TARGET AND SPACING SIZES FOR SMARTPHONE USER INTERFACES FOR OLDER ADULTS: DESIGN PATTERNS BASED ON AN EVALUATION WITH USERS

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The use of smartphones is becoming widespread among all sectors of the population. However, developers and designers do not have access to guidance in designing for specific audiences such as older adults. This study investigated optimal target sizes, and spacing sizes between targets, for smartphones user interfaces intended for older adults. Two independent variables were studied — target sizes and spacing between targets — for two common smartphone gestures — *tap* and *swipe.* Dependent variables were accuracy rates, task completion times, and participants' subjective preferences. 40 older adults recruited from several daycare centers participated in both tasks and a post-session questionnaire. The recommendations drawn from the authors' research support two interaction design patterns relative to touch target sizes for older adults, and are presented in this paper.

Keywords: Design patterns, older adult, touchscreen, smartphone, target size; tap gesture, swipe gesture, user study, interaction design

1. INTRODUCTION AND CONTEXT

There has never been such a high percentage of older adults in industrialized countries as there is nowadays and this trend is going to keep increasing (Cavanaugh & Blanchard-Fields, 2006)Datasets indicate that the percentage of older people (defined as over 65 years of age) in 2010 was 13% in the United States (Department of Health & Human Services, 2011) and 17.4% in the European Union (European Commission & Economic Policy Committee, 2011). By 2030-2035 the percentage of older adults is expected to reach 19.3% in the U.S (Department of Health & Human Services, 2011) and 23.8% in the EU (European Commission & Economic Policy Committee, 2011)

In addition, according to the International Telecommunication Union (2012), it is estimated that mobile phone subscriptions in Europe are around 119.5 per 100 people, meaning that there are more mobile phone subscriptions than individual persons and, on a larger scale, 86.7% of the world's population is estimated to own a subscription (International Telecommunication Union, 2012).

However, current design and development of mobile telecommunication devices has not been taking into account older adults specific needs and expectations (Czaja & Sharit, 1998; Zaphiris, Kurniawan, & Ellis, 2008; Ziefle, 2010)

More recently and given the proliferation of touchscreen devices, a few studies have been conducted to investigate optimal touch target sizes for the general population (Henze, Rukzio, & Boll, 2011; Lee & Zhai, 2009; Parhi, Karlson, & Bederson, 2006; Park, Han, Park, & Cho, 2008; Perry & Hourcade, 2008; Sears, Revis, Swatski, Crittenden, & Shneiderman, 1993) but very few have concentrated on touch target sizes for older adults (Jin, Plocher, & Kiff, 2007). In fact, current smartphone Operating System (OS) guidelines, such as Apple's "iOS Human Interface Guidelines"[1] Google's "Android Design"[2], and Microsoft's

1 http://developer.apple.com/library/ios/#DOCUMENTATION/UserExperience/Conceptual/MobileHIG/Introduction/Introduction.html
2 http://developer.android.com/design/index.html

"User Experience Design Guidelines"[3], do not offer guidance in designing for specific user groups, such as older adults.

Furthermore, it is well accepted that as a result of ageing several alterations occur to the sensory, cognitive and motor systems and that these changes might cause many products to be less adequate for, or even unusable by, older adults.

Modifications such as the yellowing of the eye lens and the shrinking of the retina result in issues such as reduced visual acuity, color-blindness, less contrast sensitivity, and diminished visual search abilities. Making it harder to perform tasks that involve small font-sizes, colors with similar hues or low-contrast levels, or user interfaces (UIs) with too many visual items presented at once (Fisk, Rogers, Charness, Czaja, & Sharit, 2009; Kurniawan, 2008).

Additionally, losses in muscle tissue and bone density occur, which contribute to the reduction of capabilities such as strength and endurance (Cavanaugh & Blanchard-Fields, 2006). In addition, common conditions among older adults such as osteoarthritis, rheumatoid arthritis, and osteoporosis, or malnutrition (Carmeli, Patish, & Coleman, 2003), declining physical activity and sedentary lives are also common conditions affecting their muscular and skeletal systems (Vandervoort, 2002). Accompanying physical changes in muscle tissue and bone density, cognitive and sensory modifications also cause older adults to conduct movement efforts in a different form than their younger counterparts (Ketcham, Seidler, Van Gemmert, & Stelmach, 2002). These alterations are related to poorer perceptual feedback, deteriorating motor pathways, and strategic differences in task resolution (Fisk et al., 2009; Goodman, Brewster, & Gray, 2005; Pak & McLaughlin, 2010). Research has shown that older adults take 30% to 70% longer than their younger counterparts to perform certain motor-related tasks, but that they are not necessarily less accurate than younger adults in accomplishing the end goal of a movement (Ketcham et al., 2002).

Likewise, age-related changes to the central and peripheral nervous systems affect the sensation of touch (Wickremaratchi & Llewelyn, 2006). Older adults have been found to sustain reduced ability in detecting vibrotactile stimulation, perceiving differences in temperature (Nusbaum, 1999), and noticing light pressure touches. Tactile acuity also suffers significant declines with the ageing process, with bodily extremities (e.g., finger-tips, toes) being the most affected (Wickremaratchi & Llewelyn, 2006).

However, to our knowledge research regarding touch target sizes on smartphones for older adults has not yet been extensively explored. Kobayashi, Hiyama, Miura, et al., (2011) investigated target sizes for *tap* gestures on mobile touchscreen devices but considered only three different targets sizes for individual targets with no neighbors. Jin, Plocher and Kiff (2007) also conducted a study to evaluate touch target sizes for older adults, considering six different target sizes for both adjacent and non-adjacent targets, as well as five spacing sizes for adjacent targets. Although their study investigates *tap* gestures and target dimensions for older adults, it was conducted using a 17-inch touchscreen tablet fixed on a stand and

3 http://msdn.microsoft.com/en-us/library/hh202915(v=vs.92).aspx presented at a 45º angle to the participants. Therefore, these results are not applicable to mobile devices such as smartphones.

Our research aims to extend existing knowledge regarding older adults and touch targets on small touchscreen hand-held devices, namely regarding target sizes and spacing for *tap* and *swipe* gestures. In order to do so, the authors tested target sizes, and spacing sizes between targets with older adults for both adjacent and non-adjacent targets on a smartphone. Furthermore, the authors wanted to investigate if any difference exists between ideal target sizes according to two different types of common touchscreen gestures — *tap* and *swipe*. The outcome of this research was then compiled in the form of design patterns.

Design patterns have been found to be an efficient form of compiling and sharing HCI knowledge, both within multidisciplinary teams (Borchers, 2001; Dearden & Finlay, 2006; Erickson, 2000) and pedagogical environments (Borchers, 2002; Carvalhais, 2008; Koukouletsos, Khazaei, Dearden, & Ozcan, 2009; Laakso, 2003). For these reasons, the authors decided that design patterns would be the best form of sharing their findings with the community.

This paper introduces two patterns:

1. LARGE SIZE *TAP* TARGETS
2. LARGE SIZE *SWIPE* TARGETS

In the future, these patterns are intended to be part of a larger pattern language for designing user interfaces that are usable by older adults.

2. DISCOVERING TARGET SIZES AND SPACING BETWEEN TARGETS FOR SMARTPHONE USER INTERFACES (UIs) TARGETED AT OLDER ADULTS

The patterns presented in this paper are supported by tests conducted with older adults participants. Although large target sizes are generally used in interfaces targeted specifically at older adults, our own research aimed to assess the actual effectiveness of larger target sizes on older adults performance when interacting with smartphones. Accordingly, in order to investigate *tap* and *swipe* target sizes, we conducted a study with 40 older adults. The study consisted of two individual tasks — one for *tap* gestures and another for *swipe* gestures.

Given the necessary repetition of each gesture throughout both tasks, we decided to conduct the study by using two games that we thought would better motivate older adults to participate. Games have been found to provide enjoyable experiences, while motivating players to achieve a defined goal even when certain actions need to be extensively repeated (Lazzaro, 2008). Likewise, games have been found to benefit older adults by contributing to the improvement of reaction times, visuo-motor coordination, and quality of life (Torres, 2011).

Firstly, the *Tap* Game or *Insect Game* was played by smashing a target insect while avoiding other neighboring insects. Neighboring targets could be present or the target insect could appear alone. This intends to simulate occasions where only one button (non-adjacent target) occupies most of the interface (e.g., application login), or others where a set of targets (adjacent targets) is closely placed together (e.g., soft keyboard).

Next, the *Swipe* Game or *Helicopter Game* consisted of dragging a helicopter from one side of the screen toward a target located on the opposite side. Once again, the game simulated the existence of adjacent and non-adjacent targets, as would occur in the regular usage of a smartphone.

The following section provides further detail regarding participants, apparatus used, test procedure, and finally our main findings.

2.1 Participants

40 older adults (30 female and 10 male) aged from 65 to 95 (*Mean* = 76.88) years old were recruited from several day care centers within the city of Porto, Portugal. All participants completed the *tap* and *swipe* tasks, as well as filling out the post-session questionnaire.

2.2 Apparatus

All tests were performed on a *Samsung Nexus S* with a 52.32 mm by 87.12 mm display at 233 PPI. All participant data was logged on the smartphone itself, therefore there was no need to collect any audio or video during any of the sessions while also avoiding peripheral equipment that could hinder the participants' interaction with the smartphone.

2.3 Procedure

A within-subject design was used, in which two within-subject variables were included — touch target size and spacing between targets.

Based on the average size of a human fingerpad, which is about 10mm to 14mm (Dandekar, Raju, & Srinivasan, 2003), five levels of touch target size where used: 21mm, 17.5mm, 14mm, 10.5mm and 7mm. That is, target sizes considered the higher bound of the average human finger, which is 14mm and then added or subtracted 14/4 = 3.5mm in order to obtain the remaining sizes, e.g., 14 + 3.5 = 17.5 mm and 17.5 + 3.5 = 21 mm for the bigger sizes; the same procedure was used to find the smaller sizes.

Spacing between targets obeyed the same criteria and included another 5 levels: 0 mm, 3.5 mm, 7 mm, and10.5 mm, plus an additional level for non-adjacent targets (a single target with no neighbors).

Each factor was measured three times per participant. Resulting in 5 (sizes) x 5 (spacing sizes) x 3 (repetitions) = 75 *taps* for the first task and 75 *swipes* for the second task, per participant.

There were three dependent variables: accuracy, task completion time and number of errors per task. Accuracy was measured as the number of times a target was missed before correctly acquiring it, so if a participant tried to hit a target twice but only managed to do so on the third try, then accuracy would be 1 (accurate hit)/3 (tries) = 0.33%. Task completion time was considered as the average amount of time participants took to accurately complete a task, and finally, the error rate was only accounted for in the *swipe* task, and represents the number of times a target was dragged and released before reaching the destination mark.

All users completed both tasks. Each task consisted of a game which we thought would better motivate users to participate, given the high levels of gesture repetition that the tasks required.

Finally, each game assessed target sizes and spacing dimensions for one of two types of common gestures performed on existing smartphones — *tap* and *swipe.*

3. RESULTS

The following section presents individual results for the *Tap* Game, then for the *Swipe* Game, and finally we compare results for both tasks. Charts 1, 2, 3 and 4 provide an overview of our findings.

In general, target sizes were found to have had a significant effect on participants' performance, both regarding accuracy rates and task completion times. On the other hand, spacing between targets did not seem to influence participants' performance.

3.1 *Tap* game

A repeated measures Analysis of Variance (ANOVA) with a Greenhouse-Geisser correction showed that the mean accuracy measures for different button sizes was significant ($F(1.184, 46.160) = 46.914$, $P < 0.001$). Participants' mean accuracy decreased as target sizes got smaller. Mean accuracy was significantly lower for button sizes below 14 mm, although no significant differences where found for targets larger than 14 mm square. Our finding that older adults' accuracy decreases as targets get smaller is consistent with other studies conducted by Jin, Plocher and Kiff (2007) and Kobayashi, Hiyama, Miura et al., (2011). In addition, task completion time was also influenced by *tap* target sizes ($F(1.456, 56.770) = 24.895$, $P < 0.001$). Mean task completion times were higher for targets smaller than 14 mm square. A significant difference was also found between 17.5 mm and 14 mm size targets, where the bigger target resulted in longer task completion times.

Chart 1 Mean accuracy rates for the *Tap Game* according to target size and spacing size between targets

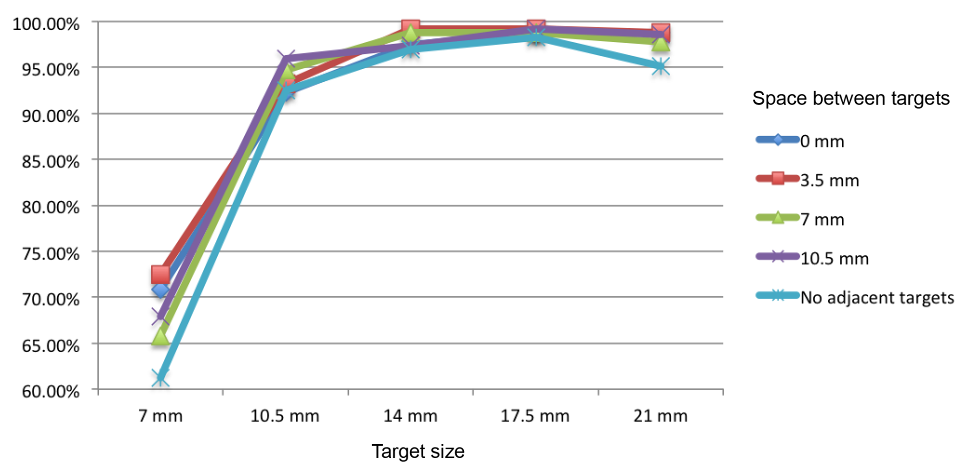
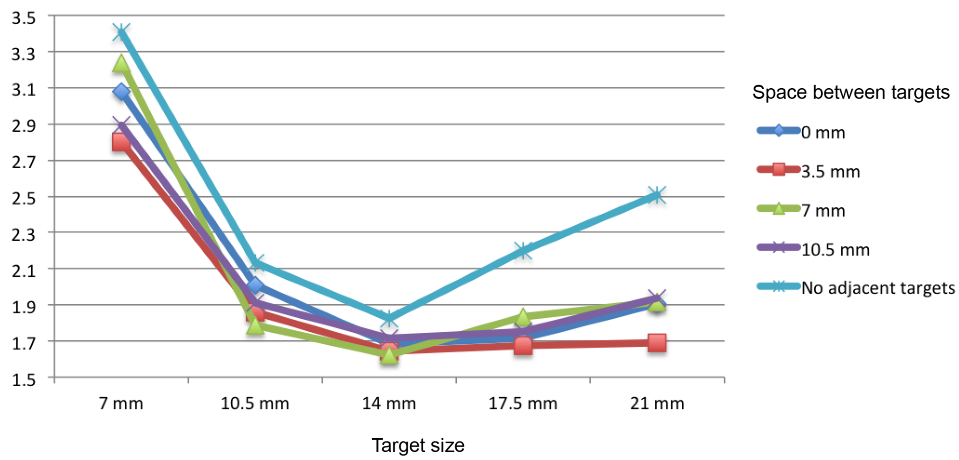


Chart 2 Mean task completion times for the *Tap Game* according to target size and spacing size between targets



3.2 *Swipe* Game

A repeated measures ANOVA with a Greenhouse-Geisser correction showed that the mean accuracy measures for different *swipe* target sizes was significant ($F(2.083, 81.247) = 16.809$, $P < 0.0001$). Mean accuracy measures decreased as target dimensions became smaller. Accuracy was significantly lower for *swipe* target sizes below 10.5 mm, but no significant differences were found for targets larger than this.
Contrary to the *Tap* Game, target sizes did not have a significant effect on the time it took participants to complete *swipe* tasks.

Chart 3 Mean accuracy rates for the *Swipe Game* according to target size and spacing size between targets

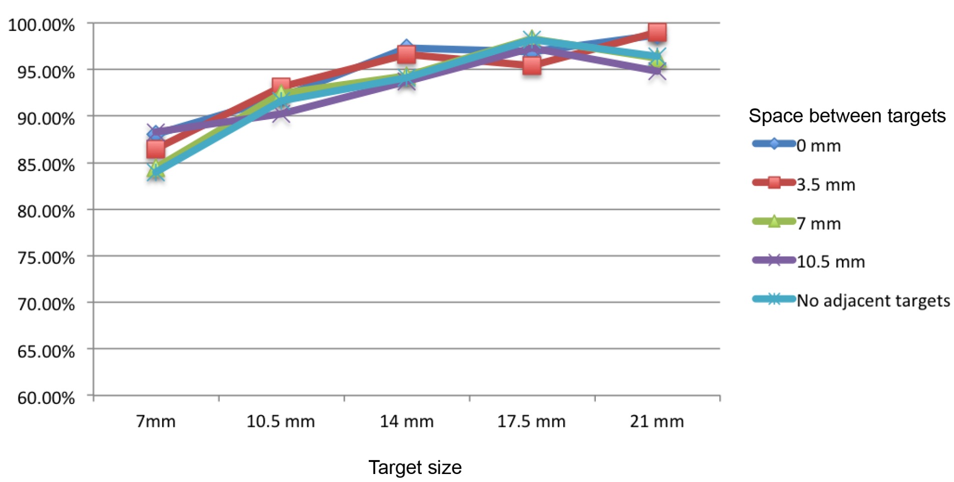
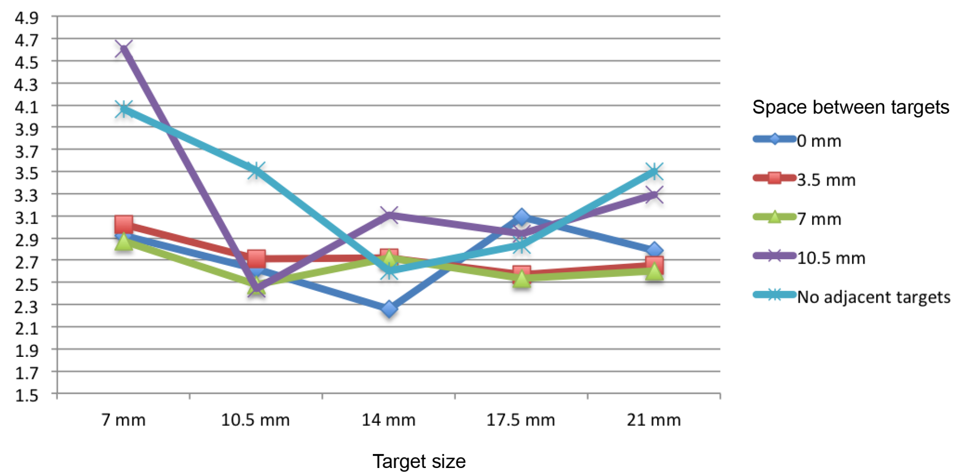


Chart 4 Mean task completion times for the *Swipe Game* according to target size and spacing size between targets



3.3 Comparison of *Tap* and *Swipe* results

For the purpose of developing patterns to guide UI designers in constructing more usable interfaces for older adults, satisfactory target sizes where considered as those with a mean accuracy rate over 97%. Consequently, for *tap* gestures that would include target sizes larger than 14mm square and for *swipe* gestures this value is slightly higher at 17.5 mm square. Lastly, spacing between targets did not show significant effects in either of the tasks.

4. PATTERN FORMAT

Our patterns largely follow the structure presented by Christopher Alexander *in A Pattern Language: Towns, Buildings, Construction* (1977), and that was later reused by Jan Borchers in *A Pattern Approach to Interaction Design* (2001).

Each pattern starts with its name written in small caps. An individual ranking is attributed to each pattern, representing the level of confidence that the authors deposit in it. This ranking can range from zero to two asterisks, where zero represents the lowest level of confidence and two represents the highest.

The pattern identification elements are followed by the context that describes the reader's current situation, as well as the goal of the pattern and the environment within which it is located. The title and context will give the reader an immediate perception whether the pattern is applicable, or not, to their particular problem.

After context is set, the problem statement is presented in bold and is followed by a longer problem description. It is in the problem description that contradicting forces are explained and the problem's empirical background is presented.

Next, the solution appears in bold. Then, examples of the solution applied in real-world interfaces close off the central body of the pattern, and aim to make the solution more understandable by providing a simple illustration of its real-world applicability. However, given the nature of our patterns, which focus on touch target sizes, the examples provided do not intend to be general examples of good interface design for older adults, but rather examples of interfaces that make use of large touch targets as a form of compensating for sensory and psychomotor age-related declines that impact the usability of a given interface.

5. DESIGN PATTERNS FOR CONSTRUCTING SMARTPHONE USER INTERFACES FOR OLDER ADULTS

5.1 LARGE SIZE *TAP* TARGETS **

… you are developing a smartphone user-interface (UI) targeted at older adults. This may be the first time you are designing for this specific audience, or you might already have some experience and have chosen to review the design decisions made in previous projects. You are now in a phase of the project where decisions need to be made regarding target sizes for *tap* gestures. Choosing target sizes for a particular gesture is an important decision as it will determine whether your intended users will, or not, be able to complete necessary actions and tasks throughout the flow of your UI.

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As a result of the ageing process, sensory and psychomotor capabilities undergo several declines and these alterations may render conventional *tap* target sizes as inadequate for older adults. In addition, existing smartphone OS guidelines[4] do not provide guidance concerning specific audiences, such as older adults.

Previous research has explored adequate target sizes for *tap* gestures on large touch-surfaces (Colle & Hiszem, 2004), PDAs (Parhi et al., 2006; Park et al., 2008; Perry & Hourcade, 2008; Sears & Zha, 2003) , or more recently on tablets (Jin et al., 2007) and smartphones (Henze et al., 2011), but very few have explored target sizes for older adults on smartphones. Consequently, most guidelines currently available guidelines[4] do not aid designers in creating a smartphone UIs that adequately responds to older adults' specific characteristics.

It is commonly accepted that visual acuity, contrast sensitivity, visual search capabilities (Fisk et al., 2009), fine-motor skills, hand dexterity (Carmeli et al., 2003) and touch sensitivity (Carmeli et al., 2003; Fisk et al., 2009; Nusbaum, 1999; Wickremaratchi & Llewelyn, 2006) suffer considerable losses with age. Additionally, natural age-related declines of the sensory and psychomotor systems can be further aggravated by diseases

4 Android: http://developer.android.com/design/style/metrics-grids.html
iPhone: https://developer.apple.com/library/ios/#documentation/UserExperience/Conceptual/MobileHIG/Characteristics/Characteristics.html
Windows Phone: http://msdn.microsoft.com/en-us/library/hh202889(v=VS.92).aspx

such as Age-related Macular Degeneration, cataracts, presbyopia and glaucoma — relative to visual abilities, and multiple sclerosis, arthritis, osteoporosis, stroke and Parkinson's disease — related to psychomotor issues (Kurniawan, 2008). Movement can be severely affected by these diseases, causing symptoms such as weakness, numbness, loss of muscle coordination, pain, stiffness, tremors, rigidity and slow movement. Therefore, one cannot safely assume that target sizes that have been found to be adequate for younger adults will also provide a comfortable user experience for the elderly.

It is clear that special considerations need to be taken into account when designing UIs for older adults. Targets for all gestures should be resized to fit the elderly population's particular characteristics. *Tap* target sizes are no exception. Our own research conducted with older adults revealed that their performance is best with targets between 14 and 17.5 mm square. While, official guidelines recommend targets between 7 and 9 mm square for *tap* gestures, which are considerably smaller than our own findings for older adults.

In accordance, many interfaces developed specifically for older adults make use of large *tap* targets. Below are examples of "Big Launcher"[5], "AlzNav"[6], "Smart Companion"[7], "Dance! Don't Fall"[8], "Phonotto"[9] — for Android, "WP for Senior Citizens"[10], "Big Button Dialer"[11] — for Windows Phone, and "Eye Read"[12] — for the iPhone. The authors do not intend to provide these applications as examples of effective interface design for older adults, but rather as examples of the usage of large *tap* targets with the objective of compensating for the previously mentioned sensory, and psychomotor age-related declines, that unfold with the ageing process. The use of large *tap* targets makes it easier for older adults to see targets, to distinguish between adjacent targets, as well as allowing them to more accurately acquire *tap* targets, as larger touchable areas compensate for issues related to movement control and hand dexterity.

In addition, as demonstrated by the examples below, although targets are larger than usual in interfaces designed specifically for older adults, they still may vary in size depending on the amount of targets that need to be displayed, on the available screen real estate to do so, as well as according to the relative importance of each target. For example, the targets shown in the dial-pads of "Phonotto" and "Big Button Dialer" are smaller than those presented in the home screens of "BIG Launcher" or "WP for Senior Citizens", as the amount of screen real estate available for such a large number of targets is limited; and as seen in "Smart Companion" and "AlzNav", although all targets are considerably large, information hierarchy also determines the relative size of each target, where more relevant targets tend to be larger. Accordingly, our own research showed that although

5 https://play.google.com/store/apps/details?id=name.kunes.android.launcher.activity&hl=en
6 https://play.google.com/store/apps/details?id=pt.fraunhofer.navigator&hl=en
7 http://smartcompanion.projects.fraunhofer.pt/
8 https://play.google.com/store/apps/details?id=pt.fraunhofer.dancedontfall&feature=search_result#?t=W251bGwsMSwxLDEsInB0LmZyYXVuaG9mZXIuZGFuY2Vkb250ZmFsbCJd
9 https://play.google.com/store/apps/details?id=com.gammapps.SimplePhone&feature=search_result#?t=W251bGwsMSwyLDEsImNvbS5nYW1tYXBwcy5TaW1wbGVQaG9uZSJd
10 http://www.windowsphone.com/en-GB/apps/b51b275f-3417-4b10-87fe-5db8717bf76f
11 http://www.windowsphone.com/en-US/apps/278ae89c-8d11-489b-8c98-517e6dd2b66b
12 http://itunes.apple.com/us/app/eyeread/id345271596?mt=8

accuracy rates decrease and task completion times increase as targets get smaller, older adults' performance measures still maintain themselves within acceptable levels for targets larger than 10.5 mm square.

Still, the relatively large size of these *tap* targets could raise issues related to the number of targets that need to be displayed and the available screen real estate to do so, which in turn could lead to the need to make certain compromises. One of these compromises could be to place all UI elements in a large scrollable VERTICAL LIST (Hoober & Berkman, 2011), or to divide the content into several pages — PAGINATION (Hoober & Berkman, 2011; Tidwell, 2010). However, opting for any of these solutions would either result in an increased number of necessary *swipes* to navigate a long list, or in a larger amount of navigation layers. In both cases, the complexity of the navigation system would increase and could in fact become an issue for older adult users, who have been found to have more difficulty in operating complex navigation systems (Ziefle, 2010; Ziefle & Bay, 2004). On the other hand, an alternative solution could be to reduce the number of functionalities and/or options included in your interface, thus avoiding the need for long list of items, or for an excessive amount of pages. However, while a reduced set of functionalities could be effective for your target older adult population — whom are likely to have low levels of technology proficiency, it might not be suitable for younger users who could be expecting a broader range of services from your interface.

Therefore...

If screen real estate is not an issue and the task requires high performance levels, use *tap* targets that are significantly larger than those found on conventional smartphone interfaces. However, in particular cases throughout the screen flow of your UI, where screen real estate is limited, and a decrease in older adults' performance measures is acceptable, it might be necessary to (a) use targets that are slightly smaller than the ones employed throughout the remainder of your UI, or (b) redistribute your content through PAGINATION (Hoober & Berkman, 2011; Tidwell, 2010), or into scrollable VERTICAL LISTs (Hoober & Berkman, 2011), or finally, (c) reduce the number of available funcionalties and options displayed on your interface.

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Tap targets can be BUTTONs (Hoober & Berkman, 2011), TABS (Hoober & Berkman, 2011), LINKs (Hoober & Berkman, 2011), INDICATORs (Hoober & Berkman, 2011) or KEYBOARDS & KEYPADAS (Hoober & Berkman, 2011). Whatever their particular form, these targets should appear to be "clickable" or actionable — ACTION BUTTON (Van Welie, 2008) — as to inform users of their specific functionality, as opposed to other static UI elements. In addition, when such targets are manipulated they should make use of HAPTIC OUTPUT (Hoober & Berkman, 2011) and/or auditory TONES (Hoober & Berkman, 2011) as the appropriate feedback to confirm interaction. Finally, when many related targets are necessary, consider making use of BUTTON GROUPS (Tidwell, 2010) to arrange clusters of similar targets in a logical way.

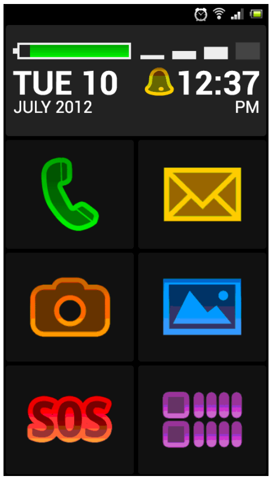

Fig. 1. *Big Launcher* for Android

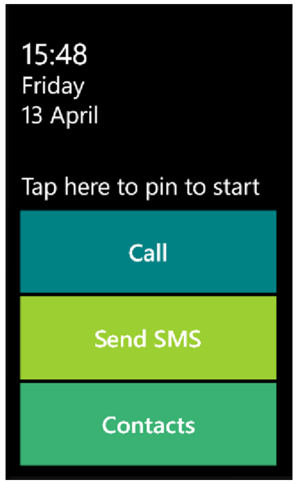

Fig. 2. *WP for Senior Citizens* for Windows Phone

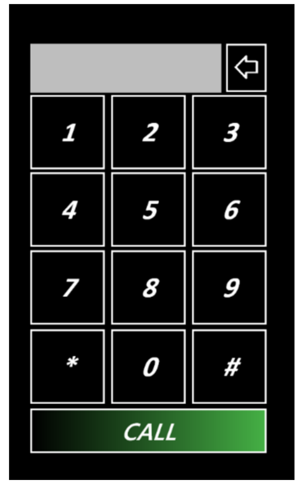

Fig. 3. *Big Button Dialer* for Windows Phone

Fig. 4. *AlzNav* for Android

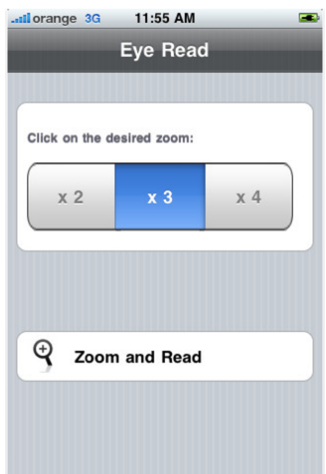

Fig. 5. *Eye Read* for iPhone

Fig. 6. *Smart Companion* for Android

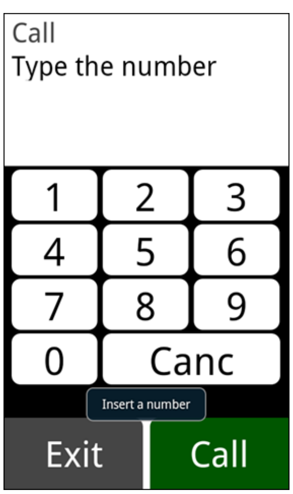

Fig. 7. *Phnotto* for Android

5.2 LARGE SIZE *SWIPE* TARGETS **

… Consider you have recently started prototyping the visual layout of a UI targeted at older adults. This might be a new audience, with which you have never worked before, or it is also possible that you already have considerable experience in designing for this user group but want to review strategies used in previous projects. You are now in a position where you need to decide on specific target sizes for *swipe* gestures. They are an important issue, as they will determine if your users will, or not, be able to complete many actions and tasks throughout the flow of your UI.

Selecting a range of target sizes that are most adequate for a given group of users requires a thorough understanding of their particular characteristics, expectations and preferences. Official smartphone OS guidelines such as, Window's "User Experience Design Guidelines"[13], Google's "Android Design"[14], and Apple's "iOS Human Interface Guidelines"[15] do not provide guidance in designing *swipe* targets for specific groups of users such as older adults.

These official guidelines recommend target sizes that are smaller than the average human finger (10 to 14mm) (Dandekar et al., 2003), raising issues such as target occlusion while performing a gesture and/or accidentally touching neighboring targets.

It is well accepted that visual acuity (Fisk et al., 2009), movement control, hand-eye coordination, hand dexterity (Carmeli et al., 2003) and touch sensitivity (Carmeli et al., 2003; Fisk et al., 2009; Nusbaum, 1999; Wickremaratchi & Llewelyn, 2006) suffer considerable losses during the aging process. Thus making it harder to see small targets and to perform the necessary movements in order to accurately acquire them.

Additionally, vision and psychomotor capabilities can be further compromised by common diseases among older adults such as Age-related Macular Degeneration, cataracts, presbyopia glaucoma — relative to visual abilities; and multiple sclerosis, arthritis, osteoporosis, stroke and Parkinson's disease — related to psychomotor issues. Movement can be severely affected by these diseases, causing symptoms such as weakness, numbness, loss of muscle coordination, pain, stiffness, tremors, rigidity and slow movement (Kurniawan, 2008).

Inevitably, accurately acquiring small targets becomes increasingly difficult as age progresses. Providing targets that are too small makes a UI more difficult to use and could result in frustration and anxiety among older adults (Czaja & Sharit, 1998; Laguna & Babcock, 1997; Turner, Turner, & Van De Walle, 2007) and should therefore be avoided.

Our own research conducted with older adults revealed that performance was best for *swipe* targets larger than 17.5 mm square. When compared with the findings for *tap* targets, where

13 http://msdn.microsoft.com/en-us/library/hh202915(v=vs.92).aspx
14 http://developer.android.com/design/index.html
15 http://developer.apple.com/library/ios/#DOCUMENTATION/UserExperience/Conceptual/MobileHIG/Introduction/Introduction.html

best performance was found for targets larger than 14 mm square, it seems that the end intention of a movement — whether to finalize in a *tap* or in a *swipe* — influences older adults accuracy and the time they take to correctly acquire touch targets.

Accordingly, many interfaces specifically designed for older adults make use of large *swipe* targets. Below are examples of "iDown"[16], "Guardly"[17], and "Pillboxie"[18]. Although the authors do not intend that these be examples of effective interface design for older adults, their use of large *swipe* targets makes it easier for older adults to see targets, to distinguish between them, as well as to correctly acquire them. The larger touchable areas compensate for movement control and hand dexterity issues that occur with age. Therefore, allowing for easier interaction with, and manipulation of a touch interface.

However, the use of large *swipe* targets throughout an interface might not always be possible due to screen real estate limitations, which are often an issue on mobile UIs. For example, in cases where many targets are needed on a particular screen, it might be necessary to recur to techniques such as PAGINATION (Hoober & Berkman, 2011; Tidwell, 2010), or a VERTICAL LIST (Hoober & Berkman, 2011), as forms of accommodating all the information that needs to be displayed. In turn, these solutions force the user to either perform more *taps* to select a page, or more *swipes* to scroll a long list. Thus, in any of these situations, navigating the content might become frustrating for users in general, and for older adults in particular (Ziefle, 2010; Ziefle & Bay, 2004) as many actions are needed to access several layers of hidden content. In this context, as an alternative to creating overly complex navigations mechanisms, it might be necessary to restrict the number of options and/or functionalities provided, as a form of reducing the number of targets that need to be displayed. However, when restricting the available functionalities, UI designers should be aware of potentially excluding younger, and more technology proficient users, who could be expecting a broader set of functionalities. On the other hand, as previously mentioned, if the complex navigation mechanisms needed to accommodate a larger number of targets are indeed implemented, the UI might exclude older adult users (Ziefle, 2010; Ziefle & Bay, 2004).

Therefore...

In cases where available screen space for *swipe* targets is not an issue and the task requires high performance measures, use large *swipe* target sizes. Otherwise, you might need to (a) redistribute the UI content through PAGINATION, or a VERTICAL LIST, or (b) limit the provided functionalities, in order to accommodate *swipe* targets that are sufficiently large for older adult users.

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Swipe targets can be of many different kinds — CAROUSELs (Tidwell, 2010;Hoober & Berkman, 2011), FILM STRIPs (Hoober & Berkman, 2011; Tidwell, 2010), SLIDESHOWs (Hoober & Berkman, 2011), SCROLL (Hoober & Berkman, 2011) bars, ALPHABET SCROLLERs

16 http://itunes.apple.com/us/app/idown/id374806701?mt=8
17 http://itunes.apple.com/us/app/guardly/id400742014?mt=8
18 http://itunes.apple.com/ca/app/pillboxie/id417367089?mt=8

(Tidwell, 2010), and MECHANICAL STYLE CONTROLS (Hoober & Berkman, 2011) such as sliders, and spinners. Whatever their form, consider implementing these targets in addition with HAPTIC OUTPUT (Hoober & Berkman, 2011) and/or auditory TONES (Hoober & Berkman, 2011), as forms of providing the appropriate feedback to users. Finally, when many related target are necessary consider using BUTTON GROUPS (Tidwell, 2010) in order to logically group sets of similar targets.

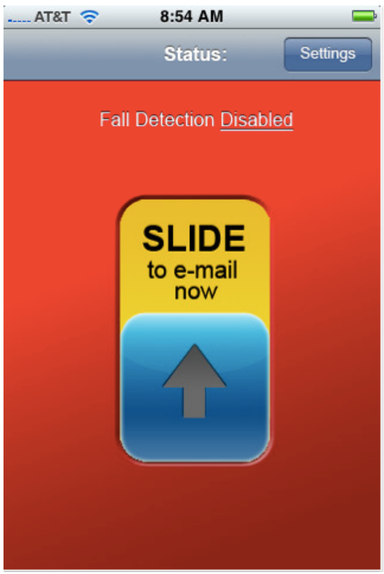

Fig. 8. *iDown* for the iPhone

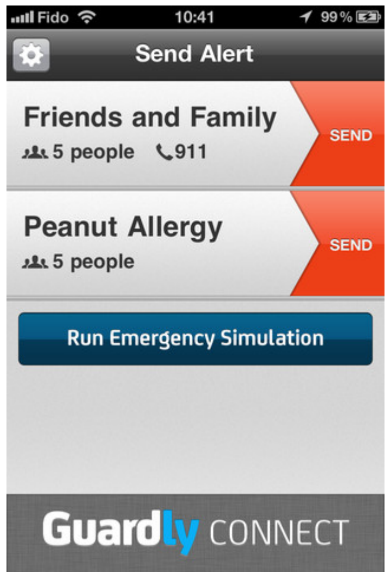

Fig. 9. *Guardly* for the iPhone

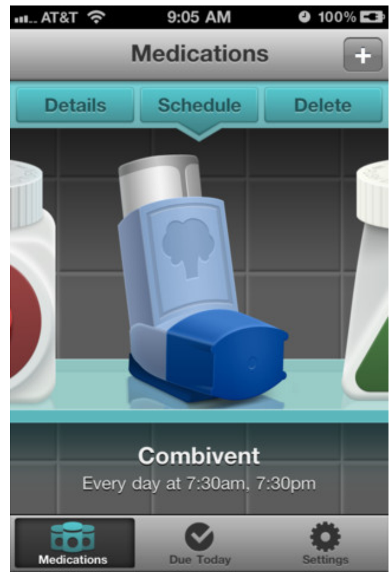

Fig.10. *Pillboxie* for the iPhone

6. CONCLUSIONS AND FUTURE WORK

The two patterns here presented explore the use of large size *tap* and *swipe* targets as a means for compensating for visual and motor issues that occur with ageing. The smartphone UI examples presented in these patterns intend to demonstrate the use of large touch target sizes in UIs specifically developed for older adults, however, the authors do not intend that these examples be understood as general good UI design for older adults. In the future, the authors aim is that these patterns be the starting point of a larger pattern language, that will be aimed at UI developers and designers, as well as teachers and students interested in learning about or designing smartphone user interfaces for older adults.

It is the authors' intention to extend our research by conducting further tests with users. Accordingly, the next step of this research will be to evaluate screen comfort zones for both *tap* and *swipe* gestures for older adults using smartphones. Additionally, the authors plan to assess performance rates for both direction and orientation of *swipe* gestures in order to provide a set of comprehensive patterns regarding gesture performance, target sizes, target spacing sizes, and comfortable activity zones, on small mobile touchscreens for older adults.

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