Older Adult Performance Using Body Gesture Interaction

Abstract

Gesture interfaces are becoming an increasingly popular way to interact with technology, as they are considered very easy to learn and use. However, most gesture interactions studies focus on the average adult or, when focusing on older adults, it is usually in the gaming or physical activity contexts. In this study, we evaluate the suitability of gestural interfaces for older adults, in order to interact with a general technological interface. To this end, we asked 14 older users to perform a set of navigation and selection tasks; two tasks required to interact on most technological interfaces. For each of these tasks, we evaluated two alternative gestures. All senior participants were able to complete almost all the proposed tasks, and enjoyed using this type of interface. We concluded that gestural interfaces are adequate for the senior users, and derived a set of design implications that future developers should take into account when developing gestural interactions for the older people.

Keywords

Body gestures, older adults, Kinect, natural user interface.

1. INTRODUCTION

Over the last decade, gestural interfaces have earned increasing interest, both in the commercial industry as well as in research. This type of interface gained popularity in the video game context where, usually, users move their body that acts as a controller to play video games. However, due to the broad availability and low cost of gesture recognition hardware, several applications are being developed out of the gaming context.

Since people express themselves and interact in everyday social life through gestures, gestural interfaces are considered very natural and easy to use [Correia13]. Therefore, body gesture interfaces provide for easier technological interactions for groups that, until now, have shown some resistance in adopting technology, such as the older adults. In general, seniors find traditional computer interfaces overly technical and difficult to use [Cody99, Namazi03], which deprives them from the benefits technology has to offer. The number of ageing adults is growing and due to our healthier lifestyles we live longer, and are likely to be physically, socially and cognitively active until older ages. By captivating the interest of senior users in technology, it is possible to fight isolation and exclusion and allow them to be more productive, independent and to have a more social and fulfilling life.

However, seniors have particular physical characteristics that can be a hindrance when using gestural interfaces. Research shows that ageing brings along a significant decline in cognitive, perceptual and motor abilities. Motor issues of older adults include slower motion, less strength, less fine motor control and decreased range of motion and grip force [Nichols06]. Therefore, interactions should be designed carefully in order to avoid fatigue, exhaustion and fine motor control. On the other hand, since some degree of physical activity is required to interact with gestural interfaces, it is likely to positively impact the health of the senior users, even if the intensity of physical activity is low [Saposnik10].

Figure 1. Participant using gestures to select a target on a TV screen.

Current literature focuses mainly on gesture interactions for average adults or, when it focuses on older adults, it is usually in the gaming context. Therefore, seniors' performance and acceptance towards body gesture interfaces are not well understood, particularly considering their specific needs and abilities out of the gaming context. In this study, we aim to understand how older adults can benefit from gesture based interactions, in terms of suitability and acceptance, when interacting with technological interfaces in general. To this end, we focused on two types of tasks required to interact on most technological interfaces: navigation and selection. For each task, we developed and evaluated two alternative gestures (Figure 2). Regarding navigation, we defined a Swipe gesture and a Grab and Drag gesture. For the selection task, we developed a Point and Push gesture and a Point and Hold gesture. An experimental evaluation with the target user group was performed, where we measured both performance and acceptance of the defined gestures. Our results showed that that this type of interface can, indeed, be successfully used by seniors, since most participants enjoyed using gestures and completed all the proposed tasks more or less easily. We also systematically compare the results for each task, concluding with the better suited alternative for the seniors. The results of this study are transversal to many applications, since most interfaces require navigating through information and selecting a particular target in a set.

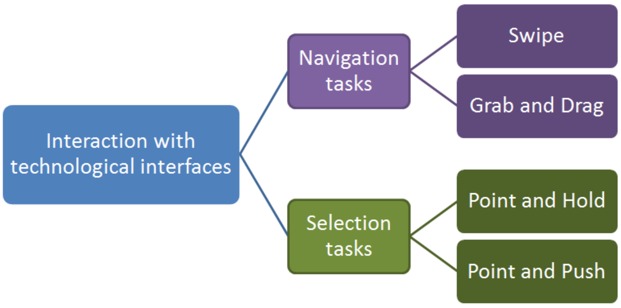

Figure 2. Diagram showing the evaluated gestures to interact with a general technological interface.

2. RELATED WORK

Gesture recognition can be seen as a way for computers to understand human body language, interpreting body gestures via mathematical algorithms. There are two main ways of achieving gesture recognition: with devices that have motion sensing capabilities (e.g. accelerometer, gyroscope, magnetometer) or video capturing and processing – also called computer vision or remote sensing – to detect users' movements. The usage of gestures to control technological devices is a discipline being investigated for some years now [Hummels98]. However, in recent years, body gesture interfaces have become more popular due to the video game industry. Most gestural interactions we reviewed are based on the Microsoft's Kinect device, since it has advantages over the competition as we depict in the next section. In the first subsection, we analyze general gestural interaction interfaces for the average adult, while in the second subsection we analyze the studies performed with older users.

2.1 General Body Gestures Studies

Despite the Kinect having been primarily developed to interact in video games, several applications are emerging in a diversified range of scenarios. Maidi et al. [Maidi13] developed a gestural interaction that allows controlling a photo viewer application. Authors defined four gestures: a push gesture to select a picture; a pull movement to enable returning to the parent level of hierarchy; and moving the hand to the left or right in order to look around all the photos. Although this study has the novelty of controlling a media interface with hand motion, no experimental evaluation was performed. Henze et al. [Henze10] analyzed static and dynamic gestures to interact with a music application. Static gestures refer to the user's pose or spatial configuration, and dynamic gestures to users' movements in a certain time interval. Authors performed an experimental evaluation with 12 participants and found that dynamic gestures are easier to remember, more intuitive and simpler for controlling their application. Panger [Panger12] focused on using Kinect in real-life kitchens, which allows interacting even when users' hands are messy. He implemented a recipe navigator, a timer and music player. One of the main challenges was preventing accidental commands, since intentional commands are interspersed with the cooking movements. A five subject experiment, in each user's home, revealed that installing the Kinect was simple and that subjects felt successful interacting in this context.

Indeed, a major concern regarding gesture recognition is the recognition of a few significant gestures from a continuous sequence of movements, as studied in [Kim06]. Authors proposed a sequential identification scheme that performs gesture segmentation and recognition simultaneously and achieved a 95% recognition rate for smart home environments to control lights and curtains. Kim et al. [Kim11] purpose Ambient Wall, a prototype of a smart home system that can display the current status of the house through a projection on a wall. Their scenarios include changing channel on the TV, control the room temperature, check for messages, and turn off all devices. Their main focus is to enable users to monitor what is happening in their house at a glance, and control their surroundings by performing simple gestures that do not require any physical interface device. Another system that allows to control various devices in the house is HandsUp [Oh12], which uses the Kinect device together with a projector to display an interactive interface onto the ceiling of a room. Authors argue that this surface is a perfect screen for when people lay down on the bed or sofa.

2.2 Studies Focused on Older People

As we already stated, gesture recognition interfaces gained popularity in the video game industry. Probably due to this, most studies evaluating body gestures interfaces with older people still fall on the scope of games. Jung et al. [Jung09] examined the impact of playing Nintendo Wii games on the psychological and physical well-being of seniors in a long-term care facility. Although the game was not specifically adapted to older users, the seniors enjoyed playing it and found it stimulating. Moreover, a substantial amount of physical activity is required to play these games, which is likely to be beneficial in the health of the older users. Identical findings were observed in a similar study [Saposnik10].

Other approaches focus on developing gesture controlled games for seniors, taking into account their physical limitations [Gerling12]. Authors developed and tested 4 static and 4 dynamic gestures with institutionalized older adults. Results showed that the gestural game was successful among older adults, and even had a positive effect on the participants' mood. Static gestures were generally easier to perform. However, they also found that recalling gestures was too challenging for some participants. Authors also found that institutionalized older adults represent an extremely heterogeneous group, and defend that gestural interfaces should be individually adjusted to each user. Similar to this study, Ganesan et al. [Ganesan12] aims to find the factors that play an important role in motivating older adults to maintain a physical exercise routine, a habit recommended by doctors but difficult to sustain. An early game prototype was developed for the Microsoft Kinect and preliminary results were promising.

More recent studies are adapting gestural gaming devices to interact with technological devices in general. Bobeth et al. [Bobeth12] evaluated how older users performed using in-air gestures to control a TV menu. Authors compared 4 gestures and results showed that directly transferring tracked hand movements to control a cursor on a TV achieved the best performance and was preferred by the users. Hassani et al. [Znagui11] developed an assistive robot that used Kinect in order to help older people perform physical exercises. Results showed that seniors enjoyed using this simple gestural interface.

3. EXPERIMENTAL DESIGN

Gestural interfaces became more prevalent in the video game industry, through devices such as the Nintendo Wii Remote, Microsoft Kinect and PlayStation Eye/Move. How gestural-based interfaces fare, for older users, in more traditional tasks such as navigation and selection of items remained largely unexplored. When comparing gesture based interaction using the Kinect to other gesture based devices, Kinect has the benefit of not requiring any accessory to operate, making it more practical and comfortable to use. The direct competitors, Nintendo Wii Remote and PlayStation Move, require a handheld controller to perform the gesture detection. Therefore, Kinect allows more direct and natural interactions and also the tracking of the whole body, as opposed to gestural interfaces that require a controller and only track the forces applied to that controller – usually handheld. Moreover, considering the case of the older adults, remote sensing is better suited since users that suffer from arthritis may have difficulties in holding a controller. Therefore, we decided to use Microsoft's Kinect sensor in our study.

3.1 Research Questions

This user study aims to answer 3 main research questions:

1. Are gestural interfaces adequate for older adults to interact with general technological interfaces?
2. Which type of gesture allows for fastest navigation and selection with the lowest error rate?
3. Do older users enjoy and easily adapt to gestural interfaces? Which gestures do older users prefer?

3.2 Implementation

In order to understand if gestural interfaces are suited for seniors when interacting with a general technological interface, we focused on two types of tasks: navigation and selection. For each task, we evaluated two alternative gestures (Figure 2). We designed simple one hand gestures, thus avoiding problems that may arise with bimanual interactions [Nichols06]. For all the defined gestures, it is only required that seniors move their dominant hand above the hip and in front of their body for a short period of time. Therefore, all the gestures are relatively simple and physically easy to achieve.

Regarding navigation, we evaluated Swipe and Grab and Drag gestures. To perform a Swipe, users should drag either hand in the air and perform a horizontal motion to the desired direction. A Swipe gesture is only considered when users horizontally move their hand for at least 30cm. The vertical motion of the hand should not exceed 10cm, or the gesture is not considered a horizontal Swipe. The time interval of the gesture should be between 0.25 and 1.5 seconds. Regarding the Grab and Drag gesture, we used the implementation of Microsoft's Kinect SKD. To perform the Grab and Drag, users should raise either hand so that a hand cursor appears on screen. The hand should be open, and the palm should be facing the Kinect sensor. Then, users can close their hand to "grab" the content and then they can drag the hand in the desired direction to scroll. To scroll more, users have to open their hand to "release", so they can Grab and Drag again. This alternative may require more movements and coordination than the Swipe gesture, but we expect users to have more control on the navigation process. The Swipe gesture strives for simplicity.

For the selection task, we developed Point and Push and Point and Hold gestures. For both gestures, users should raise either hand towards the screen so a hand cursor appears. Then, to perform a selection through the push gesture, users should move their hand in the direction of the screen, as if they were touching the target. For this gesture, we also used the implementation in Microsoft's Kinect SDK. Regarding the Point and Hold gesture, users should keep the hand cursor over a target for 1.5 seconds to select it. The interface gives feedback about the selection state of the target by progressively filling its background with a lighter color, like a sandglass. When the target is completely filled, it is selected. We expect the Point and Push gesture to be more precise, since it will not restrict the time users have to aim. The Point and Hold is simpler, as the users only have to keep pointing for a while to perform a selection. Prior to performing the user tests, all the developed gestures were evaluated by a physical therapist to access their suitability taking into account seniors' potential physical limitations. The physical therapist concluded that these gestures posed no danger of overexertion or lesion on older people.

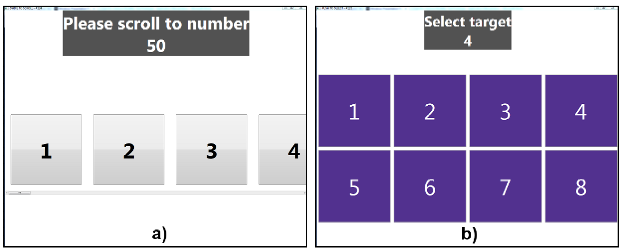

Figure 3. The navigation (a) and the selection (b) screens.

Our test prototype was implemented as a Windows Presentation Foundation application, and the gesture tracking was developed using Kinect for Windows SDK. To test the navigation gestures, we had a list of horizontally scrollable numbers, as shown in Figure 3a. For the selection gestures, a different number of targets were displayed on the screen, and users were asked to select a particular target from the set, as shown in Figure 3b.

4. USER STUDY

We conducted the user study described in this section in order to evaluate which gestures allow better performance and user satisfaction on navigation and selection tasks.

4.1 Participants

Fourteen older people, 3 men and 11 women, took part in our user study. All participants were aged over 60 years old and all had some experience with computers, being that only one of them did not own a computer at home. None of them had prior experience with gestural interfaces. Most users had some sort of physical movement limitations, such as slight rheumatism, tendinitis, osteoarthritis, ankylosing spondylitis, but nothing particularly severe. These conditions did not prevent them from using gestural interfaces. All precautions were taken to let them rest if they felt tired or had aching articulations.

4.2 Apparatus and Setup

In order to simulate an interaction scenario as close as possible to a real-life scenario where users could benefit from using a gestural interface to interact with technology, we performed the user study in an environment that resembled a living room (Figure 1). The output device was a 55” Samsung LED TV with 1080p, connected to a Dell laptop with quad core 3.2 GHz processor and 4 GB of RAM. We used a Kinect for Xbox, connected to the laptop through an adaptor cable. Participants were at a distance of 2.5 meters from the TV and the Kinect sensor.

4.3 Procedure

The user study had two main phases: training and evaluation. At the beginning of the training phase, we explained how the gestures were performed and participants were allowed to try each gesture for a maximum of 2 minutes. However, if the monitor found that the senior had understood and was already comfortable performing the gesture before this time interval, he would skip to the next gesture. Participants were free to choose the pose that was more comfortable to them, either standing or sitting.

In the evaluation phase, users were asked to perform specific tasks for navigation and selection. To test the navigation gestures, participants were successively asked to scroll to a predetermined number that was displayed on the screen (Figure 3a). After the user scrolls to the required number and that target stays visible for 2 seconds, the application automatically shows a new target. We imposed this 2 second target visibility period in order to exclude cases where the user did not have enough precision to scroll to a particular number, and thus avoid activation when participants just quickly passed by the target. The required navigation numbers order was chosen in a way to cover 3 conditions: large, medium, and small ranges of scroll. A total of 8 navigations were required for each navigation gesture.

Regarding the selection task, the application asks to select a random target in a grid of 2 targets, then in a grid of 4, then in grid of 8 (Figure 3b), and finally in a grid of 16 targets. The varying number of selectable targets allows us to access the performance and precision of the developed gestures relative to the target number and size. This procedure is repeated 3 times, so a total of 12 selections were performed per participant. When users select the desired target, the application automatically moves to the next target selection task. In case of a wrong selection, the application logs it as a missed hit and the user is asked to select the same target again. If a participant makes 3 wrong selections, the application assumes the user failed completing that task and would automatically switch to the next target selection task.

Between each successfully completed navigation and selection tasks, a 5 second period was imposed where users could not interact. This allowed for frequent relaxation of the older users’ arm, as well as simulate more realistic interactions, since users typically have to process the newly displayed information after interacting with a technological system. In order to avoid any bias related to the sequence of the performed gestures, the application randomizes the order of the tested gestures for the navigation and selection tasks. Participants’ performance was automatically measured by logging the task completion time, as well as the number of errors. After performing all the required gestures, the users answered a simple questionnaire with 3 questions for each gesture regarding the easiness of performing that gesture, whether it was tiring, and the accuracy of the gesture detection. We opted to perform a simple usability questionnaire since, from our previous experience, older users find exhaustive questionnaires like TAM3 [Venkatesh08] too complex and have difficulty discerning between questions. A whole user test took an average of 25 minutes to complete.

4.4 Dependent Measures and Analysis

We used a within-subjects design where each participant tested all conditions. We performed Shapiro-Wilkinson tests on the observed values for the task completion time and number of errors to assess if dependent variables were normally distributed. If they were, we used the parametric paired t-test. If measures were not normally distributed, we used the non-parametric Wilcoxon test.

5. RESULTS

In this section, we quantitatively analyze the time required to complete the proposed tasks, as well as the number of errors that participants made while performing those tasks. We also qualitatively analyze the questionnaires’ answers and the users’ comments.

We must note that the results we are presenting are not completely uniform, as we slightly changed the way our application gave feedback to users in Swipe tasks. In the first 5 user tests, no visual feedback was given about the state of the gesture recognition in Swipe tasks. However, participants reported that they missed visual feedback, which is present for the Grab and Drag gesture. So, after the 5th user, we decided to incorporate a simple feedback mechanism. It consists in showing a hand icon on the bottom-right corner or bottom-left corner of the screen (depending on the hand used) when users raise their hand above the hip, thus indicating that the system is ready to detect Swipes. The hand icon is static and does not replicate users' movements; it is just meant to be a simple indicator of the system's gesture recognition state. After integrating this simple feedback mechanism, users commented that this type of feedback was very useful. It did not change, however, the performance nor the number of errors, as the means are similar before and after the improvement, so we consider the results comparable.

5.1 Task completion time

The boxplot in Figure 4 illustrates the time required to perform the proposed tasks, grouped by gesture. Regarding navigation tasks, users completed them faster when using the Swipe gesture. Indeed, a paired t test revealed that the differences are statistically significant ($p<0.005$). This occurred mainly because Swipes allow to scroll bigger distances faster. Moreover, most senior users found the Grab and Drag gesture to be more complex and harder to perform than the Swipe gesture. Some participants reported that they needed to be very focused in order to coordinate the motions required to perform the Grab and Drag gesture. Indeed, one participant (who recently had a stroke) was having so many difficulties performing this gesture, we had to end this task before the user completed it. On the other hand, some users preferred the Grab and Drag gesture because it allowed a finer control, especially for small distances. For the Swipe gesture, only one senior user had major problems using it.

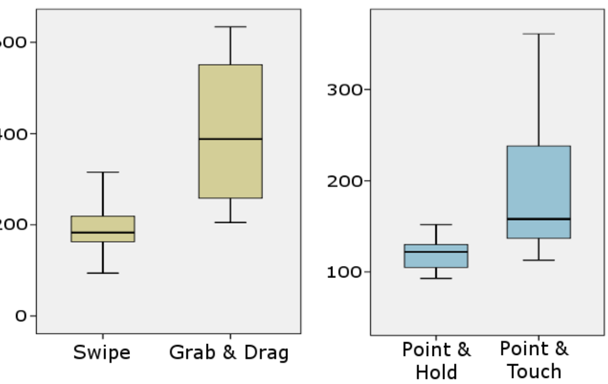

Figure 4. Time required, in seconds, that users took to complete the proposed tasks.

Regarding selection tasks, the Point and Hold gesture allowed for a better performance when compared to the Point and Push alternative. A paired t test showed that this difference is statistically significant ($p=0.009$). Since both gestures require pointing at the screen, we can conclude that users took more than 1.5 seconds to perform the push gesture – the time required in Point and Hold to perform a selection. Almost all users performed the selection tasks without difficulties, finding the gestures easy to perform. The exception was the same user unable to perform the Grab and Drag gesture, which also did not manage to conclude all the Point and Push gesture tasks.

5.2 Error rate

Regarding navigation tasks, we considered and classified errors into three categories: Direction, No Output and Precision errors. Direction errors occur when users are asked to navigate in one direction but end up scrolling in the opposite direction. This can happen when participants did not fully understand or did not perform the gesture correctly, or when the system fails to recognize the users' movements. No Output errors are considered when users move their hand with the intention of navigating, but no actual scrolling occurs. This may occur when the gesture is not wide or fast enough or when the Kinect failed to precisely recognize the motions of the user. Finally, Precision errors happen when users are scrolling in one direction to get to a particular number but, due to lack of precision of the gesture, pass it by. In this case, users have to perform another gesture to acquire the desired number. Regarding selection tasks, we considered an error when users selected a different target from the one they were required to select. We must note that not all errors were due to users' fault, but because the technology still lacks accuracy in some cases. Nevertheless, since this type of technology is still being improved, it is expected to be more accurate in the near future.

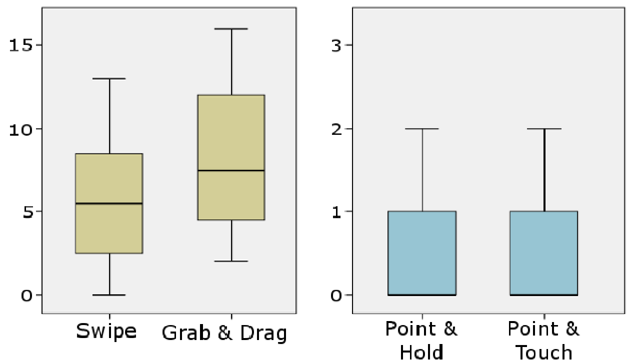

Figure 5. Number of errors for each gesture.

Figure 5 summarizes the number of errors that users made when performing the proposed tasks. As we can see, the total number of errors in both navigation tasks is similar. Indeed, a paired t test showed that there are no statistically significant differences ($p=0.18$). However, the types of errors users committed on alternative navigation gestures are slightly different (Figure 6). By far, the most common type of error was Direction, and users made more of these errors using the Grab and Drag gesture. When performing this gesture, direction errors occurred mostly because of lack of coordination. In order to perform consecutive scrolls in the same direction using this gesture, users have to close their hand to grab, drag the hand to the desired direction, then open the hand and bring it back again to repeat this motion. However, some users would forget to open the hand between these steps, which made them scroll in the wrong direction, to the point where they started. This error occurred more frequently in the beginning of the test, when users did not have so much experience. Regarding the Swipe gesture, direction errors occurred mainly because sometimes it is difficult to algorithmically interpret the intention of the user. To segment and recognize the intentions of the user in a continuous space of gestures is a complex challenge, magnified by the fact that each user has his/her own way of interacting.

Regarding the No Output errors, both navigation gestures had similar results (Figure 6). These errors occurred when users' movements were so slight that the system did not recognize them as intentions to scroll. Finally, regarding precision errors, the Swipe gesture had 50% more than the Grab and Drag (Figure 6). This is mainly because the Grab and Drag gesture allows users to get instant feedback and direct mapping of hand movements to scrolling. However, for the Swipe, the scrolling only happens after the gesture is performed. Users do not have instant feedback while performing this gesture, which does not allow a precision as good as on the Grab and Drag gesture.

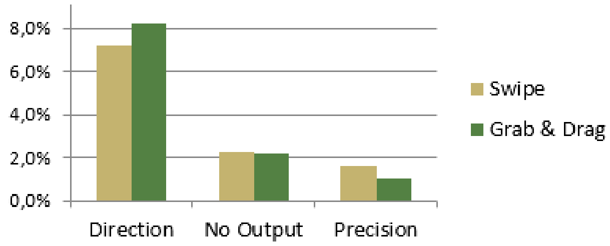

Figure 6. Percentage of errors, grouped by type of error, that participants committed in navigation tasks.

In Figure 5 we can see that for selection tasks both gestures achieved very similar results. However, for the Point and Hold gesture, most errors occurred when there were only 2 or 4 targets on screen (83% of errors). This happened because the users would start pointing at an undesired target, but they did not have enough time (selection is effective in 1.5 seconds) to adjust the hand position to the desired target, and then an erroneous target selection would occur. On the other hand, most errors that were made on the Point and Push gesture occurred when there were 8 and 16 targets on screen (60% of errors). In this case, the reason was the lack of precision users had when performing the push gesture. Indeed, users had no trouble pre-selecting the desired target by putting the hand cursor above it, but when they were performing the push gesture they would slightly move their hand and would accidently select another target.

5.3 User Satisfaction

At the end of the user study, participants were asked to answer a satisfaction questionnaire regarding the easiness of performing the gestures, whether it was tiring, and the accuracy of the gesture detection. A 5 point Likert scale was used, with the higher score being the better. Figure 7 shows a boxplot of the results of the satisfaction questionnaire. Regarding navigation tasks, we found that both gestures achieved similar satisfaction results. A Wilcoxon signed-rank test showed no statistically significant differences between the Swipe and the Grab and Drag gestures, for every measured metric. Participants were divided between these two gestures: some would prefer the Swipes and others the Grab and Drag. For selection tasks, a Wilcoxon signed-rank test showed that there were statistical significant differences, being the Point and Hold gesture easier to perform, although with lower confidence ($Z=-1.813$, $p=0.07$). For the tiring and accuracy measures, no statistically significant differences were found.

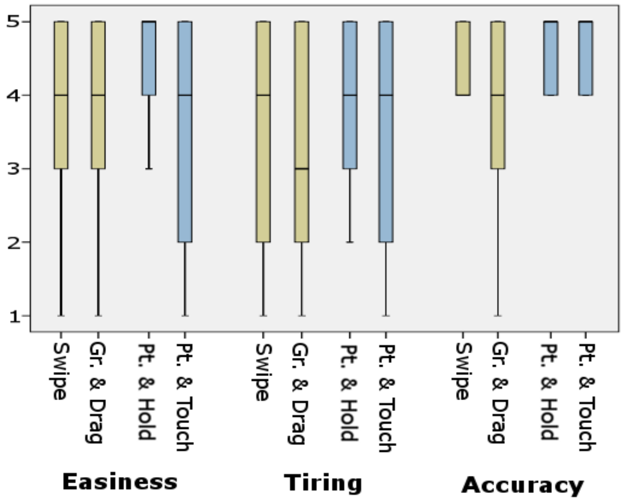

Figure 7. Results of the satisfaction questionnaire.

Besides the satisfaction questionnaire, we performed an informal interview and also gathered participants' comments while interacting. Regarding the navigation gestures, participants reported that the Swipe is easier to learn and execute than the Grab and Drag gesture. Therefore, Swipe was considered a more natural gesture. Some participants found the Grab and Drag too complex and demanding in terms of coordination, considering it a gesture that is not usually performed in everyday life and thus harder to master. Some participants also linked the difficulty of performing navigation gestures with the lack of practice. However, they were optimistic that if they had more time to practice, they would get used to it and would be able to use both gestures more proficiently.

Regarding the precision of the gestures for the navigation tasks, users reported that the Swipe did not allow for very precise scrolling, particularly when users wanted to scroll very little. Indeed, participants who were able to perform the Grab and Drag gesture usually preferred this alternative over the Swipe, since it allowed for more control and precision. However, some users reported discomfort while performing the Grab and Drag gesture, stating that since the hand palm needs to be facing the television screen, it is an uncomfortable position. Besides this, seniors did not regard either navigation gestures as tiring, except for a couple of participants who suffered from arthritis and mobility and balance issues.

The selection tasks were performed more easily when compared to the navigation tasks. For selection tasks, most users preferred the Point and Hold gesture. They reported this gesture to be very simple and easy to perform. Even when the targets got smaller, users reported that it was easy to aim and select the desired target. Participants also enjoyed the Point and Push gesture, but reported that it was a bit more tiring to the arm. Some users started to perform the gesture with the arm already stretched. In this case, there was no room for the arm to stretch more and perform the "push" part of the gesture, resulting in users stretching the whole upper body painfully. Some users had no problem pre-selecting, i.e. getting hand over target, but when performing the push would lose precision and press on another target.

6. DISCUSSION

After analyzing all data, we can now answer the research questions proposed at the beginning of this study.

1. Are gestural interfaces adequate for older adults to interact with general technological interfaces? Despite not having any previous experience with gestural interfaces, most senior users performed all the proposed tasks without major problems. Only one user was not able to complete all the tasks in the Grab and Drag and the Push gestures, but she had expressed her motivation in participating in tests of "natural interaction" precisely because she had a stroke and had difficulties in understanding and concentrating. All the other participants, even the ones suffering from other health problems, had no major hindrances performing the whole user test. Moreover, previous studies found that even these low intensity exercises positively impact the health of the older people [Saposnik10]. Therefore, in short, gestural interfaces proved to be a solid alternative for older people to interact with simple technological interfaces.

2. Which type of gesture allows for fastest navigation and selection with the lowest error rate? Regarding navigation, the Swipe gesture outperformed the Grab and Drag gesture in terms of speed. The Swipe gesture is simpler and easier to learn and perform, and also allows users to scroll bigger distances faster. In terms of number of errors, both alternatives achieved similar results. For selection tasks, the Point and Hold gesture allows for faster selections than the Point and Push. Both gestures are similar in terms of error rate, although the Point and Hold allows for greater precision.

3. Do older users enjoy and easily adapt to gestural interfaces? Which gestures do older users prefer? Most seniors adapted very well to our gestural interaction. They found it easy to use and enjoyed using it. All the developed gestures achieved good rates on our satisfaction questionnaire. In terms of preference for navigation gestures, some older adults preferred the Swipe, while others preferred the Grab and Drag, which resulted in a tied satisfaction score. Regarding the selection gestures, participants agreed that the Point and Hold is easier to perform than the Point and Push.

This user study also allowed us to have some insights that may improve our original solution. One of the problems of the Swipe gesture was recognizing the direction the user intended to scroll, as some users had a way of interacting that led the system in generating a Swipe in the opposite direction. A possible solution to this problem is to only allow each hand to Swipe to a particular direction. However, despite certainly reducing number of errors, this solution limits the number of possible interaction scenarios as it requires the user to have both hands free in order to navigate in both directions. Regarding the time and distance thresholds we imposed for the Swipe gesture, we found that they were not perfect for all users. For some users it was too wide, for other users it was too short. Therefore, despite having defined reasonable thresholds that allowed all users to adapt and perform all the proposed tasks, we conclude that each user has his/her own particular way of interacting.

We also observed that the Swipe gesture allowed users to fulfill the navigation tasks faster, but the Grab and Drag gesture allowed for more control and precision. Therefore, for technological interfaces where precision plays a big role, the Grab and Drag gesture may be a better alternative. Nevertheless, we must stress that some of our senior participants had difficulties in coordinating and performing this gesture, so it may not be the best choice for this particular age group. Regarding the Point and Hold gesture, the time required to hold over a target to select it should be increased, as participants erroneously made some errors because they did not had the time to adjust to the right target before the selection was made.

Transversal to all gestures, for we noticed that users had a tendency to perform better in the second gesture that was tested. This probably occurred due to the increased experience with gestural interfaces and also to the reduction of stress associated with a test environment, which is usually higher at the beginning. Participants also expressed that they would certainly perform better if they had more time to practice. We must also note that the conclusions we present on this paper may not apply to other cultures, as very different cultural backgrounds, either on different meanings of gestures as well as familiarity with technology, may induce differences on the final results.

7. DESIGN IMPLICATIONS

From our results, we derive the following design implications for gestural interfaces:

Keep the defined gestures as basic as possible. Gestures that may look simple for the average adult, such as Grab and Drag, may prove to be coordination challenges for older adults. Our gestures that were composed by two distinct steps (Grab and Drag, Point and Push), demanded more concentration from seniors, which led to a reduction in performance. The simpler the gesture, the easier it is to learn, which also increases motivation to keep using it.

Develop gestures that allow to be used by any hand. In this study we tried to simulate a real life scenario where gestural interfaces bring value, such as a living room. In this scenario, users may not have their dominant hand free. Therefore, and related to the previous design implication, the gesture must be simple enough to be used by the non-dominant hand. All participants have only used their dominant hand to perform the Grab and Drag gesture, but some seniors used both hands to perform the Swipe gesture in both directions. The Swipe, by being simple enough to be performed by any hand, allows for greater freedom in interactions.

Give visual feedback of the state of the gesture recognition. In our first implementation of the Swipe gesture there was no visual feedback simply because, for this gesture, there is no direct mapping from hand movements to the elements on screen. However, senior participants felt lost when no visual cues were given, wondering on when they could perform the gesture. Participants felt more confident performing Swipes when visual feedback was given, even if it was as minimal as simply displaying an icon on screen when the user's hand was raised.

Allow personalization and adaptation. Each user has his own particularities in the way he moves, both in speed and distance. This makes static thresholds not optimal for all population. Gesture recognition is a great challenge per se, but the optimal solution involves adapting these thresholds to each user, preferably automatically. Otherwise, manual personalization should be available.

8. CONCLUSION

In this study, we showed that gesture interactions are an appropriate way for older adults to control a general technological interface. Our results showed that older people enjoyed using gestural interfaces, finding most of the evaluated gestures easy to learn and use. We found that the simpler the gestures, the better performance participants had in completing the tasks we proposed. The Swipe gesture, used for navigation, was simpler and therefore allowed users to complete the proposed tasks faster. The Grab and Drag gesture, did not have such a good performance, but allowed users to have more precision and control over the navigation process. Regarding selection tasks, the Point and Hold gesture was better since it allowed for accurate and fast selections. Older users highly rated all gestures in the satisfaction questionnaire, which means that this type of interaction was widely accepted. In general, the senior participants showed a positive attitude towards gesture-based interactions.

9. ACKNOWLEDGMENTS

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