Age Invaders: User Studies of Intergenerational Computer Entertainment

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Abstract. The design goal of the Age Invaders[1] system is to make a mixed reality interaction platform that can facilitate meaningful social interaction with players, from many backgrounds and demographics, at appropriate levels of physical exertion for their age. This paper discusses a multidisciplinary approach to analyzing the user experience and re-assessment of the context of use of the Age Invaders system. This paper tests the effectiveness of the system in promoting the intended design goals and the results show strong support for intergenerational interaction using digital technology. Additionally, the results of the study help to focus the refinements of the existing platform and development of further novel games and interactive applications for this mixed reality system, and provide insights into the user in complex mixed reality experiences.

Key words: Mixed reality entertainment, social computing, family entertainment, game play, user-centered design

1 Introduction

The research reported here aims to show the user acceptance of the Age Invaders (A-I) game system [4] by players of various ages. As a design goal, Age Invaders aims to provide engaging physical and virtual play for elderly and young together in a novel mixed reality entertainment system. Unlike standard computer systems, A-I requires whole body movements over a large play area rather than constraining the user to sit in front of the computer for long periods of time. Age Invaders provides family entertainment that is attractive to, and inclusive of, all family members including the elderly and young. The system encourages and promotes human interaction at the physical, mental and emotional level. A-I provides a means to re-connect family members in shared activities across locations, thus increasing cross-generational interaction. The research situation aimed to better understand the users of the A-I system and to take inventory of recurring user experience issues. The methods include questionnaires and other

[1] Videos and photos of the work can be accessed via the website http://ageinvaders.mixedrealitylab.org
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qualitative data analysis borrowing from the grounded theory approach [2]. Our selection of users varied in many respects including age, physical ability, familiarity with computers and electronic games, and level of education in order to gain as much relevant input as possible.

2 System Description

The system consists of a game server which is connected to the Internet through a router, large floor display platform with embedded RFID tags, online virtual client for real time remote game play, Bluetooth display, controller and special slipper with embedded RFID reader for tracking of players. The system's inter-devices communication is completely wireless.

2.1 Age Invaders Game Play

The concept of the Age Invaders game is shown in Figure 1, two children are playing with two grandparents in this interactive physical space while up to two parents can join into the game via the internet as virtual players, thus increasing the intergenerational interaction. The grandchildren form a team and the grandparents form another. The parents' role is to balance the game between the two teams.

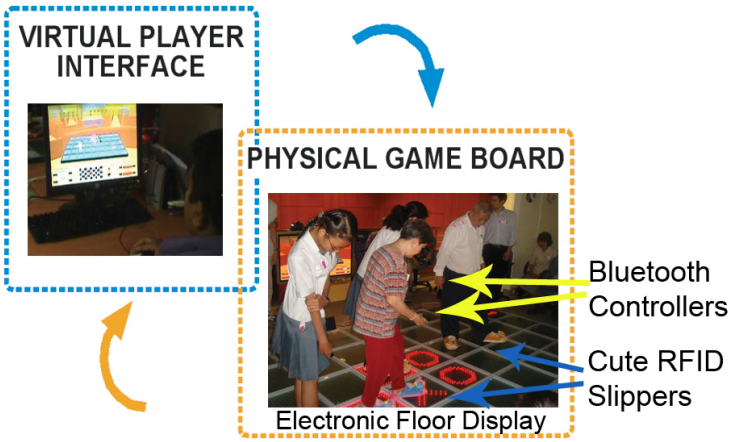

Fig. 1. Age Invaders: An inter-generational, social and physical game.

Grandparents and grandchildren put on lanyard-style Bluetooth LED display for the purpose of displaying some game events. The players then wear the special slippers and pick up the Bluetooth controller.

Each game lasts for up to 2 minutes. The players gain points by picking up bonus items and avoiding laser beams. The player is out of the game when his or

her energy level drops to zero. The game ends prematurely if the energy level of both players of the same team became zero. Otherwise, at the end of 2 minutes, the team with the highest score wins.

During the game play, as the player presses a button on the handheld device, a laser beam image is displayed on the game board and heads towards the opponent. If the grandparent launches the laser, its speed is fast so that the grandchild has to react quickly. On the other hand, the grandparent has more time to react to the much slower laser beams launched by the grandchild. This balances the game difficulty between the ages.

In order to make the difficulty of the game strike a balance between the young and the elderly, Age Invaders imposes some challenges in an innovative way for the invader players (the young and more dextrous). The invader footprint is one of these challenges. In the game, the invaders have to physically follow the footprints and have to remain in the squares with footprints indicated with a pattern of lights which they see on the floor square. Each invader has two footprints from which to select as their next step. In any case that they are not stepping in the square that has their footprint indicated for a certain period of time, their energy is deducted. This period is determined by the invaders' footprint speed which can also be adjusted by the virtual players at any time. To be fair to these players, they are rewarded with one bonus health point by following the footprints correctly ten times in a row.

The parents as virtual players, can drag-and-drop barriers or energy on the virtual player interface which appears almost immediately on the physical game board rendered in patterns of lights. The physical players can pick up the bonus to gain extra energy and barriers will block laser beams. Parents can also adjust the game parameters as mentioned previously including: laser speed and the speed of the dance step patterns for the young players to follow. All the actions in the virtual environment are translated to the physical game board in real time. This provides a seamless game interaction between the real world players and the parents in the virtual world.

The game play challenges and aids are summarized below:

Young Player

- Must follow the dance steps as they appear
- Speed of laser beam is slower
- More difficult to collect power-ups unless intended for the player, due to need to constantly follow dance steps

Older Player

- Can move freely on the game board
- Speed of laser beam is faster
- Power-up hearts can be collected easily

Virtual Player

- Placing power ups and barriers
- Balancing the play experience by adjusting the step speed and laser speed

3 Method

3.1 Design

Games play sessions were conducted in a controlled laboratory setting. Users answered questionnaires before and after game play sessions to gather levels of enjoyment, contributing and detracting factors on the game play, and social aspects of the experience.

Additionally, case studies of other sources of data were reviewed using a grounded theory approach borrowing from the methods offered by Glaser [1]. We conducted focus group discussions with users immediately following a two hour session of game play and began the note-taking process.

As more of the themes emerged, some categories of issues affecting user experience provided a framework to organize the concepts. Subsequent review of data gathered from open ended questions from the same user group helped to confirm these categories and in some cases provided candid feedback that respondents in a group situation chose to withhold. For the older adults, we also conducted a follow up focus group session 5 weeks after the first focus group session. In this later focus group, we probed the issues of the gameplay experience to understand the lasting impressions and the issues that were most memorable for positive and negative aspects of the game play. The design team then reviewed the categorized data and wrote summaries of the observations. The researchers were also encouraged to reflect on the observations and user statements of players and spectators engaged in the system during the conference exhibitions and to compare against the more structured game play sessions. With the categories defined and researcher notes gathered, the process of producing the theory of the user experience issues in the form of linear and coherent statements was undertaken.

3.2 Data Sources

Among the data sources reviewed were video recordings from platform demonstrations at conferences, structured game play observation of 49 players in a structured format, questionnaires involving closed and open-ended questions, 3 focus group discussions involving the 49 players immediately after the gameplay and 7 of the older adults 5 weeks after the game play, and 4 semi-structured interviews with the design team and gameplay facilitators.

4 Results

4.1 Profile of Users

The data from the users came from observations made at various conferences and exhibitions including CHI 2006 (Canada), Interactive Tokyo 2006 (Japan), Greenfield 2006 (Singapore), Singapore Science Center i-Future 2007 (Singapore), NUS Arts Festival 2007 (Singapore).

In the first focused gameplay sessions, there were 2 groups from the Ngee Ann Polytechnic in Singapore, taking part in a study module about electronic games were invited. These initial sessions involved a total of 37 total participants. The average age of the participants was 19 years old. The gender of these participants was 24 males and 13 females.

An additional gameplay session was organized involving the intended age disparity of the players. There were 10 students from the Hougang Primary School, with average age of 11.7 years. There were 7 females and 3 males. The opponents were the older players who were invited from a community center in the Jalan Basar area of Singapore. The ages of these players ranged from 58 to 80, and an average age of 68.7 years made up of 7 females and 3 males. It is worthy of note that a majority of the older adults self reported that they are illiterate. The older players spoke Hokkien or Cantonese, yet understood Mandarin that was spoken by the children. The children spoke in the Chinese dialects of the older players, but also Malay and English amongst themselves.

4.2 Teen Player Study

The first formal studies were aimed at showing the acceptance and enjoyment of the Age Invaders game by younger players that have familiarity with contemporary electronic gaming. Prior to game play, the respondents were asked to rate themselves in experience level with electronic games choosing between the categories Newbie, Casual User, Moderate User, and Hardcore User. The results showed that 78% of the players were casual to hardcore users. All of the users reported that they do play some kind of electronic games.

After the game play sessions, the users answered additional questions pertaining to the game experience. Most importantly, the respondents were asked to rate their enjoyment level with the game. Overwhelmingly, the respondents enjoyed the game play as shown in and would recommend it to be used for encouraging social interaction within families. The users were asked to indicate their level of agreement with the statement, "I enjoyed the gamplay experience." As shown in Figure 2a all respondents chose "Agree or Strongly Agree."

Players were also asked to rate their agreement with the statement, "I would recommend this game to be used to encourage social interaction within a family." The strength of their positive sentiment is shown in Figure 2c. Only one of the players disagreed with the statement.

The players were asked to indicate their level of agreement with the statement, "The skills required by the game were well matched to my skills and experience." The responses showed that 84% Strongly Agree to Somewhat Agree that the game play experience was well matched to their skill level and experiences. The responses are represented in Figure 2d.

The users showed preference to the four-player configuration compared to the two-player format according to their responses. The responses showed again that 84 % Strongly Agree to Somewhat Agree that the four-player game was more enjoyable. This is shown in Figure 2b. In the focus group discussions, the

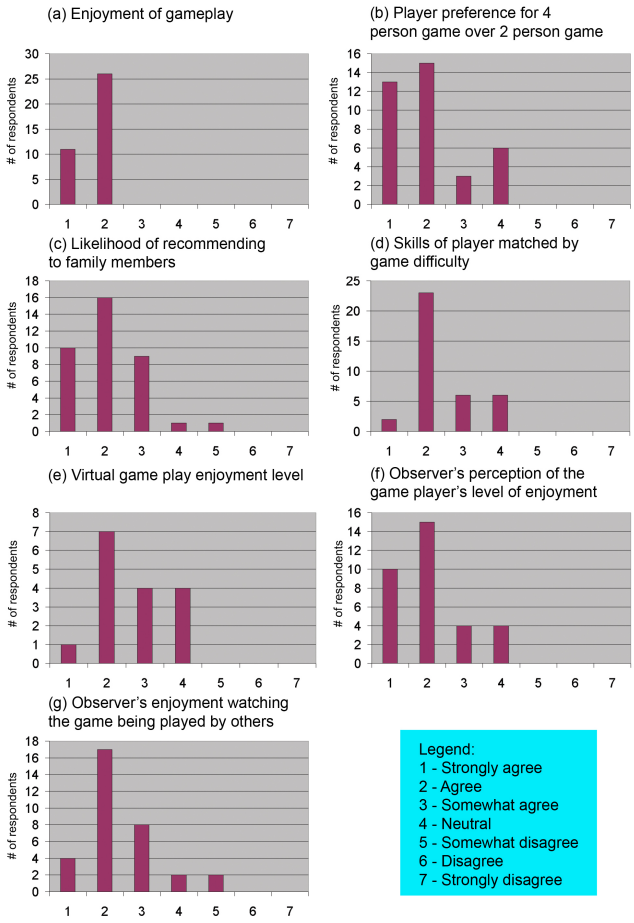

Fig. 2. Responses to questions based on a Likert scale. 1-Strongly Agree to 7-Strongly Disagree.

users explained that the four-player games were more exciting and having a team member to engage in cooperative competition

Most players also had a chance to take part in the game as a player in the Virtual role. The level of enjoyment was less, but showed positive sentiment towards the virtual play. In this case, the players were asked to indicate their agreement with the statement, "Playing via the virtual player was fun." The results of the satisfaction levels are shown in Figure 2e.

In order to determine what was enjoyable vs. not enjoyable, we discussed the virtual game play in the focus group discussions and some themes emerged and were reinforced. These themes are discussed in the Emergent Themes section.

Because the game system may have spectators, we also asked questions about the experience as an observer. Respondents were asked to indicate their agree-

ment with the statement,"The game seemed fun to play from the observer's point of view" This data is represented in Figure 2f. Additionally, the spectators agree that watching the game is enjoyable as shown in Figure 2g.

4.3 Young and Elderly Player Study

With a general understanding that the game is enjoyable to play from the younger audience point of view, the more critical study came when conducting the play sessions for the older generation playing with a younger generation as shown in Figure 3.

Fig. 3. Age Invaders players taking part in a gameplay session.

The questionnaires were made in simpler language and with fewer questions in general to avoid overloading their first experience with electronic games. An important assumption to test first was our thought that the older players were not familiar with electronic games. Responses showed that 80 % of the children reported playing computer games, while the adults all reported never having played electronic games.

In order to determine their habits with their families, all players were asked if they play any games non-electronic or otherwise with their families. 60 % of the young reported that they play some type of game, while only 30 % of the older players reported playing games with their families. Those that do play games with their families reported similar types of games regardless of age. The older generation reported playing chess and cards with their families, while the children reported cards and board games.

In order to "break the ice" and to get the two generations of players to interact and converse, players were organized into 5 teams of 4 players each. Each team was made up of 2 young players and 2 older players. These players made name tags for each other, introduced their teams and the children were designated as the scribes of the teams and would help the older players to fill out the questionnaires in English. Each team was also designated a game studies

facilitator from our lab who helped to ensure that the questionnaires were filled out appropriately and honestly. The game sessions were conducted similarly to the previous studies mentioned earlier. Again, overwhelmingly the players enjoyed the game experience with all respondents reporting a positive sentiment with nearly all respondents showing positive experience and only one reporting a neutral experience.

The user's were also asked, "Can you imagine your family enjoying the game?" The overwhelming response showed a high motivation to play the game with their families. All of the young people reported that the game would be appropriate for family play, while 80 % of the older players answered positively. In order to understand the differences in the age, we discussed this in the focus group and found that the respondent who did not imagine playing the game with her family did not previously consider extended family members when answering the question. In the focus group she mentioned that she discussed the game with her niece and felt that she would enjoy playing the game in a family setting.

4.4 Focus Group Session with Older Players

Five weeks after we conducted the initial user study for the elderly and young, we went back to the senior center to conduct a follow up focus group session with 7 of the elderly players. Our aim was to investigate the longer lasting impact of the Age Invaders game. When prompted the most memorable thing about the game, all of them mentioned the launching of lasers, avoiding lasers and chasing after the hearts on the game board. "This is a fresh idea and it was my first time playing" quoted by a few of the elderly. They are all excited about this new entertainment platform. Two elderly have shown some interest to understand what technology is behind the platform. Many related Age Invaders to the popular arcade game, Dance Dance Revolution. In almost identical questions, there were two older adults that stated, "I suppose there are computers controlling the shoes, controller and floor display, but how?" More detailed technical explanations were given, and we then asked if they have an increased interest in trying out other electronic/computer based games as a result of their experience with A-I. To this question, all of them gave a negative answer. Some of the reasons given were the fact that they are illiterate and they have no prior experience with operating computers. It seems as though the older adult players see the game system as being so different from traditional computer systems that the relative level of comfort with traditional computer platforms is unchanged after playing the A-I game.

Among other issues, a consensus was made amongst the elderly that the sound was too soft in the game and they strongly suggested that the new version of the game incorporate louder sounds and music to accompany the play session in addition to the sound effects already present. More specifically, most of the players expressed a desire for a sound event indicating the game outcome and a larger screen for displaying the game score. "We do not understand words, so just display the numbers like those in a basketball tournament", was suggested by one of the elderly.

When asked what skills were involved in playing the game and about the difficulty level, all agreed that the game was easy to learn, and that the game speed was fine, but a few mentioned that the pace could be a little slower in order to play for longer amounts of time. However, they emphasized that the game speed cannot be too slow otherwise it would become boring. The current game pace is exciting for them. This was well stated by one of the players, "The game gives me good exercise. When you see heart, you have to run to collect it. If a laser is approaching, you have to avoid it quickly. The game is very engaging and can we play it again?" This supports the design goal of providing a game that challenges the elderly in terms of visual-motor coordination and physical activity level.

When asked about how much fun was the game you played, they all gave the maximum rating. "Thinking about it now, we can't wait to play again!" said one of them. It is obvious that the elderly players have enjoyed the game and have high motivation to play the game again. Of particular interest is the fact that the users don't see a strong connection between this system and traditional electronic gaming and computing in general. This high motivation level is valuable in and of itself as confirmation that older adults can be engaged in new technologies and have high enjoyment levels.

4.5 Emergent Themes

As the data coding process continued, the themes developed into to two main categories. These categories were related to the Physical Player and Virtual Player. Issues that were reported by user statements and supported by additional observation are now presented.

Physical Player Issues Regarding the physical game space and player activities, there were Four issues that emerged: Strategies were developed, Stepping action was enjoyable, The smart slipper should be user friendly, and the handheld device and personal display should have more features.

Strategies Developed

Through demos, exhibitions, and user studies, the researchers observed many interesting strategies employed by the defender team. The defender team member, knowing that the invader only has two boxes to stand in, blocks one of the spaces. This prevents the invader from moving in any direction. The defender can then trigger the laser beam and the invader loses a heath level. The aspect that makes an activity a game is the need to make decisions [3] [6]. Defenders derive satisfaction from the game play as they claim direct responsibility for winning the game due to their strategies in the game. On the other hand, the invaders have less freedom of movement as they have to constantly follow the flashing patterns on the floor. Failure to do so means losing a health level.

Stepping Action is Enjoyable

The invaders often enjoy following the dance step-like patterns on the game board despite being limited to two squares at any one time. This could be affected

by the presence of audience members who are spectators to the performance. In traditional computer games, the audience passively watches the player exploring the game. However the performance play elements introduced by the dance step-like movements give the invaders an expressive visibility which encourages acting by the player and more audience support. We observed that the audience is continually shouting to the invaders as to where he or she should step next. This is especially useful when the patterns are behind the invaders and the audiences give a timely cue to power up. Following the step patterns requires some level of physical exertion that brings the invaders to a highly energetic game play. The audience's support and feedback also gives invaders a sense of responsibility for the performance that they put up. Some invaders are overwhelmed by the tasks of following the step patterns, avoiding the approaching laser beams and trying to launch one at the same time.

It turns out that the footprint makes the game more interesting and challenging to the young and easier for the elderly. The young players have to constantly search in all directions for the footprint patterns on the floor and at the same time try to launch laser beams towards the opponents and avoid the opponents' laser beams. Furthermore, the young players' laser beams are, by default, significantly slower than their older counterpart. This has encouraged great team work between the elderly and young player as the older team player always alerts the young player for approaching laser beams.

The Smart Slipper Should Be Easy To Use

The usability of the smart slippers presented a particular challenge to the older players most likely due to their reduced mobility and dexterity. All of the adult players agreed that easily adjustable slippers are needed. One generally accepted feature change idea by the older players was to use an adjustable velcro strap to adjust tightness of fit. Otherwise, the use of the slipper was enjoyable and its cute styling was well received.

Performance Aspect

This theme came up in many aspects which have been mentioned in most other topics. This may be a parallel to human nature as seen in professional sports. The "happening" itself is a large portion of the experience. The players often responded to the cheers and shouts from the audience and reacted to suggestions and hints. The audience helped to raise the awareness of which team was winning and losing and also seemed to raise the excitement level of the players. Some of the younger players were shy at the beginning of the game, however, they would loosen up quickly and the shouts from the audience were encouraging them to play freely. Some of the younger players adopted a special finesse to their play which was accompanied by their playing off the audience and making exaggerated gestures when facing challenges and scoring points.

Virtual Player Issues The players were briefed about the design goal of having a parent fill the virtual player role. In the proposed user scenario, grandparents and children would play in the physical space and the parent would join in as a virtual player while away from the home. Users of all roles were asked to

describe their impression of the family interaction scenario and most imagined that their family would enjoy this interaction. The players that had also played in the physical space also had a chance to play in the virtual player role. The most prevalent issues that arose regarding the virtual player were as follows:

Virtual Player Role Is Currently Not As Much Fun As The Physical

Although the players enjoyed the virtual role, the sense of connectedness and ability to take part in the gameplay was not as enjoyable.

More Features Desired For The Virtual Player Experience

Most of the suggestions offered included a desire for more and varied power-ups and obstacles as a way to expand the sense of presence in the game play.

Balancing Gameplay For Other Players Was An Interesting Concept

The virtual players took on a sense of balancing the game play between invaders and defenders, not focused solely on helping just one team. Being in the constantly switching team position, one instant helping the invaders, but in the next moment helping defenders, the virtual players often did not identify themselves with either the winning or losing team but agreed that the interaction was rewarding as an activity of facilitator of fun. In this sense the virtual player has to follow the game progress closely and provide assistance where it best contributes to the overall game experience for all players. Suggestions for improvement include having a virtual helper for each team in the competition scenario. During the game play, the physical players can communicate in the physical space by eye contacts, body gestures, speech and laughter which introduce a high level of engaging and immersive game play. However when translated to the virtual player's interface only the coordinates of the physical players are represented and the emotional connection is not as firmly established. In the future developments, web cam and voice over IP could be introduced to facilitate better coordination and interaction amongst all players and within teams.

5 CONCLUSION

Our play based user studies support the claim that the Age Invaders system is engaging for the physical and virtual players of all ages. We have identified key areas that contribute and detract from the experience.

The older players have shown a high motivation to play the game again immediately after the game play and even after considerable time has past since they have played the game. Players have given feedback that physical movements and skills needed in the game, such as collecting hearts, avoiding lasers and launching lasers, and the aspect of performance made for very exciting and enjoyable play. It may be that the introduction into the computing world using this game system may help to reduce the fear of technology and therefore reduce the social barrier between the generations. This may be more fully explored with future user studies over a longer period of time and with more game configurations for the platform.

Playtesting of game iterations is especially important for the elderly because their familiarity with gaming technology is limited. Mere interviews and surveys

attempting to gather feedback from the elderly can not gather useful results. These players confirmed that it is more appropriate to offer a prototype to evaluate by experience.

The familiarity with electronic games and computers in general is an important factor in the player experience. Those most familiar with contemporary computer games can enjoy more simplified game graphics such as in the Age Invaders prototype, but the challenges need to be presented at appropriate levels to hold the player interest and motivation.

Unlike conventional computer games, Age Invaders encourages large physical movements over a wide area. The user study results support our claim that the Age Invaders game is a form of exercise for the elderly. Participation in such an activity helps the elderly feel healthier and encourages movements that may promote health [5]. In the future, user studies will be conducted to investigate to what degree the elderly visual-motor reaction time improves through playing the A-I game on a regular basis.

Social interaction has been identified as the key factor that attracts the elderly and young to play the game harmoniously. 84% of the players enjoyed the experience of playing the four-player over the two-player game. The elderly and young gave feedback that the game should be played with many spectators.

Another strong point indicated was the performance aspect of playing the game. We will explore this more closely to determine how the audience affects the game experience and search for limits and optimum scenarios of interaction.

It is our hope that this project will encourage more future works aimed at fusing art and digital games to fulfill the scientific objective of improving the welfare of older people and the entire family.

6 Special Thanks

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