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Design and evaluation of a mobile user interface for older adults: navigation, interaction and visual design recommendations

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Abstract

Smartphones are becoming increasingly widespread around the globe and are ever more accessible to everyone, including older adults, who are traditionally seen as experiencing difficulties in interacting with information and communication technologies. While these devices are increasingly being used to cover health needs, there are not sufficient studies addressing usability of smartphone user interfaces for older adults. This paper describes the design and evaluation process of the user interface of a smartphone application designed to promote exercise and prevent falls amongst older adults. Iteratively, three successive versions of the user interfaces were tested with different groups of older adults. The results and findings from three rounds of usability tests led to recommendations regarding inclusive design and designing for older adults that may be a useful contribution to the broader community when designing interfaces for smartphones.

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Keywords: Older adults; usability tests; recommendations; smartphone; user interfaces.

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1. Introduction

The population in industrialized countries is older than ever, and it is expected to get even older[1,2]. Today's seniors are living longer, are healthier, wealthier, have a better academic education, and are more experienced with technology. The life expectancy of the Portuguese population has been rising, with current estimates of 81.8 years for women and 75.9 years for men[3]. As a result of advances in healthcare and improvements in working conditions, seniors are enjoying a healthier life after retirement. Despite still being quite low, the average value of pensions in Portugal is five times greater than it was twenty years ago[4], thus allowing for greater purchasing power amongst older adults. The number of individuals with the first cycle of basic education has also been gradually increasing[4]. Since most interactive devices require that users be able to read in order to use them, many of today's seniors have the basic skills that allow them to use most interactive devices, and thus, are more likely to already be familiar with computers, mobile devices, and related technology.

Smartphones are more prevalent than ever, and there is a tendency towards growth. Smartphones already account for 57% of the market share of mobile devices in the EU5 and nearly 75% of phones acquired in December 2012 were smartphones[5]. In the U.S., 14.6% of people over the age of 55 own a smartphone, while in the EU5 region this percentage is slightly higher, with 18.9% of smartphone users being over the age 55[6]. Along with an ageing population, and the opportunities presented by smartphones, solutions that reflect on the needs of this particular user group are in demand.

Amongst older adults the risk of falling is a common and serious concern. As people age they start to show lower levels of physical activity, and are affected by physiological changes that alter their postural stability[7]. This increases risk of falls amongst seniors. Doctors can assess seniors' fall risk through clinical tests in which patients have to complete some simple movements and answer questionnaires[8,9]. However, these are rarely performed on a regular basis, and thus, ineffective in detecting sudden changes. Staying active is important to counteract possible increases in the risk of falling. Given that older adults often enjoy dancing[10], and that they are capable of interacting with mobile devices, a dance game can be employed as a method to administer clinical tests that assess the fall risk, and simultaneously promote physical activity, amongst seniors.

While these potential benefits exist, they will be rendered ineffective is older adults are not able to interact with such game. It is known that older adults often experience difficulties in interacting with technology, namely smartphones, and that designers should place special care in how User Interfaces (UIs) are designed, so that they are accessible, usable and inclusive[11]. At the moment there are already guidelines and recommendations towards designing UIs for older adults[12,13]. Nevertheless, UIs should undergo thorough testing for validation amongst the intended audience. While there are older adult specific guidelines for general graphical user interface (GUI) elements, content display or for specific devices[14,15,16], literature is still scarce on examples of and recommendations for smartphone use interfaces for older adults.

This paper explores the design process of a dance and fall risk assessment application for the Windows Phone 7 (WP7) platform, targeted at older adults, that aims to address the aforementioned usability concerns. This document briefly describes the application, and details the methodology followed during iterative testing with older adults. We address each one of tests conducted and report our main findings. The design and evaluation of the UIs covered different aspects of older adults' interaction with the application, ranging from layout, over to navigation and wording. Each test led to improvements that were subsequently tested. Based on the findings, we propose general recommendations for the design of a mobile interface targeted at older adults. Even though some of the recommendations are specific to the WP7 platform we believe that most of them can be generalized to the design of mobile interfaces and may be useful to other designers working with and for older adults.

2. The application: Dance! Don't Fall

The game, *Dance! Don't Fall,* is based on technology developed by Fraunhofer AICOS that enables a smartphone to run a gait test using its sensors[17]. The WP7 version, grounded on the fundamentals of an Android version of the same game[18], is the subject of this paper. The game monitors users' performance in order to assess their risk of falling. The game aims to prevent falls, and to foster physical exercise among older adults. Users can

either dance alone, or enter a dance competition against their friends. The goal of the competition mode is to promote social activity, and to motivate seniors to continue dancing by allowing them to compare results with friends and family. In order to play the game, users need to attach a smartphone to their lower backs while they are dancing, and follow the dance steps on a Google TV. While users are dancing, the phone's sensors are collecting data and processing them according to four different attributes: accuracy, timing, stability and grooviness. The fall risk is then assessed based on the quality of users' locomotion and supplemented by a brief clinical questionnaire that appears when users may be at risk.

In order to fully experience the game, users must be able to interact with the smartphone and the TV. This paper focuses on the design and usability evaluation of the smartphone UIs and does not reach the point of testing the whole system. This presented a challenge: even though we have tried to tap semantics, this proved hard to achieve without a complete experience of the game. We, nevertheless, present the results regarding wording and semantics, but we mostly focus on interaction and navigation.

3. Methodology

Overall, all tests followed the same basic procedures. Tests took place at local day-care centres from where participants were recruited, and each test lasted about twenty minutes. Participants did not own a smartphone or any other touch device, but some were familiar with smartphone from previous usability tests. Tests were conducted with an HTC Titan (with a 4.7' screen) or with an HTC Radar (with a 3.8' screen) running WP7 and the testing material was only available in portrait. Two researchers were present during the sessions. Each would introduce the session, deal with the informed consents, and then conduct the session itself. Each session was organized in the following parts: 1) introduction; 2) teaching and training vertical and horizontal *swipes*; 3) tasks; 4) user satisfaction questionnaire; and 5) debriefing. Sessions were devised with tasks according to previously defined research questions, e.g. "Input shoe size" to assess the usability WP7 List Pickers. The teaching materials are described in detail in Leitão (2012)[19] and the general protocol followed existing guidelines for usability testing with older adults[20].

Sessions were video recorded and later analysed. These resources were then used to measure tasks and allow for a detailed analysis of participants' performance. For each participant the following data were assessed: 1) task completion; 2) task completion time; 3) number of errors per task; 4) time necessary to recover from an error; 5) notes and comments for qualitative analyses; and 6) answers from the user satisfaction questionnaire.

4. Test sessions

4.1. Session 1

The first series of usability tests aimed at evaluating the interaction paradigms of WP7, namely the Panorama and Pivot controls, to evaluate the system structure, and to evaluate ease of interaction. Nine participants agreed to take part in the study and signed the informed consent: two men and seven women, with ages between 65 and 92 and mean age of 80.7.

Participants were divided into two groups and each tested one of two prototypes presenting the typical navigation options provided by WP7[21]: Panorama or Panorama along with Pivot controls (Figure 1).

Figure 1 Panorama version on the left, Panorama with pivot controls version on the right.

4.1.1. Findings from session 1

The results from the first series of tests revealed how difficult it is for seniors to understand the navigation models of WP7 – the Panorama and Pivot controls. The organization and hierarchy of Panorama controls did not appear to be grasped with ease, and participants seemed to be expecting the application's main options to appear on a home screen, as they complained about not finding the options they were expecting on the screen that first appeared when the application was launched. In the case of the Pivot controls, participants did not perceive the partially hidden headings as actionable buttons, nor did they *swipe* to reveal content hidden to the left or right sides of the screen. There is not enough contrast in these headings, and in most cases, the text is not legible because the word is cropped Figure 1. Since the size of headings is controlled programmatically, it is not possible to control how they are displayed.

While performing *swipes* participants tended to drag objects rather than trying to drag the whole screen. Older adults did not seem to have internalized the interaction model of swiping, but rather perceived elements on the screen as figures or ground. Accordingly, they apply their knowledge about the behaviour of real-world objects: in the physical world one does not move the environment, only the objects on it. For instance, when an object was partially hidden, they tended to try and press that element in order to drag it into sight. In cases where content was hidden to the bottom of the screen, participants would often accidentally trigger the phone's hardware buttons while trying to select the partially hidden item and drag it into view.

Another interesting finding was that older adults tended to press icons, not the text associated with it. The WP7 interface relies heavily on text as button, but strictly textual buttons did not seem to convey the correct affordance to this group of participants.

4.2. Session 2

The results from the previous usability tests with older adults led us to conclude that Panorama and Pivot controls would not fit the application's purpose and could in fact be undesirable in terms of user experience. Accordingly, the new interface explored the effectiveness of a more traditional interface, with a home screen that displays the application's main options on launch (Figure 2). The second round of tests targeted the evaluation of: 1) system structure; 2) ease of interaction; 3) wording choices; 4) text input. We recruited a different group of nine participants: five men and four women, with ages between 68 and 89 and a mean age of 76.4.

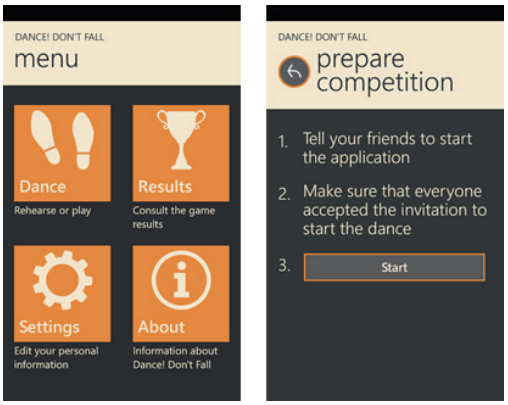

Figure 2 Second prototype: Home screen on the left and 'Prepare competition' screen on the right.

4.2.1. Findings from session 2

Participants were able to understand the new concept for the home screen. They were able to navigate through the application hierarchy and go back and forward as needed. This new layout was found to be easier to use than the previous version. This is shown by the time spent in wrong actions while trying to navigate to the intended screen: in session 1 participants spent an average of 1 minutes and 17 seconds to find the 'Results' page that was displayed on the Home menu; in session 2 participants spent an average ten seconds to find the item 'Compete' that was found on a second layer of the application (within the 'Dance' menu).

In tune with previous usability test results, participants pressed the icons within the buttons, and not the text associated with it. In addition, participants continued to accidentally hit the phone's hardware keys when trying to perform vertical *swipes* or when pointing to elements on screen while reading. Two participants triggered the keyboard by accident while trying to perform a vertical *swipe*. Therefore, on the following iteration, a horizontal bar was added to the lower end of the screen (except on the home screen), to highlight the bottom of the screen and try to prevent users from accidentally tapping the hardware keys (Figure 3).

Participants had a hard time using the virtual keyboard: 1) they could not find the letters – they commented on them not being in alphabetical order; 2) they could not read the characters, which were too small; 3) they could not hit the correct key – they would either hit the key to the side or to the bottom.

Participants read all the information provided in each screen. This was evident in a screen with numbered instructions where participants read all the instructions out loud before tapping the "Start" button at the end (Figure 2).

As expected, since participants did not get the chance to experience the full game and dancing to the instructions provided by the TV, some terms did not seem to fit into older adults' semantic field around 'dancing'. For instance, participants did not seem to associate dancing with competing and producing results. They also did not see the possibility of 'dancing against someone' as natural. Moreover, older adults did not seem to be familiar with wording related to games when associated with dancing (e.g. they did not see themselves as playing a game, but as dancing). Based on participants' comments, the wording was then worked upon in order to fit older adults' semantic field around dancing.

Perhaps due to the age group, the act of dancing is not associated with an individual activity, but rather with an activity performed in pairs. As such, participants reported not being at ease with the concept of 'Dancing with other players', as for them it is obvious that dancing is not an activity they would perform alone, but rather with another person to form a couple.

4.3. Session 3

The third round of usability tests was used to evaluate the changes made to the interface as a result of the findings from the previous phase, with emphasis on: 1) the semantic analysis of the wordings used in the interface; 2) the intelligibility of icons; and 3) the ease of use of WP7 List Pickers. This round was conducted with seven older adults, with ages between 65 and 96 (mean = 84.4).

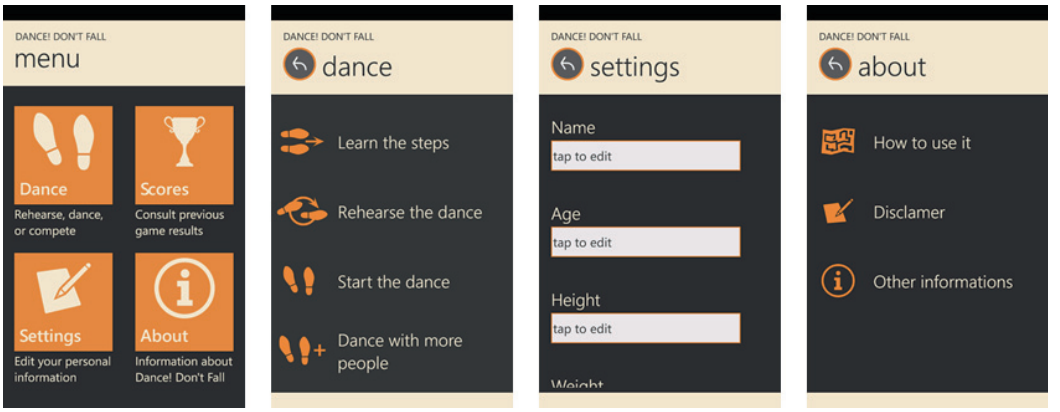

Figure 3 Third prototype screens (from left to right): Home, Dance, Settings, About.

4.3.1. Findings from session 3

Preliminary results regarding wording choices led us to conclude that, for participants, the difference between 'Learn the steps' and 'Rehearse the dance' seemed unclear. Participants also found it slightly easier to grasp the intended meaning of 'edition' on the 'Settings' option. The icon used in this session (Figure 3) seemed slightly more effective in this case than the more conventional 'clock wheels' (Figure 2).

Participants seemed to have trouble in associating different gestures with different tasks. Once they learned how to perform a *swipe* gesture, they would try to *swipe* items to select them. They did not seem to understand that *tap* is used to select or activate actionable items, while *swipe* is used to scroll lists. Accordingly, they would often try to *swipe* over menu buttons.

Participants were not familiar with the concept of navigating back to the main menu. They seemed not to understand the concept of entering a certain section, or a second navigation level, and then being able to go back to the first level. Accordingly, six out of seven participants tapped icons on the screen when trying to navigate back to the main menu. Also, three participants tried scrolling up to reveal the previous screen, suggesting that they expected all the content to be on the same page, either higher up or lower down according to the page hierarchy. Even still, the average for task completion reached 100% (Table 1).

For this version of the application, the space between selectable items was increased with the intention of avoiding accidental presses on items while scrolling. The results suggest that the use of generous spacing between items does seem to contribute positively to avoid accidental presses on the text fields.

None of the participants were able to use the WP7 List Picker controls without help from the test facilitator. It is our understanding that this could be due to the lack of affordances on these pickers, which have no arrow, nor any other indication that they can indeed be pressed.

Table 1. Comparison of task performance results: Session 2 and Session 3.

Task description	Test	Session 2	Session 3
Find 'results' page	Tap	100%	100%
Find results for a specific day	Vertical swipe	88.89%	100%

Return to homepage (1)	UI back button	55.56%	100%
Find screen to insert personal data	Wording choice	88.89%	100%
Return to homepage (2)	UI back button (retention)	57.14%	100%
Find 'compete' option	Hierarchy	55.56%	100%

Although none of the participants were able to immediately understand or make use of either the hardware or the UI back buttons, they were still able to learn how to use the back button to navigate through the application after being asked if they could not find any interface element that would allow them to go back to the main menu, or after a demonstration from the facilitator. In addition, after learning how to use the back buttons, many participants would start making use of them in situations where they did not know what else to do. Accordingly, this finding leads us to believe that the back button is important as a "fail safe" mechanism, that older adults rely on when they do not know how to solve a given problem.

Overall, participants were able to identify, and distinguish between button controls and non-actionable targets. However, they had trouble in identifying and operating WP7 List Pickers, and in some cases, participants tried to *tap* or *swipe* over regular text. As previously mentioned, the trouble in identifying WP7 List Pickers could be related to the lack of affordances of these controls; whereas the problem with the wrong *taps* and *swipes* related to the false affordances of these elements.

Although this group of participants was not familiar with gestural interaction, four participants were able to perform a scroll action without the facilitator's help. However, the remaining participants were able to perform a vertical scroll action only after being reminded that additional content could in fact be hidden from view. Accordingly, it seems that scrolling might not be an issue for older adults, as long as a previous demonstration of this gesture exists. This demonstration is needed[22] because the interface does not clearly expose the available gestures, and therefore older adults are not immediately aware of how they can manipulate the interface.

5. Recommendations

5.1. Navigation

5.1.1. Be cautious about the use of Panorama and Pivot controls

Our results suggest that Panorama and Pivot controls should not be used when designing for older adults, or at least, they should be used with caution and carefully tested. Older adults in our tests had a hard time using these default navigation controls, as it was difficult for them to develop a mental model of the organization and hierarchy of these components.

5.1.2. Use the home screen menu as a safe point of return

In accordance with the previous recommendation, display all of the application's main categories on the start screen so that users are able to more easily understand hierarchies and system structure. Use this screen to provide a safe point of return and a sort of table of contents.

5.2. Interaction

5.2.1. Use the back button as a safeguard for older adults

After learning how to use the back buttons, either on their own or after a demonstration from the test facilitator, participants were able to use these to navigate through the application structure. Also, participants seemed to use the back button when disoriented. Therefore, test results lead us to believe that the back button is important as a fall-back mechanism that older adults rely on when they do not know how to solve a given problem.

5.2.2. Take advantage of scrolling if the application requires it

Our results suggest that, after being taught how to do it, older adults are able to perform a *swipe* gesture to navigate an interface. Given that *swiping* to scroll might not be an issue for older adults, it could be possible to make use of it without the need of additional visual aids, such as arrows on the screen.

5.2.3. The use of the keyboard should be minimized

Keyboard usage should be minimized, because it was found to be a very tedious and error prone task for this user group. Although there is no real alternative the QWERTY keyboard, which was found to be unfamiliar to users, alternative approaches to data input should be sought. Components such as pickers (provided that they convey the right affordance) or checkboxes can be explored as a worthwhile alternative. The virtual keyboard layout should also adapt to the type of content whenever possible, for instance, by using a number keypad when only numbers are required. Nevertheless, all of these options should be subject to further testing.

5.2.4. Use wordings that suit older adults' semantic field

The wordings used in the interface should correspond to older adults' vocabulary and take into account, to the widest extent possible, the context in which the application is used. The choice of words needs to account for the differences in educational and cultural backgrounds, and should be further tested with actual users in a scenario closer to real use.

5.3. Visual Design

5.3.1. Provide generous spacing between items

Generous spacing between actionable items is recommended, in particular if the page allows scrolling. Our tests suggest that, on long pages with several actionable items, additional spacing between items prevents indeed accidental presses. User interface guidelines for WP7[23] already address this issue and recommend minimum spacing between adjacent elements; however, these recommendations do not account for the peculiarities of designing interfaces for older adults. The decision regarding the exact gap size between elements, as well as the dimensions of the button itself, should be based on recommendations for the design of buttons that target older adults[22], and tested with actual users.

5.3.2. Use icons along with text when designing buttons

In possible, make use of icons next to textual labels in order to improve the affordance of elements. Given the results from our evaluation with users, we can conclude that older adults prefer to tap the icon even when both the icon and text work as a button. Although textual buttons are common, they might not always convey the right affordances to older adults, and can mislead users to regard those buttons as non-actionable information. Consequently, also make sure that both the icon and the text trigger the same action; they should be working as a single element.

5.3.3. Be cautious about the positioning of interactive elements towards the edge of the screen

When positioning elements on the screen take into account how older adults interact with the device, and how that can lead to unnecessary problems. For instance, interactive elements positioned towards the bottom edge of the screen can lead participants to trigger the phone's soft buttons by mistake.

6. Conclusions and future work

This paper has described the procedures and findings within the design and evaluation of UIs for older adults. These findings were compiled into recommendations regarding navigation, interaction and visual design aspects of mobile UIs targeted at older adults. Literature offers guidelines and recommendations for designing for older adults. Nevertheless, we believe our tests have contributed to existing knowledge on this particular subject.

Even though some issues were tested in more than one round, further tests could be needed to confirm certain findings or to test alternatives to elements that represent nuisances or barriers to older adults' interaction with the smartphone. Furthermore, even though we have sought to gather a diverse group of older adults, the samples used may not be representative of older adults in general. Older adults in Portugal tend to be less familiarized with information and communication technologies as compared to other countries and there are high levels of low literacy – characteristics which may convert these samples into particular ones.

This series of tests covered usability issues. However, given that the application is indeed a game, future work should focus on user experience. These aspects should be accounted for and tested, preferably within a real context of use.

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