Elders Using Smartphones – a Set of Research Based Heuristic Guidelines for Designers

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Abstract. Smartphones and an increasingly aged population are two highly visible emergent attributes in the last decade. Smartphones are becoming the canonical front end for the cloud, web, and applications from email to social media - especially so if you include pads in the same category. In Europe, the Americas and Asia the ratio of over those over 65 compared to the total population that is becoming increasingly skewed. This paper is about the intersection of these two socio-technical vectors, or more to the point about the mismatch between them: a mismatch which can lead to an increase in the digital divide rather than the decline that the more affordable smartphones could promise. We present a study of literature and results of a design process in the form of heuristics to support smartphone/tablet designers making useable and useful products for elder end-users.

Keywords: Smartphone, Small touch screens, Older adults, Hueristics, GUI design guidelines.

1 Introduction

Smartphones and an increasingly aged population are two highly visible emergent attributes in the last decade. Smartphones are becoming the canonical front end for the cloud, web, and applications from email to social media - especially so if you include pads in the same category (see **Fig. 1**).
In Europe, the Americas and Asia the ratio of over 65 population is producing a now common inverted triangle graph (see **Fig. 2**). This paper is about the intersection of these two socio-technical vectors, or more to the point about the mismatch between them; a mismatch which can lead to an increase in the digital divide [1] rather than the decline that the more affordable smartphones could promise.

adfa, p. 1, 2011.

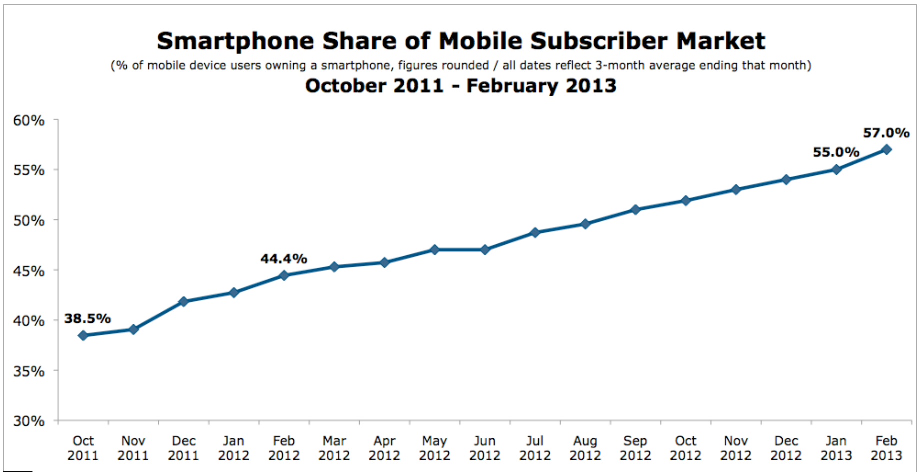

Fig. 1. – Smartphones Share of Market

The current population of elders (65-70 and above) were too old to be raised with home computers, beyond calculators; as a result the level of computer literacy of this segment of the population is considerably lower than the generation below them and far below the current generation of software/hardware designers and early-adopters [2]. This is compounded by the inevitable sensory and possible cognitive decline by this group. This creates initial difficulty in using the powerful connecting applications such as email and social media, and for those who choose to try and use these often leads to early abandonment of effort. Further, as the world becomes more digitally connected, avenues for accessing things like banking, appointments and something as simple as searching for a phone number without use of a computer (and here we include and perhaps really mean smartphone) become unavailable.

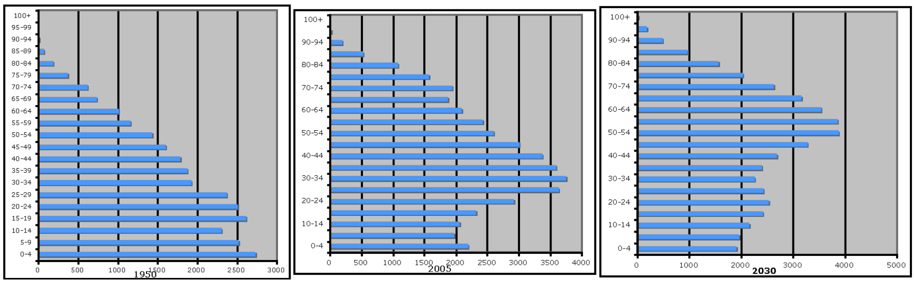

Fig. 2. - Age Spread in Spain 1950-2030

Smartphones are the epitome of economy of scale and mores law. Their rapid ride in popularity has driven costs down faster than previous hardware advances (modulo iPhones). The confluence of so many technologies into the smartphone means that in one small package you often find Wi-Fi, Bluetooth, NFC, GPS, 3-D accelerometers, compass, microphones, cameras (still and video), gyroscope, and proximity sensors;

and the explosion of information that can be gained by sensor fusion. These phones can currently connect with others and the Internet by phone service, Wi-Fi, GRPS and new evolving wireless technologies. Combining the two advances listed previously the phones enable the sorts of context awareness and ambient intelligence that provide abilities and information only accessible to the very few previously. As the form factor of smartphone became capable of being smaller and smaller, the affordances for I/O become similarly constrained. Input becomes based on touch screens, on screen keyboards, on gesture and finger input; the output is delivered by small low-powered speakers and tiny high definition screens.

Elders with smartphones are a great way to facilitate the lowering of the digital divide – low cost, portable, able to access every application and information type (music to video). Except that they are hard to understand and use by elders and have had the lowest market penetration of all age segments over 15 (see **Fig. 3**) [3]. Identifying the cause of the non-adoption is the first step towards ameliorating this situation; having identified the problem the next step would be to design around the obstacles that were designed into the systems. Here we have to concern ourselves with 1) workarounds for the I/O issues described above and 2) provide tools for designers to use to provide systems that retain existing factuality and usability but become accessible to as many potential users and possible. Our approach to supporting design work is not add-ons or special accommodations for special populations but to provide guides that maximise broad use while increasing the quality of fundamental design styles and approaches.

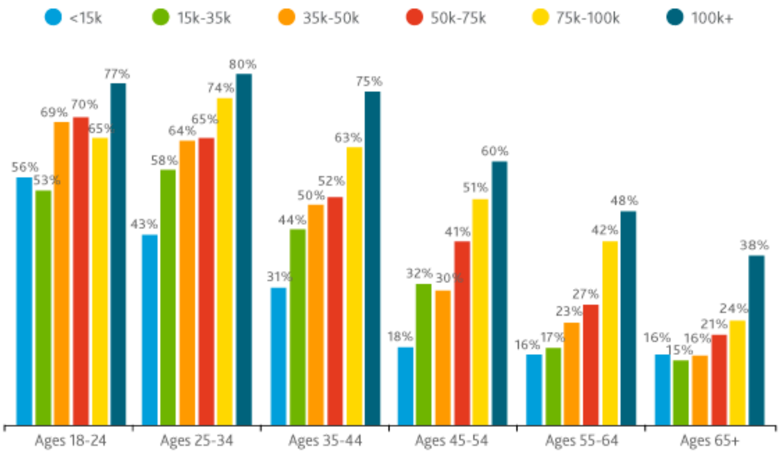

Fig. 3. - Smartphone Penetration by Age and Income (Jan. 2012)

2 Gathering Heuristics

Our approach to producing a set of heuristics followed the typical path of literature research and user studies. Works on elders and design include general approaches [4-8] and several approaches to systemic guidance [9, 10]. Also included were more specific works on elders and small factored portable devices like smartphones and tablets [11-14].

With this perspective we performed two sets of user interviews and focus groups. The population was drawn from the cities that would be evaluating the ASSISTANT smartphone application [15]: Paris (France), Vienna (Austria), and San Sebastian (Spain).

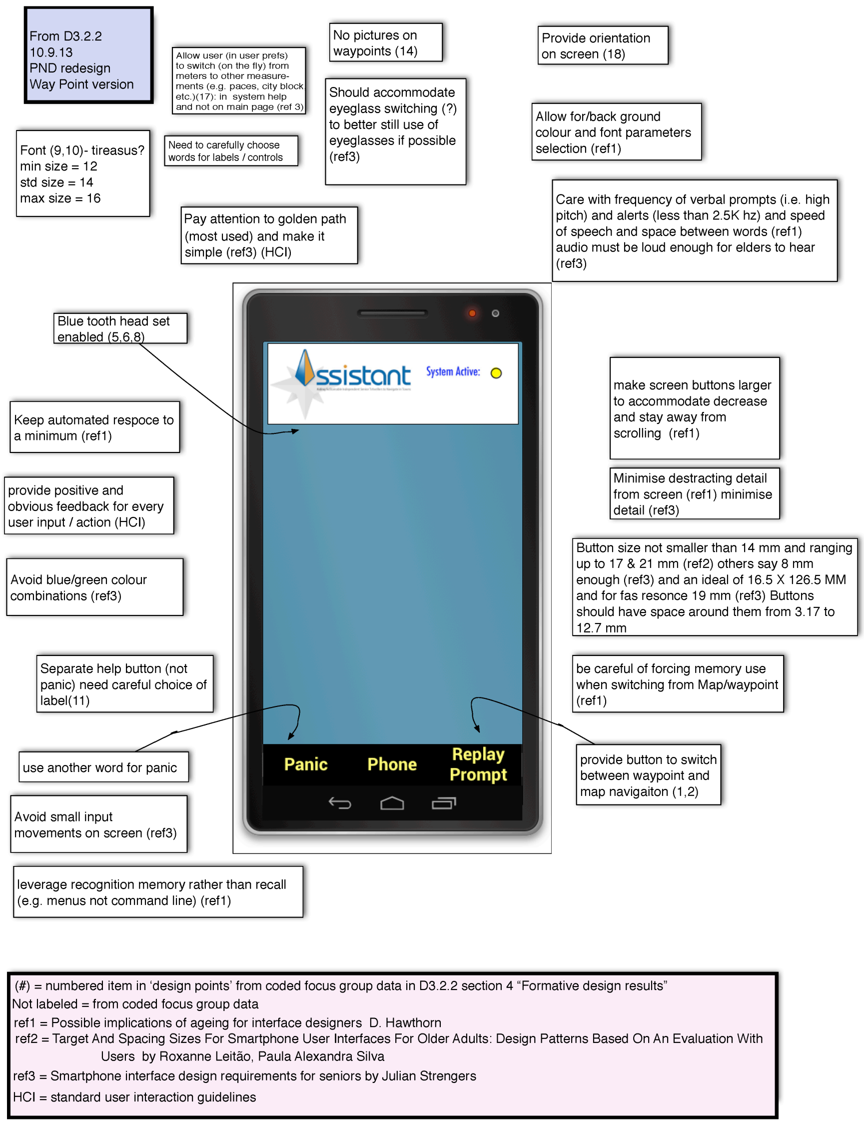

Fig. 4. - ASSISTANT Smartphone initial design guidelines

Firstly, interviews were used to identify user needs and requirements and know better the use of this kind of systems and public transportation by elderly. From these first sessions we extracted that in the last years the use of mobile phones by elderly is more common. Most of them have a mobile phone especially for emergencies. We conducted interviews in different countries, and we saw that the use of mobile phones is different. For example, in Spain is not common to see an elderly using a smartphone and they usually have it just for making or receiving calls. In the case of France or Austria more elderly have a smartphone and they access to more functionalities such as Internet navigation. The people who use little functionality said that the menus are very complicated to learn using them.

Secondly, according to the collected and processed information we made three different designs, which were evaluated in some focus group sessions by elderly. The aim of these second sessions was to identify the most interesting functionalities and also elements of the UI design preferred by elderly. We identified that the application for the smartphone should be easy to use, with only important tasks and using representative words. The information must be showed with short and clear instructions. Buttons should be big enough and not more buttons than strictly necessary.

Elements in the Cognitive category include Mnemonic issues and structural issues based on recognition/recollection analysis like menu layers and icons. Visual topics span icon style and size (which may vary by language localizing, i.e. the difference between English and German phrases for the same item), button size and label, icon size, label and familiarity. Input issues for elders (and others with motoric / sensory disabilities) include interacting with touchscreens, like gesturing, selecting, drag and drop actions; onscreen and tiny keyboards can be difficult to unusable by elders. Design on limited screens can be constrained by generations and cultural issues, metaphors and mental models of the system as well as verbiage for common actions.

From this body of information a set of heuristics specific to our application (guiding Seniors in use of public transportation using real-time information on smartphones) were developed. The heuristics were divided into six sections:

- **Cognitive:** Experts also insist on the importance of the information architecture. Deep and too many menus are complicated for elderly and finally they do not use them. So different literature recommend avoiding deep hierarchies, selecting only the necessary actions, and trying to group information [12, 16, 17]. Spreading information across screens or forcing scrolling may be problematic due to working memory decline[4] and decline in ability to coordinate multiple tasks using attention switching [5]. Because spatial cognition declines [5, 17] providing maps for guidance may be less effective than waypoints or landmarks. Because of attentional and memory constraints, screens that present too many options or buttons may become confusing due to elders scanning the whole screen towards their goal rather than zeroing in, by visual cues, on what they are looking for [17].
- **Visual**: this application is focused on elderly who usually have visual problems because the age. Some of these problems can be solved using glasses but not everyone is wearing glasses all the time (because they are reading glasses) so for using the phone this can be a problem. This is the reason because most of elderly prefer

to have haptic (vibratory) or sound alarms, or in some cases spoken instructions. With the aim of solving some visual problems, according to the literature it is recommended to use only colours and graphics[11], of course these must have the alt text attribute filled in to enable screen readers. If written text is needed it should be in 12-14 point size [4, 7, 10, 16, 17]. Font type is also important to help people reading text easily. The experts recommend not using decorative fonts [16] and using serif or sans-serif types such as Helvetia, Times New Roman or Arial [5, 9, 16]. The text should be left justified in countries using left writing, with spacing between lines, and important information must be highlighted and in the middle of the screen [16]. Main body must be written in lower cases and with short sentences [16] because capital letters must be used to draw attention to something important [5, 7]. Colours are also important to make readable the texts. For people blind to colours the important information should not be signalled by colours, or not only by colours. The contrast ration between background and text must be 50:1 [5, 7, 16] and ideally background must be in white and text in black [5, 7, 10] because elderly people have problems with background colours[11]. Blue and green tones and the brightness changes between screens should be avoided.

- **Input:** elderly people, because the age, usually have dexterity problems, which evokes difficulties to work with a touch screen. This application is based on a smartphone, so most input should be done by a touch screen. Buttons of touch screens react too fast and this is a problem for the elderly [11], so it is recommended to add a small delay and feedback (auditory or haptic) when a button is pressed [5]. Only basic actions (go back or close the application) will be done by hardware buttons. There is some evidence about that the elderly use back button more than young people because they understand it such as undo actions [17] so this function is very important to be implemented. According to the literature, scrolling and double click is difficult for elderly because it is not intuitive, it should be learned [16, 17]. Smartphones usual keypad is not good for elderly and the physical buttons from mobile phones are too small [18] so text input should be avoided and replaced by speech-to-text [11]. To solve the identified problems with touch buttons the main actions of an application for a smartphone should have big buttons [5] no smaller than 16.5x16.5mm (for faster responses 19.05x19.05mm) [11, 19, 20]. Some experts conclude that there is no evidence about the spacing between buttons for elderly, but they recommend 3.17 mm [13]. Others recommend at least 6.35mm [5, 17, 19], which is preferred by adults[11].
- **Audio:** according to Fisk et al. [5] 10% of middle-aged adults suffer hearing losses, but in the case of people over 65 years old, the half of men (50%) and the 30% of women has hearing problems. Hawthorn [10] also says that the 75% of the people over 75-79 have audio impairments. So it is clear that the hearing problems appear with the age. Because of this, when some instructions of a UI want to be given by voice, some recommendations must be taken into account. Some experts recommend using frequencies between 500-2,000Hz [7, 10] and avoiding frequencies over 4,000Hz [5, 7, 10, 21]. In the case of warning signals they should be lower than 2,000Hz, most preferable is 500Hz if they are fast (less than 0.5sg of sound and 0.5sg of silence) [21] or more than 2,000Hz but longer than 0.5sg [7]. About

the intensity experts agree that it should be 60 dB, and 50dB for conversional speech. Regarding the speech speed for texts, Fisk et al. [5] recommend a rate of 140 words per minute or less. Female's or kid's voice have higher frequencies, and because of that they are not recommended except on cases where it is needed to pay attention [5, 7]. Artificial voices (synthesized) must be avoided also [5, 7]. The volume adjustment must be configurable according to each user's needs, and it is recommended to use redundant information for any audio signal (light or haptic signals, text…)

- **Haptic:** with the age also the sense of touch changes and the thresholds for temperature and vibration perception increase [5, 7]. For UI design, if we are using vibration signals for warning the user, in the case of elderly some issues should be taken into account:
  - Every people are more sensitive to vibration in upper body sites than lower ones [5].So in the case of elderly, to ensure that they are noticing the warning they should have the phone next to upper side. In this case, the designers cannot control it. It is also recommended to use low frequencies for vibration in the case of elderly. Fisk et al. [5] recommend 25 Hz for warnings.
  - Because elderly has problems to identify haptic signals, it is recommended to use other kind of identification to help with sensitive problems. For example, Farage, Ajayi and Hutchins [7] recommend using colour contrast in hardware buttons because the elderly has problems to differentiate them by touching.
- **Generational/ cultural:** Elders may have problems with mental models of the application and the computer itself. Things that are familiar, like check boxes and menu systems may be incomprehensible to new, older users ("where is the 'any' key?") [4]. Icons that may be 'standard' but have lost the original meaning due to technology changes (i.e. the printer icon) may be mystifying to the elder [17]. Verbiage also may have this property as well as require an understanding of computer basics to make sense [17]. Buttons may be seen as decorative (especially decorative buttons) and not functional. Presenting 'common sense' choices "save the file to this folder?" may cause problems with retrieval.

3 Heuristics

The list of heuristics for UI designers focusing on small touch screens (smartphones) for the elderly:

Area	Heuristic	Comment
Cognitive	Shallow menus	Spread functionality across menu bar and pages.
	All information for a given need on one page	Don't force leafing back and forth between pages, or scrolling up and down – hiding information causes mnemonic problems.

Area	Heuristic	Comment
Cognitive (continued)	Avoid deep hierarchies, group information	Spread across pages – avoid one page does it all approach.
	Select important actions and make them easiest	Determine what are the most frequent acts that the user wants to do and make them easy. Less frequently used ones can require more effort.
	Be consistent with details of interface	Using different designs between screens can cause frustration and confusion.
	Don't force use of multiple tasks	Allow tasks to be accomplished serially, don't force them to be done at the same time requiring cognitive switching.
	Support easy paths	Always provide a 'home' button, and let users know 'where' they are.
Visual	Use colours, icons and graphics	Often better than using text.
	Font size: 12-14 point	It could be a problem when same text has to be written in different languages and resultant phrase has different length.
	Font type: serif or sans-serif (Helvetia, Arial, Times New Roman…)	Avoid decorative fonts. Recommended: Helvetia, Arial, Times New Roman…
	Text left justified for left writers	Important text should be centre justified to highlight it.
	Spacing between text lines	Try using short sentences. If they are longer than one line, use at least usual spacing.
	Lower cases	Capital letters must be used for highlight important text.
	Colours: don't use to convey critical information (for people blind to colours)	They can be used if they are combined with other signalling (icons, symbols …)
	Contrast ratio: 50:1.	Best: text in black, background in white.
Input	Delay and feedback when pressing a button	The touch screen buttons react too fast.
	Back button provided	It can be implemented by hardware buttons.
	Avoid scrolling and requiring double click	It is not intuitive, it should be learned.
	Avoid use of keypad in smartphones	Replace with drop down menus, choices or speech-to-text.

Area	Heuristic	Comment
Input (continued)	Buttons size: 16.5x16.5 mm	This can be designed for a size of screen, but it is difficult to define a concrete size if the application can be used in smartphones with different screen sizes. For faster responses use 19.05x19.05mm.
	Buttons spacing: 3.17-6.35mm	There is no evidence about the appropriated spacing, but older adults prefer 6.35mm spacing.
Audio	Frequencies: 500-2,000Hz	Warning signals >2,000Hz with duration of 0,5sg. or <2,000Hz.
	Intensity: 60dB	50dB for conversational speech.
	Speech speed: 140 wpm	No faster than 140wpm.
	Male voice	Female/child voice only to draw attention.
	Use redundant information: light or haptic signals as well as audio.	The combination of several signals is recommended for elderly, i.e. haptic feedback when clicking in buttons.
Haptic	Best warning frequency: 25Hz.	Always use lower frequencies.
Generational / cultural	Avoid 'technical terminology	Be aware that words the designer may find commonplace may be arcane to an elder.
	Avoid assuming that the elder has a usable mental model of the smartphone	Asking the elder to perform acts like 'scroll down' to expose the status/notification screen may be incomprehensible and lead to frustration and abandonment.
	Avoid relying on gestures that may be novel	Better to give a virtual button than force the user to do 'invisible' actions.
	Find representative words and icons	Use common words or icons or check with final users if they mean what you expect.
	Carefully use icons	'Standard' icons may be unfamiliar –use with care or better reinforce with words
	Always provide an exit	Small problems may escalate to abandonment when use is backed into a screen that apparently has no way to exit.

In Figures 5 and 6 you can see examples of the above heuristics. Cognitive concerns include keeping all information on one page and easy paths between screens. According to the visual heuristics we can say that the text size and type has been respected. The instructions are short (in one sentence) in the middle of the screen but they are centre justified, not left justified, with the aim of highlighting the instructions such as main text. The colours and the contrast ration are also the same as in the heuristics.

The input is done with touch screen buttons which has the proposed size in the literature. Because there is no evidence about the minimum spacing, it has not been respected, but with the aim of avoiding wrong clicks, the buttons have been delimited by a clear black line which visually helps the user differentiate the space of each button. Scrolling and double clicking have been avoided; also the design keeps all the important elements in one screen.

Fig. 5. - ASSISTANT project Personal Navigation Device (PND) interface

In figure 6, to avoid the need to scroll, arrows had been added to go ahead or back in contact list. While not visible in the figures, the audio and haptic alert are in the right frequency range and with signal modality redundancy. The wording is carefully chosen and checked with elderly in Focus Groups and many functions are represented by easy to understand icons.

Fig. 6. ASSISTANT PND Auxiliary Interfaces

The start of building a set of heuristics consisted of compiling these lists into a design document for the mobile user interface for the personal navigation device for ASSISTANT, implemented on a Samsung Galaxy 3 android smart phone. With a pilot type system out first pilot tests will be performed in April 2014 and we expect that they will give us further feedback to clarify and extend the heuristics we have so far codified.

The difference between this set of heuristics and the anticipated final set are the replacement of adjectives ('large enough', 'high contrast') with quantifiable goals ('san serif, larger than 14 point font', contrast levels following WCAG 2.0 conventions) that are easier for novice designer to follow.

The paper has presented the initial heuristics derived in the first half of the ASSISTANT project. These heuristics and data derived from use studies will be examined in the ASSISTANT pilot study with a goal of expanding and clarifying these guidelines.

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