5 Conclusion

The aim of this study was to assess how and to what extent is the industry taking into consideration the existing usability and accessibility guidelines to design suitable mobile interfaces for older people. To assess the industry, 22 industry-built mobile Apps were selected. These Apps included sample Apps specifically targeted at older people and sample Apps designed for critical city services that may benefit older people, but targeting a broader audience. These

Apps were then evaluated on the basis of two sets of checkpoints, retrieved from available age-specific academic and industry design guidelines.

It was observed that overall the Apps had a weakness in all the accessibility principles that make an interface perceivable, operable, understandable and robust for the older people [10,13]. The most concerning checkpoints were the lack of text resizing and zooming in more than 70% of the Apps. Although, it was also observed that most of the Apps (95%) supported the platform's accessibility settings, which allowed to zoom and adjust the font size. However, a major issue with this, as pointed in [12], is that older people are being forced to find such settings in the platform's menu, which generally represents a complexity for them. For operability and understandability the most surprising finding was the lack of adequate instructions, without which the interface turns incomprehensible and inoperable for older people. Finally, regarding robustness 55% of the Apps were found to not set the virtual keyboard to the type of data entry required, which facilitates older people inputting data through a smart phone.

An interesting finding from the study was the relevant difference between the results from the research-based guidelines and design standards. In Fig. 1 (Left), it was observed that at least half of the Apps fully included 82% of the checkpoints. While in Fig. 1 (Right), only 45% of the checkpoints were fully included in at least half of the Apps. As shown in Table 6, the Apps obtained a higher level of accessibility when evaluated on the basis of the research-based checkpoints. In this case, 54% of the Apps scored between high and high moderate. While in the case of the design standards set, only 9% of the Apps obtained a high-moderate level of accessibility, and no Apps reached a high level of accessibility. This difference in scores can be explained because at least half of the checkpoints from each set measured different usability and accessibility aspects. This reveals that the industry is considering more accessibility aspects related to the research-based guidelines than the design standards.

On the Apps total score on Table 6, none of the Apps achieved a high level of accessibility and only 23% achieved a high-moderate level of accessibility. From the remaining Apps, 41% moderately includes age-specific aspects, but not enough to be regarded as fully accessible Apps. Meaning that only 23% of the sample Apps can be considered accessible enough for older people. This clearly shows the low efforts from the industry to implement age-friendly guidelines in the design of mobile Apps for older people. Thus, there is still a lot of work to be done to reach an inclusive smart city that benefits older people as much as any other citizen. As the results of this study show, a good starting point to do so are smart phones, which are key component that provides a way for older people to interact with the smart city through their mobile Apps. Thus, mobile Apps in the context of smart cities should be designed in such a way that they are accessible by all citizens.

5.1 Limitations and Future Work

Even though this study presents some insights into how accessible are mobile Apps for older people in smart cities, its findings are subject to some limitations.

First, the Apps evaluations was not performed by old users. However, a set of guidelines previously tested by older and impaired people, was employed in this study. This type of guidelines, have been suggested as an effective heuristic-tool when the end-user is not available. Second, the study was performed using free Apps only and this might have limited the sample set. Thus, in the future it is interesting to evaluate paid Apps and compare them to the results obtained in this study. Third, not all guidelines could be evaluated, and these could have an impact on the final results. So, as future work, the evaluation can be performed including all the guidelines from the research-based guidelines and design standards. Despite of the limitations, the study provided useful information to use available usability and accessibility guidelines for the evaluation of age-specific mobile Apps. This study shows weaknesses of mobile Apps today, to avoid them in future age-friendly mobile App design. Thus, it can be used as a framework by designers in the industry when developing mobile Apps targeted at older people.

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