

Gaming and Healthcare. An intelligent way to help our elders.

Laura Martínez Sanahuja

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Thesis supervisor: Joan Cabestany Moncusi

Departament d'Enginyeria Electrònica

Universitat Politècnica de Catalunya

Co-supervisor: Andreu Català Mallofré

Departament d'Enginyeria de Sistemes, Automàtica i Informàtica Industrial

Universitat Politècnica de Catalunya

Facultat d'Informàtica de Barcelona

Universitat Politècnica de Catalunya (UPC) – BarcelonaTech

Facultat de Matemàtiques

Universitat de Barcelona (UB)

Escola Tècnica Superior d'Enginyeria

Universitat Rovira i Virgili (URV)

Abstract

World population is aging, and aging carries a lot of health issues. To check this health issues it is needed a doctor, but we can always have some training to help our skills to be maintained or even improved. Tests are boring, so thanks to serious gaming we can gamify these tasks and make them more entertaining.

In this thesis I will develop an application to evaluate the physical and mental state of the elderly over time using different games that interact with different abilities.

First I'll introduce and explain some information about population and gamification. Then there will be the explanation of the proposal and a state of the art to see what's on the market and what can be developed.

After having an idea of what it can be done, I'll write the description of the project and do the development. Finally I will have a big evaluation of the result.

Index

| | |
|-----------------------------------|----|
| Abstract | 3 |
| Index..... | 4 |
| Introduction and motivation | 6 |
| Objective | 9 |
| State of the art..... | 10 |
| Abilities and exercises | 10 |
| Logic | 10 |
| Memory..... | 12 |
| Attention | 14 |
| Analysis..... | 15 |
| Fine motor skill | 16 |
| Other abilities..... | 17 |
| Comparison table | 18 |
| Product definition | 21 |
| Logic Games | 25 |
| Series..... | 25 |
| Patterns..... | 26 |
| Logic games evaluation | 26 |
| Memory Games..... | 27 |
| Memory..... | 27 |
| Color sequence | 27 |
| Memory games evaluation..... | 27 |
| Attention Games | 28 |
| Previous image | 28 |

| | |
|-----------------------------------|----|
| Overlapping | 29 |
| Attention games evaluation | 29 |
| Analysis Games..... | 29 |
| Classify..... | 29 |
| Open the door | 30 |
| Analysis games evaluation | 30 |
| Fine Motor Skill Games..... | 30 |
| Mandalas | 30 |
| Labyrinth | 31 |
| Fine motor games evaluation..... | 31 |
| Development of the proposal | 32 |
| General application | 32 |
| Games development | 35 |
| Memory - Memory..... | 35 |
| Logic - Series | 37 |
| Attention - Previous Image | 37 |
| Analysis - Classify | 38 |
| Fine Motor - Labyrinth | 39 |
| General application extras..... | 40 |
| Final game | 42 |
| Evaluation of the proposal | 43 |
| Conclusions..... | 50 |
| References | 52 |
| Art..... | 54 |

Introduction and motivation

The elderly population is growing over the years. According to WHO's information between 2015 and 2050, the proportion of the world's population over 60 years will nearly double from 12% to 22%. The pace of population aging is much faster than in the past and we live longer. This carries a lot of health issues.

It is well known that elders tend to forget recurrent episodes, leave aside habits or hobbies and they usually have difficulties orienting themselves in time and space, among others. Common conditions in older age also include hearing loss, cataracts and refractive errors, back and neck pain and osteoarthritis, chronic obstructive pulmonary disease, diabetes, depression, and dementia. Furthermore, as people age, they are more likely to experience several conditions at the same time. Cognitive control and working memory are important because they have a central coordinating role.

Over 20% of adults aged 60 and over suffer from a mental or neurological disorder and 6.6% of all disability among people over 60 years is attributed to mental and neurological disorders. The most common mental and neurological disorders in this age group are dementia and depression, which affect approximately 5% and 7% of the world's older population, respectively.

There are some tests and techniques to detect different disorders or lack of functionalities, like the CODEX test to detect Alzheimer disease in early stages, the Folstein's test to detect any other dementia problems or the clock evaluation, where different memory functions are checked, such as praxis and spatiotemporal orientation.

Those tests are performed by neurologists that evaluate the results and the overall state of the person before diagnosing a mental disease. However, if we change them slightly, we can introduce the practices in a routine for other aspects like helping to maintain or improve certain abilities before they start to worsen.

This is the main motivation of this project, to provide a group of activities that may help on the maintenance of the functionalities (mostly mental, but some physical too) of elderlies. And here's where gaming is introduced, especially, serious gaming.

Serious games are a category of video games that are not just for entertainment, but they also have a particular kind of goal. They are usually used by industries like defense, education, scientific exploration, health care, emergency management, city planning, engineering, and politics. Serious games are a means, not an aim.

Games have the potential to support self-efficacy; self-confidence in one's own abilities and one's attitude towards (new) technologies. By stimulating intrinsic motivation, there is no need to deploy rewards to make people play.

Designing games for seniors is not about making games more accessible. Offering elders the same content as young people but with a bigger font size is just not going to work. Seniors, more than young people, want a clear pay-off. In other words, they want to gain something out of the game that interests and helps them.

If games have a positive effect on the cognitive skills of seniors, there are many benefits to gain, especially within the context of the rise in the aging population. Cognitive training can slow down decay but is experienced as aversive. In contrast, dedicated computer games may protect against cognitive decline, while being entertaining. Nowadays we know that the brain retains its plasticity and that new brain cells are produced up to a very advanced age, so if we keep practicing all our life we can possibly maintain our brain active.

Health care is one of the main areas where games have been developed, as there are many wide fields where they can be fit in (i.e.: cognitive and emotional health, exergaming, active gaming and fitness, rehabilitation, social interaction, education and training in health). It is well known that regularly playing games is good for your eyesight; it improves the eye-hand coordination, slows down memory loss or even prevents it and is also good for developing problem-solving qualities.

The tendency of video games in health care was explained by Jeroen van Mastrigt in the STT 76 (2011) study about serious gaming:

'Since the arrival of video games in the eighties, games are being developed and applied for health care and this trend is likely to persist. For five years now the number of game applications for health has

grown fast. There is a vast accumulation of knowledge, competence, and experience in using games in the domain of health. The number of publications, conferences, and workshops is increasing, worldwide and in the Netherlands. There is better hardware and software to develop health games. The number of companies and organizations that develop these kinds of games is growing. It looks like we have an all systems go.'

Some years ago society didn't see elders as gamers, but in 2008 The Dutch National Gaming research stated that 57% of Dutch population over 50 years old was playing video games regularly. They've also said that elder gamers play more frequently because they have more time to play than younger generations. We need to think also about how much accessible and powerful technology has become during those last years.

In 2018 gaming report from the Entertainment Software Association (ESA) it's shown that 23% of the total gaming population in America (that represents the 64% of the total population) are elders. If we take into account that the US population is around 327M there are almost 50M elder gamers just in the US. If we extrapolate other year's data, we can see that this number is growing, and not just due to the fact that gamers are growing older and will eventually become senior gamers, but because people are seeing the benefits of gaming for their health.

But of course, all those elder gamers are not the same person. As individuals, they all can have different abilities and health issues, so it is very important to find the correct training level to prevent them from giving up this practice that is beneficial for their health. And here's where Artificial Intelligence has its own place.

Sander Bakkes, an IT and health care researcher at the CREATE-IT Applied Research knowledge center of Amsterdam University of Applied Sciences, explained in the STT 76 (2011) conference about serious gaming how AI can help this kind of games to fit perfectly to their purpose by personalizing the application. An intelligent system could not just take the perception of the user into account, but also make the connections between somebody's personal history, current measurements, and suggestions for the desired behavior to get the best experience and training possible.

Objective

The objective of the work performed in this thesis is to create an **intelligent game platform** oriented to the **elderly population** where they can **test different skills** in different games.

This skills testing will be trying not just to evaluate the state of each of the abilities, but also to try to maintain or train the skills to prevent the degeneration produced because of the aging.

The platform will have some intelligence to personalize the difficulty of each of the games or tested skills to the person capacities. We can agree that depending on the background of each person and its current health status, the top difficulty of the game will not be the same, as for example in a calculus exercise or a fine motor activity. This AI process will take place every time the user plays some of the games by checking all the progress and trying to push a little to make it more interesting.

During all the usage of the application, the platform will keep the progress over time that shows the results obtained per game or ability, among the difficulty levels where the user can perform better. With this progress, there will be the possibility to generate graphs with the outcome of the results per skill or per game so it can be sent to relatives or also to healthcare professionals.

The evaluation will be divided into two parts. The first one will be a technical test, where some scenarios of different users will be recreated to see if the application applies the correct difficulty to each game (testing the intelligence of the platform) and if the progress being saved and sent is correctly generated.

Then the second part of the evaluation will be a test with some users in order to see how they feel about the usage of this platform for working their skills. The group of people being tested will vary not just the age, but also the gender and their affinity to video-games. In this evaluation with users I'll try to get as much information as possible by providing them with a formulary with open questions so they can express opinions not just based on grades.

State of the art

First of all, in order to evaluate what it is already in the market similar to this work approach, there's a need to analyze the abilities that can be worked on to help the user improve or maintain them. As humans, we do have a lot of different skills, so the first part is to get the ones that get more affected when we age. This process ended up by choosing 5 abilities that are listed below.

The next part done in this state of the art was to search for exercises that train each of the abilities. None of them train just a unique ability, but they're classified in the one they affect the most.

Finally, after listing some other skills that would have made it into the list but they weren't going to give visible results for this work, there's a research on already existing games that shows which areas do they work with and which is the difference with this approach.

Abilities and exercises

Logic

This ability can be defined as the study of correct and incorrect reasoning. In fact, logic is one of the basic thinking skills that we have as humans that help us for example to make distinction between right and wrong. Improving this ability provides some benefits such as:


- Improve learning skills.
- Correlate easily events and objects.
- Reduce the chance of making mistakes.
- Perform better establishment of cause and effect relation.
- Develop right strategies.

To develop this ability there are plenty of exercises, as it is a discipline of thinking. Some of the most useful exercises that can be found in this area are:

- Math problems (Mathematics is one of the most logic subjects)

- Equation solving (images, text, numbers...)
- Pyramid of values
- Puzzles
 - Solve a puzzle
 - Find a missing piece of a pattern (or by the piece sides)
 - Sudoku
 - Tangram
- Series
 - Numerical (evens, odds, primes, Fibonacci sequence...)
 - Letters
 - Figures (rotation, addition, edges...)
 - Colors (Simon)
 - Sounds
- Chess
 - Full match
 - Given certain pieces, achieve an objective
- Detective-related activities

$$\begin{aligned}
 \text{🍏} + \text{🍏} + \text{🍏} &= 30 \\
 \text{🍏} + \text{🍌} + \text{🍌} &= 18 \\
 \text{🍌} - \text{🥥} &= 2 \\
 \text{🥥} + \text{🍏} + \text{🍌} &= ?
 \end{aligned}$$



| | First Names | Detectives | Breakfast Cereals |
|-------------------|-----------------|------------|-------------------|
| Days Off | Monday | | |
| Days Off | Tuesday | | |
| Days Off | Wednesday | | |
| Days Off | Thursday | | |
| Breakfast Cereals | Bran Flakes | | |
| Breakfast Cereals | Fruit Loops | | |
| Breakfast Cereals | Honeycomb | | |
| Breakfast Cereals | Shredded Wheat | | |
| Detectives | Nancy Drew | | |
| Detectives | Nero Wolfe | | |
| Detectives | Sherlock Holmes | | |
| Detectives | Veronica Mars | | |

Logic Puzzles
 Presented by Puzzle Baron
 Puzzle ID: O512PD
 For hints, solutions and more puzzles, go to
[www.Printable-Puzzles.com!](http://www.Printable-Puzzles.com)

| Days Off | First Names | Detectives | Breakfast Cereals |
|-----------|-------------|------------|-------------------|
| Monday | | | |
| Tuesday | | | |
| Wednesday | | | |
| Thursday | | | |

1. The one who eats Bran Flakes is Elizabeth.
2. The person whose favorite detective is Sherlock Holmes has a day off later in the week than the one who eats Fruit Loops.
3. The one who eats Shredded Wheat is not Anna or Brooklyn.
4. The one who eats Shredded Wheat has a day off later in the week than the one who eats Honeycomb.
5. The one who eats Fruit Loops is not Brooklyn.
6. The one who eats Honeycomb doesn't enjoy Veronica Mars mysteries.
7. Either the one who eats Shredded Wheat or the one who eats Fruit Loops loves Nancy Drew mysteries.
8. The one who eats Bran Flakes doesn't enjoy Nero Wolfe or Veronica Mars mysteries.
9. Of Elizabeth and the one who eats Shredded Wheat, one has Wednesday off and the other has Thursday off.
10. The one who has Wednesday off is not Amari.
11. The one who has Monday off loves Veronica Mars mysteries.
12. The one who has Tuesday off is not Elizabeth.

All the previously mentioned exercises can be easily transformed into a game as they have just one solution, and do not depend on the user experience. Among that, they are easy to escalate to adapt its difficulty level, for example, you can divide an image from a 2x2 puzzle until a large number (we can find board puzzles over 40000 pieces).

Memory

This ability is the one that makes us capable of remembering things. Memory is the faculty of the brain by which information is encoded, stored, and retrieved when needed.

There are multiple types of memories:

- **Sensory memory:** memory used during any action that is taken in by sensory receptors and processed by the nervous system. Through this process, we do not store any information, but we get a detailed representation of our entire sensory experience, such as images (iconic memory), sounds (echoic memory), tastes (gustatory memory), smells (olfactory memory), and touches (haptic memory) that can later on be converted in the short-term memory.

The only way to develop this skill is by improving the attention (check it in the next ability) and the short-term memory.

- **Short-term memory:** it is also known as “working memory” or “active memory”, is the capacity for holding, but not manipulating, a small amount of information in mind in an active, readily available state for a short period of time. Thanks to that temporary memory we can remember the shopping list at the supermarket, a phone number before write it down or a name of the book that a friend just recommended us in the library.

This is one of the areas more damaged due to aging and one of the main affected ones in Alzheimer's disease, aphasia, schizophrenia and posttraumatic stress disorder (PTSD).

Some exercises that can help with this type of memory are:

- Detail observation: by paying attention to details, we force our brain to actively remember visual inputs. An exercise can be to pay attention to an image and then write down 4 details (for example in a picture with a woman: hair color, ring shape, presence of a hat and color of the clothing).
- Repeat a sequence: it can be a color sequence (Simon game), a set of images, words, sounds... Any exercise that makes you remember what you just saw or heard works with the short-term memory.
- Select the most repeated one: imagine a window, where an image appears (2-3 images in total). After certain repetitions of the opening window, the user needs to select the image that has appeared the most. This helps you remember some facts that happen in a short amount of time.
- Memory: a classic card game where pairs of images are hidden in a card matrix and by turning over any two cards per turn you try to make all the pairs.

All those exercises can be converted to games easily. They share a lot with logic and attention games, as they act in details and sequences too.

There are other activities that can be performed from time to time that help with the evaluation of Alzheimer's disease, such as the CODEX (cognitive disorders examination) test. This test consists of 3 activities:

- Remember 3 easy words (ex: bike, spoon, apple).
- The clock test: in this activity a clock is provided without the numbers. Then the user is required to write the hour numbers. Finally, a random hour is provided and the user must put the clock hands correctly. The evaluation is in both parts, to check that the numbers are correct (and correctly placed) and that the clock hands are in the correct position (and with the correct length).
- Repeat the 3 words from the first activity.

If the results of the two/three tests are normal, the probability of suffering from Alzheimer's disease is almost none. On the contrary, if the two tests are abnormal, the odds are high and it is recommended to go to a specialist.

The clock test is an awesome exercise to check any other type of dementia too.

- **Long-term memory:** this is the stage where memories are stored. Long-term memory is a key element to successfully completing daily activities independently. This type of memory refers to the brain's ability to store experiences, events, concepts, or skills, and recall them later. Long-term memory is a complex skill that has many different facets, and uses different parts of the brain. This is why it is sensitive to brain damage. Luckily, brain training and practice can help improve this key cognitive function.

For training this type of memory it is needed to stimulate specific neural activation patterns. Through the repetition of these patterns, we can help strengthen and improve the neural connections used in the memory process. This can help create new synapses able to reorganize and/or recover damaged or weakened cognitive functions.

Long-term memory is damaged in Alzheimer's and Parkinson's diseases, as well as with many other types of dementia.

This kind of exercises are the more difficult ones to convert to a game, as they require to ask facts to the user, ask for them after certain time and compare the results. This adds more difficulty because of the natural language processing that has to be made by the game to evaluate it. One of the found games that does something similar is Brain Training by Nintendo, where Dr. Kawashima asks you a question or to draw something and after some time it does the same, but it lets you compare the results, so it does not evaluate if it is the same or not.

Attention

This ability corresponds to the process of selectively concentrating on a discrete aspect of information while ignoring other inputs.

The best way to exercise this skill is by making sure that the user is focused on a certain goal or objective:

- Spot the difference: comparing two images, it is necessary to find the differences. It is in the details where this usually changes, so the user needs to focus on certain spots of the picture, and not on it as a whole.
- Where's Wally?: any exercise of this type helps the user focus on the goal of finding a certain pattern/figure/color...
- Overlapping images: by overlapping certain silhouettes or figures and making the user decide between certain images, we can focus the attention on the shapes and colors to distinguish from the rest.
- Follow instructions: there are several games that fit this purpose as “Simon says” where you need to follow the instruction just if the previous sentence is said before the instruction, or any game that requires to follow a process, such can be preparing a meal in “Papa’s Cooking”.

All those exercises can be performed in a videogame perfectly and they add more value as they can be much more interactive.

Analysis

This ability is the process of breaking a complex idea into smaller parts in order to gain a better understanding of it.

Some exercises that can be done to develop this skill are:

- Classification games: any type of classification game helps us analyze the details to group the objects. For example in “Guess Who?”, those details are the human features (presence or absence of hair, hair color, eyes color, gender, face shape...) that help us by asking analytic questions to know who’s the other player choice.
- Need to go from a point A to a point B: when it is needed to make a path from a point to another with certain specifications (not repeating tiles, fixed pieces...) the user needs to analyze the environment. Some



games into this category are “Connect the pipes” where you’re asked to bring water from one point to another by rotating the already set pipes, or “Rush hour” where you have a car stuck in traffic and by moving the rest you need to unblock it.

- Strategy games: all strategy games have a lot of analysis behind as you are not just trying to win, but to defeat the opponent. In here there can be seen some games as “Dominoes” or “Battleship”. There can also be found here more complex games as “Mini metro” where you need to connect certain shape stations with different lines without collapsing the city.

These types of activities are already gamified. They are fun games that also help us with our analysis.

Fine motor skill

This ability, also named dexterity, is the hand-eye coordination, where we relate the movement of muscles, bones, and nerves with the eyes to produce a small, exact movement. Thanks to this skill we’re able to pick a pencil with the index finger and the thumb and to point to a point on a mobile or tablet screen, as well as to zoom an image with two fingers. One of the diseases that struggles the most with this ability is Parkinson’s disease.

Some exercises than can help while working on that skill are:

- Connect the dots: one of the activities that we do as children is to grab a sheet full of dots and connect them following the numbers in ascending order. This is an awesome exercise to develop our fine motor skill, as it requires first to search for the dots and then precision to draw a line from one point to another.
- Drawing and painting: this is another cool exercise to develop this ability and it can be performed by following certain techniques.
 - Free drawing: given an idea, drawing what it represents helps you to focus on a small area to describe with lines the object. Thanks to artificial intelligence, we can have a computer that analyzes the result and checks if it is the object described, no matter how bad the user is at drawing.

- Symmetry drawing: given half draw, the user is asked to copy symmetrically the painting.
- Free painting: if the user is provided with any image with closed spaces such can be a mandala and a bunch of colors, he/she can paint it in a freeway (everything can be the same color) as the important part is the ability to point the paint first and the area later.
- Painting by numbers: we've all painted a picture with numbers some time. It can be similar to the previous one but fixing the colors or a pixel painting, where the user needs to zoom to paint pixel by pixel a small image.
- Physical movement: hands movement can be also considered part of the fine motor system, so by helping us from the accelerometer on the device, the user can perform movements that have a result, as can be moving a ball through a labyrinth from one point to another. It can be done as easy or hard as wanted because there can be small labyrinths or complex ones with secret passages.

Of course, this ability has a lot of potential of being gamified, as its exercises are easy to perform in a mobile device.

Other abilities

There are other abilities than the previously listed, but for this work we've taken the ones that were easy to see results in a short period of time.

Here's a list of some other skills that can be worked to either maintain or improve thanks to videogames:

- **Language:** the usage of the language can be improved with games that, for example, help the user to speak by repetition of sentences or that helps him/her to use other techniques to communicate, such as pictograms. We can also play with word searches, crosswords, chained words... And if more complexity is wanted some reading and writing exercises can be converted to games, as well as some word-forming through letters or half-words. We can

also include word categories to separate concepts. There are a lot of exercises involving language.

- **Spatiotemporal orientation:** in this skill we can find needs to know where the person is after a disorientation, so it may be a good exercise to relate some objects to certain spaces (cook in the kitchen, shower in the bathroom, bed in the bedroom...) so once those objects are identified, the person can remember where he/she is. Another idea could be to make the user reach a certain point given some directions over a fictional map.
- **Learning:** a skill that we start developing since we're born and needs to be maintained forever, as in each life stage we learn different things, and not just academics but life processes (new meals, easy ways to do some activities...). For elders, learning can be taught, but thanks to gamification, new processes and ideas can be introduced into our brain easily.
- **Mobility:** this kind of ability is key for elders to help them exercise. Some non-gaming applications can help (such as Google Maps) to reach directions or avoid being lost, but is much funny if we add to it a little gaming (like Pokémon Go, that adds an augmented reality layer over a map).
- **Social:** elders tend to be alone, and this is one of the main facts that can derive in depression. There are many social games and thanks to the technology we do not need to force them to go out. Online games are a reality and a lot of activities can connect people together with the same purpose, to talk, to play, to share...

Comparison table

As the last step of this section, I want to make a summary of some of the games I've been checking to get possible exercises and abilities to work with. In the following table it can be seen if the games work for the categories I've decided to work with or similar ones.

| Game | Company | Logic | Memory | Attention | Analysis | Fine Motor Skill |
|--|------------------|-------|--------|-----------|----------|------------------|
| CogniFit | CogniFit Inc. | X | X | X | X | X |
| 60 Brain Games: Free Mental Training! | Peoresnada.com | X | X | X | X | |
| Memory Games: Brain Training | Maple Media | X | X | X | X | |
| Train your Brain | Senior Games | X | X | X | X | |
| NeuroNation | NeuroNation | X | X | X | X | |
| Big Brain Academy | Nintendo | X | X | X | X | |
| Brain Training | Nintendo | X | X | X | | |
| MentalUp | MentalUp | X | X | X | | |
| Einstein's Riddle Logic Puzzles | Rottz Games | X | | | | |
| Color Match | Ricrobreg | | X | | | |
| Simon Says - Memory Game | Hackman | | X | | | |
| Memory Test: Memory Training Games, Brain Training | SimFun | | X | | | |
| Alzheimer's Speed of Processing Game - ASPEN | Tiny Happy Steps | | | X | | |
| Guess The Character | JanduSoft | | | | X | |
| Classic Labyrinth | Cabbie Games | | | | | X |
| Mandala Coloring Pages | PeakselGames | | | | | X |

After this summary I would like to compare the ones that work with all or most of them with this approach and see the differences and what this work is supposed to contribute to the community.

Before checking the ones that are more similar I'd like to mention that I've noticed that there are much more games that work just with one exercise (as the last 8) than games that train multiple abilities. I guess that this is because it is much easier to develop just one game than multiple games. This approach will offer a more complete experience in just one app than having to download one per each game. It is the main objective of the development and also a big challenge.

Almost all the rest of the games (top 8) have similar exercises to train the skills. As it can be seen in the table there are few of them that train fine motor skill, and from the top there are also two that do not train analysis either.

Under my understanding the fine motor skill is the most difficult to check, because the difficulty resides on the evaluation of the progress. However, CogniFit does it by training coordination with several games. Another nice thing about this game is that they have specific brain training programs for people who suffer some type of cognitive impairment such as Alzheimer's, Parkinson's, Dementia, Multiple Sclerosis...

Almost all those top applications listed have daily notifications to remind the user that he/she has to train. That is a cool feature that it is also integrated in this approach. Humans easily forget things, so a reminder does never go against the purpose.

If you try it, CogniFit is an awesome application, so it is hard to compete against it. Analyzing its features I found out that there are two features that can be an improvement in this approach. The first one is a weekly report that can be sent to anyone who cares about it. It can be either a family member or a doctor that finds those results interesting enough for the medic report of the user. And the other, and more important one, is the ability to adapt the difficulty of the game by analyzing the previous games.

This last feature is the main one for that approach, the usage of the AI to check the way the user is accomplishing (or not) the objectives and adapting the level of each exercise, as no human is equal to another, so the skills can vary even from one day to another.

Product definition

In this section, I'm going to describe the product definition for the game platform and the mini game that have developed.

The first step of all developments is to know who's the result for, as that can help with the definition of the features.

In this case I'm developing a game for elders who are potentially people that aren't related with technology, so the game has to be intuitive enough for those who have never played a game. When working for elders other fields need to be considered, such as a big enough font size to read easily (the less text the better, but some explanations may be needed), so those parameters need to be reflected in the settings so the application can be adapted to the user preferences.

It is also important to consider that the interface needs to be clean enough to avoid miss clicks. That also will affect the games where precision is taken into account. The feedback given per each action it is also important. As already mentioned, there would be some people that have barely used technology for entertainment, so it is important to make sure that they get clearly what they are interacting with.

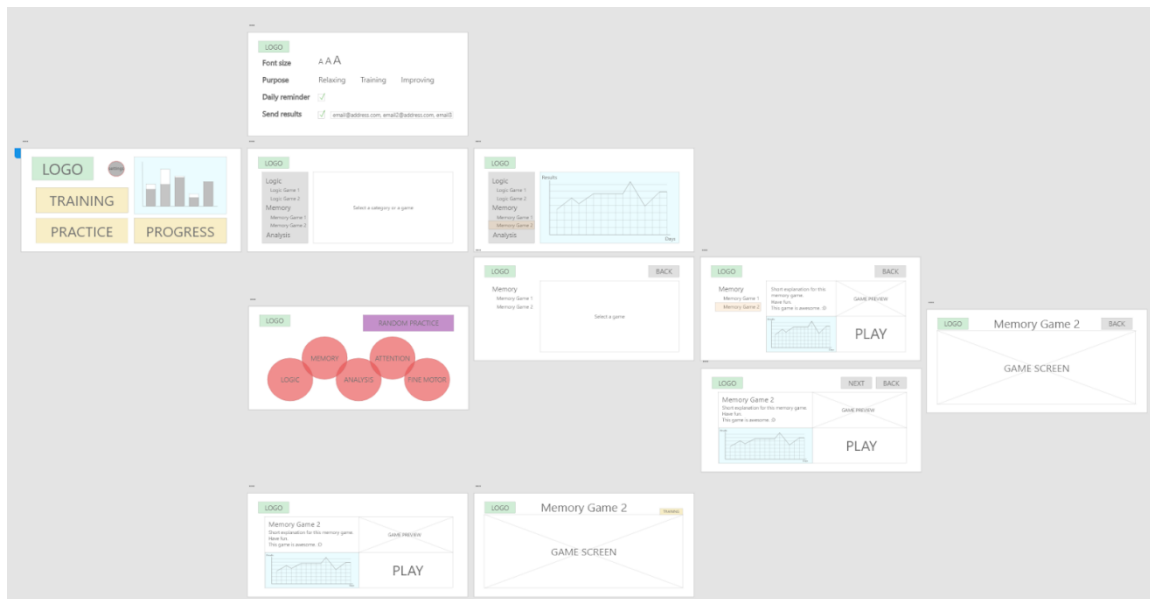
As mentioned in the introduction, seniors want a clear pay-off in their activities, so they will play this game if it interests and helps them in improving or maintaining certain skills. By the usage of serious gaming it is achieved the purpose to entertain while working on an ability, and the usage of artificial intelligence to adapt the game level to the user helps to offer them challenges every time they decide to play.

In order that the person does not use the game two days and leave, it will be offered a notification service and some graphics where the results of all their sessions will be displayed. This way they can see their progress and stay more motivated.

After this analysis of the user, it is time to talk about the hardware where this is going to be played in. Since the beginning of the process I had a clear idea to use mobile phones or tablets as they are the technology that almost everybody has nowadays in their homes. It would be much better a tablet, as the screen space is bigger and can

help the person with the visualization and the interaction, but it shall work too in a smartphone.

The next step of the process is to do a mock-up of the application, to see the scope of the application. I will start with the platform and not the games themselves. In this process I tried to be as accurate as possible, because defining things now can avoid having doubts in the future. Here's the result of the mock-up:



Once the initial idea was set in screens, I've decided Unity as the game engine used, as it is already prepared to game development in C#. For this project I will just make an application for Android, but this can be changed in the future, as Unity is multiplatform. It was time now to decide the architecture.

The application will not allow more than one user at this point, but as a future work this can be a nice feature to add. The application must save certain values that will be coming from some JSON files:

- Settings: with a default configuration at first and being updated every time that the user modifies anything.
- Game information: for each game it is required the game name, a small description, some how-to-play information, and a preview image/video. For this last part it will be provided an id or a path from where to extract these images.

- Game results: all the results for all the games played will be saved; having the time played, the results, the difficulty... There will be probably more factors that will come up during the development.

This is a proposal for the JSON files structure:

```
{
  "GameInfo": [ { "Category":"Category" ,
                  "GameName":"GameName" ,
                  "GameDescription":"GameDescription" ,
                  "GameHowToPlay":"GameHowToPlay" ,
                  "GamePreview":"GamePreview" }
                ]
}
```

```
{
  "UserName":"UserName" ,
  "Settings": [ "FontSize":"Size" ,
                "Purpose":"Purpose" ,
                "DailyReminder":"YN" ,
                "SendReport": [ { "SendName":"SendName" ,
                                   "Email":"email@email.com" }
                              ]
                ] ,
  "UserProfile": [ { "GameName":"GameName" ,
                     "AILevel":"AILevel" }
                  ]
}
```

```
{
  "GameResults": [ { "GameName":"GameName" ,
                     "Timestamp":"Timestamp" ,
                     "TimePlayed":"TimePlayed" ,
                     "Result":"Result" ,
                     "Difficulty":"Difficulty" }
                   ]
}
```

Given those results some graphs and reports will be generated. For each game the results of all the times the user has played will be set in a timestamp-results graph. If

the user plays the same game multiple times per day, two approaches can be taken. The first one will be to print all the results thanks to the timestamp. With this all the information can be set in the graph, but it may be too much to visualize it individually. The other approach will be to just print one, either the best one or the mean value. Thanks to that, the evolution will be easier to see in the graph but some individual values will be “lost”.

Then, for the category games the results will be standardized per day to see the evolution in the ability. Each category will standardize the values different, but just one value per day will be shown, no matter how many times the user has played to that category games. The reports will be formed by the weekly info shown in the category graphs. For the moment weekly information is the best approach, but this can be changed as part of the future work to monthly or even yearly reports.

Another cool-to-have feature is the notification system. First, a reminder for the user to remind to play all days. This notification can be disabled from the settings, but when enabled the user will receive a push-up notification every day at mornings. The other notification feature is the report system. If in the settings the option is enabled and there is at least one email, every week an email will be sent with the weekly report.

To have some values to start with, the first time the user will open the application a tutorial will appear and force the user to train for the first time. This will happen also once per week, to make sure that the user does not just practice the skills they want but all of them at least once every 7 days.

About the difficulty all changes will be decided by the AI but the user can decide the purpose of the application. If the user does not change the default value “training” the AI system will work depending on the evaluation of each game. However, if the user changes the value to “relaxing” or to “improving” then the AI will lower or push the evaluation.

The latest step before starting the programming part was to think about the games and how to adapt the difficulty thanks to the analysis made with the AI part. None of

the games will be against the clock, because putting pressure to the user will not give more information or better results.

As there are many games per each category, I've decided to develop one of each as a proof of concept to evaluate the usage of the application, but in the following section I decided to explain two different ones in case that I have time to implement them after the development. The AI will be analyzed as if the default value wasn't changed and always starting at the medium difficulty level.

In order to change the difficulty, the AI will analyze the 10 latest results (or the ones that are there if there are less than 10), see the tendency in respect to the mean and evaluate if the level should be changed. Ideally, this AI won't be restricted and will analyze the entire trend, but for this proof of concept it was enough.

Logic Games

Series

A serie is a sequence of numbers, letters or figures that follow certain rules between them written in a certain order. For each of the series 4 values will be provided, but just one will be correct.

Here are some examples of different types of series.

- Easy series: they can start from any value in ascendant or descendant order and requiring 1 at the beginning or at the end.
 - First 10 numbers
 - Odds
 - Evens
 - First 8 alphabet letters
 - Geometric figures rotation
- Medium difficulty series: similar to the easy ones but adding changes in size and colors.
 - Adding N and subtracting M
 - Double the previous value

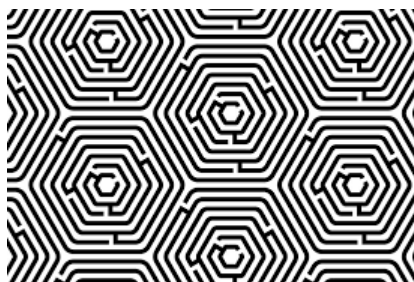
- Fibonacci
- Binary
- Geometric figures addition
- Difficult series: similar to the previous ones but adding difficulty in the operations.
 - Multiplication and division
 - Negative numbers
 - Missing values in the middle instead of in the edges
 - More complex geometric figures

Patterns

Given a certain pattern image (stripes, colored shapes, animal print...) with a missing square, the user must select the matching option from the 4 provided at the bottom.

The difficulty will be not just the pattern but the missing piece to select. For example an easy puzzle will be with up-right diagonal stripes and the options in the four possible directions, for a medium difficulty puzzle it can be an animal print and different colors, and a difficult puzzle can be a group of shapes with different colors and the color pattern and the shape are the key.

This can be an example of a medium/difficult puzzle:



Logic games evaluation

The evaluation will be the time taken to do correctly 6 series or puzzles from one level adding 30 seconds per each failure when choosing the value.

Memory Games

Memory

The memory card game is formed by several pair cards in an NxM matrix (where N can be equals to M, but the result needs to be an odd number). The user selects two cards and if they are not equal they get upside down again.

The difficulty is changed not just for the amount of pairs (matrix size) but also for the similarity of the images. The more similar the images the more difficult is the game.

Color sequence

Similar to the Simon game, this game will consist on repeating a sequence of colors augmenting each time by one the sequence.

To increase the difficulty of the game the amount of colors can be more, but the real difficulty to test the memory is to have larger sequences:

- Easy: 4 colors and the sequence will have from 1 to 5 colors.
- Medium: 5 colors and the sequence will have from 2 to 6 colors.
- Difficult: 5 colors and the sequence will have from 4 to 8 colors.

Memory games evaluation

When evaluating memory games it will count the errors made not the time taken to do so.

In the memory game there are several ways to count the errors. Assuming that a master user opens half of the cards on the matrix twice (once to discover it and the second one to match it) and the other half just once (as they already know where the match is), all the rest of the times can be considered as an error. In this particular approach, to count the result it is just needed to apply the following formula:

$$\text{Result} = \text{totalClicks} - N * M$$

The closer the result is to 0 the better it is, as it would mean that you just opened each card once. An optimal result would be between 0 and $3/2 * N * M$. To visualize it, it would be better to see the result edge inverted in the graph.

Another way to evaluate the memory game will be to count as errors all the wrong pairs made once both values are opened, but taking the distance as the error value, because it is not the same to remember the nearby cards than to open new ones or going to the totally opposed side of the matrix. This approach is much complex to develop, so for this proof of concept is the other the one that will be developed.

For the repeating the color sequence, errors will be count when one color of the sequence is a mistake. Then this sequence will be repeated until the user makes it right or it reaches a maximum of 3 tries on the wrong sequence level.

Attention Games

Previous image

This game uses the change in one of the different features of an image to check if the shown card is the same as the previous one. The screen must show a stack of cards and two buttons, one for “is equal” and another for “is different”, except for the first card, where the button will be just one for “start”.

Then, the user needs to remember the top image, when he/she clicks the start button, the game will discard the top card and show the next one. If the image is the same the user must click “is equal” or it will get a negative point. No matter if he/she fails, the top card will be discarded and used to compare the next one.

The difficulty on this game is the amount of features that can change. For an easy game it can change the color, as it is something easy to distinguish. For a medium difficulty game another feature can change as the shape (and the color) but just one at a time. For a difficult game the previous features can change at the same time, and it may possibly appear a third feature, a pattern (plain, dotted or striped).

To not make this game last forever, the amount of cards will be fixed for all levels between 10 and 30 (it will be decided on the development).

Overlapping

Overlapping silhouettes makes the user check the features of certain images to select them. This game will consist on an image with certain overlapped silhouettes (distinguishable enough) and certain amount of options to select to fill the silhouettes.

For an easy level, the silhouettes will be just 2, to distinguish from 4 different enough images. In a medium one the silhouettes will also be 2, but there will be 6 images to choose from and they won't be that different. Finally for a difficult level there will be 3 silhouettes and 6 images that will look really similar but with a certain feature to distinguish them.

Each time the user selects an image that does not correspond to any silhouette it will count as an error, but it will keep the same image with the same options to give another chance to the user. The number of overlaps to solve will be fixed during the development.

Attention games evaluation

When evaluating the attention skill, it has to be taken into account the number of correct choices, but also rely on the errors made, and the time taken for the activity. For those particular games, each correct choice will be 1 point, and every error will be -1 point. The time will be divided by the amount of correct choices that shall be done (the number of cards in the stack of the first game and the number of silhouettes shown in the second one). To this value it has to be added and subtracted the correct and wrong choices points and gives the result. The best result will be the best time when selecting only the correct options ($\text{time} / \text{totalChoices} + \text{totalChoices}$).

Analysis Games

Classify

Classification is an awesome way of analysis as you need to check the features of an object and then classify by at least one of them. For this game the user must classify figures or images.

To modify the difficulty the amount of objects to classify will be increased as well as the similarity of those objects.

Open the door

This is a labyrinth game where you can't walk on your steps and that you need to get at least one object to finish the level. It is important that the user checks the possible routes before starting, so he/she needs to analyze the path. There will be a reset button that will start again the level.

The difficulty will not just be on the labyrinth itself but on the amount and location of the needed objects.

Analysis games evaluation

The evaluation of the analysis done shall take the errors into account as well as the time. In the classification game the time will depend on the total amount of objects to classify and add 20 seconds per each wrongly classified object.

In the other game, where you need to go from a point A to a point B but with the restrictions of getting all the objects and not repeating the path every time that the user needs to restart will count as an error and the time taken will be divided by the amount of steps of the minimum path that accomplish all the objectives. For each reset that the user does, 20 seconds will be added.

Fine Motor Skill Games

Mandalas

Allowing the user to paint freely is one of the ways to test not just fine motor skills but also creativity. In this game some mandalas will be provided with different levels (it depends on how many spaces there are and how small/big they are) as well as some colors (fixed for all levels). The user must be able to zoom the image to paint what they want.

Labyrinth

This game uses the accelerometer and the gyroscope from the device to move a ball through a labyrinth. The user will need to tilt the phone or tablet in the direction the ball needs to move.

The difficulty will be the labyrinth itself. For more difficult games obstacles can be added such as a black hole where it should not fall or without edges around.

Fine motor games evaluation

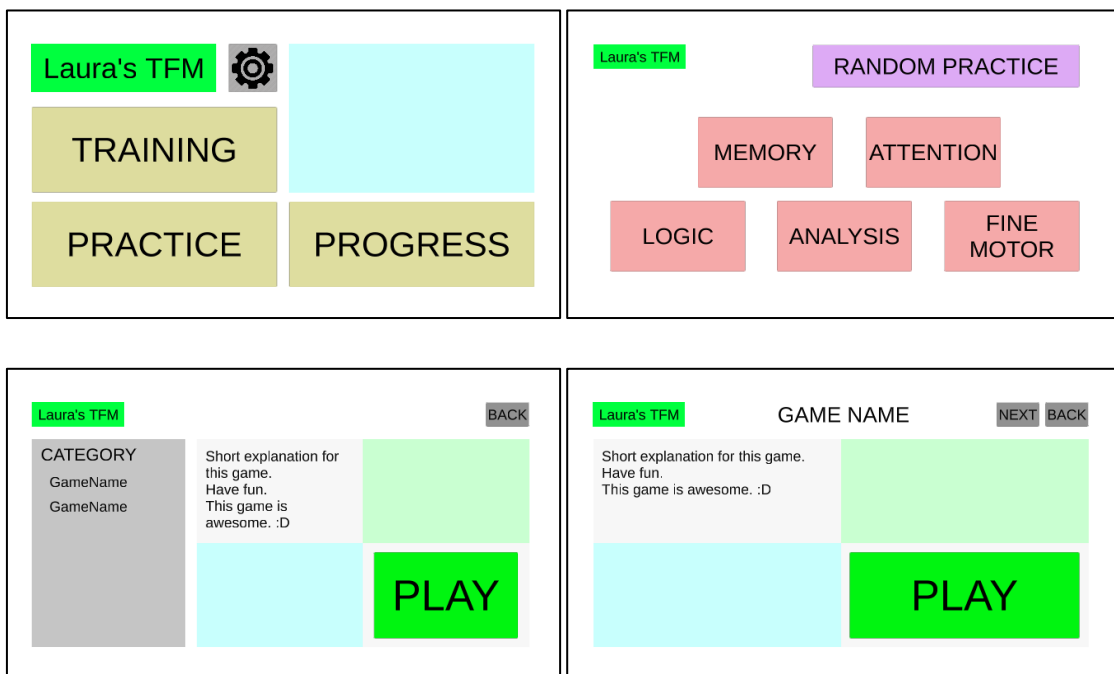
To test this ability, it must be checked the accuracy of the clicks and movements. There is no right way to paint a mandala and you can take as much time as wanted, so the best way to test that they painted the area they wanted is how accurate they were in respect to the center of the painted zone. For the labyrinth happens something similar, as the important fact is to reach the end, but it does not matter how many time you need or how many times you fail, but how do you perform in the line. The more accurate will be to go always through the middle of the path.

Development of the proposal

For the development I've decided to use a private GitHub repository to use Git as a version control service and to be able to provide the final result with a release that will contain the apk to install it directly to an Android device.

General application

The first step of the development was to create the scenes with the mockup screens and add all the components needed so that they work with all the buttons. This is how it looked like after finishing this part.



As it can be seen I've decided to change where the game name appears in the preview screen without the group. I've also changed the way the training will be. The screen that will appear is the same as the random preview one (bottom right) but without the next/back buttons and also removing the functionality of the logo to go to the main menu screen.

After checking how Big Brain Academy differentiated between the training and the practice I've made some more changes. The first one is that the main menu training button will open a screen to start the training, as it will require to do 1 game from each category one behind the other and no returning to the main menu will be allowed.

After fixing a little bit more the location of the screen elements it came the first challenge. The lists of categories and games shall be dynamic, in order to allow the addition of more games during the development and in the future.

The first idea was to get all that information from a JSON file, but Unity has the ability to support scriptable objects, that are a special type of object with the particularity that can be initiated directly from the editor. With that, I was able to create one object per each category and game, so when required, I can pass it entirely by parameter, without having to do the entire parse from the JSON file every time.

The problem with these scriptable objects came when I was trying to put them in a scroll view. I've created an asset for the category, with a text for the category name and a place to locate the other asset, the game one that contained a text for the game name and a button object that was the one that started the functionality to show the game preview or the graphs in the future.

Then it was time for the game preview screen that loaded the data passed in the parameter game object. The preview was prepared to have directly an image associated so it requires just the link to that image at the end of the development. I've decided to do the graphs as one of the last steps, as I first needed all the games and their outputs from the gameplays to be sure how to show them. Finally, the play button still wasn't able to do anything, but I've put a debug log with the game name to be sure I was going to execute the correct game.

For the random selection in the practice I've implemented a function that returns one of the games that exist. This list of games is developed once in the application by setting in a list all the games that has each category. After testing this functionality I realized that there were some times where the random gave the same value, so it returned the same game. To fix that I've decided to save the previous game index and put it in a while loop to make sure it was not the same at any point.

To test the training I've decided at first to use the random selection. For this functionality I did a coroutine that made the play button work as if it was the finish of the training. This was needed because for the training there are a lot of things that are

changed in the view (like disabled buttons) so it was mandatory to revert those changes.

As a next step I've decided to add the adjustable font size from the settings. The first idea I had was to get the value from a JSON, but then I decided that as this value will just affect the device resolution and there is no login to change users and its parameters, I will store it in the Unity player preferences. For this purpose I've created an integer variable named "FontSize" with 50 as the default value that is saved in PlayerPrefs class.

I didn't wanted all the texts to change the value, but the ones that affect descriptions, settings options, and categories and games names, so I saved a list of text elements and every time the user presses on a text size in the settings I go through all of those and change the size. I've decided that the categories will be a little bit bigger, so I added 10pt to those.

This seemed great for the small sizes but the big ones caused overflow on the game names, so I set some logic to expand its height depending on the text size, as for the TextMeshProUGUI elements I was using for the texts I couldn't know if they will overflow when screen-printed.

The last part to fix the font size change was to set all the descriptions and other big texts in a scroll view in order to see all the information.

In the settings I've added the rest of the options but without functionality because I haven't yet developed its features.

The last step before starting with the development of the games was to fix the training game selection. To do so I've did a for each loop to go through all categories selecting a random game from each. I needed to change the debugging to make it work with an array. At that moment every time I clicked the play button I was redirected to the same screen but with the next game preview. After the development of the games, this will be changed to: I click on the play button, the game appears, I have to play it and once I finish, the same screen is shown with the next game info. If it is the last game it is redirected to the main menu.

Games development

Then it was time to start developing the games. As a first step, I've implemented the functionality where later I could introduce the game. In the mock up I've decided to use just part of the screen to set the game inside, but when I reached that point, where I already disabled all the buttons of the game, I changed the view to a full-screen one.

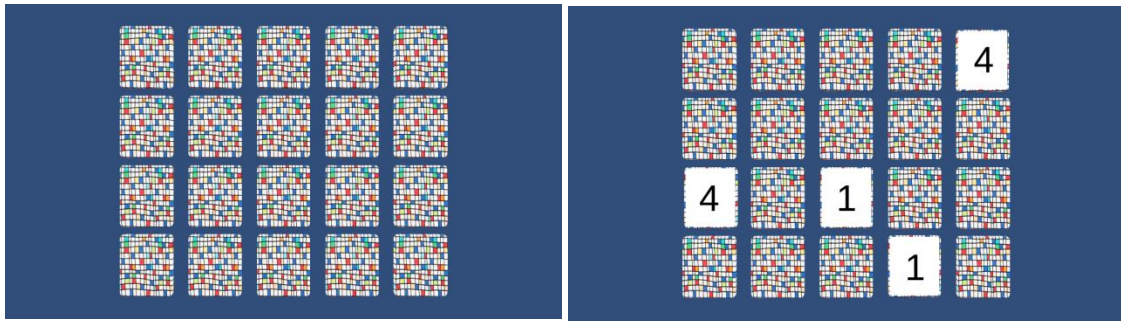
For each game I've created a new scene and a manager that will be the one in charge of creating the game, allowing the user to play, saving the results and returning the notification to reload the menu screen. In order not to lose the status of the main scene, I've decided to just set the scene as inactive before starting the game and active after the game.

I'd like to point out that all for all AI methods I just compared the last N values of the current level. It won't be fair to compare the results from an easy level to a difficult one, as they might differ and it won't give any valuable information. Among that, it has to be taken into account that levels are finite (you cannot go lower if you are in an easy level, and the opposite with the difficult one where you cannot raise it).

I finally just developed one game of each category, as the development of each of them took longer than expected. than I thought, as well as the AI for each category. For this project having one per each is enough, as it is just a proof of concept, but if it finally becomes a real product, there need to be between 1-5 games per each category.

Memory - Memory

The first game I've developed was the Memory card game. I've created a card prefab that has a back image, a front image, and the value. For testing purposes I haven't tested with the images of the cards, but the integer value that they had assigned. Then I've created a matrix that is filled with those cards and the functionality of the game.



For the difficulty change, I've set a variable that changes the mechanic, and a dictionary that knows the matrix sizes. To change the images from the cards I've named them as <level>-<value>, so it was referred immediately.

Then it was time to save the results and develop the AI that will analyze those. As said in the description of the analysis of memory games no time was taken into account, but the amount of errors made in the latest plays of that exercise. I've finally decided to save the results locally in a JSON file, but having one file per execution, as it was easier to get the latest 10 values from that level by the name of the file that is a timestamp from the moment the result is saved.

To get the level it calculates the average of the percentage of the latest game results and depending on some parameters it decides to raise or lower the error. The percentage is evaluated with the following equation:

$$\text{Percentage} = \text{expectedMaxResult} / (\text{expectedMaxResult} + \text{result})$$

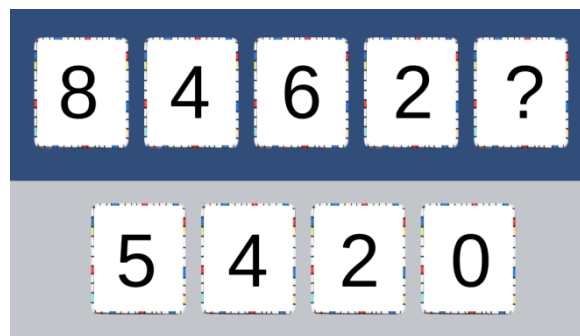
With that formula I'm able to consider 100% if the user does just needs 1 click to open everything and 50% if the user follows the 3 clicks per every 2 cards, that is the expected result for a memory game. I can consider the user is doing a great job in the level if the average percentage is between 50% and 70%, but otherwise I need to lower or raise the difficulty.

This is the game explanation:

The main objective of this game is to make pairs. Click on two cards so to see their values. If they are a pair, you can continue turning cards up. If not, remember those values and keep trying to make pairs.

Logic - Series

For the series game I've created two objects: one that is the serie itself that has the values of the serie with the position that has to be filled, the correct value, and the incorrect values; and another object for one of the values that are printed in screen. This second object is also the one that helps the game decide if it is one of the clickable objects or not. In the serie I decided to generate also the incorrect values to try to make tricky options.



In order to get the results I've decided to save the total clicks made and the also the time spend in the game. The final result time is calculated by adding to 10 seconds per extra clicks, calculated by subtracting the number of series to the total clicks. At first I thought that 30 sec will be great, but while developing and playing the game it resulted to be too much, so I've set it to 10 seconds.

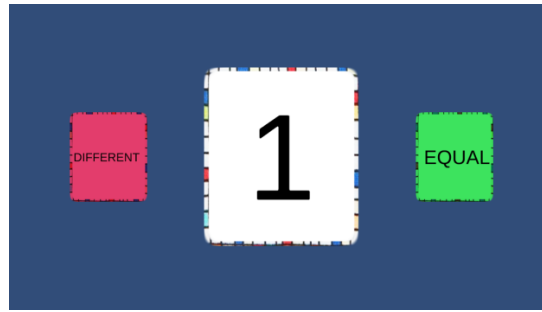
The AI that analyzes logic games gets the average result time of all the games and checks if the latest result time is in between $\pm 25\%$ of the average. If the value is above the max the lever is lowered but if it is below the min the level needs to be raised.

This is the game explanation:

Follow the series. Just one value is the correct one.

Attention - Previous Image

This game was pretty easy to develop, as it just consists of a stack of images and two buttons, one to say that the value is the same than the previous one and the other that says they're different.



The stack order is randomly generated with different number of pictures per each level, as it is the best way to increment the difficulty, as well as making the images more similar when reaching the difficult level.

The result is calculated by dividing the total game played by the expected result (the total of cards in the stack) and then adding the correct results and subtracting the wrong ones. The best result would be the one with less time in game and having all results correctly.

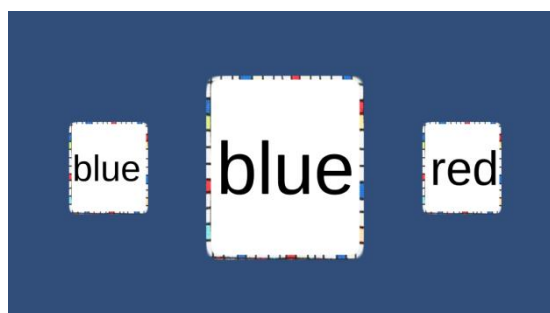
The AI analyzes this value and changes the level if it is above the 95% of the average or below the 85% of it for that level.

This is the game explanation:

Pay attention to the first value. Check the next one and click on the corresponding button if they are equal or not. Now remember the value just evaluated as if it was the first and repeat the evaluation.

Analysis - Classify

The classification game is very similar to the Previous Image game, as it consists of a stack of cards and two buttons. In this occasion, the buttons are not to see if they are the same or not, but to classify the images or at least one of its features.



To play with the difficulty it will be changed the classification feature and the similarity of the images. The easiest level will consist on a group of images which are red or blue, and they need to be sorted by color; the medium level asks the user to classify two different objects: cars and motorcycles; and finally I have the difficult level, that consists on classify different colored pentagons and hexagons by its shape, where the images can also be rotated.

The result of this game is calculated by adding 10 seconds per each failure to the time used to classify 20 images. By using the average of the last 10 games of the current level, if the last time is greater than the average + the 15% of it, it raises the level, but if it is below the average - 15% it lowers the level so that the user can play in an easier mode.

This is the game explanation:

Classify the value in the center to its corresponding category on the side.

Fine Motor - Labyrinth

The labyrinth game was one of the most fun to develop, as I've never worked with the accelerometer input. The levels are taken from free 3D mazes from the internet.



For each level I needed to set a different camera, light and ball size, as they had different measures and the walls were not with the same width.

For this category my plan was to check the results with the accuracy, but it turn out that this value is not easy to take, and it is not easy either to control the ball that much. So I finally decided to set as results the time taken to reach the end on the maze. To have multiple start-end pairs in each maze that are similar (time taken to reach B from a point A) I decided to manually write those combinations and then choose one of them randomly.

The AI considers this time and evaluates that if you've taken 15% more than or equal to the average the level needs to be lower, and if you do it at least 5% of the average or lower, it needs to raise.

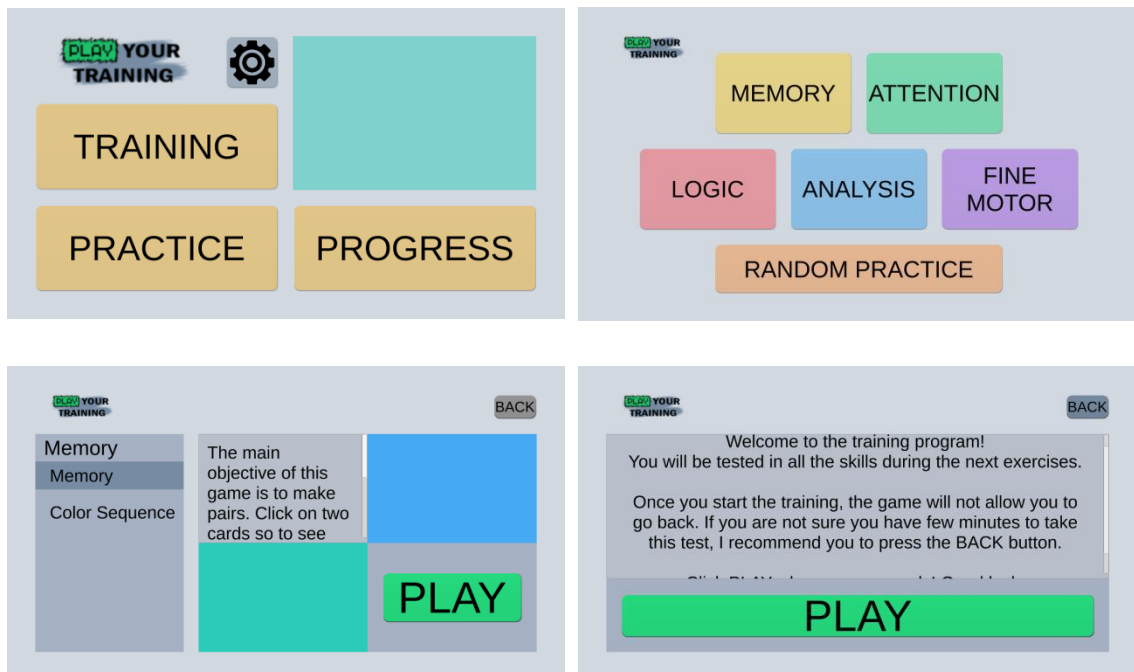
This is the game explanation:

Move your device to pass the red ball through the labyrinth from the red point to the finish line.

General application extras

After finishing the games development I've decided to fix the art that is shown in the application and in the games.

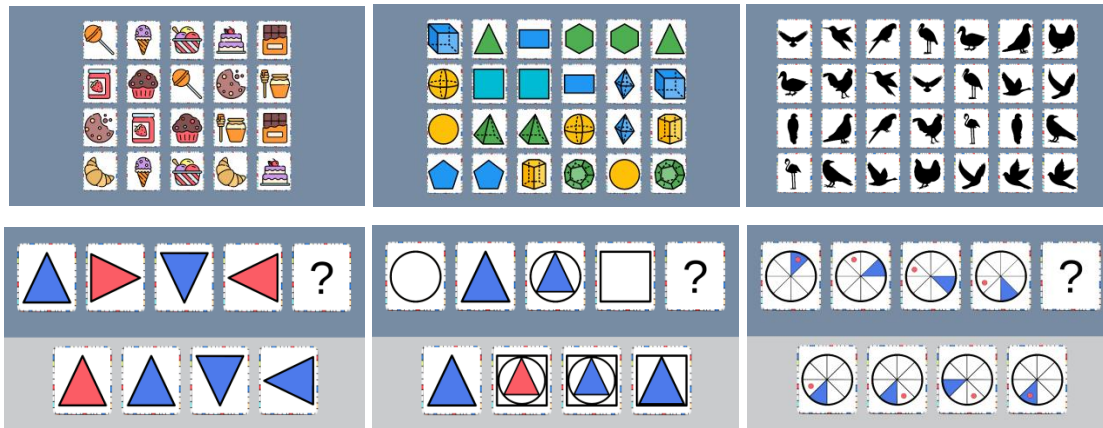
I've started changing the buttons and the colors of the UI, as well as adding the logo. I've decided to name the application "Play your training" as it is based on small games to train the abilities.



For the color palette I've decided to use the German palette from FlatUIColors, as they are vivid colors that match perfectly and were so easy to combine.

As it can be seen in the practice menu image, I've decided to reorder the buttons, as when they had colors it seemed so empty to have nothing on top.

After fixing the UI I've searched for different icons to add to the games. The main page that provided me these images is Flaticon but I also created some using a photo editor.. Here are some screenshots from the results of the Memory and Series games (easy, medium and difficult).



One of the things I haven't done is adding sounds and animations that help the user know the choice is not correct, but of course it can be added in the future work.

For the graphs part I create some graph elements that consist of the x value, the y one and an extra index for if I want to paint them in color depending on its difficulty.

In the main menu there is a graph bar, that shows the average and the best value for a user in the last level he/she played. All those values are normalized and in percentage. This graph is generated every time the player reaches the main menu, as it can be after a game that changed the difficulty or the best try value.

For the progress view, I've decided first of all to remove the graphs per categories, as it can be seen in the menu one, but as planned I did some dotted graphs with the results the user is getting in the last games. The results are separated by the time that happened between those two games, so if they are so apart that will be printed outside the graph; I'm not printing them at the moment. In the future work I will escalate this difference in time so that the maxX is constant and the dots are more together.

The results of the games are made in a way where 0 is the best you can get, so it is important to set 0 as the top value in the graph, to really have the knowledge if the user is getting better or not.

The last graphs I've added are a copy of the previous ones that appear on the game previews, with exactly the same data.

About the rest of the settings, I've decided not to implement them as it is not the main purpose, such as the games themselves or the AI, in which I spend most of the time of this project. Both the daily reminder and the emailable reports are features that can be implemented thanks to unity facilities, but I would have to spend a lot of time with the internet connection and saving the data in a database instead of locally.

The AI purpose feature, I think it would be a pretty useful tool to give the application different uses with the same games and categories, but it will require much more time than this whole project. The values need to be perfectly tested in order to decide depending on the purpose the user wants to do it. As well, the main purpose was to develop a game that uses AI, and that is done. All the extras that I wanted to do in the beginning were ideal, without taking in consideration the effort needed for the platform, the games and the AI that gets the values.

Final game

The final version of this project can be downloaded from this URL:

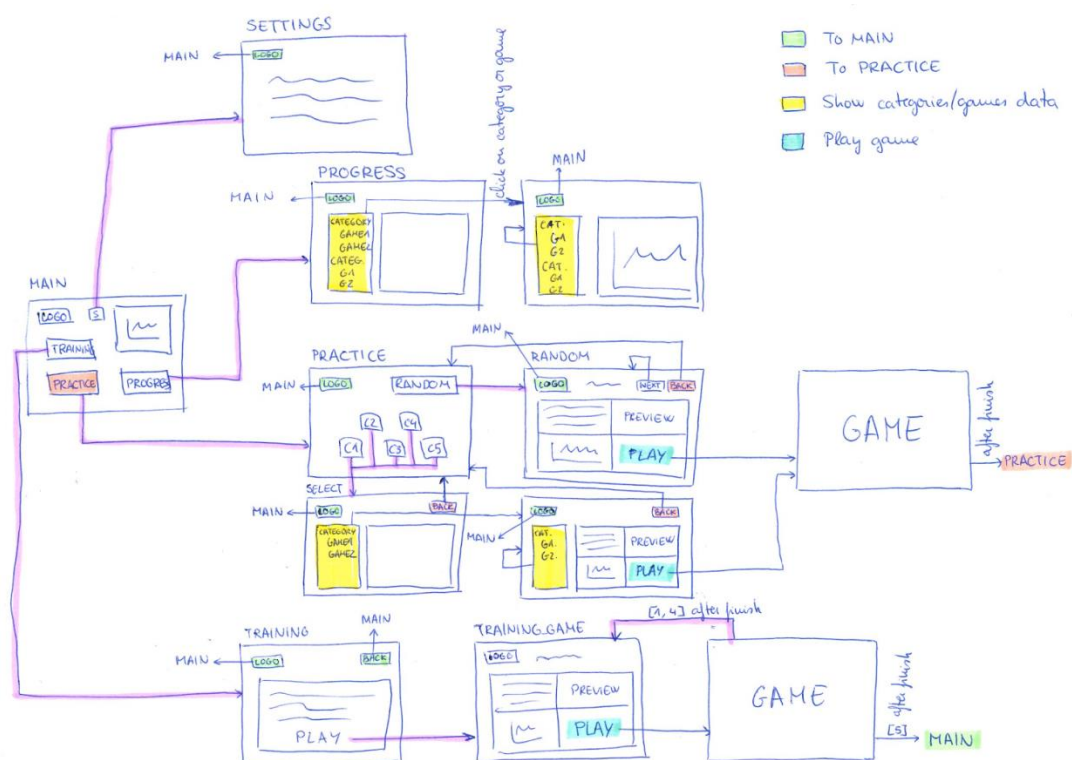
<http://tiny.cc/PlayYourTraining-v3>

For the installation it is just needed to download the previous file in an Android device, allow its installation as it is totally safe and start the application.

Evaluation of the proposal

In the first part of the evaluation consists on a group of technical tests divided in 3 subcategories. The first one is the testing of the navigation, the second is the testing of the functionalities and the games and the last one the AI difficulty according to the parameters described per category.

The navigation of this application is easy to check, as it is mainly lineal. I've made sure that the following diagram worked and no other is allowed.



After checking the navigation I did the tests on the games. I have checked the basic path of the game, doing my best, to see that the game performed as expected and the results were correctly saved. This is one of the more important parts to test, as if the results fail when being saved or when calculated then neither the AI nor the graphics will show up correctly.

After checking the basic games I did test the extreme cases, such clicking on non-clickable objects in each game, clicking after the game ends, doing the worst path to reach the end... In most of them I found some bugs that I already fixed. The user tests will provide more info for this testing, as users tend to interact unexpectedly.

Before checking the AI, I did check all the other extra functionalities: graphs & settings.

In the settings I've checked that the values remain saved even when the application is closed and reopened and that the font size changes for all the expected texts and its functionality is not affected (scrolling, buttons...).

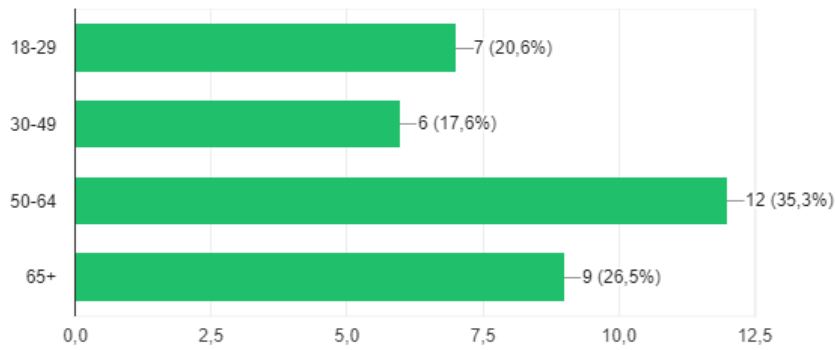
About checking the graphs, I've generated several results to see they are shown correctly in each game graph, and I've also started from scratch and check the graphs generated by the results of the gaming process. All the graphs had the correct values, the main menu screen graph shows the results for the average and the best result in the category for the latest difficulty as a percentage and the progress of each game, both in the game preview and the process view, have the correct dots and they are separated by the right space.

The last technical test was to check that the AI worked correctly so I've checked its correct behavior in two different ways, the first one by writing the results by hand having all the cases covered, and then by performing as a real user to see that it changes depending on the results.

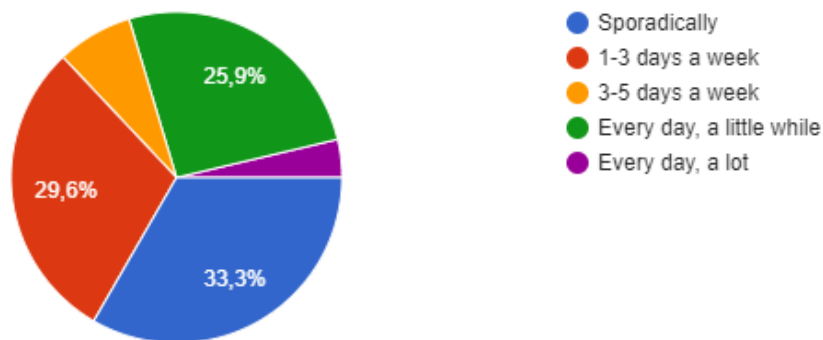
All tests shown that the application accomplishes the expected results and performance, so it was time to approach the users to see their evaluation.

I've created a formulary with certain questions separated in 3 blocks. The first set of questions is about the user and their knowledge of mobile gaming and games for elders or games with the purpose of maintain abilities. The second block was right after explaining the project but before they can see the actual result, and I ask questions about the idea they were told and if they consider it can be interesting. The last part was after giving them the capacity of testing the actual result, and I've asked several questions about the outcome and their impressions.

In total 34 people have been evaluated, half men and half woman. The ages vary, as I've tried to do a representative part of the population:

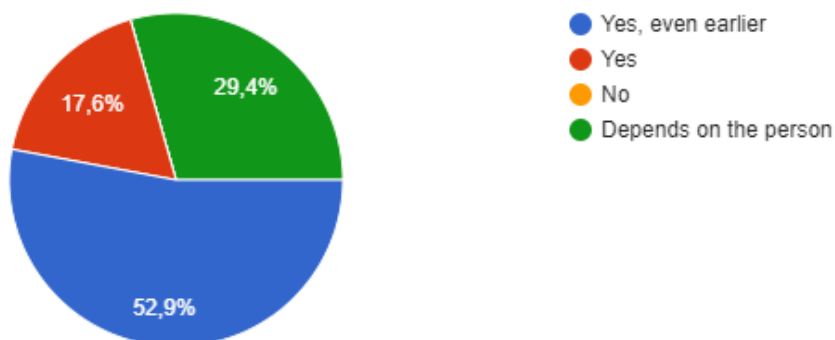


A 79,4% of the people said that they play in their phones or tablets, and this is the distribution of time during the week they dedicate to this entertainment:

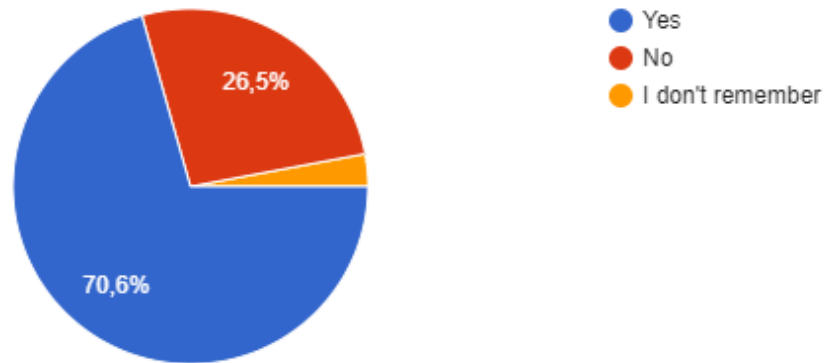


I also wondered how people perceive gaming, as not that many years ago it was considered a bad thing, and nowadays it can even be considered an addiction. The 23,5% didn't hesitate when saying it is positive, but the great majority, with a 73,5% of answers said that it depends on the game.

I've also asked what people thought on the following statement: "People over 65 loose faculties". I was really shocked for the answer, as nobody said no, and the majority said that it is even earlier than 65 years old.



Before presenting the proposal nor the game, I asked the users if they have ever tried a game to train their skills, such as Big Brain Academy, Brain Training, CogniFit... The majority has tried at least one.



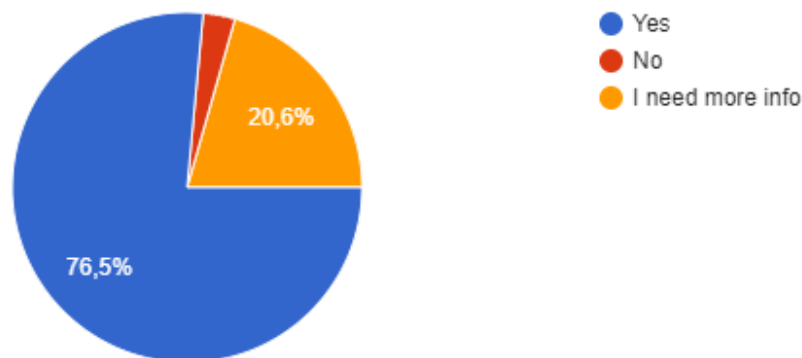
And about those games I've asked if they're really useful for training and if they are suitable for people over 65. For the first question 73,5% of the people said that it is useful, and 23,5% didn't know. For the second one, I wasn't really surprised because 74,2% of the users didn't know the answer. Less than 10% said that they're not and that to adapt the current ones several things need to be changed:

- Make them easier in navigation and options.
- Make them easy and intuitive.
- Change the font size, preferably that it can be configured by the user.
- Add some features such as adapted keyboards, appropriate art, louder music, big font size, easy to access the games...
- Changing the categories: follow drawing, mandala painting, music games...

In the second part, after I presented the application, all the users seemed enthusiasts about the idea and they also said that it is a great idea to take advantage of technology to help elders train or improve their abilities in a ludic way.

Some of them also commented that there is yet some work to do in the technology for elders, and that a proposal like this, that adds gamification to some of the exercises they really need to do to improve their skills is a great idea. A drawback that someone commented is that it needs to be used adequately, and that the games need to be attractive for the user, or in other case he/she will not train as it should.

The vast majority of the people, just knowing from the proposal were already OK to give it a try or recommend it for their elders.



Before handing them the real application, I've asked the abilities that they consider that need to be tested, as I didn't wanted to condition them. There's a huge variety, but the most repeated ones have been memory, attention and fine motor skills. Some users also suggested that would be nice if the application adapts the abilities to the user, as not all people need to train the same.

This is the list of skills the users suggested:

- Memory
- Logic
- Attention
- Language
- Orientation
- Fine Motor
- Sensory Stimulation: visual/auditory perception, music therapy...
- Multiple intellectual functions
- Fun
- Music
- Social Skills

After all those questions, I gave access to the application and then I've asked some scoring over 5 to see the output. Here's the table with the results:

| Category | Question | Punctuation (1-5) |
|-------------|------------------------------|-------------------|
| Application | Intuitive menus | 4,45 |
| | Number of options per screen | 4,60 |
| | Easy to understand | 4,36 |
| | Easy to use | 4,55 |
| | Navigation between screens | 3,73 |
| | Colors | 4,27 |
| | Font and font size | 4,45 |
| Games | Difficulty | 3,91 |
| | Art | 4,18 |
| | Interaction | 4,55 |
| | Suitable for the category | 4,64 |

In the comments about the application some users were complaining as the application is just in English for the moment, and most of them, especially the elders, where only Catalan/Spanish speakers. Some other problems the people have and are easy to fix were the responsiveness of the application and the navigation buttons.

Another user also commented that he did not understand the difference between Training and Practice. This can be improved by doing a tutorial on the application the first time the person tries it.

A repeated complain is about the graph size, as the values are so little. I don't really know how to fix that, but it is something that needs to be taken into account.

About the categories, everybody liked the choice I made. They consider those categories as the main ones and they are not too complex neither too easy. Some

users suggested to add something to work social skills, as cooperative games, or even competitive ones.

Just 42,9% of the users are sure they've had different difficulties in a game, and 21,4% are not sure. This makes me think about putting this difficulty on the game preview screen, so the user knows he has changed the level on the game.

I've also received some additional comments that I would like to copy and comment:

- "Arrows are missing to switch to the previous screen or return to the menu": I've decided to use the logo instead of arrows to let the screen clearer. It seems people are not that used to use the logo as the "home" icon as I thought so I will add this "back" or "menu" button in every screen, apart from the logo functionality. It can also be fixed by adding a back arrow, or by adding the back functionality to the back button of the phone (bottom left-arrow).
- "In the Previous Image game it is not clear if one asks if what is equal or different is the form or the color": this shall be clearer, as I don't want to cause a bad result on the user because it was badly written. It shall be the whole image the same or not (color, form...).

The game that the people liked the most was the Labyrinth one because of the usage of the phone to move the ball, and then the Memory one, as it fits the perfect difficulty. The one that they didn't liked so much is the series one, as it can be difficult for some elders, or the previous image, as it can be kind of boring after some time.

All the tested users know that this was a proof of concept, but they really want to see how this is evolved and which other games are fit in the game.

Conclusions

This project has let me explore some fields I've always been interested, such as helping elders, gaming, AI and developing an application. It is the very first time I've done anything related to those categories, and I think I had a good idea that can probably be converted to an actual product after some more work.

In my planning I was thinking of developing 10 games, with an AI for each category and some extra functionalities, such can be the settings or the graphs. It turned out I wasn't able to complete all the games neither some parts of the settings. This happened because I've never did anything related to applications, games or even AI, so it took more time than expected, but I also enjoyed each of the parts so much and I wanted to do my best even if it was just in a part of the application.

In my opinion, the output of this project is a great start for something more product oriented, and for that I appreciate a lot the feedback I got from the users in the evaluation. I got some great ideas that can be developed in a future iteration to convert this proof of concept in a real application.

There is yet a niche in the market for elders, especially for this type of apps that can be used for entertainment but are also used with a mean that is training and maintaining our elders' skills.

From the evaluation I got a lot of great ideas and also a very great output. The score for the application and the games has been a 4,34 out of 5 (8,68 over 10) so that makes me feel like there is a great idea, and a well-done proof of concept that made the people feel good about the outcome and its possibilities in the future.

Of course I will need to add more games if I want to create a final product, but I will also check all the comments I got from the users and rethink the functionalities to make them more attractive or easier to use by the final customer. In here we will have the navigation button to go back, the tutorial to understand the differences in the application and a better way to see the graphs (bigger font size but with all the information).

Another missing thing for a product would be the server part, an API to get and save the results to a database, a login or user structure to have different users in the same device... I've fixed all this for this project using the local environment of the device to store this information that it is not a bad idea, but it may consume unnecessary memory if the user plays a lot.

The two aspects that got less score from the users were the navigation between screens, because not all users understood that the logo was the "home" button, and the difficulty of the games. I think this is because not all tested each game more than 2 times, but it can also be because there's no actual place that says the level you're playing in a certain moment rather than the color of the ball in the graph.

About the categories I've decided to use, I really like that the people found them adequate, but I would like to add some more, as I've mentioned in the State of the Art, such as language, orientation or also social skills.

From what the users expected, as it can be seen in the first part of their evaluation to the final project output, I think I got a great idea that thanks to this final result and the evaluation received, it can be continued to get a nice final product.

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Art

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