Design of a Social Game for Older Users Using Touchscreen Devices and Observations from an Exploratory Study

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Abstract. Previous studies about tactile interaction by older adults show some important design considerations that should be applied in order to create more usable and accessible applications. The related results have been applied during the development of a serious game destined to support a social activity with older adults using touchscreen devices. An exploratory study investigates the use of touchscreen mobile devices by 17 older adults and 5 children. The results of an empirical observation allow a description of the participants' appreciation of touchscreen devices, a typology of common errors, the gesture strategies of tactile interaction and design proposals to support interaction.

Keywords: Serious game, interaction techniques, touchscreen, older adults, interaction error, participative user-centered method.

1 Introduction

Older adults' attitudes towards new technologies can interfere the way they perceive and interact with technologies. The subjective evaluation of handiness, control and ease of use of technologies can prevent from anxiety, misgivings and reluctance [1]. Touchscreen devices are perceived as ready-to-use and manipulate thanks to the mobility of the devices and direct interaction on the display screen [2]. Besides, the popularization of touchscreen mobile devices and their perceived usefulness are impacting their acceptance and older adults' motivations.

Digital games have entertainment and therapeutic values for older users [3]. They could be used to learn interaction techniques, prevent from technological exclusion and support social activities.

In order to evaluate the use of social and ludic activities to facilitate the discovering of touchscreen devices, we designed a serious game. The system "Puzzle Touch" is consisted of tactile puzzle games. The pieces of the puzzle representing parts of an image should be re-arranged by tactile interaction. The images used for the puzzle

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games represented views of the city where the participants live in, extracted from old pictures, postcards, maps and engravings provided by the city hall archives.

Age-related changes on functional skills and little experience with technologies are pointed out as factors affecting usability issues of digital games [3]. Besides, older users special needs and difficulties have to be taken into account when designing or developing applications destined to their use. Several studies evaluated interaction techniques and interfaces for older adults and they provide important information to conceive more accessible and usable interactive systems.

This paper describes how the results of previous experiments were applied during the design of the social game "Puzzle Touch".

This game was installed on 7 handheld touchscreen devices with different screen sizes (3.5 to 10 inches) and allowing pen or finger interaction. 17 older adults (58 to 85 years old) participated of this exploratory study. 5 children (9 years old) were invited to join one group of participants in order to create inter-generational activity. The activity took place in a public place where the participants were used to take computer lessons.

The next section 2 presents some related work. Then, the conception phase presents how the related studies results have been included on the development of this system, on section 3. Our exploratory study is presented on section 4. Section 5 presents the results of this study, including participant's appreciation, a typology of common errors and an analysis of gesture strategies. Finally, section 6 presents a conclusion and some perspectives for future work.

2 Related Work

Several studies evaluated interaction techniques for older adults using touchscreen devices and provided guidelines and recommendations for conceiving more accessible and usable systems and applications [4–11]. Literature review about tactile interaction of older users shows that several parameters should be taken into account during the design phases of an application [12]. Some reviews focus on one specific situations of use, as recommendations for mobile phones [13] or the use of handheld computers [14].

Older adults are a heterogeneous populations due to the individual age related changes and the evolution of their characteristics [15, 16]. Several studies suggest participatory activities to conceive devices and systems, including future users during the development phases to get their point of view and feedback [14, 17]. However it is not easy to include older users on research studies [17]. One of the reasons is transport or displacement to the university or laboratory. Besides, controlled activities can be used for specific studies but they are sometimes very different than ecological and realistic situations of use. Some authors proposed group studies or working in pairs during the experiments in order to help users feel comfortable and observe the possibilities of partnership and support [18–20].

Older users could really benefit from some advantages of touchscreen and handheld portable devices. In addition to health care and medical assistance applications

[2, 21], games and ludic activities can be helpful to maintain social activities and networks [3, 22], providing cognitive stimulation and also initiating new users to technologies.

The next section describes how the results of previous studies about interaction techniques for older adults using touchscreen have been applied for conceiving a system destined to support a social activity with older users. Then, an exploratory study is conducted on a familiar place where participants were used to take computer lessons.

3 Conception of a System to Support a Social Activity with Older Users Using Touchscreen Mobile Devices

The objective of this system is to help older adults discovering touchscreen handheld devices and learning tactile interaction techniques. The serious game "Puzzle Touch" should also support a social activity, facilitating the acceptance and affecting user's attitudes towards new technologies. The observation of the interactions should provide information about the users' difficulties and strategies.

The system should be suitable to the different screen sizes of handheld devices. The chosen orientation mode is portrait so right handed and left handed users could use the same gestures. This configuration has also been successfully used in two previous studies [7, 22], by consequent targets will be initially placed at the bottom of the screen.

The system should support pen and finger interaction. This first version is single-touch: only one piece should be moved at the time.

Some studies about the gestures of interaction of older users indicate a preference for long gestures instead of taps [1, 8, 23, 24]. This system simulate drag and drop on the touch screen: the user touches to select a piece and slips his finger or pen through the screen to move the target (drag). When the user releases the touch, the target stops moving (drop).

Most studies about better target sizes concern only tap interaction. Tapping for selecting targets on vertical monitors (17 inches screen), authors recommend 16 mm targets width and 3 to 6 mm spacing for older users without motor impairment [4]. As the available handheld devices have smaller screen sizes, the system "Puzzle Touch" uses smaller targets sizes. One study concerning tap gestures on a small screen (4.3 inches) compares 5, 8 and 12 mm width targets for 9 targets placed on a 3x3 grid. Target spacing compared is 1 and 3 mm between targets. Authors describe better results when touch selection is followed by audio or audio tactile feedback and bigger target sizes [5]. Another study used 6 mm width targets on small screens size (3.7 inches) during digit input tasks. Results show better performances when the touch is followed by a magnifying visual feedback [9].

For this system, target sizes vary according to the number of puzzle pieces and the screen sizes. The system presents different numbers of targets: 9 large, 12 medium or 16 small pieces according to the game options. As the puzzle pieces are placed randomly in the bottom of the screen, it is not be possible to generate enough spacing

between targets and targets can overlay. Our proposal is to add a visual feedback (the touched target is placed on the top of the others) and a thick black border (1 mm) replacing the space between targets (Fig. 1). Target sizes according to the number of puzzle pieces and the screen sizes are detailed on the Table 1.

Table 1. Target sizes according to the screen sizes of two different devices, Galaxy Note II (WXGA 1280x720 Super AMOLED) and Galaxy Note 10.1 (WXGA 1280x800 LCD)

Number of targets	Target sizes on 5 inch screen	Target sizes on 10 inch screen
9	25x16 mm	46x35 mm
12	19x19 mm	19x16 mm
16	35x35 mm	35x27 mm

The interactive system uses old images of the city (postcards, old pictures and engraving reproductions kindly provided by the city hall archive) as well as pictures of historical places. Puzzle games were generated from the selected images, cut on with 9, 12 or 16 rectangular pieces. Images had different colors (grayscale, soft colors or colored photography) and represented different subjects (landscapes, portraits, statues, objects, maps). A watermark is displayed on the background of the grid (30% opacity) (Fig. 2). The task consists of placing the targets on the grid (Fig. 3).

The system should be functional on different operational systems. HTML5, Javascript, JQuery and Php have been chosen as they support all the necessary interaction.

The Table 2 below synthetize the parameters that have been taken into account during the design phase.

Table 2. Characteristics and design choices for the system

Characteristics	Design choices
Task	Target selection, displacement and positioning on the grid
Gesture of interaction	Move (drag and drop)
Target size	Large, medium and small
Target color	Grayscale and color
Target number	9, 12 or 16
Target position	Bottom of the screen
Spacing between targets	Replaced by thick borders (1mm)
Feedback	Visual feedback

4 Exploratory Study

4.1 Methodology

The study was consisted of two sessions with two groups of users. It took place in a public place where the participants were used to take computer lessons. Each section last about 90 minutes:

- 30 minutes: 1) presentation and explanation about the main principles of the game, 2) exchange about the touchscreen devices and 3) interview about participant's previous experiences with puzzle, video games and use of information and communication technologies.
- 60 minutes: free playing, individually or in small groups (2 or 3). Participants were allowed to choose and try the different devices and input techniques. After each game, an electronic questionnaire asked user appreciation.

Data were collected through empirical observation and questionnaires. The interactive system recorded tactile interaction data on the touchscreen. The experimenter observed the activity, took notes and helped the participants to use the devices.

Fig. 1. One piece of the puzzle and the black border

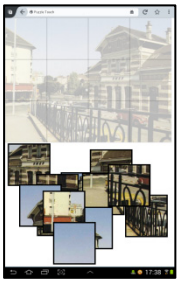

Fig. 2. Screenshot of the puzzle game at the beginning. The targets are randomly placed at the bottom and the grid with a watermark is displayed at the top.

Fig. 3. Screenshot showing a state of the game

4.2 Apparatus

The system described on section 3 were installed in 7 handheld touchscreen devices with different screen sizes and allowing finger or pen interaction: 3 iPads with 9.7 inches screen, 1 Galaxy Note with a 10 inches, 1 Galaxy Note II with a 5 inches screen and a pen, 1 Samsung S3 with a 4.7 inches screen and 1 IPhone with a 3.5 screen.

Table 3. Characteristics according to the situation of use and user's choice

Characteristics	Used devices and situation of use
Situation of use	Inside a room, with tables and chairs, artificial lights and windows. Wi-Fi connection available. Monitors and instructors available to help if needed.
Device position	Handheld or fixed (over a table)
Screen sizes	3.5 to 10 inches, resolution 149 to 306 ppi
Screen orientation	Portrait mode (locked)
Input technique	Single-touch, with finger or pen

4.3 Subjects

The first group was composed of 6 older users, 2 men (58 and 76 years old) and 4 women (66, 67, 75 and 85 years old). The second group was composed of 11 older adults, 4 men (74 to 83 years old) and 7 women (70 to 87 years old) and 5 children, 2 girls and 3 boys (all 9 years old). Two women didn't want to tell their ages, but they had more than 65 years old and they were retired.

According to previous studies about older user's interaction with computers and touchscreen, the age-related changes on cognitive[9], motor [25] and visual skills [22] affect user's performances. The conditions of this study didn't allow measuring the user's skills. Nevertheless some effects related to manual dexterity have been observed and reported.

Three women had some difficulty to use the devices. One of them wore a splint on the right hand. She was right handed, she wasn't able to hold the devices but she could still uses her left hand or the right hand fingers to interact. One had arthritis and complained of some pain on the arms at the end of the section. One had arthrosis and deformation on the index finger. She used the middle finger to interact.

None of the participants were visually impaired uncorrected. All of them were able to play puzzle games with small 16 pieces, even on the 3.5 inches screen device.

Other aspects of life history and individual characteristics can also be used as predictors of performances such as education [20], health conditions [2] and previous experience with technologies [19, 26]. Most of the participants (12 of them) use a computer every day or almost every day. The children do not use a computer so often, but they have more frequent access to touchscreen devices. Only one older participant has a touchscreen tablet and uses it every day or almost every day.

All the participants have already played puzzle games, mostly with jigsaw shapes on cardboard. Only one older adult plays it regularly. Three older adults use to play electronic games almost every day (Facebook apps, online Flash games, computer games with conventional input techniques as mouse and keyboard).

5 Results

5.1 Participants Appreciation

The benefits of a social activity as shown by other studies about ludic activities and digital games seem to be confirmed [3, 22]. All the participants were pleased to learn how to use tactile devices with this entertainment activity. They said it was preferable to learn how to interact with an unknown technology during a ludic activity, without constraints or judgment. Playing games affected positively older users' attitudes towards technologies. They felt comfortable to ask the instructor or the more experienced users help when they had some difficulties during the activity. Working in pairs or in group help them learning to one from another, as practiced by some group studies [19, 20].

They were also able to discover solutions to common errors or difficulties together. For example, as the children had more experience with touchscreen devices, they

were able to help the older users. Children helped the older ones to start interaction and also observed their main errors, providing solutions or correcting the gesture. Showing their interest on touchscreen devices, they encouraged older users to be more curious about it and try to discover new tips.

5.2 Common Errors during Touchscreen Interaction of Older Adults

Common errors have been observed and classified into four categories according to their causes: devices (Table 4), input techniques (Table 5) and interactive system (Table 6). This analyze must be completed through more broad studies.

Table 4. Common errors related to the device

Description	Proposals
Pushing physical buttons: turn off, volume controls. Small buttons are hard to find, to identify and to push.	Special case to hide physical buttons (i.e. inside a box with a flap, a slipping panel) New design and explicit buttons.
Touching soft buttons: back to home, back to another page, take screenshots. Soft buttons are hard to find and to identify.	Possibility of disabling soft buttons Define a constant location Better design for easier identification
Reflection on the screen	Protector film
Finger marks on the screen	Pen interaction, cleaning tissue
Problems to hand hold	Special case to prevent the device of slipping or falling down

Table 5. Common errors related to the input technique

Description	Proposals
Pen: Touches with the side of the pen, pen only works straight up	Pen could have touch points by the sides
Pen: Buttons change the interaction if pushed	Pen could have explicit buttons Pen buttons could be disabled by the user
Fingers: Single touch detection of another point of interaction	Identify accidental touches

Table 6. Common errors related to the interactive system

Description	Proposals
Pieces come back to the second touch position	Prioritize target interaction zone according to the context

Some errors or difficulties could be related to the user's skills or impairments. As the condition of this study did not allow measuring user's visual, cognitive or motor impairments, the table below only report some errors probably related to the individual manual dexterity (Table 7).

Table 7. Common errors probably related to the user's manual dexterity

Description	Proposals
Place the palm of the hand on the screen to control the movements of the fingers	Define interaction and non-interaction zones
Hiding the screen	Adapting target sizes
Unregistered touches (low capacitance, dry skin, fingers side or nails)	Pen interaction would be more convenient

5.3 Strategies for Touchscreen Interaction

Users adapt themselves according to the situation and device. Different strategies for interacting with the targets have been observed and analyzed. They are described on the table below (Table 8).

Table 8. Gestures and strategies of interaction on touchscreen by older users

Kind of gesture	Supported by the system	Proposals and support
Slipping the finger or the pen from the initial position to the final position: slowly	Yes	N.A.
Slipping the finger or the pen from the initial position to the final position: fast	No, the pieces arrive later	Optimize the system's performances
Small gestures pushing the piece	Yes	Smoothing the gestures Tutorial Online help to new users
Fast gestures, pushing the pieces as they would continue on the same direction	No, pieces stay where the finger released the screen	Similar to a swipe, test the direction and continue the trajectory of the targets

6 Conclusion and Planned Activities

Touchscreen devices and the system "Puzzle Touch" can be used to support game and inter-generational activities. This seems to facilitate the appropriation of new technologies.

The existing studies about tactile interaction of older adults are helpful but don't embrace all the different situations of use and the individual characteristics of this heterogeneous population. It is not possible to designers to determinate or to know in advance what kind of devices will be used neither the screen sizes nor position. Furthermore, all the characteristics of use have an effect on user's interaction. It is not possible either to preview user's abilities or impairment. So systems should be responsive and flexible [20].

The results of this exploratory study give important issues to design more accessible, usable and ergonomic interfaces. This observation method could be considered as a contribution for the participative user-centered method.

Following the results and the proposals of this study, a new version of our system "Puzzle Touch" can be released. The next version of this interactive system should support the use of different input techniques (pen, finger) but also or multi touch interaction. The detection of multi-touch should prevent accidental touches from interrupting the interaction, i.e. when the user touches outside the targets, it should not be considered to the game. Touching outside the gameplay area or pushing buttons should not interrupt the activity. A detailed analysis of older users' tactile gestures could provide more information to support their interaction.

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References

1. Umemuro, H.: Lowering elderly Japanese users? resistance towards computers by using touchscreen technology. Univers. Access Inf. Soc. 3, 276–288 (2004)
2. Piper, A.M., Campbell, R., Hollan, J.D.: Exploring the accessibility and appeal of surface computing for older adult health care support. In: Proc. 28th Int. Conf. Hum. Factors Comput. Syst., CHI 2010, vol. 907 (2010)
3. Ijsselsteijn, W., Nap, H.H., de Kort, Y., Poels, K.: Digital game design for elderly users. In: Proc. 2007 Conf. Futur. Play - Futur. Play 2007, Toronto, Canada, November 15-17, p. 17 (2007)
4. Jin, Z.X., Plocher, T., Kiff, L.: Touch screen user interfaces for older adults: Button size and spacing. In: Stephanidis, C. (ed.) HCI 2007. LNCS, vol. 4554, pp. 933–941. Springer, Heidelberg (2007)
5. Hwangbo, H., Yoon, S., Jin, B.: A study of pointing performance of elderly users on smartphones. Int. J. Hum. Comput. Interact. 29, 1–10 (2013)
6. Lepicard, G., Vigouroux, N.: Touch Screen User Interfaces for Older Subjects. In: Miesenberger, K., Klaus, J., Zagler, W., Karshmer, A. (eds.) ICCHP 2010, Part II. LNCS, vol. 6180, pp. 592–599. Springer, Heidelberg (2010)
7. Lepicard, G., Vigouroux, N.: Influence of age and interaction complexity on touch screen Color and position effects on user performance. In: 12th IEEE Ine-Health Netw. Appl. Serv (Healthcom), Int. Conf. e-Health Netw. Appl. Serv., pp. 246–253 (2010)

8. Hourcade, J., Berkel, T.: Tap or touch?: pen-based selection accuracy for the young and old. In: CHI 2006, pp. 881–886 (2006)
9. Tsai, W.-C., Lee, C.-F.: A study on the icon feedback types of small touch screen for the elderly. In: Stephanidis, C. (ed.) UAHCI 2009, Part II. LNCS, vol. 5615, pp. 422–431. Springer, Heidelberg (2009)
10. Chung, M.K., Kim, D., Na, S., Lee, D.: Usability evaluation of numeric entry tasks on keypad type and age. Int. J. Ind. Ergon. 40, 97–105 (2010)
11. Lee, J., Poliakoff, E., Spence, C.: The effect of multimodal feedback presented via a touch screen on the performance of older adults. In: Altinsoy, M.E., Jekosch, U., Brewster, S. (eds.) HAID 2009. LNCS, vol. 5763, pp. 128–135. Springer, Heidelberg (2009)
12. Genaro-Motti, L., Vigouroux, N., Gorce, P.: Touchscreen interaction of older adults: a literature review. In: AAATE 2013, Vilamoura, Portugal, September 19-22, vol. 33, pp. 837–843. IOS Press (2013)
13. Al-Razgan, M.S., Al-Khalifa, H.S., Al-Shahrani, M.D., Alajmi, H.H.: Touch-Based Mobile Phone Interface Guidelines and Design Recommendations for Elderly People: A Survey of the Literature, pp. 568–574 (2012)
14. Zhou, J., Rau, P.-L.P., Salvendy, G.: Use and Design of Handheld Computers for Older Adults: A Review and Appraisal. Int. J. Hum. Comput. Interact. 28, 799–826 (2012)
15. Sears, A., Hanson, V.L.: Representing users in accessibility research. ACM Trans. Access. Comput. 4, 1–6 (2012)
16. Hanson, V.: Age and web access: the next generation. In: Int. Cross-Disciplinary Conf. Web, vol. 44, pp. 7–15 (2009)
17. Dickinson, A., Arnott, J., Prior, S.: Methods for human – computer interaction research with older people. Behav. Inf. Technol. 26(4), 343–352 (2007)
18. Apted, T., Kay, J., Quigley, A.: Tabletop sharing of digital photographs for the elderly. In: CHI 2006, pp. 781–790. ACM (2006)
19. Harada, S., Sato, D., Takagi, H., Asakawa, C.: Characteristics of Elderly User Behavior on Mobile Multi-touch Devices. In: Kotzé, P., Marsden, G., Lindgaard, G., Wesson, J., Winckler, M. (eds.) INTERACT 2013, Part IV. LNCS, vol. 8120, pp. 323–341. Springer, Heidelberg (2013)
20. Gonçalves, V.P., Ueyama, J.: Um Estudo sobre o Design, a Implementação e a Avaliação de Interfaces Flexíveis para Idosos em Telefones Celulares. Simp. Bras. Fatores Humanos (2010)
21. Hollinworth, N., Hwang, F.: Investigating familiar interactions to help older adults learn computer applications more easily. In: BCS-HCI 2011 (2011)
22. Leonard, V.K., Jacko, J.A., Pizzimenti, J.J.: An exploratory investigation of handheld computer interaction for older adults with visual impairments. In: Proc. 7th Int. ACM SIGACCESS Conf. Comput. Access., ASSETS 2005, pp. 12–19 (2005)
23. Kobayashi, M., Hiyama, A., Miura, T., Asakawa, C., Hirose, M., Ifukube, T.: Elderly user evaluation of mobile touchscreen interactions. In: Campos, P., Graham, N., Jorge, J., Nunes, N., Palanque, P., Winckler, M. (eds.) INTERACT 2011, Part I. LNCS, vol. 6946, pp. 83–99. Springer, Heidelberg (2011)
24. Moffatt, K., McGrenere, J.: Slipping and drifting: using older users to uncover pen-based target acquisition difficulties. In: Proc. 9th Int. ACM ASSETS 2007, pp. 11–18 (2007)
25. Nicolau, H., Jorge, J.: Elderly text-entry performance on touchscreens. In: Proc. 14th Int. ACM SIGACCESS Conf. Comput. Access., ASSETS 2012, vol. 127 (2012)
26. Findlater, L., Froehlich, J.E., Fattal, K., Wobbrock, J.O., Dastyar, T.: Age-related differences in performance with touchscreens compared to traditional mouse input. In: CHI 2013, pp. 343–346. ACM (2013)