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Android App for Elderly Dementia Patients
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Abstract – With the lack of any medical treatment for dementia patients and the proven effects of reminiscence therapy and the growing popularity of tablet gaming, making use of Android games to improve the conditions of elderly dementia patients is a viable solution. (Abstract)

Keywords - Android; games; dementia; elderly

1 INTRODUCTION
In the last century, technologies had advanced with speed which no one had expected. While technologies such as computers and smartphones have certainly made our lives easier, their usefulness may have yet been fully exploited in the medical field. Although there are currently many technological solutions available in the healthcare industry, most are providing indirect help to the doctors or patients. Examples include the use of mobile computing and information technologies in Saudi Arabia healthcare facilities [1] and computational technologies in image processing diagnosis [2].

With the lack of any effective medical treatment for dementia patients [3], the increasingly popular smartphones and tablets may provide the solution to this illness. The purpose of this project was to develop an Android app (which comprises multiple games and a backend score-tracking system) for elderly patients suffering from dementia and their caregivers or doctors. Much research was done to determine the effectiveness of similar methods [4] [5] and the results were promising. These research works had proven that it is possible to reduce the effects of dementia in elderly patients through the administration of reminiscence therapy using Android apps.

While there are also many websites that provide similar games and services, most of those games are mostly targeted at kids or adults, which may not be suitable for the elders. And even fewer cater alternative languages for non-English speaking players. These are the areas which our Android app aimed to improve on. We had ensured that the games are suitable and user-friendly for the elders. We also provided both English and Chinese instructions for all the games. The user-friendliness of tablets also meant that the learning curve will be manageable even to the dementia patients.

2 ANDROID APP
2.1 BACKEND
The Android app comprises a backend interface and the multiple games. The backend interface will only be used by the caregivers of the patients. Its functions include the selection of games for the patients and also the tracking of their game scores, conditions and progress.

2.2 GAMES
As mentioned earlier, the main objective of the Android app was to help reduce or prevent the effects of dementia in elderly patients. To achieve this, we had adopted a similar strategy which Lumosity [6] used – each game focused on improving the patients’ cognitive abilities in one of the following five categories: Memory, Attention, Flexibility, Problem Solving and Speed.

Based on the positive results of the various research which made use of Lumosity’s games, participants who played the games had improved performance compared to those who did not play [7]. And a study carried out in 2012 showed that although older players started out with lower game scores, after just twenty-five game sessions, they were able to improve to be about as good as the younger players’ baseline performance [8].

2.3 DESIGN CONCERNS
Besides the five categories, there were a few other criteria to meet when designing the games.

Firstly, the interfaces of the games must not be overly complicated with confusing layouts or too many decision paths. The options available to the players must be straightforward and logical, and the path to an action should not consist of too many steps. To facilitate this, the back button function was overridden with another function that pauses the game and displays a popup prompting if the player wants to exit the game.

Another consideration is the Android activity stack, which in normal circumstances, holds the memory of previous activities and once the activity in the foreground ends, the stack pushes the previous activity back to the foreground. For example, the first activity is the main menu, so when the player starts the game, another activity for the game starts and the main menu activity gets pushed onto the stack. So when the game activity ends, the main menu activity gets popped back to the foreground, even though the player had selected the exit option. This might be confusing for the players, and thus, we ensured that all the activities will end (and...
not get pushed onto the activity stack) after transition to the game or demonstration activities, to prevent it from coming back.

Secondly, the fonts that were used must also be larger than normal to ensure that the elderly patients can see them with ease and no fanciful fonts too. The buttons or pictures were made larger also, so the players can press them easily. This is very important because tablets do not have physical buttons, and are relying on touch screens for the inputs, so if the buttons were too small, it would result in wrong inputs very often.

Thirdly, the learning curves of the games must not be too steep, it should be easy enough for the dementia patients to learn within a relatively short time. This means no complicated controls and rules. The game objectives should be direct and not too many. Most important of all, the instructions provided in the games must be clear and easy to follow. It is quite likely that the patients would forget how to play the games after the initial session, so there should always be an option to view the instructions while in the games.

Other than instructions, demonstration is also included in the games. In case the players still could not understand how to play the games after following the instructions, they can always choose the “How to play” option that only has the essential elements and without any “Gameover” possibility. This allows them to try the game at their own pace, without worrying about losing their game “lives”. Fig 1 is an example of a “How to play” option available in the game. It does not have the additional information about the current level, number of lives left or the scores. It also has instructions in the background to remind the players what they are supposed to do. And the game reacts in the same manner as it would during a normal game round whenever it receives the user inputs, such as the green tick or red cross that appears after the player had chosen a correct or wrong answer, respectively.

Fourth, the difficulties of the games must be well-adjusted to suit the players. The games must be difficult enough to provide fun and challenging obstacles, so they would not get bored. But they should also not be overly difficult to the point where most would lose the motivation to continue with the games.

Lastly, feedbacks should be provided by the games for every input by the players. This is necessary to inform them that they have made an action in the game. Because the tablets are touch screen, there is no physical feedback like pressing a button would give, so the app should provide the feedback instead, either with sound, visual change or slight vibration of the device.

2.4 SPEED

This refers to how fast people are able to process information presented to them.

The game, shown in Fig 2, developed for this category is called “Push That Button”. This game presents the player with twenty-five buttons in a five-by-five arrangement and each round of the game lasts one minute. During the round, one random button will be highlighted by turning green colour and the player is required to press that button before it returns back to normal (and another random button turns green). As the player “levels” up, the time at which the button turns back to normal decreases.

Basically, the aim of this game is to train the players to process information faster. The idea is very simple – press the green button, no additional task. Players are not required to think of complicated problems or solutions, just press the green button as quickly as possible, before it returns back to normal. It really is a game to test the reflex of the players, to see how quickly they can react and how coordinated their eyes and hands are. And by doing this repetitively, the patients can improve their reaction time.

Because this was the first Android project which the author had worked on, much time was spent searching for guides and helps online. For example, without knowledge on the “OnClickListener”, all the twenty-five buttons were typed out manually in the XML template file, and then programmed individually in the Java file, all of which could have been done with just a simple loop.
Another difficulty faced is the management of process threads. The game requires the use of a timer (updates itself every second), which was setup using the timer and timertask classes in Java. In order to execute the programme with timer, a separate thread is needed. However, Android only allows the main thread to modify the interface. Luckily there is a method that forces the program to run on the main thread even when called by other threads.

2.5 PROBLEM SOLVING

This refers to how well the people are able to derive logical solutions to the problems given to them.

The game, shown in Fig 3, developed for this category is called “The Maze”. The player is presented with a maze, with the exit in the northwest corner and a ball located in the southeast position. The objective of this game is to navigate the ball to the exit using only the tilting motions of the Android device. The size and complexity of the maze increase as the player progresses through the levels.

The objective of this game is to train the players in solving problems, and in this case, they are required to visually find the path that can lead the ball to the exit. Usually, when people are navigating in physical mazes, they tend to rely on their sense of direction and memories to guide them to the exit. However, the challenge that this game offers is slightly different. Because the players are able to see the entire maze, they can mentally plot out their routes first, instead of making a decision instinctively at every intersection. Therefore, this requires them to think and derive the solution, much like solving logical problems.

There were two major obstacles while developing this game – maze generation and 3D rendering of the maze.

To make the game more dynamic, the maze should be generated dynamically at each game round, so this requires a maze generation algorithm. Fortunately, there are many resources and guides available online for this. In the end, the depth-first search algorithm was used.

The second problem was not so smooth sailing. For 3D rendering in Android, there were only OpenGL ES or Unity engine to choose from. And after some tutorials and hands on trying, OpenGL ES was chosen.

OpenGL was still pretty difficult and complicated to learn. There were buffers, shaders, vertices, colours, lightings and other stuff to consider even when creating simple 3D models. And the situation looked pretty grim towards the end of the project because no decent progress had been made. Fortunately, after following a few more tutorials and extracting code snippets from examples found online, everything was completed on time.

2.6 SPEED + PROBLEM SOLVING

This refers to how fast people can derive the solutions.

The game, shown in Fig 4, developed for this category is called “NumberPop”. In each round, the player is required to solve a mathematical problem, which involves two operands with a randomized operation (addition, subtraction, multiplication or division). The player is given four answers to choose from. Each answer will fall to the bottom of the screen at a different speed, and the player has to make the correct choice before any of them reaches the bottom. The higher the level, the faster the answers fall to the bottom and the greater the values of the operands. Every five correct solutions advances the player by one level. The possible choice of operation for the different levels is as followed: level 1 – addition; level 2 – addition and subtraction; level 3 – addition, subtraction and multiplication; level 4 and higher – addition, subtraction, multiplication and division.

The “problem solving” element in this game is of course the mathematical problems. Players must calculate the answers for each question using only mental calculations. Since they are only allowed to use their brains, all the questions generated by the app have positive integers as answers, with no fractional values. We also ensured that for multiplication and division
questions, the operand values are not too big, to prevent the question from becoming too difficult.

The “speed” element of this game is the time factor. In order to make the game more interesting and exciting, time limits are enforced in every round. Just solving the mathematical problems is not enough, the players must solve it quickly or, risk losing their “lives”. The purpose of adding a time limit is because having the players to solve the problems will not be very significant if they can have all the time in the world to slowly derive the solutions. Instead, they are forced to think and process the problems quickly and correctly. By doing so, it trains the patients not just on thinking, but thinking fast too.

There were many challenges when developing this game. The first problem was the animations of the falling numbers. Before this, the author had only used the default XML template framework provided by Android, and did not know what kind of animation function is suitable. So after some searching and trying, the animation was done using the canvas draw methods available in Android.

The second problem was the generation of the questions and answers. For addition and subtraction, the operands can range from zero to current level times ten. The solutions for division questions should only be whole numbers and the values of the operands in multiplication and division problems should not be too large. To get whole number solutions, the same method to generate the questions for multiplication was used, then swap the answer with one of the operands. Instead of using current level multiplies by ten, the operands for multiplication and division questions are randomly selected from zero to current level multiplies by three.

3 DISCUSSION

Overall, the games developed had met the objectives of this project. However, there are several areas where improvements could be made.

3.1 DESIGN

The designs of the games were created with concerns for older players in mind. The fonts of instructions and labels were deliberately made larger and easy-to-read font styles were used. We also ensured that the colours used were well contrasted and were not too flashy.

Although the designs were well-catered for the elderly players, they were a little too simple. Future revisions of the games can include beautifying the overall design of the games.

3.2 LANGUAGE

Currently, the games only support English and Chinese, because these two are the most spoken languages in Singapore. Future upgrades can include the addition of more languages such as Malay and Tamil.

3.3 GAME MODE

As of now, all the games only have a single mode, and after a while it may become too boring for the patients. Additional game modes can be included in future updates, such as time attack or extra game elements, so the players will not get bored too quickly.

3.4 DATA COLLECTION AND ANALYSIS

Presently, the player performance information which the Android app captures is not very comprehensive – only nominalized scores. Thus the level of analysis the app can provide is quite limited. In order to deliver better and more comprehensive performance tracking and analysis for each patient, the app can be expanded to record more data, such as time taken, number of attempts, and numbers of actions (swipes or touches).

3.5 OTHER PLATFORMS

Other than Android, the app can also be ported over to other mobile operating systems such as the iOS and the Windows mobile. The benefit of doing this is that if the caregivers or healthcare centres already own one of the abovementioned devices (other than Android), they do not need to incur additional costs for the purchase of an Android-powered device.

Besides mobile operating systems, the app can also be expanded to console platforms like the Wii, PlayStation or Xbox. We can take advantage of the availability of full body motion detection of these consoles and design new games which can incorporate those features in. In a research by Cay Anderson-Hanley et al, results showed that the concurrent use of both cognitive and physical activities had greater effects on older adults [9]. This means that the use of the consoles’ motion control and...
the cognitive stimulations from the games could have a more significant impact on improving the conditions of dementia patients.

The downside is that the games are restricted to players who are mobile enough, especially for the Xbox’s kinect. Patients that have difficulties moving about may find it difficult or impossible to play on these consoles.

3.6 MULTIPLAYER
At the moment, all the games only support single player mode. This can be expanded to include multiplayer modes, where the players can either team up with each other to achieve a common goal or compete amongst one another. The connection can be formed either via Bluetooth/Wifi (short range) or over the internet (long range).

As demonstrated in a research by Li, K.A. and S. Counts [10], playing the same games together brings upon the players a sense of community. However, cooperation play seemed to have a counter effect, due to the causal nature of the games. And surprisingly, having the players competing with each other increased their motivation.

3.7 GAME CUSTOMISATIONS
Currently, the interfaces and background music are preloaded into the games. This area can be improved by allowing the patients to load their own pictures and music into the game. As a form of reminiscence therapy, patients can be “prompted” of their past experiences and memories by their favourite pictures, music or any other stimulants [11].

Therefore, by allowing them to customise some basic features of the games, it may provide greater stimulations to the patients, that can lead to more positive effects.

3.8 IN-GAME ACHIEVEMENTS
Similar to the achievement systems available in Xbox’s, PlayStation’s and Wii’s games, it may be possible include this in the Android app as well. Basically, in-game achievements refer to the optional objectives that the players can complete in order to receive an in-game trophy or badge. For example, if the player managed to beat the game without making any mistake, he or she can get a badge that represents the completion of this objective.

Implementing this feature may provide additional source of motivation for the players as well. Just like how we got so happy when we received a gold star sticker from the teachers for attaining full marks in our tests. Similar concept applies here as well, the dementia patients may be motivated to achieve better scores or collect more badges so they can show off to their friends or caregivers.

4 CONCLUSION
As so many research studies have proven, letting the dementia patients to play specially designed games is beneficial for them. And with the addition of the backend system to keep track and analyse the performance and conditions of the players, the Android app will be helpful to the caregivers and doctors as well, by providing them with more information regarding the patients.

And with so many upgrade possibilities, the potential of this is very significant. Especially with the inclusion of motion control of gaming consoles, the benefits of this type of therapy are even greater.

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