

Promoting Healthy Ageing through Cognitive Exercises: Introducing the Brain Boost application

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ABSTRACT

Frailty is a state where older people are more vulnerable to become an elderly person with disabilities. Helping frail people to live actively (both physically and mentally) can prevent them from obtaining disabilities due to the ageing process. It is important for the brain to receive new stimulations which increases the brain activity and that will help keep the brain healthy and active. Therefore, a mobile application for frail users to practice cognitive exercises has been designed.

Through the user-centered design method, stakeholders have been identified and their salience was determined. Moreover, the barriers and needs of stakeholders have been determined. With the help of research and interviews, personae have been created, which were the focus during the development of the prototype.

After this process, a concept was proposed: an application for the iPad where users could train their brain through solving cognitive exercises called Brain Boost and an application for the caretaker which could be connected. If the frail users finishes a specific set of exercises, they will receive a reward. This reward can be set by the caretaker or the reward can be predetermined by the application in the form of discounts.

Before developing the actual prototype of this concept, usability and accessibility requirements were created. These were based on research conducted. The requirements were ordered by importance and were implemented within the prototype wherever possible.

The prototype was created in five different iterations: starting from a paper prototype, the prototype was transformed into digital screens and, in the end, a high-fidelity prototype which included most of the user interactions.

It was not possible to test the prototype through actual end-user testing, but the requirements were checked. For the usability testing, the heuristics were either met or not applicable within the application. For the accessibility requirements, the ‘must’ and ‘should’ requirements were all implemented. Three ‘could’ requirements were not implemented due to complexity and time constraints. The ‘won’t’ requirements were left out on purpose.

Looking back at the project, several recommendations could be given to improve the prototype in the future. First, the unmet requirements were proposed, such as integrating notifications and improving help features so they would be more personalised. Moreover, recommendations were deducted from expert feedback such as limiting text and improving consistency throughout the application.

It should be noted that the process lacked real end-users and it is difficult to draw hard conclusions without having real feedback from end-users. Moreover, the requirements were based on research and could have been different if different research had been chosen or different assumptions of importance had been made.

TABLE OF CONTENTS

Abstract	2
Table of Contents	3
1. Introduction	6
1.1. RELEVANCE OF PROJECT	6
1.2. COGNITIVE EXERCISES	6
1.3. PROJECT DESCRIPTION	7
2. Context of Use	8
2.1. METHODS	8
2.1.1. STAKEHOLDER IDENTIFICATION	8
2.1.2. STAKEHOLDER SALIENCE	8
2.1.3. STAKEHOLDER RESEARCH AND INTERVIEWS	9
2.1.4. STAKEHOLDER MAP	9
2.1.5. PERSONAE	9
2.1.6. USER SCENARIOS	9
2.2. STAKEHOLDER IDENTIFICATION	10
2.3. STAKEHOLDER SALIENCE	10
2.4. STAKEHOLDER RESEARCH & INTERVIEWS	11
2.4.1. STAKEHOLDER RESEARCH	12
2.4.2. STAKEHOLDER INTERVIEWS	13
2.5. STAKEHOLDER MAP	13
2.6. USER GROUPS	14
2.7. PERSONAE	14
2.8. ENVIRONMENT	15
2.9. CONCEPT DESIGN	16
2.10. COGNITIVE EXERCISES	17
2.10.1. TASK 1: CALCULATE NUMBERS	17
2.10.2. TASK 2: CONNECT NUMBERS TO ALPHABETS	17
2.10.3. TASK 3: FIND WORD IN A WORD PUZZLE	17
2.10.4. TASK 4: FIND THE WORD IN AN IMAGE.	18
2.10.5. TASK 5: HANGMAN VARIETY (BUTTERFLY FROM COCOON INSTEAD OF HANGMAN)	18
2.10.6. TASK 6: CONNECT PICTURE TO WORD	18
2.10.7. TASK 7: MEMORY CARD WITH FINDING THE MATCHING CARDS TO WORD OF THE DAY	18
2.10.8. TASK 8: FIND THE IMAGES WHICH IS THE SAME CATEGORY AS THE WORD	19
2.10.9. TASK 9: FIND ODD ONE OUT	19
2.10.10. TASK 10: SPELL WORDS BACKWARDS	19

2.10.11. TASK 11: CHOOSE THE CORRECT COLOUR FOR THE ITEM	19
2.10.12. TASK 12: CHOOSE THE CORRECT SPOT/PLACE WHERE YOU FIND THESE ITEMS	20
2.11. USER SCENARIO CONCEPT	20
2.12. USER SCENARIO TASK-BASED	20
3. Usability and Accessibility Requirements	21
3.1. USABILITY REQUIREMENTS	21
3.2. ACCESSIBILITY REQUIREMENTS	21
3.2.1. MUST REQUIREMENTS	22
3.2.2. SHOULD REQUIREMENTS	22
3.2.3. COULD REQUIREMENTS	23
3.2.4. WON'T REQUIREMENTS	23
4. Development of High Fidelity Prototype	24
4.1. FIRST ITERATION: LOW FIDELITY PAPER PROTOTYPE	24
4.2. SECOND ITERATION: FIRST DIGITAL SCREENS	24
4.3. THIRD ITERATION: SECOND DIGITAL SCREENS	26
4.4. FOURTH ITERATION: FIRST HIGH FIDELITY PROTOTYPE	27
4.5. FIFTH ITERATION: FINAL HIGH FIDELITY PROTOTYPE	29
5. Internal Evaluation of Usability and Accessibility	32
5.1. USABILITY TEST	32
5.1.1. VISIBILITY OF SYSTEM STATUS	33
5.1.2. MATCH BETWEEN SYSTEM AND REAL WORLD	33
5.1.3. USER CONTROL AND FREEDOM	33
5.1.4. CONSISTENCY AND STANDARDS	34
5.1.5. ERROR PREVENTION	34
5.1.6. RECOGNITION RATHER THAN RECALL	34
5.1.7. FLEXIBILITY AND EFFICIENCY OF USE	35
5.1.8. AESTHETIC AND MINIMALISTIC DESIGN	35
5.1.9. HELP USERS RECOGNISE, DIAGNOSE AND RECOVER FROM ERRORS	35
5.1.10. HELP AND DOCUMENTATION	36
5.1.11. SKILLS	36
5.1.12. PLEASURABLE AND RESPECTFUL INTERACTION	36
5.1.13. PRIVACY	37
5.2. ACCESSIBILITY TEST	37
5.2.1. MUST REQUIREMENTS	37
5.2.2. SHOULD REQUIREMENTS	37
5.2.3. COULD REQUIREMENTS	37
5.2.4. WON'T REQUIREMENTS	38
6. Conclusion	39

6.1. THE PROCESS	39
6.2. THE PROTOTYPE	39
6.3. FUTURE RECOMMENDATIONS	39
7. Discussion	41
7.1. LACK OF REAL END-USERS	41
7.2. REQUIREMENTS BASED ON RESEARCH	41
7.3. HEURISTICS EVALUATION	41
References	43
Appendix A: Personae	44
Appendix B: 127 Usability Requirements as proposed by Gómez et al. (2014)	47
Appendix c: Paper prototype	66
Appendix D: Internal Usability Evaluation of Brain Boost	68

1. INTRODUCTION

Within the introduction to this project, the relevance of the project will be explained. Furthermore, the importance of cognitive exercises to the frail population is specified. At the end of the introduction, a more detailed explanation of the project will be given, including the structure and content of the rest of the document.

1.1. Relevance of Project

Frailty is a state where older people are more vulnerable to become an elderly person with disabilities. When people are frail, they are at higher risk for certain events, such as falling, which could have detrimental consequences for their overall health, recovery and quality of life. Frailty is a consequence of the normal ageing process. Therefore, frailty is something that will happen when the person ages. However, the age at which frailty persists differs per person and can be pushed further back by doing exercises. These preventative exercises are important to delay the ageing process and they can prevent the frail person from becoming disabled. Therefore, it is a user group that requires more medical attention and is at greater risk of becoming more dependent on their social circle.(Buckinx et al., 2015) The definition of frailty is a discussion between many entities and is difficult to be precisely formed. However, one thing is clear: helping frail people to live actively both physically and mentally can prevent them from obtaining disabilities due to the ageing process.

The World Health Organization has published that the elderly population of people aged above 60 was 600 million in the year 2000, but it was expected to rise to 2 billion by the year 2050. (Ageing and Life Course) As frailty is a consequence of ageing, these numbers demonstrate that more and more people will become a part of the frail population. Thus, it is crucial that applications are created to help frail people (as well as current younger generations) age healthy and actively. The earlier these applications are integrated within their lives, the more frailty and its consequences can be prevented.

1.2. Cognitive Exercises

As we age, our memory and mental activity decreases. As you develop routines, the brain requires less activities to perform certain actions. This decrease in brain activity results that people ultimately use their brain less. As is the case with any muscle or organ within the body: when you don't use it, it becomes lazy. Therefore, it is important for the brain to receive new stimulations which increases the brain activity and that will help keep the brain healthy and active. These stimulations can be produced using different type of exercises, both physically and cognitive. For this specific project, we will focus on cognitive exercises and stimulation in order to create new stimulations within the brain.

Within their research, Costa and Veloso (2014) evaluate the influence of playing games on the user's brain. They explain that "games often provide immediate feedback (sense of reward) and trigger successive increases and decreases in the brain activity". With this, they mean that these successive increases and decreases within the brain activity ensures that the brain keeps being stimulated in different ways and that is actively engaged while playing games.

Gaming is also a great way to keep users engaged and motivated to repeatedly keep playing the exercises, for games provide a sense of achievement when a new level has been reached or a barrier has overcome. However, when designing a game, one must provide a balance within the game: if the game is too easy, users will most likely not feel engaged and will be bored while playing the game. On the other hand, if the game is too difficult and the user cannot advance within the game, users are more likely to stop playing the game altogether. Therefore, the right balance between these difficulty levels must be found before a gaming application can be successfully used in the field of cognitive exercises for the frail population.

1.3. Project Description

This project has been conducted as part of the course e-Health. This course is part of the master Human Computer Interaction and Design with the specialisation on Accessible and Adaptive Interaction at UPM in Madrid.

For this project, an application will be developed for frail users to help them perform cognitive exercises regularly, which will, in turn, improve their mental health. This project will be conducted by keeping the users central during the development phase. Due to the fact that it is difficult to perform a true user centred design process in the limited time frame and with limited to no access with potential end users, a variation of this process will be performed.

At the beginning of the project, some user interviews will be conducted. Moreover, research will be conducted in order to understand the needs and barriers of the target users. Furthermore, the professors of the course will provide expert feedback throughout the project which will help us design the application in the correct way for the end users. Both internal and external evaluations will be performed in order to make the application usable and accessible. Unfortunately, the user experience cannot adequately be tested due to the lack of access to potential end-users.

The second chapter of this document will be focused on the context of use and will describe the users, the environment as well as the tasks the user needs to perform. The third chapter will focus on determining the usability and accessibility requirements for the project. The fourth chapter will describe the development of the high fidelity prototype. The fifth chapter will include the internal evaluation on accessibility and usability, after which future recommendations for the project can be created. This report will conclude with a conclusion, followed by a discussion.

2. CONTEXT OF USE

The context of use describes the users, environment and tasks of the project at hand. It is important to get a clear understanding of the possible users of the project, the environment in which the project will be used and the tasks the users need to perform prior to developing an actual concept within a user-centred design process. This will ensure that the project is created with the user in mind and that the actual product or service will be usable, accessible and have a good level of user experience with the actual users.

2.1. Methods

In order to perform and evaluate the context of use of the project, several steps need to be conducted. These steps have been thoroughly explained through research. This section of chapter 2 will explain all the methods used in order to execute the tasks. The rest of the chapter will only focus on the results of these steps.

2.1.1. Stakeholder Identification

Stakeholders can be identified as “any individual, group, organisation or institution who can affect or is affected by the inter-inter-organisational system under study” (Boonstra and De Vries, 2008), or project in our case. Through understanding the project goal, we can determine the entities who will be influenced by the project outcome. In order to create a project from which they will benefit, it is vital to include them from the start of the project and throughout the overall process.

2.1.2. Stakeholder Salience

All stakeholders need to be taken into account throughout the design process. However, some stakeholders are more important to the overall project than others. Therefore, their needs, barriers, user experience and feedback weighs heavier within the designing process than other stakeholders. These levels of influence of stakeholders, also referred to as salience, is evaluated. Mitchell et al. (1997) argue that salience can be determined describing three factors, namely (i) power, (ii) legitimacy and (iii) urgency, which are defined as follows:

Power is the extent to which a party has or can gain access to coercive means (physical means), utilitarian means (material means) or normative means (esteem, prestige and social means) to impose their will.

Legitimacy refers to the generalised perception or assumption that the actions of an entity are proper, desirable or appropriate within a socially constructed system of norms, values, definitions and beliefs. For example, this can be established through legal, moral, financial or even contractual claims.

Urgency can be described as the degree to which a stakeholders claims call for immediate attention. This can be based on time-sensitive matters, but equally important are how critical the relationships are and how important the claim is.

These degrees cannot be measured, but must be estimated. These estimations can then be introduced into a stakeholder map (see sections 2.1.4 and 2.5.). Throughout the designing process, this stakeholder map can help understand how much the feedback, opinions and needs of the stakeholders must be integrated within the project, for it is impossible to please all the stakeholders within a project.

2.1.3. Stakeholder Research and Interviews

After the stakeholders have been identified and their salience has been determined, we need to gather more information about the needs, barriers and expectations of the user. This process will be completed in two steps:

First, Internet research (including scientific papers, community webpages, forums, videos, etc.) will help provide the researchers better insights into the intended target group.

Second, interviews will be conducted. Due to the limited time frame and the limited access to possible end-users, both researchers will conduct one interview with a potential end-user. The input from these interviews will help further complete the stakeholder map and it will help

2.1.4. Stakeholder Map

A stakeholder map is an overview of the different stakeholders and their needs and barriers within the project. These are factors that need to be taken into account when creating the concept and design for the project idea. The stakeholder map will show each stakeholder and describes their anticipated reaction, level of influence (or salience) within the project, the required support needed, their needs and their barriers.

2.1.5. Personae

In order to avoid including personal preferences of the researchers, personae are created: these fictional (but based on research) people will be the focus during the project. Instead of making decisions on what researchers prefer, the researchers will ask themselves how, for example, Peter would like that idea. The researchers will continuously evaluate if the product design will fit the use of the personae. A study by LeRouge et al. (2013) indicates that the usability of an application depends for 10% on the visual aspect, 30% on the user interaction and 60% is dependent on meeting user's mental expectations. This indicates that having a clear idea of the users and keeping them in mind while designing is crucial for creating a successful and useful product.

Personae are fictional characters that are created to represent a typical user. In some cases, personae can be made by creating a representative for each user group. In other cases, the most important stakeholders can be depicted in personae. It depends on the project. However, it is important that enough relevant personae are created that can guide the project. The personae are represented as an actual person with a name, photo, background information and goals and challenges. Also, their motivation is included. All of this information is included in order to create real-life examples instead of seeing personae as fictional characters. The personae are created on an online platform called XTensio.¹

2.1.6. User Scenarios

After a concept has been created, the idea can be visualised using user scenarios or storyboards. A scenario or storyboard is a visual representation of the user interaction with the concept and is usually done in the form of drawing or by using applications. Storyboard can represent two different ways of interacting with the

¹ <https://xtensio.com/user-persona/>

system: one is done on a conceptual level where you see the application as a black box and how the user would interact with the black box in their environment. A more advanced interaction is the task-based interaction where the concept is looked at in more depth. By using these visual representations, the concept can be presented to important stakeholders for feedback. Moreover, the storyboards can be used as a guidelines throughout the prototype creation process. In this particular case, the storyboard are created through an online tool used to create personalised books for dear ones, called LoveBook.²

2.2. Stakeholder Identification

During a brainstorm, different stakeholders could be identified. In general, the project is about creating an application for people to practice cognitive exercises in order to maintain or improve their mental health. Looking at this abstract description alone, it can be deferred that frail people will be our primary users and, therefore, also a stakeholder within this project.

By taking a closer look at frail people and their living circumstances, we can identify another stakeholder. The living situation of a frail person can be very different: some might live with their partner, others might live with their children and again others live by themselves. Sometimes, even when living by themselves, there is someone in the neighbourhood who comes by often and helps take care of them. This could be a relative, friend or even a professional. All these people could be stakeholders within this project and they are identified as the caretaker.

Another stakeholder could be identified quickly: when we talk about creating an application that could help improve the mental health of frail people, we should also think about the opinion and the influence of a medical professional. In many cases, the frail people visit doctors who could provide assistance or recommendations about using this application. Therefore, the third stakeholder that has been identified is the doctor.

A fourth stakeholder relevant for this project is the company behind the application itself: the company has needs and wishes when creating such an application. Therefore, they are also a stakeholder within the project.

Throughout this project, we have a supervisor. He will give us advice and suggestions in addition to expert feedback. Moreover, he will evaluate the project. As he will guide the project in the direction it will take in order to be successful for this course, he is also a stakeholder within this project.

If the company were to collaborate with external parties (for example, to provide users with certain benefits when playing the game), they should also be stakeholders within the project. Therefore, Business Partners is stakeholder number 6.

Competitors receive a special mention within this section: they do not collaborate within this project, but they can have an influence on how the project is developed and which choices will be made whilst creating the application. Therefore, they qualify as a stakeholder within the project.

2.3. Stakeholder Salience

Per stakeholder identified in section 2.2., the salience can be determined. As mentioned in section 2.1.2., this will be done considering their power, legitimacy and urgency. An overall influence level will be determined per stakeholder (high, medium, low):

Frail population: The frail population are the end users of the application. Therefore, they have a high level of power since, without them, there would be no reason for the application. The same applies for legitimacy as urgency. Therefore, the frail population has a high level of influence within the project.

² <https://lovebookonline.com>

Caretaker: The caretaker can influence the frail population to start using the application. Since they are more familiar with technology, they might come across the application sooner. Therefore, they have high power. Their legitimacy is also high, since the application must comply with their norms and beliefs if they would recommend it to their loved ones. The relationship with the caretaker is also very important, since they could be the ones helping the frail population use the application. Both of the user groups require quick service when demanded. The overall influence level of caretakers is high within this project.

Medical Practitioner: The medical practitioner could advise the frail population to start using the application. Since they are professionals in the medical field, if they were to endorse the application, users might be more inclined. Since they have high knowledge of the population, both their power and legitimacy is high. Since the medical practitioner is not actually using the application themselves, their urgency is less time demanding. However, their claim could be of high importance. Therefore, their overall influence level is determined at medium-high.

Company: The company that creates the application has high power, for they provide the means for the application. Moreover, their legitimacy claim is high. Their claims are also important and, therefore, their urgency level can also be rated as high. Overall, their influence is high. However, since they do not have the expert knowledge on the end user population, the company is aware that other stakeholders can sometimes have an equal or higher claim depending on knowledge.

University Supervisor: This project is conducted for Universidad Politécnica de Madrid. This means the project will have a university supervisor. The supervisor provides deadlines and guidelines which the project must meet. Therefore, their power and legitimacy is high. Since their claims are also important, their urgency is also high. Within this project, however, they will also function as an expert on the population, which is the more important reason why the overall influence of the university supervisor is high within this project.

Business Partners: Relationships with external parties can create benefits for the end users. However, the companies will be selected when the overall concept has been set in place: it is more important to create an efficient application for the actual end users instead of adjusting the application in such a way that companies benefit from it. Therefore, their power, legitimacy and urgency will be low and the overall influence of business partners will be low within this project.

Competitors: There are always other businesses in the same market. It is important to create something different from what is already out there. If a large company has created something similar, they will probably have more means to incorporate any added value our application offers. However, it is almost impossible to take this into account. However, their legitimacy is important, since we cannot break any copyright laws. Their urgency is low. Therefore, it is important to understand which companies are out there, which will have a medium influence level on the project.

Due to the time limit of the project, it was not possible to include all these stakeholders within the research as extensively as should have been or we would have liked. However, a very high importance to expert feedback has been taken into account and as much research as could have been done in the time frame was conducted.

2.4. Stakeholder Research & Interviews

One of our most important stakeholders is the frail population, or the end user of the application. However, we as the company do not have a lot of expert knowledge on this user group. Therefore, proper research needs to be conducted in order to create a product that is suitable for the frail population. In order to do this, two steps will be performed: first, Internet research will be conducted in order to determine what works and what does not work in applications for frail/elderly population. Moreover, some interviews will be conducted with representatives of the frail population which could give us more insight into the user group.

After conducting this research, the context of use will be further developed. After creating a concept, an interview will be conducted with a user group expert (university supervisor) in order to get more insights into the user group and the validity of the concept. This will be more efficient when a first idea has been created. The user group expert will be interviewed several times during the prototype iteration process.

2.4.1. Stakeholder Research

Different internet sources provide useful information about mobile application for elderly people and the do's and don'ts. A systematic mapping of 32 research studies written by Camila Dias de Oliveira et al. (2018) provides a list of most detected accessibility barriers for elderly people. Some of these barriers include font size, text and complex languages, lack of help options, small spaces to click and difficulty to access menus. Especially font size has been mentioned in many papers and forms large problems for the elderly population.

Another paper written by José-Manuel Diaz-Bossini and Lourdes Moreno (2013) provides an overview of different guidelines that can be followed when designing applications for the elderly population. Some of their recommendations are providing large targets, including icons that are meaningful and have labels or text wherever possible, to avoid scroll bars and that important information should be mainly centred in the middle of the screen.

Besides scientific research papers, there are also blogs that provide useful guidelines, hints and tips for creating useful and efficient mobile applications for elderly users. One blog (Clutch, 2017) gives the tip to include color blindness options within the application in case users need to change the colours within the application in order to distinguish between different elements. Moreover they say that elderly people take longer to tap the screen and that it is inadvisable to use double taps within the application.

They also put a large focus on creating high contrast between text and background. Moreover, they suggest to use a solid background color in order to allow elderly users to more easily read necessary informations. They also stress that icons should be labeled and large enough to be tapped. Also, font size is important.

Another article on Medium written by Anastasia Egorina, who works at Rosberry (2017) writes about making mobile applications more accessible to people with disabilities in general. For example, text should be readable and have a high contrast color. It is also recommendable to add icons in additions to text in order to enhance perception by disabled people. The structure of the application should be structured and, if possible, on one screen to avoid using scroll bars. Moreover, animations should be kept to a minimum.

Last but not least, the W3C provides a list of guidelines on their webpage *Developing Websites for Older People: How Web Content Accessibility Guidelines (WCAG) 2.0 Applies*. Here, they also recommend to use large font text, to avoid fully aligned or center aligned text, to avoid large italic texts or upper case text, to not only use color to convey information and to use specific contrast levels.

All this research is important when developing the mobile application: these findings have been found through research or practical testing, meaning that it would save us time changing the design of the concept if we keep them in mind from the very beginning. These findings will later be translated into requirements that can be followed through designing the high fidelity prototype.

2.4.2. Stakeholder Interviews

In order to gain a better understanding of our user group, both researchers would conduct an interview with a potential end user of the application. Both interviewees are from very different backgrounds and have very different experiences with technology. However, some valuable information could be provided.

The first interviewee is an Indian woman called Vasantha who is 77 years old. She has always been a homemaker. Her husband passed away six years ago and now she lives with her son and his family who take care of her. She notices they do many things for her, but she still easily gets physically tired from walking short distances. Her family means everything to her. She also has a son who lives abroad. "So, I use a mobile phone to talk to him. I understood that if I learned how to use a mobile phone, I could talk to him and see him every day. It was tough, but I learned it." Her daughter-in-law, who is her caretaker, has also noticed that her health is deteriorating gradually. She notices it in the small things, like forgetting her medicine or glasses. Even though they both notice these changes, Vasantha has a difficulty to accept these changes in her health.

Jet is an 83 year old woman who lost her husband 3 years ago. She lives alone, but her son lives around the corner and they have dinner at least once a week. She is all about routine: she will walk to the grocery market every day at the same time, go to sleep at the same time and she visits her friends on the same day every week. Jet owns an iPad and some time ago, her son created a Facebook account for her. Whenever he visits, they scroll through her Facebook account together so she can see all the updates from her children and grandchildren. She understands he iPad more and more: she would like to learn new things on her iPad, if her son teaches it to her. She is quickly worried she will do something wrong using the technology. She does not worry much about her own health, but she hates it when her children worry about her. Therefore, if it pleases her children, she is happy to try new things in order to improve her health.

2.5. Stakeholder Map

The different stakeholders can be portrayed in a map which shows their anticipated reaction, level of influence, support required, needs and barriers. The map is shown in *Table 1*.

	Frail (Very/Medium/Beginning)	Caretaker	Medical Practitioner	Company	University Supervisor	Business Partners	Competitors
Anticipated Reaction	(Somewhat) Resistant/ Interested	Interested	Hesitant	Enthusiastic	Interested	Variable	Variable
Level of Influence	High	High	Medium-High	High	High	Low	Medium
Required Support	Necessary	Necessary	Not applicable	Not Applicable	Some	Necessary	Not Applicable
Needs	Handle limitations Feel less tired Keep things familiar Age gracefully Independence Quality of life	Prevent burden See family age gracefully	Prevent workload Keep patients healthy for as long as possible	Earn money Gain users	Create meaningful project Apply learned knowledge	Earn more money Get more customers	To obtain or maintain monopoly within the industry
Barriers	Low affinity with technology Dependent on other people for help Lack of skills Usability Accessibility	Lack of skills Lack of knowledge Usability Accessibility	Lack of knowledge about applications Low affinity with technology	Users do not update the application. Notifications switched off: difficult to reach and motivate users	Time limit	Seeing the actual benefits of collaborating (do they actually gain more customers)	Other companies could surpass their products by providing an added value to the product

Table 1: Stakeholder map

2.6. User Groups

After conducting the stakeholder interviews and research, and after talking to a user group expert, it became clear that there are large differences between people within the frail population user group. Therefore, it was decided to create three different categories which would all be kept in mind whilst creating the application.

Beginning Frail Population: The caretakers of this population segment barely notice a change within the behaviour or the abilities of the person. However, this stage is the best stage in which to intervene, since it is still possible to become less frail and more healthy. When the first signs of frailty have been detected, it is vital to start exercising as soon as possible.

Medium Frail Population: People with a medium level of frailty have a higher chance of returning to a lower level of frailty or at least avoiding disabilities if they perform exercises. Within this stage, frailty is more commonly known and the person is probably more aware of a decreasing stage. Moreover, caretakers might find it easier to recognise frailty in this stage and recommend exercises to their loved ones.

Very Frail Population: Within this stage, it is most vital to do exercises of any kind. If the person passes from this stage of frailty to disability, the person is not able to return to a frail or healthy stage. Therefore, the person could become disabled and remain disabled for the remainder of their life. Doing exercises can decrease the level of frailty within people, making it essential to reach people who are in a very frail stage.

Exercises can be beneficial to all people, no matter their frailty level. However, some people might be easier to reach than others. Moreover, for some people, performing these exercises might be more crucial than for people who have a lower frailty level. However, seeing as performing these exercises can increase the health status of all users, all levels of frailty must be considered. In the end, the way to reach the different user groups might be different and changes could be made according to having a more specific user group in mind.

2.7. Personae

Personae can help researchers stay focused on the intended user group. Instead of making decisions based on their own preferences, personae are used to try and design for the intended user group. For this project, we have created five different personas: one user from every frailty level mentioned in section 2.6., a medical practitioner and a caretaker. Since these are our most important caretakers, these personae will guide us through the design and development phase of the prototyping.

The different personae have been created:



Figure 1: Declining Peter



Figure 2: Proactive Martha



Figure 3: Fun-Loving Julia



Figure 4: Caring Cathy



Figure 5: Ambitious Mike

Figure 1 represents a very frail user named Peter, figure 2 represents a beginning frail user named Martha, figure 3 represents a medium frail user named Julia, figure 4 represents a caretaker named Cathy and figure 5 represents a medical practitioner named Mike. The full description of the personae that have been used during the design and development phase can be found in Appendix A.

2.8. Environment

The application will be able to be played on mobile devices. For the sake of the project, the application will be created for an iPad: elderly users are more familiar with an iPad and the screen size allows for more interaction and design possibilities for this particular user group.

The user can have several different living situations. For example, frail people can live together with a partner, they can live together with family or they can live alone. When they live alone, many have family or friends nearby who take care of them. Others might have professional help to come by every so often. In other cases, elderly people could live in places designed for the elderly population, such as a nursing home. However, seeing as our target group is the frail population, most of them will be living independently from institutions or medical facilities.

Frail people rely a lot on their partner, family and friends. Therefore, this might be something that could be used in a concept idea: caretakers, family or friends can have a good influence on the frail user and that could be used as an advantage for the concept.

2.9. Concept Design

After the researchers conducted a brainstorm session, a concept idea was created. Inspiration for the idea were cognitive exercises provided by the supervisor of the university. Moreover, the concept idea was further refined after receiving feedback from the supervisors.

The concept would consist of two different applications that would work as one concept: an application for the frail population called Brain Boost and an application for the caretaker called the Brain Boost Tracker.

The Brain Boost application would allow frail users to complete cognitive exercises. When opening the application, a screen would provide a theme for ten levels (e.g. fruit). Every day, one level should be completed by the frail user. When opening the level, the frail user has to complete an exercise. After fully completing an exercise, another exercise would be given. This would be repeated until four different exercises have been completed. Four completed exercises would make a completed level.

The exercises would be randomly chosen from a set of exercises given in section 2.10. Every level (four exercises) would be centred around one word: it would be possible, therefore, that this word would need to be recalled across exercises. After finishing all ten exercises, a reward will be unlocked and given to the frail user. This reward can either be created by the caretaker (through the Brain Boost Tracker app) or they can be discounts for stores and events the frail user likes.

The Brain Boost Tracker app allows the caretaker to be connected to the Brain Boost app. They can see how many exercises still need to be completed until the reward is given. Moreover, the application can be used to create rewards that are given to the user after completing a task. The caretaker can create their own rewards (e.g. going to the park together). These rewards can be anything and the caretakers are free to decide. However, the theme for the exercises are also given, allowing them to create rewards related to the exercises of the frail user.

Settings for the Brain Boost application can be changed in both the apps and can therefore also be changed by both the user as well as the caretaker. This has been incorporated to allow for support across distance from the caretaker to the frail user and to decrease the number options the frail population must understand in order to play the game with a high level of user experience.

2.10. Cognitive Exercises

Within this application, 12 different exercises have been established. These exercises are based and inspired by "Cuaderno de ejercicios de estimulación cognitiva" provided by our teacher. These exercises are already given and distributed to people who are frail. When the application is developed further, more exercises can be added to give a larger variety of exercises to patients.

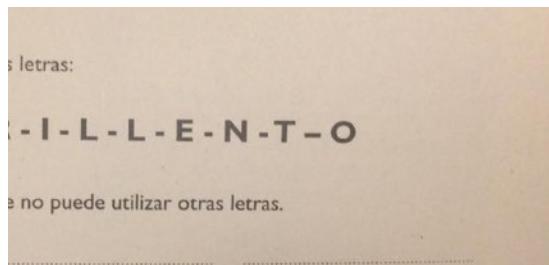
The idea is to have four random exercises per day. After completing these four exercises, the level will be complete. Each level will be centered around one word. Therefore, the user will sometimes need to recall the word in order to be able to complete the exercises. This adds some to the difficulty level of the game as well as it stresses the importance of recalling a word, which is one of the more difficult cognitive exercises and something that trains the brain well.

2.10.1. Task 1: Calculate numbers

- 1- Realice las siguientes sumas y restas:
- A. $1 + 3 + 4 + 5 + 4 =$
 - B. $7 + 4 + 5 + 7 =$
 - C. $14 + 6 + 12 + 7 + 5 + 3 =$
 - D. $38 - 3 - 9 - 6 =$
 - E. $15 - 7 - 4 - 2 =$
 - F. $27 - 6 - 9 =$
 - G. $17 - 5 - 5 + 1 =$
 - H. $15 + 10 - 2 + 8 - 4 =$
 - I. $12 + 6 - 3 + 3 =$
 - J. $14 - 4 + 7 + 8 + 2 =$
 - K. $25 - 6 - 5 =$

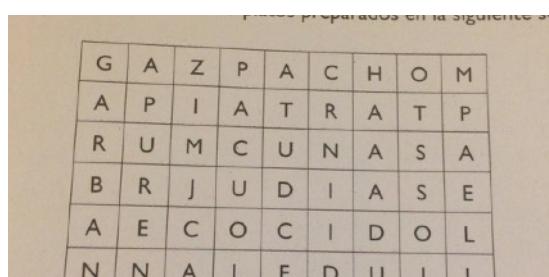
The first task is completing simple addition and subtraction exercises. Every problem will result in a number less than 26, which will then correspond to a letter in the alphabet. This can then be used in other tasks such as task 2.

2.10.2. Task 2: Connect numbers to alphabets



The second task corresponds numbers to the letters of the alphabet. This was not found in the regular exercises, but the regular exercises do include spelling and counting, making it a probable good addition to the application.

2.10.3. Task 3: Find word in a word puzzle



The third task is a familiar game where you have to find a certain word in a grid of letters.

2.10.4. Task 4: Find the word in an image.



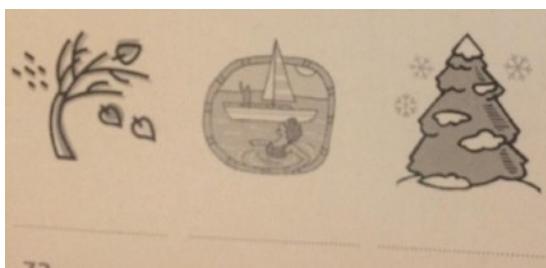
The fourth task is finding a certain word within a picture. Here, the example could be to find the fork or the butter knife.

2.10.5. Task 5: Hangman variety (butterfly from cocoon instead of hangman)

TEND....R	SEC....ETA....í
CALC....T....N	SUP....RMER...
ARM....R....O	MAN....EL....R
PE....UQUE....ÍA	EN....ALA....A
DROGU....R....A	SON....ISA

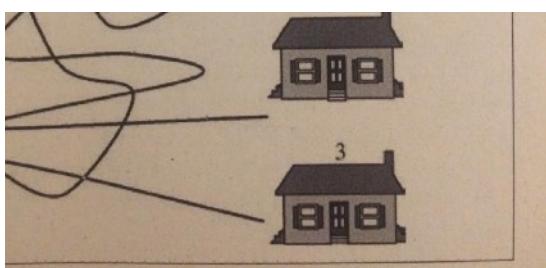
The fifth task is hangman. This could not be done on paper exercises and was also not found within the examples. However, we feel that it is a good game to train the brain with. However, instead of having hangman, we wanted to make a more positive version (e.g. you have 7 guesses before the butterfly leaves the cocoon and flies away).

2.10.6. Task 6: Connect Picture to word



Task six is about connecting a picture to a word: when the word is given (or recalled from previous games), the user must find the correct corresponding picture.

2.10.7. Task 7: Memory card with finding the matching cards to word of the day



Task seven is a digital version of memory where the user has to find all the cards that correspond to the word of the day. The user needs to find all the correct ones in order to move on to the next task.

2.10.8. Task 8: Find the images which is the same category as the word

2- Lea las siguientes palabras y señale la que no corresponde al grupo:

TROMPETA	PIANO	VIOLÍN
GUITARRA	FLAUTA	ORDENAD

Palabra que no corresponde:

¿Por qué?

Lea las siguientes palabras y señale la que no corresponde al grupo:

Task eight is about finding images that belong to the same category. Within the sample exercises, this same exercise was done using words and grouping them into the correct category.

2.10.9. Task 9: Find odd one out

2- Lea las siguientes palabras y señale la que no corresponde al grupo:

TROMPETA	PIANO	VIOLÍN
GUITARRA	FLAUTA	ORDENAD

Palabra que no corresponde:

¿Por qué?

Lea las siguientes palabras y señale la que no corresponde al grupo:

Task nine is very similar to task eight: here, instead of grouping the ones that are similar, the user must now find the one word or image that is different than the rest.

2.10.10. Task 10: Spell words backwards

6 7 4 9 4 2 5 3 6 el inverso es

5 4 1 3 6 8 2 6 7 el inverso es

6 4 8 6 6 2 5 1 3 el inverso es

5 6 4 7 8 8 2 2 5 el inverso es

Task ten is a little more difficult, where the user has to spell the word of the day backwards. Within the sample exercises, the user also had to do backward exercises, but they were given the numbers they needed to mirror. In this exercise, the user also needs to recall the word from previous games.

2.10.11. Task 11: Choose the correct colour for the item

MAR	VERDE
PLÁTANO	NARANJA
CÉSPED	ROJO
ZANAHORIA	AMARILLO
SANGRE	AZUL

Task eleven is about finding the right color for the item. This can only be done when colours are very obvious (e.g. an apple cannot be blue, etc.)

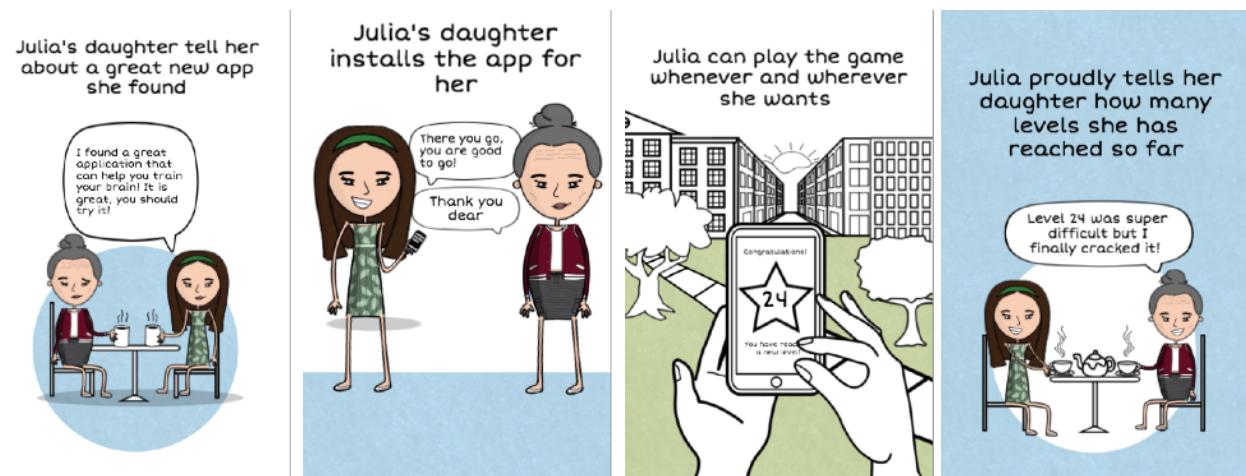
2.10.12. Task 12: Choose the correct spot/place where you find these items

guante	cuchara
tenedor	cuello
secador	bosque
folio	manguera
árbol	pelo
corbata	mano
bombero	pedal
	llave

Task twelve is about finding the place where the item can be found. For example, the question could be where you find milk and the options could be fridge, dishwasher, bathtub and bed. Here, fridge would be the correct option. Here, it is about establishing relationships between items and locations. Only obvious choices can be provided, as is also the case for task eleven.

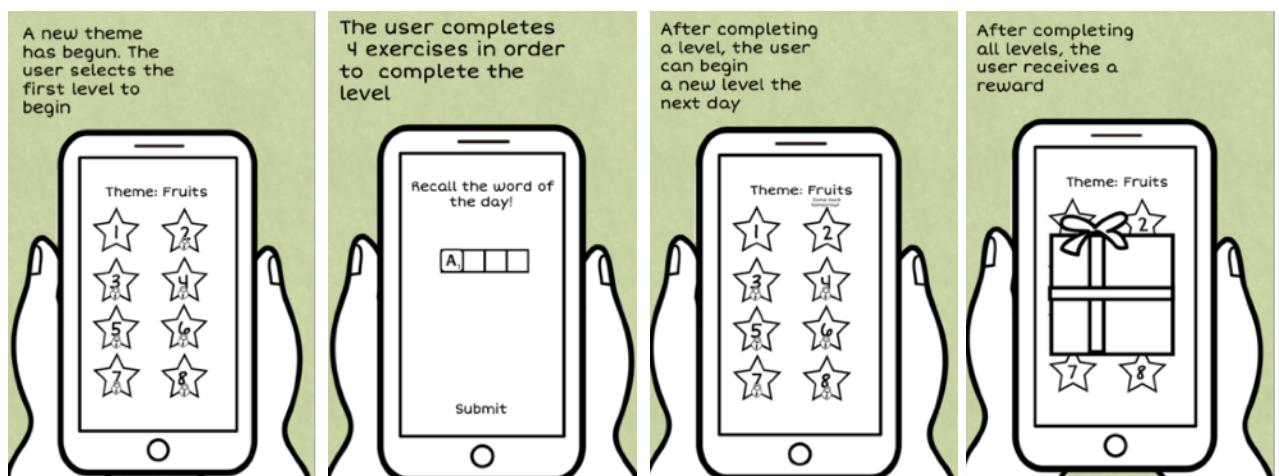
2.11. User Scenario Concept

Users will be able to use this application within their environment. The following scenario aims to demonstrate the usage of the application within the normal environment of the user.



2.12. User Scenario Task-Based

Within the application, a user is required to perform certain tasks. The following scenario aims to demonstrate the main tasks the user will need to perform within the application.



3. USABILITY AND ACCESSIBILITY REQUIREMENTS

When creating a prototype, it is important to create requirements. These requirements are based on research done and create a focus for the researchers: it allows them to understand what should be included within the prototype. Some features might be really nice to have, but are not required for a well working product. However, it is easy to work on features that are fun, but not necessarily important. Requirements ensure that the researchers stay focused on the task at hand and creating a well-working product. The requirements are described in two different categories, namely usability requirements and accessibility requirements.

3.1. Usability Requirements

In order to determine the usability of our application, a heuristics evaluation will be conducted. This evaluation will be based on a paper called *Heuristic Evaluation on Mobile Interfaces: A New Checklist* (Gómez et al., 2014), which expands the *10 usability heuristics for user interface design* by Jakob Nielsen (1995). This article describes 127 requirements categorised into 13 different categories:

1. Visibility of System Status - 15 Requirements
2. Match Between System and Real World - 20 Requirements
3. User Control and Freedom - 16 Requirements
4. Consistency and Standards - 30 Requirements
5. Error Prevention - 12 Requirements
6. Recognition Rather than Recall - 27 Requirements
7. Flexibility and Efficiency of Use - 7 Requirements
8. Aesthetic and Minimalistic Design - 26 Requirements
9. Help Users Recognise, Diagnose and Recover from Errors - 1 Requirement
10. Help and Documentation - 16 Requirements
11. Skills - 7 Requirements
12. Pleasurable and Respectful Interaction - 15 Requirements
13. Privacy - 13 Requirements

This list of requirements will be used as guidelines whilst developing the prototype and a check of the list will be done in order to internally evaluate the prototype on usability. The list of all the 127 usability requirements has been added as *Appendix B*.

3.2. Accessibility Requirements

In order to create an accessible application, the research conducted in chapter 2 must be translated into requirements. The requirements will be organised by giving them a level of importance or prioritising them. When creating requirements, it is important that they are measurable. Once they have been measured within the prototype, they can be checked off as either yes or no.

One way to prioritise functionalities is by using the MoSCoW method (Waters, 2009). MoSCoW stands for “must have”, “should have”, “could have” and “won’t have”:

Must-have: These functionalities must be included in the prototype. These functionalities create the minimal viable product to be tested.

Should-have: These functionalities are not critical, but are very important to be included in the prototype. Therefore, it has a lot of added value if these functionalities are included.

Could-have: These functionalities are nice to be included, but are not essential and can be left out if time becomes critical.

Won't-have: These functionalities are deliberately excluded from this version of the prototype, but are functionalities that may be included in future iterations or future development.

The prioritisation of the requirements allows the researchers to understand which things need to be included within the prototype. Therefore, it allows the researchers to understand which tasks they must complete first, and which tasks are only added if time permits.

The stakeholder interviews as well as the research found online in section 2.4. were the basis for the list of requirements given below. Some requirements were duplicate to the usability requirements in section 3.1.. However, since we found the requirements very important, we decided to rather have duplicate requirements than accidentally missing an important one by leaving it out of one of the evaluations.

3.2.1. Must Requirements

- RQ1: The font size must have a minimum of 14 pt for normal text in the application.
- RQ2: The font size must have a minimum of 20 pt for headings in the Brain Boost Tracker application
- RQ3: The font size must have a minimum of 28 pt for headings in the Brain Boost application
- RQ4: There must be "white" space between buttons
- RQ5: The customisation button must allow users to resize text
- RQ6: The user must always be able to exit to the main page of the application
- RQ7: Images must not contain text
- RQ8: Color must not be the only visual means of conveying information, indicating an action, prompting a response or distinguishing a visual element.
- RQ9: The text must have a contrast ratio of 3:1 (all text is considered large text, items that are purely meant as decoration are excluded from this requirement).
- RQ10: Navigation must be presented in the same relative order across a website
- RQ11: Components with similar functionality must be identified consistently across the application
- RQ12: Changes of context must only be initiated by the user
- RQ13: Instructions must be provided when content requires user input.
- RQ14: Users must be able to correct information that is incorrect.
- RQ15: If an input error is automatically detected, the item that is in error must be identified
- RQ16: The interface must use a simple solid background (e.g. no pattern on background).
- RQ17: Icons must be accompanied by a label
- RQ18: The user must be able to use the app by using the 'tap' gesture only
- RQ19: Buttons should be at least 9mm (width and height) in size
- RQ20: Icons must be simple
- RQ21: The user must see their progress within a level
- RQ22: The user must see when a level is unlocked
- RQ23: The Brain Boost Tracker app must be able to connect to the Brain Boost app by scanning a QR code
- RQ24: The Brain Boost app must be able to connect to the Brain Boost Tracker app by scanning a QR code

3.2.2. Should Requirements

- RQ25: The help option should be available to the user at all times within the application
- RQ26: The application should not require reading ability more advanced than the lower secondary education level
- RQ27: The application should not include jargon.
- RQ28: The text in the application should be left-aligned.
- RQ29: The text in the application should not have text decoration (underline, italic, bold, etc.) unless it marks a link or important statement.

-
- RQ30: The text in the application should have the same font style.
 - RQ31: The customisation button should allow users to increase line spaces
 - RQ32: The screen should have a clear title that describes the purpose of the screen
 - RQ33: Menu should include a back button
 - RQ34: The app should not include any scroll functionalities, for it keeps vital information outside of the visual screen
 - RQ35: The application should not require double clicks (or double taps)
 - RQ36: Animations should not be present
 - RQ37: Icons should be meaningful
 - RQ38: The most important information should be portrayed in the center of the screen
 - RQ39: Irrelevant information should be avoided on the screens
 - RQ40: The background should not be white, blue or green
 - RQ41: The system should provide input feedback
 - RQ42: The submit button should be greyed out until all fields are filled in.

3.2.3. Could Requirements

- RQ43: The application could provide extensive feedback on errors made by users during the game
- RQ44: The system could provide hints for the recall game
- RQ45: The system could be able to send push notifications to the user
- RQ46: The system could calculate the amount of levels needed to complete the week and update this in the Brain Boost Tracker app
- RQ47: The caretaker could be able to set a date for the reward in the calendar in the Brain Boost Tracker app
- RQ48: The user could be able to turn off notifications
- RQ49: The user could be able to turn off sound
- RQ50: The user could be able to switch language
- RQ51: The user could set settings to blind mode
- RQ52: The hint in the recall game could be unlocked after an hour

3.2.4. Won't requirements

- RQ53: The screen must orientate correctly both vertically and horizontally
- RQ54: If an input error is automatically detected, the error is described to the user
- RQ55: Notifications should be sounds within the audible range of the frail user.
- RQ56: Users could receive notifications when a new level is unlocked and open to play

4. DEVELOPMENT OF HIGH FIDELITY PROTOTYPE

To develop the final high fidelity prototype, several iterations were performed. Each iteration will be briefly described and examples of changes will be provided.

4.1. First Iteration: Low Fidelity Paper Prototype

The first step towards creating the prototype was putting the concept we had into an actual sketch of how it will look as an app. There was a lot of brainstorming on what to include and what not to include and how it should look. We did go through some research to see what the already existing layouts are which are used in normal games (specifically in games designed for the elderly population) and tried to incorporate them for the elderly.

We started the prototype with creating the different pages we wanted in the app and the features available in them. This was done through a paper prototype. Images of the paper prototype have been added in Appendix C. We also looked at the connection/interaction between the pages. From the beginning itself we have discussed about the small or very evident accessibility criterium that can be met for the app, so as to have a better idea about fulfilling the needs for the elderly from the start itself. These rough sketches helped in understanding the overall layout as well as the small features of our concept. Even though the main app will have lot of exercises, we have decided to use 4 of those (which completes one level in the game) for the prototype.

4.2. Second Iteration: First Digital Screens

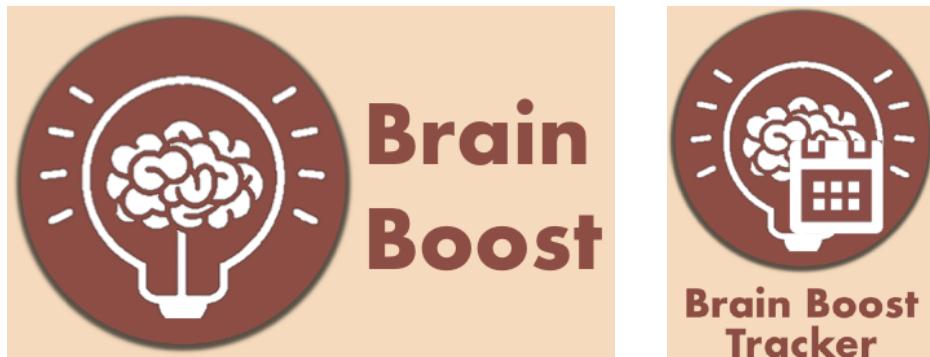
Once we had a clear idea of what the layout is supposed to look like, we decided to create the first set of screens to see the actual look of the final prototype interface. The designing tool we decided to use for this project was Sketch, since we had experience using that tool.

We started by choosing a very soothing color palette for the elderly. We found a website which described which colours would be nice for a particular age group, such as the elderly population (Resene.co.nz, 2018.) The first choice was Resene Sandy Beach for the background, black for the rest of the body, grey for inactive elements and Blue for showing the current status or highlights. We have also used Green and Red for correct and wrong answers and for some buttons with specific purposes (Reset, next, quit, confirm). But due to the lack of aesthetics of black on the background color, we changed it to Resene Mexican Red (during the third iteration).



The next step was to choose the right font type for the app. We did more research and found out different font types that are most suitable for the elderly, and decided to move forward with "Futura" as the font type style for the app (Pettengill, 2017). After choosing the colors and font type, we started by creating a logo for both

the Brain Boost app and the tracker app. We decided to keep the design same for both and just add an extra icon for the tracker app for its differentiation. The font can be seen in the following images:



We were very careful in the choice of icons, we wanted to use very simple, understandable, standard icons for all the main elements of the app. This helps in the aesthetics of the app as well as easy understanding for people who prefer visuals rather than text. We also made sure to use consistent style throughout the app for the icons. Examples of icons used within the application are shown in the following images:



For the rest of the first digital screen prototype, it was just creating the same screens as those that was decided in the sketches. But there were some changes that were made while designing due to space constraints or time-consuming issues and all. One main change was the status bar for the main screen and for each of the task screens. It was supposed to be a circular progress bar, but it was changed to rounded cornered rectangle shapes. The progress bars can be seen in the following images:



4.3. Third Iteration: Second Digital Screens

The third iteration was done by going through each of the screens and elements by ourselves and creating a list of things that needs to be changed. The main thing about this iteration was the change in the black color used for the rest of the body into Resene Mexican Red color.

We also changed the size of the Tracker logo to make the calendar icon more evident and also the placement of the text to fit more perfectly with the mobile orientation as can be seen in the images below. Also, the color of the logo was also changed because it looked a bit dull for a logo, so we decided to use the resene red shade for the logo to make it look brighter and eye-catching.



We also made changes in the style for buttons, because the one that was part of the second iteration didn't have any style to make it look more like a 3D button. For users, it is important to understand which parts of the application they can press and which actions they can perform. The changes in style to make items look like 3D buttons can be seen in the following images:



A	B	C	D	E	F	G	H	I
J	K	L	M	N	O	P	Q	R
S	T	U	V	W	X	Y	Z	

A	B	C	D	E	F	G	H	I
J	K	L	M	N	O	P	Q	R
S	T	U	V	W	X	Y	Z	

4.4. Fourth Iteration: First High Fidelity Prototype

All the above-mentioned changes were made and then we had a discussion with our tutor Rodrigo about the current status of the prototype. He gave us very important feedback and showed us certain things which we had missed out during the design process.

The first thing we changed was the layout of the task 1 where the user had to do multiple calculations in one single screen. The chances of elderly people getting confused was very high and it's always best to use less content for the elderly. So, we split the task 1 screen into 5 screens to make it easy for the users.

0 + = 1 ✓
 10 + 6 = ✓
 + 8 = 16 ✓
 3 + = 12 ✓
 + 3 = 5 ✗ Submit

Find the missing digits

0 + = 1

0	1	2	3	4
5	6	7	8	9

Next

Find the missing digits

10 + 6 =

0	1	2	3	4
5	6	7	8	9

Next

We also gave descriptive headings for each of the tasks for easy understanding for the user. The more detailed descriptions were provided in the help section, but we wanted to give a very brief and easy description in the beginning of the task itself.

Fill in the alphabets using the numbers you got

A P 1 16 16 12 5

A	B	C	D	E	F	G	H	I
J	K	L	M	N	O	P	Q	R
S	T	U	V	W	X	Y	Z	

Submit

Fill in the alphabets using the numbers you got

 1 16 16 12 5

A	B	C	D	E	F	G	H	I
J	K	L	M	N	O	P	Q	R
S	T	U	V	W	X	Y	Z	

Submit

In the third iteration, the submit button for all the tasks were placed in different locations. This is something that can confuse the users as this is very inconsistent and especially when all those buttons have the same purpose. So, during the fourth iteration, we changed the location of the submit button and put it in the same consistent place:

The figure consists of four screenshots of a mobile application interface arranged in a 2x2 grid.

- Top Left:** A math puzzle screen titled "Find the missing digits". It shows five equations: $0 + \underline{\quad} = 1$, $10 + 6 = \underline{\quad}$, $\underline{\quad} + 8 = 16$, $3 + \underline{\quad} = 12$, and $\underline{\quad} + 3 = 5$. Each equation has a green checkmark or a red X icon next to it. A green "Submit" button is located at the bottom right.
- Top Right:** A matching game screen titled "Fill in the alphabets using the numbers you got". It shows a grid of letters (A-Z) and numbers (1-5). Above the grid, there are five numbered boxes (1, 16, 16, 12, 5) each containing a letter. The first four boxes have green checkmarks above them, while the fifth one has a red X. A green "Submit" button is located at the bottom right.
- Bottom Left:** The same math puzzle screen as the top-left, but now with a "Next" button at the bottom instead of a "Submit" button.
- Bottom Right:** The same matching game screen as the top-right, but now with a "Submit" button at the bottom instead of a "Next" button.

Rodrigo pointed out how careful we had to be with the terminologies used in the app as it could be a bit misleading or confusing for the elderly users. For example, back could make users think they will go to the previous screen. However, in our context, the user would go back to the main menu. Moreover, “submit” does not fully explain what will happen in the context below. Therefore, this term was changed to “continue”:

The figure shows two confirmation dialogs side-by-side.

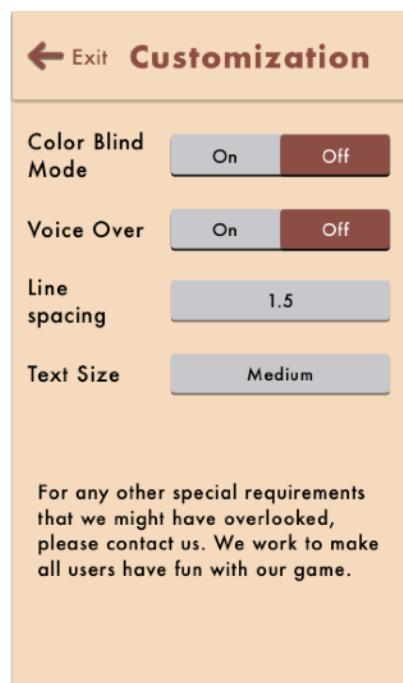
- Left Dialog:** A box with a left arrow icon and the word "Back". Below it is a "Submit" button.
- Right Dialog:** A box with a left arrow icon and the word "Exit". Below it is a "Submit" button.
- Bottom Left Dialog:** A box with the text: "Are you sure you want to customize the settings for this game? You will be changing the layout of the game." It has "Cancel" and "Submit" buttons.
- Bottom Right Dialog:** A box with the text: "Are you sure you want to customize the settings for this game? You will be changing the layout of the game." It has "Cancel" and "Continue" buttons.

We also had a section in the main screen of the app where it mentioned which week the user was playing and the theme related to it. This created a bit of a confusion as the game doesn't require the user to finish each level within a specific week. So, mentioning the week was not needed for the game, the theme alone was enough to mention:

The figure compares the main screen of the app across two iterations.

- Top Row:**
 - Third Iteration:** Shows "Week: 1" and "Theme: Fruits" side-by-side.
 - Fourth Iteration:** Shows "Today's Theme: Fruits" below the navigation icons.
- Bottom Row:** Both iterations show identical sets of navigation icons:
 - Tracker (User profile icon)
 - Settings (Gear icon)
 - Information (Info icon)
 - Help (Question mark icon)

We also made a huge change in the working of the app by including the personalized customization option in both the apps, which gives the user the option to change the game according to their specific needs and also this was something that could be changed even by the caretaker, using the Tracker app. This means that the user could apply changes through their app (such as color blind mode, voice over, text size, etc.). However, if the user is a novice user and does not know how to fix these things within their application, a caretaker could change it for them over distance through the Tracker app. The caretaker is also able to change their own customisation for the tracker app.

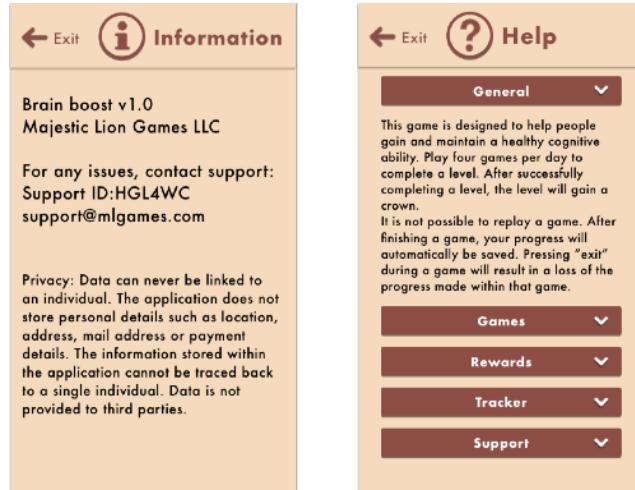


4.5. Fifth Iteration: Final High Fidelity Prototype

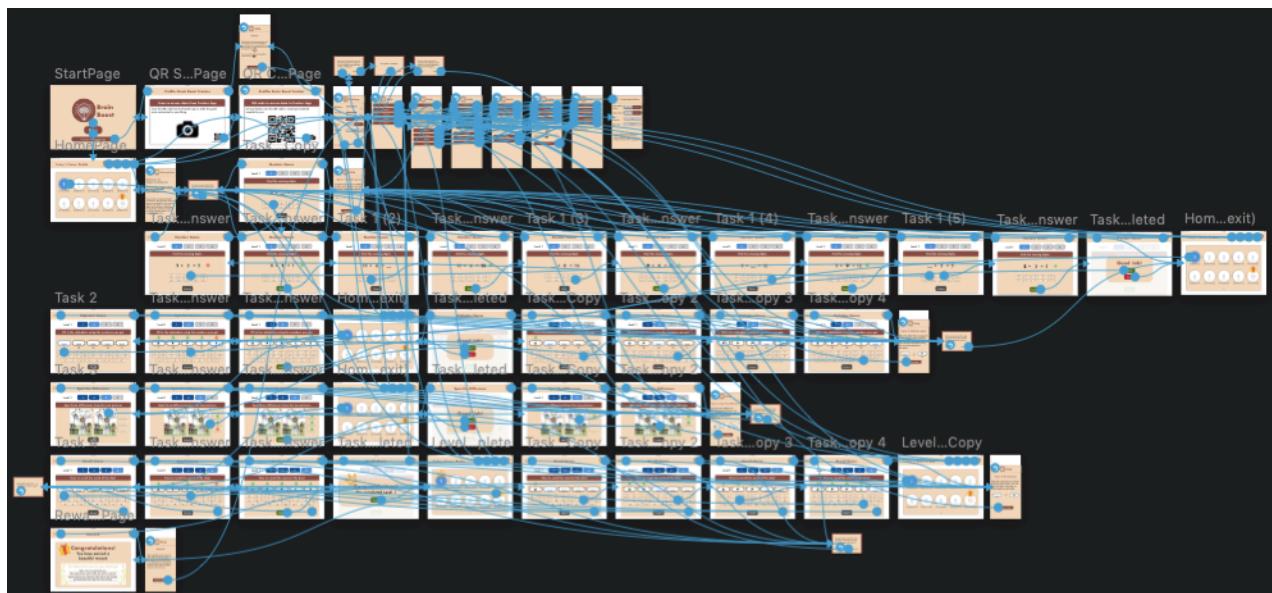
The final iteration was about focusing on and correcting the minor changes. We created all the necessary screens needed for the visualization of the prototype, especially the error message pop-ups and screens where the user makes mistakes in the tasks.

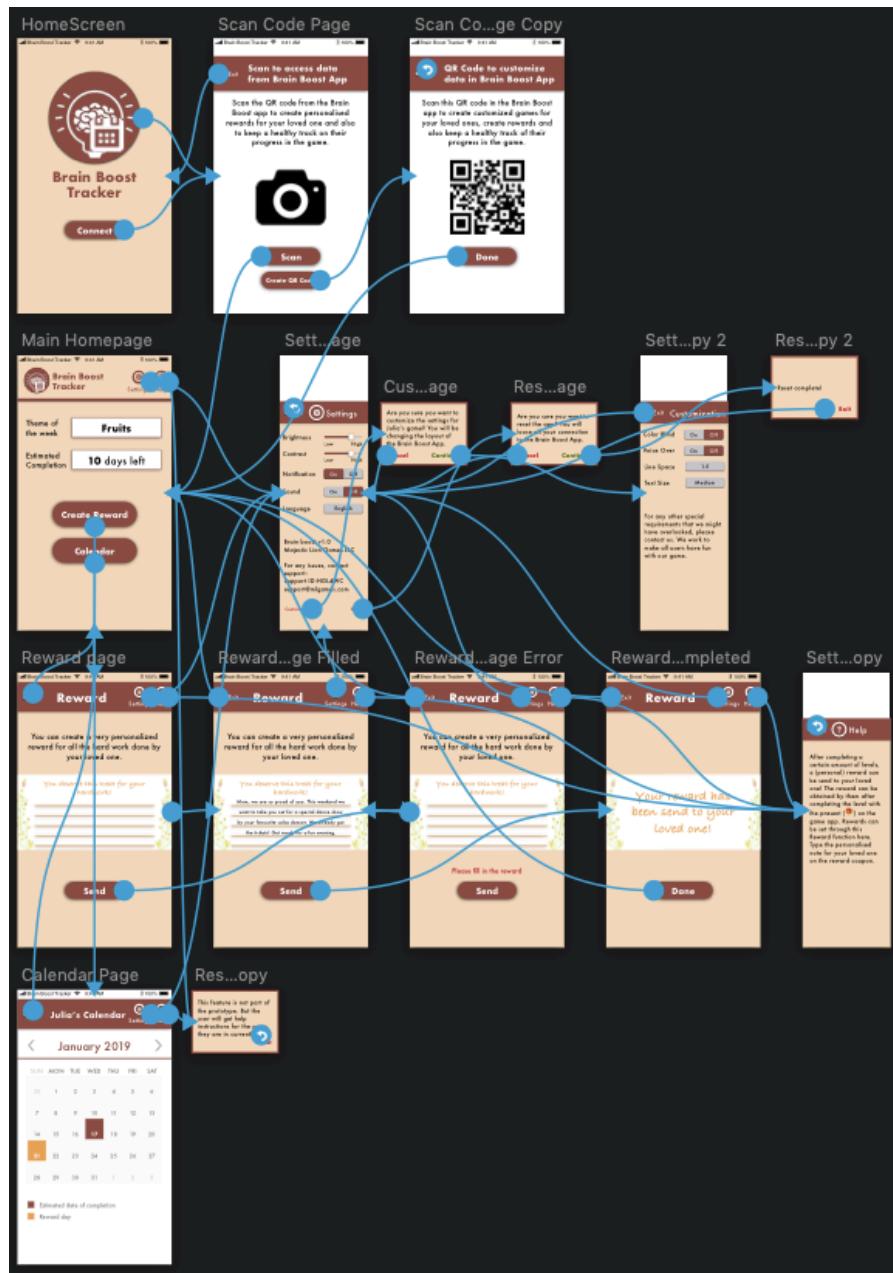
The image displays two screens from a game prototype. The left screen shows a comparison task: "Spot three differences from the two pictures". It features two side-by-side illustrations of a garden scene with trees, flowers, and two characters. Below the images is a "Submit" button. To the right is a confirmation dialog box with a dark brown header and a light brown body. The text in the dialog reads: "Are you sure you want to exit the game now? You will lose all your progress till now for this level." At the bottom of the dialog are two buttons: "Cancel" on the left and "I am sure" on the right.

We also created the information page and the help pages (for each task as well as for the overall help page).



After creating all the screens, we used InVision app for creating the high-fidelity digital prototype. This tool helps in making the Sketch screens interactive in any platform (web, mobile, iPad). It was a very time-consuming process since there were many screens and each screen had multiple elements that had connections with many other elements. So, each connection had to be done carefully and also double checking every time to see if there is a smooth flow in the app visualization during the prototype. The overall flow of all the screens can be seen in the following two images:





5. INTERNAL EVALUATION OF USABILITY AND ACCESSIBILITY

After creating the completed high fidelity prototype, a check can be done to assess if the application is usable and accessible. The requirements introduced in chapter 3 have functioned as guidelines whilst developing the prototype: the prototype has been adjusted when certain requirements were not yet met. Within this chapter, we will discuss how the high fidelity prototype meets (or does not yet meet) the different requirements.

5.1. Usability Test

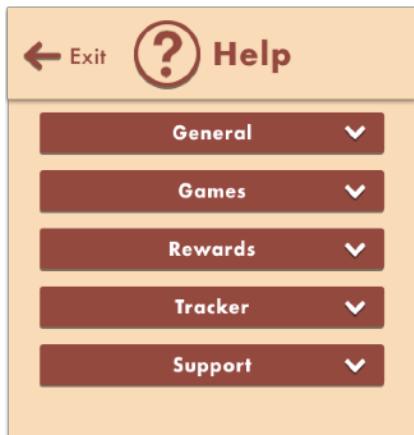
In section 3.1., we described how we would test the usability of Brain Boost. The results per category are provided in Table 2.

Category	Total Requirements	Passed Requirements	Not Applicable Requirements
Visibility of System Status	15	3	12
Match Between System and Real World	20	14	6
User Control and Freedom	16	14	2
Consistency and Standards	30	23	7
Error Prevention	12	7	5
Recognition Rather than Recall	27	19	8
Flexibility and Efficiency of Use	7	1	6
Aesthetic and Minimalistic Design	26	13	13
Help Users Recognise, Diagnose and Recover from Errors	1	1	0
Help and Documentation	16	12	4
Skills	7	4	3
Pleasurable and Respectful Interaction	15	6	9
Privacy	5	3	2

Table 2: Usability test results per category

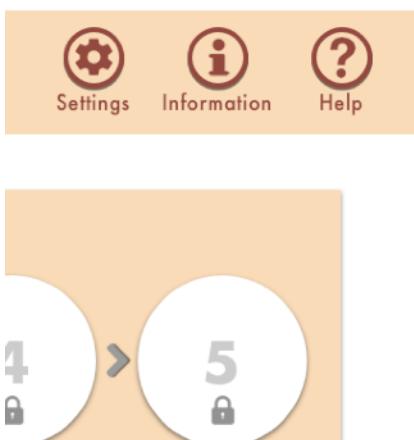
Per category, some examples will be given on how the requirements were met or how they were not applicable in the next sections. The completed list including comments for every requirement can be found in Appendix D.

5.1.1. Visibility of System Status



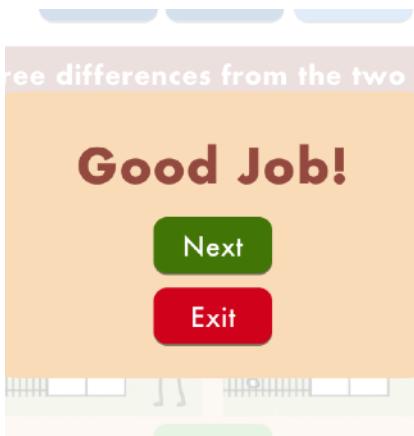
This heuristic focused on several aspects of the system, but only few were applicable. For example, the help list as shown on the left is on one page and visible in its complete form to the user. Moreover, all areas have been created to look like buttons as if they are touchable to the users. This has also been emphasised by adding arrows to show that the section will expand when the user clicks on it.

5.1.2. Match Between System and Real World



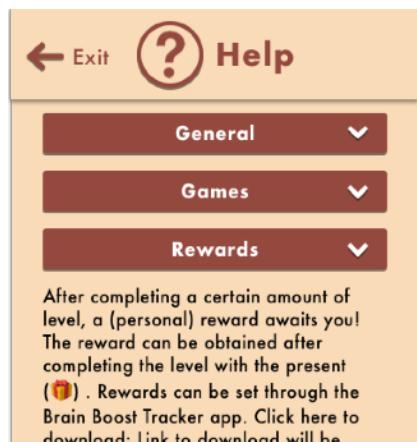
The second section focused on making logical connections between the application and real world knowledge. For example, the icons on the left are concrete and familiar since they are used many times in other applications or even in real life. Moreover, if something important would happen, it would be indicated in a bright red color which is a normal color association in our culture. The menus have been designed to fit all the heuristics as well by having logical categories and by making the menus small in order to avoid memory overload. Simplicity has also been integrated across the application through easy language and questions and avoiding jargon.

5.1.3. User Control and Freedom



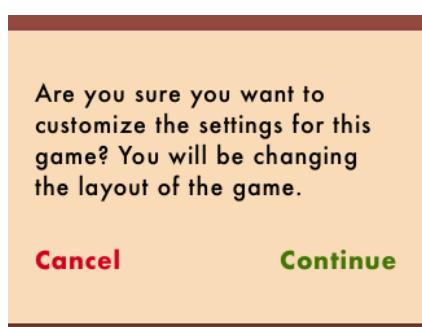
The third heuristic, focused on user control and freedom, were almost all met and applicable to the system. Navigation, forward and backward options as well as clear exits have been included in the application. As shown on the left, the user always has to agree and confirm to go to the next step. Users are also able to set some personal preferences within the application. User can exit at all times, but some progress will be lost: this was done on purpose since the user has to finish the entire exercise before being able to exit to stimulate the completion of the exercise. This is clearly indicated when the user presses exit during an exercise.

5.1.4. Consistency and Standards



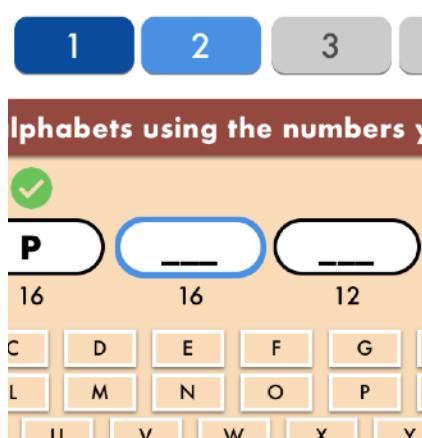
This section is quite long and focused on consistency throughout the application. Colors have been chosen specifically to match colours that are clear and suitable for elderly people. Moreover, contrast has been taken into account while designing the application. All the pages have the same design aesthetics. Icons are from the same family. Upper case and italic texts have been avoided also. As can be seen on the left, the menu items are consistent throughout the application: when opening the help when on the reward page, the same answer is given as when opening the main help menu and navigating to rewards. Menu titles are all entered and the menu choices matched the corresponding menu titles.

5.1.5. Error Prevention



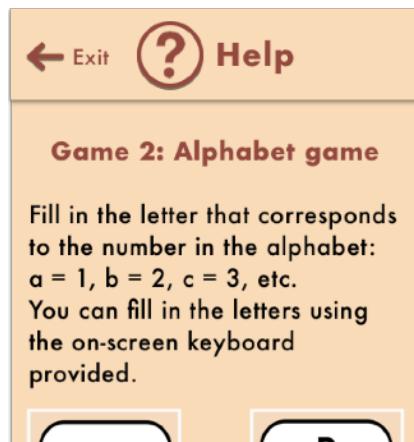
Error prevention is important to the frail population, for they might be more anxious to make mistakes within the application. Therefore, the user can only continue when the answer is correct and there is always a back or exit button included. Moreover, there is always a warning message as shown on the left when a user is about to make a change that could be an error within the system or that could result in a change of the application. Widgets have been made larger, and include a padding in order to avoid the fat-finger issues that are more common in older population.

5.1.6. Recognition Rather than Recall



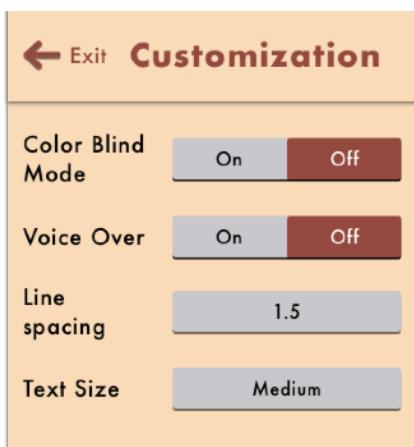
Recognition and recall is also very relevant for this population, because you cannot expect much information to be remembered throughout the application (unless it is part of one of the exercises). Therefore, menus are short and grouped to find help easily, a progress bar is included to show the status of the user, help menus can be accessed on the page so the user does not need to remember the help when trying to solve the problem. Moreover, clues are given to guide the user through the tasks, as is the case in the image on the left: here, the user can see which letter needs to be filled in next. The focus can also be changed by having the user press the next letter: the user does not need to remember which letter they are about to fill in. Also, the help menu consists of one word titles, meaning every first word is the most important one.

5.1.7. Flexibility and Efficiency of Use



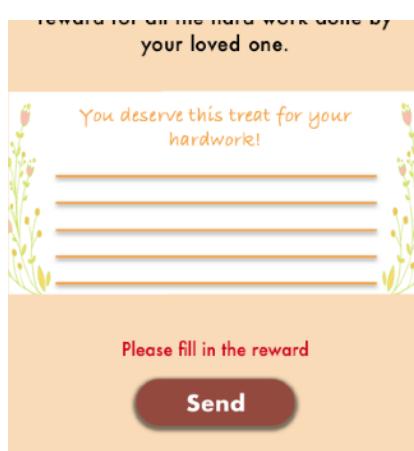
This section is almost not relevant to the application, since most of the heuristics apply to a search bar which has not been implemented within the application. However, navigation has been included by having customised help pages to the games. This means that, whilst playing a game, pressing the help button will only show the help for that particular game. This ensures that users do not need to search for the correct help page linked to the game. The user is always able to access the full help menu if they desire.

5.1.8. Aesthetic and Minimalistic Design



Minimalistic design is important in order not to overwhelm the specific user group. Therefore, recognisable icons are used. Visual noise is avoided and any action has been stated in the affirmative voice. Moreover, the icons are of one family, they stand out from the background and are visually distinct. A good example of minimalistic design is shown on the left, where the customisation menu only consists of short words and an option to be changed by the user.

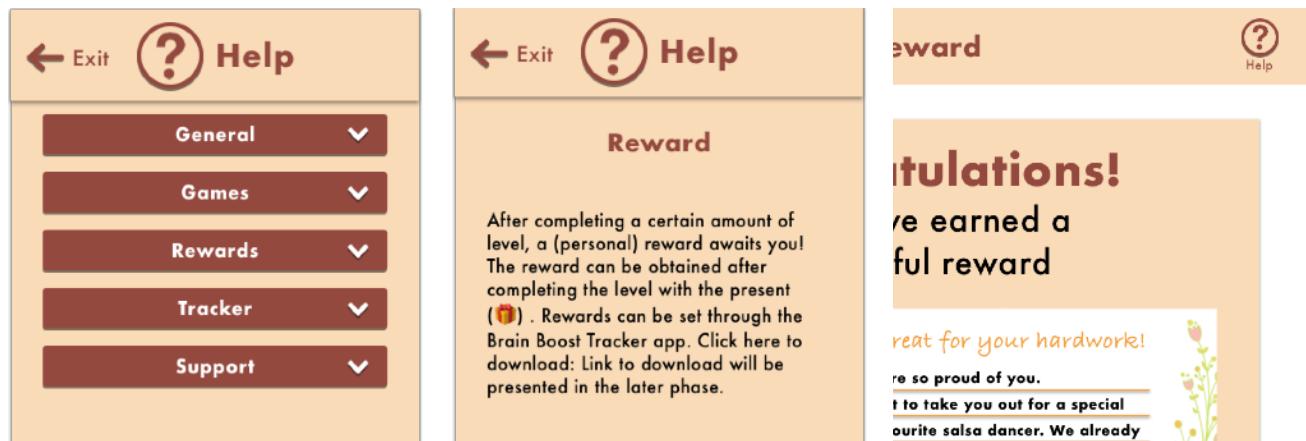
5.1.9. Help Users Recognise, Diagnose and Recover from Errors



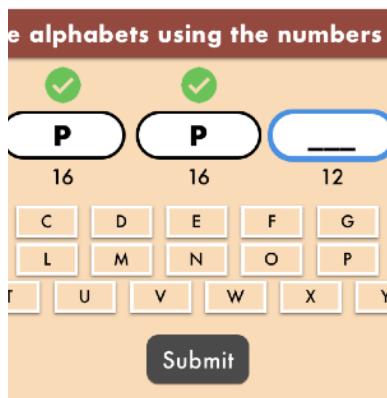
This section only consists of one heuristic, which has been met. The example is from the Brain Boost Tracker app, where the user can fill in rewards for the user for when they have completed all ten levels. However, when the reward is not yet filled in, it cannot be sent. This prevents caretakers from accidentally sending empty rewards to the users.

5.1.10. Help and Documentation

Help and documentation has been a large focus for the prototype. Every page has access to the help menu and the menu page is always adapted to the current page of the user. The icon for the help page is always the same and always on the same location on the page. It is easy to switch between the help menu and work since it works as a pop-up menu. Work can be resumed after accessing the help page.

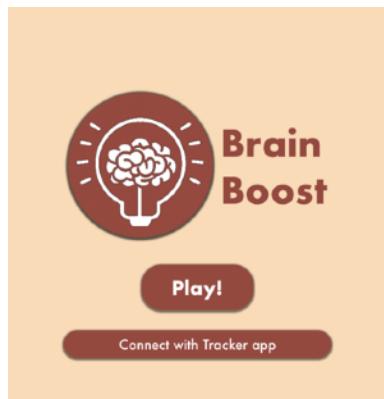


5.1.11. Skills



Only a few heuristics were applicable in this section. The word “default” was avoided throughout the application. Moreover, the user always has to initiate an action before the application continues. There is an in-app keyboard with clear functionality and large buttons that are easy to use for frail users. Moreover, important keys, such as submit, are larger than other buttons, such as the keyboard keys.

5.1.12. Pleasurable and Respectful Interaction



Since the application does not have any purchase options, this section was largely not applicable to the application. However, some were relevant and were met: the application does not store any sensitive information and does not require any logging in in order to make use of the full application. Due to this, the user is automatically logged into the application at all times. Registration does not have to be done.

5.1.13. Privacy

Majestic Lion Games LLC

For any issues, contact support:
Support ID:HGL4WC
support@majesticliongames.com

Privacy: Data can never be linked to an individual. The application does not store personal details such as location, address, mail address or payment details. The information stored within the application cannot be traced back to a single individual. Data is not provided to third parties.

Last but not least, privacy of the application needs to be considered. Within the application, there are no completely protected areas. Moreover, there are no confidential areas. There is also no personal data stored, since the application does not require any in order to work. The application has a privacy statement included and can easily be contacted for support through several ways within the application.

5.2. Accessibility Test

In section 3.2., we introduced 56 requirements that were prioritised into four categories as compliant with the MoSCoW method. After creating the final high fidelity prototype, all the must requirements must be included within the prototype. It would be nice to have the should requirements included as well, since they add a lot of value to the product. If time permits, could requirements could be implemented. Won't requirements are not implemented since they are created for future iterations or development of the product. Each category will be given and shortly explained what has been implemented and what has been left out.

5.2.1. Must Requirements

All the must requirements are met. These requirements were mostly about font sizes and visibility/understandability of icons and actions that needed to be performed by the user. Most of these could be fixed through the actual design of the application. Some of the requirements were met by implementing certain functionalities (such as always being able to exit a game) or automatic processes within the application (such as error identification).

5.2.2. Should Requirements

All the should requirements are met. These requirements were a little less basic than the must requirements. Here, text needed to be understandable and more detailed design aspects were given (e.g. the submit buttons is greyed out until the user can actually submit the answer).

5.2.3. Could Requirements

Seven out of ten of the could requirements are met. Most of the requirements focused on changing user settings and allowing users to make the application suitable for their needs and limitations. The requirements that were not met within this category are:

RQ43: The application could provide extensive feedback on errors made by users during the game

RQ45: The system could be able to send push notifications to the user

RQ52: The hint in the recall game could be unlocked after an hour

The notification was difficult to implement within the prototype. The other two requirements were more detailed feedback or player options that were left out of the application due to time constraints. However, these requirements would be of added value and are therefore recommended to be included in future development.

5.2.4. Won't Requirements

None of the won't requirements were implemented within the application as was discussed beforehand. These requirements could not be integrated for they would require an actual working application. However, these requirements would be of added value and it is recommended to investigate them further for future iterations.

6. CONCLUSION

After completing the project, it is important to look back and conclude the different findings we have come across. Within this chapter, we will make conclusions on the process, the prototype as well as propose recommendations for future development on the prototype.

6.1. The Process

For this project, we followed a user-centered design process. This means that we would first need to understand the user completely and we would need to involve them throughout the development of the prototype. By conducting research, we tried to create personae that would acquire our attention and focus throughout the development process. Due to time constraints and access limitations, the personae had to function as the real end-user of the project and the supervisors provided us with expert advise to improve our prototypes.

Based on all the input we had received, requirements were established. These requirements were focused on making the application accessible to the intended target group. These requirements were measurable and could be checked off after the prototype had been completed. The other requirements for usability were based on a research paper.

In the end, five different iterations of the prototype were performed, which led to the final end result of the prototype.

6.2. The Prototype

In the end, we have created two prototypes: one application for the frail user and one application for the caretaker. Seeing as the project was focused on cognitive exercises for frail users, we put more focus and effort on the Brain Boost application. For the Brain Boost Tracker, we tried to implement as many heuristics and functions as we could. However, we were not able to implement all the functionalities. This application was created more to show the connectivity between both the application as well as the intended features this application should have.

The Brain Boost application includes four games to give the impression of what one level would look like. The application has been developed with the usability requirements and accessibility requirements in mind. For example, special attention was given to font size, color contrast, target size, colours that are highly perceivable by the elderly population and cohesion between the different components of the application.

6.3. Future Recommendations

For future development of the project, some recommendations can be given. First, there are recommendations from requirements that were not met. These requirements could still add a lot of value to the project and they could be integrated in future versions of the prototype. The second set of recommendations derived from feedback received from expert users.

The requirements that were not implemented within the prototype consist of the three ‘could’ requirements that had been left out due to complexity and time constraints as well as the four ‘won’t’ requirements that were not implemented on purpose. The requirements are:

- RQ43: The application could provide extensive feedback on errors made by users during the game
- RQ45: The system could be able to send push notifications to the user
- RQ52: The hint in the recall game could be unlocked after an hour
- RQ53: The screen must orientate correctly both vertically and horizontally
- RQ54: If an input error is automatically detected, the error is described to the user

RQ55: Notifications should be sounds within the audible range of the frail user.

RQ56: Users could receive notifications when a new level is unlocked and open to play

Within the application, more in depth help can be provided: right now, the application can show an example of what should be done to finish the exercise. However, this help could be adapted to the actual exercise as well as the step the user has problems with. Moreover, the application could send push notifications. These notifications can be used as motivation in order to remind or help the user complete the exercise. Looking at requirement 56, the notifications can also be used to show the user a new level is unlocked and open to play: the user can only play one level per day, so a notification when they can play a new level might help the user.

Also, within the recall game, a hint button has been placed. This hint button could be locked for a certain amount of time in order to ensure that the user first has to think about the exercise before the hint can be used. Also, hints can be used in other games within the application, such as the ‘search for the item’ exercise. Here, the same ‘unlocking’ mechanism can be implemented as well.

The four won’t requirements could not be implemented, but should be implemented. The screen must orientate both horizontally as well as vertically. This should be tested before implementation can take place: for the Brain Boost Tracker app, it makes sense to switch orientation. For the Brain Boost app, it might not make sense to show the exercises in a vertical orientation.

Requirement 54 is narrowly correlated to requirement number 43: if the error is detected, the application could describe what is going wrong and help the user complete the exercise.

If notifications are implemented within the application, they should have a sound which is within the audible range of the user. As we grow older, our hearing declines and we can be less perceptible to high pitched sounds. Therefore, it is important that the sound of the notifications has a lower frequency and can, therefore, be heard by the intended user group.

There are several recommendations that were deducted from feedback by experts. First, a closer look needs to be taken at the heuristics. This is further explained in section 7.3.. Within the application, there is quite a lot of text present. It might be nice to try to confine the text more, or implement it in such a way that only very small sections of text are visible at a time.

Moreover, some options have been shown as text or links whereas others are buttons. Furthermore, the traffic light metaphor has been implemented (green is good, red is bad), which needs to be implemented very carefully for it can easily go wrong. The recommendation for both these points it to pay special attention to any inconsistencies found within the application: consistency is a very important factor within mobile applications, but more specifically so for applications created for the elderly population.

Moreover, a closer look needs to be taken at the option “exit” which could still be interpreted as “back” when placed in the upper left corner. However, the user can never go back to the previous exercise. Another word might need to replace “exit” in order to ensure that the application is more understandable for everyone.

Last but not least, a further discussion on privacy could take place. If you do collect data from users and their user profile, you could learn a lot about user groups and, perhaps, even gain information on how to help the users better to maintain or improve their health. At this point, no personal data is collected and these conclusions cannot be made. Further research and more testing is needed in order to form an opinion on this.

7. DISCUSSION

As is the case within any project, there were some factors which had an influence on the outcome of our project and things we would have rather done differently. It is important to reflect on these things since they could allow us to make changes in future iterations. Moreover, it is important to understand how we have come to our conclusions and why our conclusions could be different from other researchers. Three aspects that have been noticed during the process of this project are described below.

7.1. Lack of Real End-Users

This project was designed as a -user-centred design process project. Hence, the involvement of the end-user is vital to the success of the project. Unfortunately, due to a lack of time as well as a lack of access to actual end-users, the project had to be tested based on research. Fortunately, we did have an expert who could provide us insights on how the intended end-users would most likely interact with the system and which things we had to focus on based on his own experience of testing products with the elderly population.

However, in order to get a true sense of how people interact with this specific application and with the specific components within the application, usability testing with actual end-users needs to be conducted. Only the actual end-users could provide insights on which elements work and which elements do not work. Moreover, some confusions could come to light that would need more support within the application.

The requirements we have used whilst making the prototype were now mostly based on research. However, if these requirements are true in practical is something we do not know. Were we to repeat the project and if we had more resources, we should have included actual end-users from the very beginning of the project to receive true and relevant feedback to be incorporated. Also, every iteration should have been tested with actual end-users to improve the prototype further.

Even if we had had access to the intended user group, we would need to conduct many usability tests with many different users in order to get feedback we could use to improve the prototype: if only a couple of usability tests had been conducted, there would have been a chance that personal preferences would have been integrated rather than the opinion of a larger population group.

7.2. Requirements Based on Research

As mentioned above in section 7.1., we have based our requirements on research. However, the requirements are very dependent on which research you chose to use. For example, we have gathered a lot of research that seemed to be agreeable on a lot of points (such as font size, labels for icons, target size, etc.). However, some points within the research were different from one another and some had different specifications.

Therefore, we had to go through the research and decide which ones we found more relevant to our user group and to the purpose of our application. However, if other researchers had performed this project, they might have chosen different research and had found different requirements. The requirements proposed in this research are therefore validly based on research, but cannot be taken as facts. S

7.3. Heuristics Evaluation

After performing the heuristics evaluation, our university supervisors provided us with some knowledge they had obtained through their own usability testing with real-end users. They told us that elderly people have a different way of interacting with technology than we do. Seeing as the heuristics provided by the research paper are based on making mobile application more usable to everyone, they might not apply in all aspects to the elderly population.

For example, elderly people read mobile applications as if they were reading books: they will start in the upper left corner and go to the right after going down to the next line. Moreover, they will press the buttons they will come across. Since we have integrated our exit and back options in the upper left corner, there is a large probability that elderly users will press this button first. Therefore, even though we have followed the heuristics, this might not make sense for the user. The same goes for giving the user freedom: elderly users do not always appreciate freedom. When they receive freedom within applications, they might feel like they have too many choices and be overwhelmed by the application.

However, these observations can only become apparent when the application is tested with real-end users, as was already mentioned in section 7.1. The elderly population might even interact with the application differently based on their background, culture and general knowledge of technology. Therefore, it is most vital to test the application with the actual end-users to see which heuristics will actually apply and which heuristics should be abandoned within the evaluation. As mentioned before, only testing with real end-users will allow us to acknowledge actual barriers within the application and it is the only way to optimise the application for the intended user group.

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Ambitious Mike



"I invest a lot of time and effort on all my patients. I am open to different types of technologies and methods to make my life and my patients' life effortless or smooth."

Age: 40
Work: Geriatrician
Family: Married, 1 kid
Location: Toronto, Canada
Character: Ambitious

Motivation



Goals

- Less effort, better results.
- Make sure my patients are exercising regularly or as prescribed.
- Keeping track each patients routine easily and make customisation in their prescription.

Frustrations

- Too many unsorted data for each patients.
- Can't keep a regular track of patients healthcare routine when they are at home.

Bio

I can recommend lots of medicines and customised exercises for my patients, but it is not possible for me to know if they are doing these at their homes or even motivate them regularly. It is very important for my patients to take care of their health, doing regular physical and mental health exercises. And for me to give them customised exercises, it is very important for me to know their progress or status of what they are currently doing.

I like using technology since it helps me a lot in making my job easy. Since I handle multiple patients and they each will have tons of very important data, which are very important for their checkups. So technology helps me a lot in organising and accessing these data effortlessly. So any technology that makes my work easy and effortless, I am a huge fan.

APPENDIX A: PERSONAE

Declining Peter



Goals

- Work around my increasing limitations.
- Feel less tired and worn down mentally.
- Avoiding change; keeping to the familiar.

Proactive Martha



Goals

- Do exercises to improve my physical and mental balance.
- Stay on top of my health because my biggest fear is losing my independence.
- Feel motivated to work on my physical and mental strength. I strongly believe that prevention is better than cure.
- Keep my mind sharp and my body able.

Frustrations

- I'm worried that insurance doesn't cover the cost of all kinds of treatments.
- Taking help from anyone else. I love living a strong independent life.
- When others treat me like a very old person and don't give me the respect I deserve.

Bio

I have two young grandchildren. I wanna be around for them for a long time. I saw my mother and father suffer at young ages. I don't wanna go through that. If it's only about diet and exercise, I can at least be in control of that. I like to be proactive, and I like to feel that we're all on the same team.

With some adjustments, I'm learning ways to keep doing the things I love, which means a lot to me. Of course, I may not do them quite as fast as I used to, but I can live with that. I'm concerned about losing my independence and becoming restricted to living in something like a nursing home, which is why I try and stay on top of everything as much as possible.

I'm all about doing everything preventative I can do. I insist on walking every chance I get. I'm very careful about what I eat, and I check labels fairly religiously. I'm pleased with the progress I'm making; I actually feel a little stronger than I think I was a year ago.

Motivation



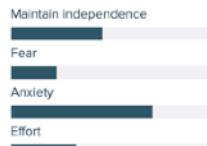
Fun-loving Julia



"I love trying different things and technology doesn't scare me yet. I am always up for the challenges life puts in front of me and I pass those obstacles gracefully."

Age: 72
Work: Retired business women
Family: Married, 1 kid, 2 grandchildren
Location: Madrid, Spain
Character: Fun-loving peaceful soul

Motivation



Goals

- Fun activities/exercises for improving my health.
- Less effort needed for maintaining my mental and physical strength.
- Less visits to the doctor and more visits to my family.
- Be knowledgeable about my health.

Frustrations

- Boring and mundane activities.
- Technology getting too complicated for me.
- Wasting too much time and money on doctor visits.

Bio

I love my family and we are a close knit one too. I am very close to my daughter and we visit each other regularly. She makes sure to check on both of us, my husband and me. She has already made a lot of changes in the house to make it more convenient and comfortable for the both of us. Some of them are a bit complicated for my husband and I have to teach him every single time. My daughter and I will always have a laugh about it. I want to be there for my family and friends.

I recently joined a group so I can talk about my concerns and ask for advice. Its always great to mingle with other people and listen to their stories, learn from them and share my experience. I love using my life experiences to help others.

It seems like I'm having more and more difficulties doing the things that I want to do. I am aware that my body and mind is changing. And I am not someone who will sit and let it win over me.

Caring Cathy



"I love my mother and I always worry about her. After my dad passed away, I am worried almost all the time, all I want is to make her living smooth and easy."

Age: 45
Work: Business women
Family: Married, 2 kids
Location: Madrid, Spain
Character: Loving and Caring

Goals

- Make my mother live in a safe environment.
- Know that she is taking good care of her health (both physical and mental healthcare).
- Less effort and more peace of mind.
- Motivate her in taking care of her health.

Frustrations

- Always worried as to if she is doing okay.
- Can't keep a regular track of her healthcare routine.

Bio

It is very difficult when your parents age. You are too busy with building your own life and can't give them the attention that they deserve. So I am always worried about my mother, especially after my father died and she has been living alone at her home. I don't know if she is taking her medications on time, if she is doing her exercises as prescribed by the doctor and so on. She used to be very active and of course as she age, it is deteriorating and I would do anything that can help her out, but not something that is very obvious, because she is someone who hates to accept the fact that she needs help.

Whenever I get time, I go to meet her and I even create some kind of small fun things for us to do together, like making a sweater for my daughter and so on. We all go out for some activities as well whenever the whole family is free. She enjoys these time with me and my family a lot and it just brings a big smile on her face, which is a big satisfaction for me.

Motivation



APPENDIX B: 127 USABILITY REQUIREMENTS AS PROPOSED BY GÓMEZ ET AL. (2014)

Heuristic	Yes	No	N/A	Comment
1. Visibility of System Status				
<i>System Status Feedback</i>				
<i>All the items on a list should go on the same page: if the items are text-only and if they are sorted in an order that matches the needs of the task.</i>				
<i>If a list of items can be sorted according to different criteria, provide the option to sort that list according to all those criteria.</i>				
<i>If a list contains items that belong to different categories, provide filters for users to narrow down the number of elements that they need to inspect.</i>				
<i>If the list contains only one item, take the user directly to that item.</i>				
<i>If the list contains items that download slowly (e.g., images), split the list into multiple pages and show just one page at a time.</i>				
<i>If an article spans several pages, use pagination at the bottom. Have a link to each individual page, rather than just to the previous and the next ones.</i>				
<i>Location Information</i>				
<i>Whenever you have physical location information on your website, link it to a map and include a way of getting directions.</i>				
<i>Response Time</i>				
<i>Splash screens too long.</i>				
<i>Download time: “Progress bar is preferable” and “Alternative entertainment if download time is greater than 20 seconds”.</i>				

Heuristic	Yes	No	N/A	Comment
<i>Selection/Input of data</i>				
<i>Low discoverability (active areas that do not look touchable): users do not know that something is touchable unless it looks as if it is.</i>				
<i>Swiping: swiping is still less discoverable than most other ways of manipulating mobile content, so we recommended including a visible cue when people can swipe. And swipe ambiguity should be avoided: the same swipe gesture should not be used to mean different things on different areas of the same screen.</i>				
<i>Expandable menus should be used sparingly. Menu labels should clearly indicate that they expand to a set of options.</i>				
<i>Presentation Adaptation</i>				
<i>Detect if users are coming to your site on a mobile phone and direct them to your mobile site.</i>				
<i>Include a link to your mobile site on your full site. It can direct mobile users who were not re-directed to your mobile site.</i>				
<i>Include a link to the full site on the mobile page.</i>				
2. Match Between System and the Real World				
<i>Metaphors/Mental Models</i>				
<i>(No) Use of metaphors.</i>				
<i>Are icons concrete and familiar?</i>				
<i>If shape is used as a visual cue, does it match cultural conventions?</i>				
<i>Do the selected colors correspond to common expectations about color codes?</i>				

Heuristic	Yes	No	N/A	Comment
<i>Navigational structure:</i>				
(not) Too much navigation (TMN).				
If the site uses hierarchical structure are depth and height balanced?				
Navigation map also known as site map or table of contents.				
<i>Menus:</i>				
Are menu choices ordered in the most logical way, given the user, the item names, and the task variables?				
Do menu choices fit logically into categories that have readily understood meanings?				
Are menu titles parallel grammatically?				
In navigation menus, are the number of items and terms by item controlled to avoid memory overload?				
<i>Simplicity:</i>				
Do related and interdependent fields appear on the same screen?				
For question and answer interfaces, are questions stated in clear, simple language?				
Is the language used the same target users speak? We will merge this statement with the following: "Is the menu-naming terminology consistent with the user's task domain?"				
Is the language clear and concise? We will merge this statement with the following: "Does the command language employ user jargon and avoid computer jargon?"				
Does the site follow the rule "1 paragraph = 1 idea"?				

Heuristic	Yes	No	N/A	Comment
<i>Output of numeric information:</i>				
Does the system automatically enter leading or trailing spaces to align decimal points?				
Does the system automatically enter a dollar sign and decimal for monetary entries?				
Does the system automatically enter commas in numeric values greater than 9999?				
Are integers right-justified and real numbers decimal-aligned?				
3. User Control and Freedom				
<i>Explorable interfaces:</i>				
Accidental activation (lack of back button)				
Include navigation on the homepage of your mobile website.				
Can users move forward and backward between fields or dialog box options?				
If the system has multipage data entry screens, can users move backward and forward among all the pages in the set?				
If the system uses a question and answer interface, can users go back to previous questions or skip forward to later questions?				
Clearly marked exits.				
Is the general website structure user-oriented?				
Is there any way to inform user about where they are and how to undo their navigation?				

Heuristic	Yes	No	N/A	Comment
<i>Some level of personalization:</i>				
<i>Can users set their own system, session, file, and screen defaults?</i>				
<i>Process Confirmation:</i>				
<i>When a user's task is complete, does the system wait for a signal from the user before processing?</i>				
<i>Are users prompted to confirm commands that have drastic, destructive consequences?</i>				
<i>Undo/Cancellation:</i>				
<i>Can users easily reverse their actions? Also found as “Do function keys that can cause serious consequences have an undo feature?” and “Is there an “undo” function at the level of a single action, a data entry, and a complete group of actions?”</i>				
<i>Can users cancel out of operations in progress?</i>				
<i>Menus Control:</i>				
<i>If the system has multiple menu levels, is there a mechanism that allows users to go back to previous menus?</i>				
<i>Are menus broad (many items on a menu) rather than deep (many menu levels)?</i>				
<i>If users can go back to a previous menu, can they change their earlier menu choice?</i>				
4. Consistency and Standards				
<i>Design Consistency:</i>				
<i>Are attention-getting techniques used with care?</i>				
<i>Intensity: two levels only</i>				

Heuristic	Yes	No	N/A	Comment
<i>Color: up to four (additional colors for occasional use only)</i>				
<i>Are there no more than four to seven colors, and are they far apart along the visible spectrum?</i>				
<i>Sound: soft tones for regular positive feedback, harsh for rare critical conditions.</i>				
<i>If the system has multipage data entry screens, do all pages have the same title?</i>				
<i>Do online instructions appear in a consistent location across screens?</i>				
<i>Have industry or company standards been established for menu design, and are they applied consistently on all menu screens in the system?</i>				
<i>Are there no more than twelve to twenty icon types?</i>				
<i>Has a heavy use of all uppercase letters on a screen been avoided?</i>				
<i>Is there a consistent icon design scheme and stylistic treatment across the system?</i>				
Naming convention consistency:				
<i>Is the structure of a data entry value consistent from screen to screen?</i>				
<i>Are system objects named consistently across all prompts in the system?</i>				
<i>Are user actions named consistently across all prompts in the system?</i>				
Menus/Tasks consistency:				
<i>Are menu choice lists presented vertically?</i>				
<i>If "exit" is a menu choice, does it always appear at the bottom of the list?</i>				

Heuristic	Yes	No	N/A	Comment
<i>Are menu titles either centered or left-justified?</i>				
<i>Are menu choice names consistent, both within each menu and across the system, in grammatical style and terminology?</i>				
<i>Does the structure of menu choice names match their corresponding menu titles?</i>				
<i>Does the menu structure match the task structure?</i>				
<i>When prompts imply a necessary action, are the words in the message consistent with that action?</i>				
Functional goals consistency:				
<i>Where are the website goals? Are they well defined? Do content and services delivered match these goals?</i>				
<i>Does the look & feel correspond with goals characteristics contents and services of the website?</i>				
<i>Is the website being updated frequently?</i>				
System Response:				
<i>Is system response after clicking links predictable?</i>				
<i>Are nowhere links avoided?</i>				
<i>Are orphan pages avoided?</i>				
Orientation:				
<i>About constraining orientation: users tend to switch orientation when an impasse occurs and, if the application does not support them, their flow is going to be disrupted, and they are going to wonder why it is not working.</i>				

Heuristic	Yes	No	N/A	Comment
<i>Navigation (horizontal and vertical) must be consistent across orientations. Some applications use a different navigation direction in the two orientations; for instance, they use horizontal navigation in landscape and use vertical navigation in portrait.</i>				
<i>Inconsistent content across orientations: “Same content,” “Keep location,” and “If a feature is only available in one orientation, inform users”.</i>				
5. Error Prevention				
<i>Accidental activation (lack of back button)</i>				
<i>Are menu choices logical distinctive and mutually exclusive?</i>				
<i>Are data inputs case-blind whenever possible?</i>				
<i>Does the system warn users if they are about to make a potentially serious error?</i>				
<i>Do data entry screens and dialog boxes indicate the number of character spaces available in a field?</i>				
<i>Do fields in data entry screens and dialog boxes contain default values when appropriate?</i>				
Fat-finger syndrome:				
<i>Touchable areas are too small. Research has shown that the best target size for widgets is 1 cm × 1 cm for touch devices.</i>				
<i>Crowding targets: another fat-finger issue that we encountered frequently is placing targets too close to each other. When targets are placed too close to each other, users can easily hit the wrong one.</i>				

Heuristic	Yes	No	N/A	Comment
<i>Padding: although the visible part of the target may be small, there is some invisible target space that if a user hits that space, their tap will still count.</i>				
<i>When several items are listed in columns, one on top of another (see the time example below), users expect to be able to hit anywhere in the row to select the target corresponding to that row. Whenever a design does not fulfil that expectation, it is disconcerting for users.</i>				
<i>Do not make users download software that is inappropriate for their phone.</i>				
<i>JavaScript and Flash do not work on many phones do not use them.</i>				
6. Recognition Rather than Recall				
<i>Memory Load Reduction:</i>				
<i>The task flow should start with actions that are essential to the main task. Users should be able to start the task as soon as possible.</i>				
<i>The controls that are related to a task should be grouped together and reflect the sequence of actions in the task.</i>				
<i>High levels of concentration are not necessary and remembering information is not required: two to fifteen seconds.</i>				
<i>Are all data a user needs on display at each step in a transaction sequence?</i>				
<i>If users have to navigate between multiple screens, does the system use context labels, menu maps, and place markers as navigational aids?</i>				

Heuristic	Yes	No	N/A	Comment
<i>After the user completes an action (or group of actions), does the feedback indicate that the next group of actions can be started?</i>				
<i>Are optional data entry fields clearly marked?</i>				
<i>Do data entry screens and dialog boxes indicate when fields are optional?</i>				
<i>Is page length controlled?</i>				
General visual cues:				
<i>For question and answer interfaces, are visual cues and white space used to distinguish questions, prompts, instructions, and user input?</i>				
<i>Does the data display start in the upper-left corner of the screen?</i>				
<i>Have prompts been formatted using white space, justification, and visual cues for easy scanning?</i>				
<i>Do text areas have “breathing space” around them?</i>				
<i>Are there “white” areas between informational objects for visual relaxation?</i>				
<i>Does the system provide visibility; that is, by looking, can the user tell the state of the system and the alternatives for action?</i>				
<i>Is size, boldface, underlining, color, shading, or typography used to show relative quantity or importance of different screen items?</i>				
<i>Is color used in conjunction with some other redundant cue?</i>				
<i>Is there good color and brightness contrast between image and background colors?</i>				

Heuristic	Yes	No	N/A	Comment
<i>Have light, bright, saturated colors been used to emphasize data and have darker, duller, and desaturated colors been used to deemphasize data?</i>				
<i>Is the visual page space well used?</i>				
<i>Input/output data:</i>				
<i>On data entry screens and dialog boxes, are dependent fields displayed only when necessary?</i>				
<i>Are field labels close to fields, but separated by at least one space?</i>				
<i>Menus:</i>				
<i>Is the first word of each menu choice the most important?</i>				
<i>Are inactive menu items grayed out or omitted?</i>				
<i>Are there menu selection defaults?</i>				
<i>Is there an obvious visual distinction made between “choose one” menu and “choose many” menus?</i>				
<i>Navigation:</i>				
<i>Use breadcrumbs on sites with a deep navigation structure (many navigation branches). Do not use breadcrumbs on sites with shallow navigation structures.</i>				
7. Flexibility and Efficiency of Use				
<i>Search:</i>				
<i>A search box and navigation should be present on the homepage if your website is designed for smartphones and touch phones.</i>				

Heuristic	Yes	No	N/A	Comment
<i>The length of the search box should be at least the size of the average search string. We recommend going for the largest possible size that will fit on the screen.</i>				
<i>Preserve search strings between searches. Use autocompletion and suggestions.</i>				
<i>Do not use several search boxes with different functionalities on the same page.</i>				
<i>If the search returns zero results offer some alternative searches or a link to the search results on the full page.</i>				
Navigation:				
<i>Use links with good information scent (i.e. links which clearly indicate where they take the users) on your mobile pages.</i>				
<i>Use links to related content to help the user navigate more quickly between similar topics.</i>				
8. Aesthetic and Minimalist Design				
<i>Recognizable application icons to be found in the crowded list of applications.</i>				
<i>Fitt's Law: the time to acquire a target is a function of the distance to and size of the target.</i>				
<i>Is only (and all) information essential to decision making displayed on the screen?</i>				
<i>Are field labels brief familiar and descriptive?</i>				
<i>Are prompts expressed in the affirmative and do they use the active voice?</i>				
<i>Is layout clearly designed avoiding visual noise?</i>				

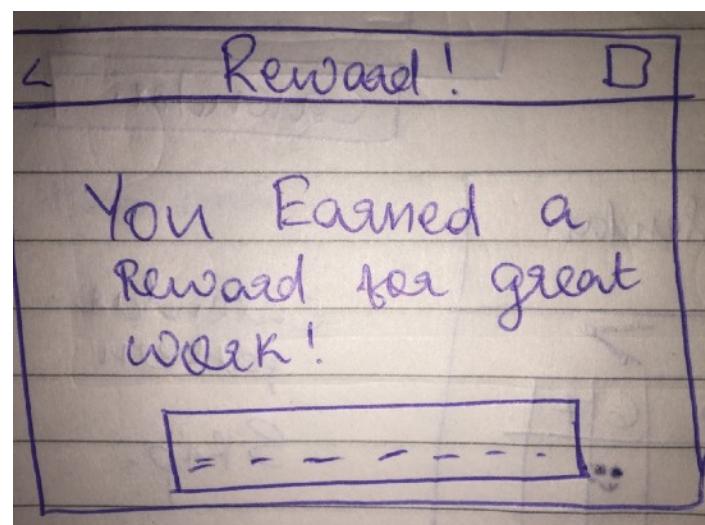
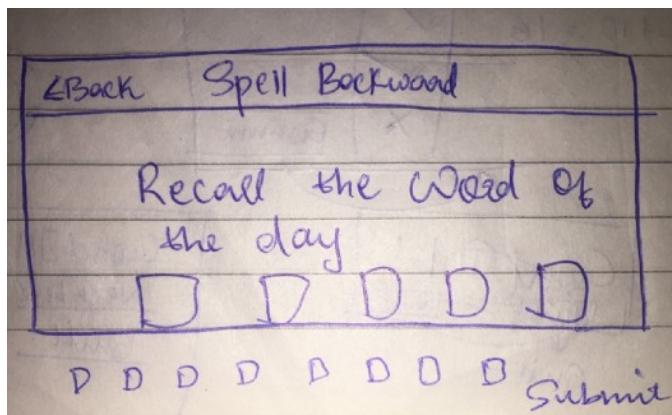
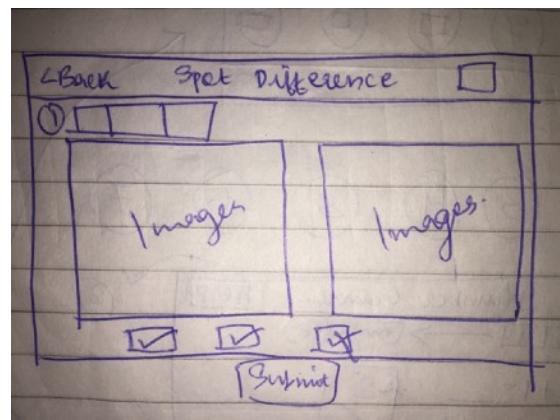
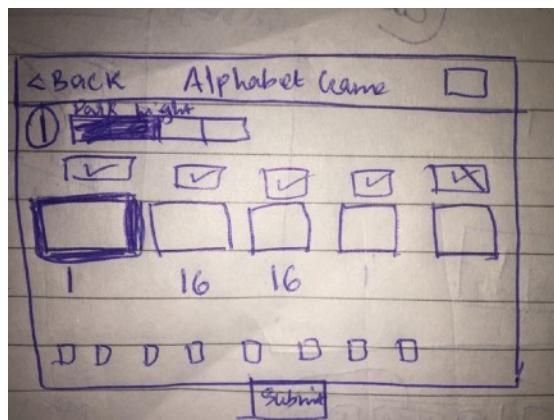
Heuristic	Yes	No	N/A	Comment
Multimedia Content:				
<i>Getting rid of Flash content.</i>				
<i>Carousels: avoid using animated carousels but if they must be used users should be able to control them.</i>				
<i>Do not use image sizes that are bigger than the screen. The entire image should be viewable with no scrolling.</i>				
<i>For cases where customers are likely to need access to a higher resolution picture initially display a screen-size picture and add a separate link to a higher resolution variant.</i>				
<i>When you use thumbnails make sure the user can distinguish what the picture is about.</i>				
<i>Use captions for images that are part of an article if their meaning is not clear from the context of the article.</i>				
<i>Do not use moving animation.</i>				
<i>If you have videos on your site offer a textual description of what the video is about.</i>				
<i>Clicking on the thumbnail and clicking on the video title should both play the video.</i>				
<i>Indicate video length.</i>				
<i>Specify if the video cannot be played on the user's device.</i>				
<i>Use the whole screen surface to place information efficiently: "Popovers for displaying information restricts size of frame where information will be shown" and "Small modal views present the same size constraints".</i>				

Heuristic	Yes	No	N/A	Comment
Icons:				
Has excessive detail in icon design been avoided?				
Is each individual icon a harmonious member of a family of icons?				
Does each icon stand out from its background?				
Are all icons in a set visually and conceptually distinct?				
Menus:				
Is each lower-level menu choice associated with only one higher level menu?				
Are menu titles brief, yet long enough to communicate?				
Orientation:				
Desktop websites have a strong guideline to avoid horizontal scrolling. But for touch screens, horizontal swipes are often fine.				
Navigation:				
Do not replicate a large number of persistent navigation options across all pages of a mobile site.				
9. Help Users Recognize, Diagnose, and Recover from Errors				
To signal an input error in a form, mark the textbox that needs to be changed.				
10. Help and Documentation				
Focus on one single feature at a time. Present only those instructions that are necessary for the user to get started.				
Are online instructions visually distinct?				

Heuristic	Yes	No	N/A	Comment
<i>Do the instructions follow the sequence of user actions?</i>				
<i>If menu choices are ambiguous does the system provide additional explanatory information when an item is selected?</i>				
<i>Is the help function visible for example a key labeled HELP or a special menu?</i>				
<i>Is the help system interface (navigation presentation and conversation) consistent with the navigation presentation and conversation interfaces of the application it supports?</i>				
<i>Navigation: is information easy to find?</i>				
<i>Presentation: is the visual layout well designed?</i>				
<i>Conversation: is the information accurate complete and understandable?</i>				
<i>Is the information relevant? It should be relevant in the following aspects: goal-oriented (what can I do with this program?) descriptive (what is this thing for?) procedural (how do I do this task?) interpretive (why did that happen?) and navigational (where am I?)</i>				
<i>Is there context-sensitive help?</i>				
<i>Can the user change the level of detail available?</i>				
<i>Can users easily switch between help and their work?</i>				
<i>Is it easy to access and return from the help system?</i>				
<i>Can users resume work where they left off after accessing help?</i>				

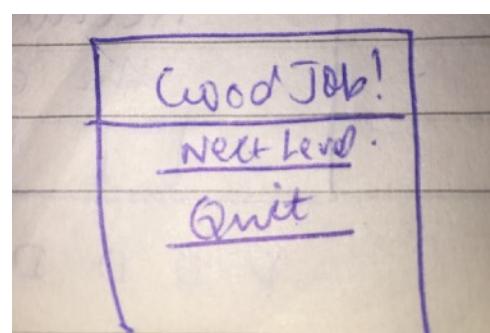
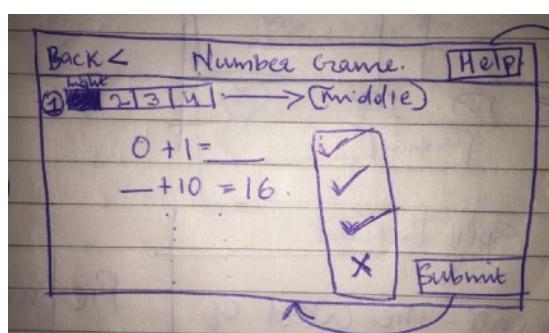
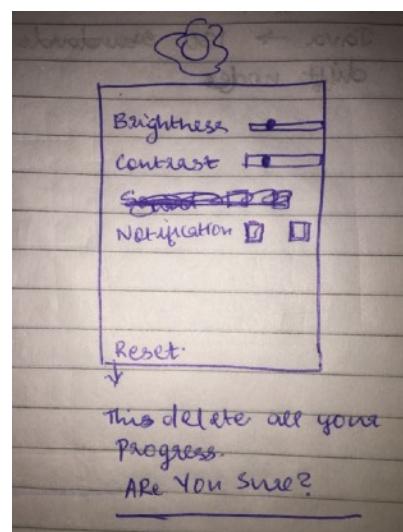
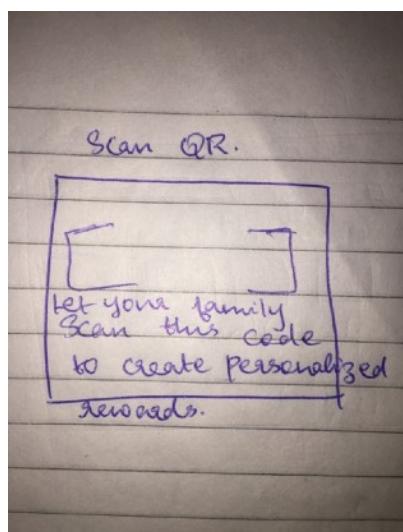
Heuristic	Yes	No	N/A	Comment
If a FAQs section exists are the selection and redaction of questions and answers correct?				
11. Skills				
Do not use the word “default” in an application or service; replace it with “Standard,” “Use Customary Settings,” “Restore Initial Settings,” or some other more specific terms describing what will actually happen.				
If the system supports both novice and expert users, are multiple levels of error message detail available?				
If the system supports both novice and expert users, are multiple levels of detail available?				
Are users the initiators of actions rather than the responders?				
Do the selected input device(s) match user capabilities?				
Are important keys (e.g., ENTER, TAB) larger than other keys?				
Does the system correctly anticipate and prompt for the user’s probable next activity?				
12. Pleasurable and Respectful Interaction				
<i>Input Data:</i>				
Users dislike typing. Compute information for the users. For instance, ask only for the zip code and calculate state and town; possibly offer a list of towns if there are more under the same zip code.				
Be tolerant of typos and offer corrections. Do not make users type in complete information. For example, accept “123 Main” instead of “123 Main St.”				

Heuristic	Yes	No	N/A	Comment
<i>Save history and allow users to select previously typed information.</i>				
<i>Use defaults that make sense to the user.</i>				
<i>If the application does not store any information that is sensitive (e.g., credit card), then the user should definitely be kept logged in (log out clearly presented).</i>				
<i>Minimize the number of submissions (and clicks) that the user needs to go through in order to input information on your site.</i>				
<i>When logging in must be done, use graphical passwords at least some of the time, to get around typing.</i>				
<i>Do not ask people to register on a mobile phone; skipping registration should be the default option.</i>				
<i>When logging in must be done, have an option that allows the user to see the password clearly.</i>				
Shopping:				
<i>When you present a list of products, use image thumbnails that are big enough for the user to get some information out of them.</i>				
<i>On a product page, use an image size that fits the screen. Add a Link to a higher resolution image when the product requires closer inspection.</i>				
<i>Offer the option to email a product to a friend.</i>				
<i>Offer the option to save the product in a wish list.</i>				

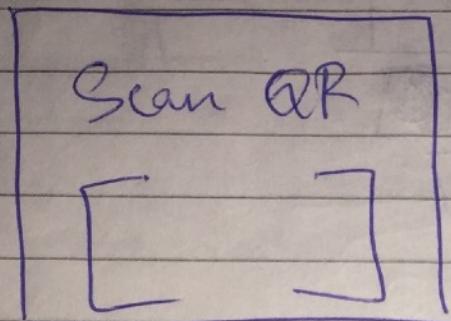


Heuristic	Yes	No	N/A	Comment
<i>On an e-commerce site, include salient links on the homepage to the following information: locations and opening hours (if applicable), shipping cost, phone number, order status, and occasion-based promotions or products.</i>				
<i>Banking and transactions:</i>				
<i>Whenever users conduct transactions on the phone, allow them to save confirmation numbers for that transaction by emailing themselves. If the phone has an embedded screen-capture feature, show them how to take a picture of their screen.</i>				
13. Privacy				
<i>For multiuser devices avoid being permanently signed in on an application.</i>				
<i>If the application does store credit card information it should allow users to decide if they want to remain logged in. Ideally when the user opts to be kept logged in he/she should get a message informing of the possible risks.</i>				
<i>Are protected areas completely inaccessible?</i>				
<i>Can protected or confidential areas be accessed with certain passwords</i>				
<i>Is there information about how personal data is protected and about contents copyright?</i>				

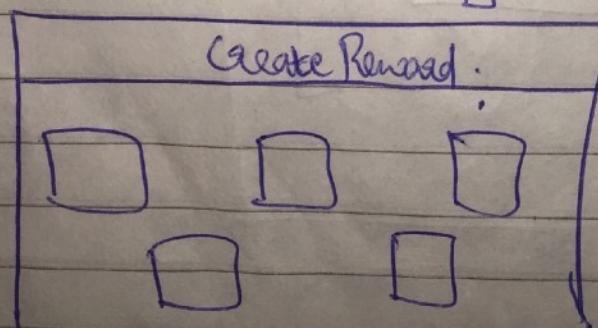
APPENDIX C: PAPER PROTOTYPE



CT (Phone)



calendar pattern
Skip.



APPENDIX D: INTERNAL USABILITY EVALUATION OF BRAIN BOOST

Heuristic	Yes	No	N/A	Comment
1. Visibility of System Status				
System Status Feedback				
All the items on a list should go on the same page: if the items are text-only and if they are sorted in an order that matches the needs of the task.	1	0	0	Help list
If a list of items can be sorted according to different criteria, provide the option to sort that list according to all those criteria.	0	0	1	No sorting options
If a list contains items that belong to different categories, provide filters for users to narrow down the number of elements that they need to inspect.	0	0	1	No list with different categories
If the list contains only one item, take the user directly to that item.	0	0	1	No list with only one item
If the list contains items that download slowly (e.g., images), split the list into multiple pages and show just one page at a time.	0	0	1	No list with slow downloading items
If an article spans several pages, use pagination at the bottom. Have a link to each individual page, rather than just to the previous and the next ones.	0	0	1	No article that spans several pages
Location Information				
Whenever you have physical location information on your website, link it to a map and include a way of getting directions.	0	0	1	No physical location information
Response Time				
Splash screens too long.	0	0	1	At this prototype level, no splash screen

Heuristic	Yes	No	N/A	Comment
<i>Download time: “Progress bar is preferable” and “Alternative entertainment if download time is greater than 20 seconds”.</i>	0	0	1	At this prototype level, no splash screen
Selection/Input of data				
<i>Low discoverability (active areas that do not look touchable): users do not know that something is touchable unless it looks as if it is.</i>	1	0	0	Buttons have been made to look like buttons and text indicates an action that can be performed
<i>Swiping: swiping is still less discoverable than most other ways of manipulating mobile content, so we recommended including a visible cue when people can swipe. And swipe ambiguity should be avoided: the same swipe gesture should not be used to mean different things on different areas of the same screen.</i>	0	0	1	No swiping elements integrated into this prototype
<i>Expandable menus should be used sparingly. Menu labels should clearly indicate that they expand to a set of options.</i>	1	0	0	Expandable list/menu is present in the help section. Should be made to look like expendable menu?
Presentation Adaptation				
<i>Detect if users are coming to your site on a mobile phone and direct them to your mobile site.</i>	0	0	1	Since this is a mobile app and not a website, this is not applicable
<i>Include a link to your mobile site on your full site. It can direct mobile users who were not re-directed to your mobile site.</i>	0	0	1	Since this is a mobile app and not a website, this is not applicable
<i>Include a link to the full site on the mobile page.</i>	0	0	1	Since this is a mobile app and not a website, this is not applicable
2. Match Between System and the Real World				
Metaphors/Mental Models				
<i>(No) Use of metaphors.</i>	1	0	0	There are no metaphors used, therefore this heuristic is met.
<i>Are icons concrete and familiar?</i>	1	0	0	Icons are concrete and are equal to commonly used icons for the allocated actions

Heuristic	Yes	No	N/A	Comment
<i>If shape is used as a visual cue, does it match cultural conventions?</i>	1	0	0	There are no stand-alone shapes that are used as a visual cue: arrows are accompanied by text label indicating their action
<i>Do the selected colors correspond to common expectations about color codes?</i>	1	0	0	In settings, there is red text used for customize. This will adjust your application, so it is important.
Navigational structure:				
<i>(not) Too much navigation (TMN).</i>	1	0	0	Almost no navigation within the application
<i>If the site uses hierarchical structure are depth and height balanced?</i>	1	0	0	Navigation does not have many deep levels
<i>Navigation map also known as site map or table of contents.</i>	0	0	1	No table of contents
Menus:				
<i>Are menu choices ordered in the most logical way, given the user, the item names, and the task variables?</i>	1	0	0	Menus are ordered logically
<i>Do menu choices fit logically into categories that have readily understood meanings?</i>	1	0	0	Menu has categories with readily understood meanings
<i>Are menu titles parallel grammatically?</i>	1	0	0	All menu items are short words describing the item
<i>In navigation menus, are the number of items and terms by item controlled to avoid memory overload?</i>	1	0	0	Short titles for menu items are used
Simplicity:				
<i>Do related and interdependent fields appear on the same screen?</i>	1	0	0	Everything that is necessary together appears on the same screen.
<i>For question and answer interfaces, are questions stated in clear, simple language?</i>	1	0	0	Questions are clear and simple
<i>Is the language used the same target users speak? We will merge this statement with the following: "Is the menu-naming terminology consistent with the user's task domain?"</i>	1	0	0	Language is everyday, simple language and menu - naming terminology is consistent with user's task domain

Heuristic	Yes	No	N/A	Comment
<i>Is the language clear and concise? We will merge this statement with the following: "Does the command language employ user jargon and avoid computer jargon?"</i>	1	0	0	There is clear and concise language without the use of jargon.
<i>Does the site follow the rule "1 paragraph = 1 idea"?</i>	0	0	1	No paragraphs.
Output of numeric information:				
<i>Does the system automatically enter leading or trailing spaces to align decimal points?</i>	0	0	1	No monetary entry values
<i>Does the system automatically enter a dollar sign and decimal for monetary entries?</i>	0	0	1	No monetary entries
<i>Does the system automatically enter commas in numeric values greater than 9999?</i>	0	0	1	No monetary entry values
<i>Are integers right-justified and real numbers decimal-aligned?</i>	0	0	1	No number entries
3. User Control and Freedom				
Explorable interfaces:				
<i>Accidental activation (lack of back button)</i>	1	0	0	There are back or exit buttons on every screen
<i>Include navigation on the homepage of your mobile website.</i>	1	0	0	Home page includes navigation on top
<i>Can users move forward and backward between fields or dialog box options?</i>	1	0	0	Our intention is that they should not go back. They can always go back
<i>If the system has multipage data entry screens, can users move backward and forward among all the pages in the set?</i>	1	0	0	After completing a task, it is marked as done. Therefore, there are not multipage data entry screens.
<i>If the system uses a question and answer interface, can users go back to previous questions or skip forward to later questions?</i>	0	0	1	Users cannot move forward to future questions or move back to past questions. This is specifically done to ensure the game does not become too complicated. For other question-answer interfaces it is not applicable
<i>Clearly marked exits.</i>	1	0	0	Exits are marked on every page

Heuristic	Yes	No	N/A	Comment
<i>Is the general website structure user-oriented?</i>	1	0	0	The application has been created with the user in mind: simple architecture that is easy to navigate to
<i>Is there any way to inform user about where they are and how to undo their navigation?</i>	1	0	0	Users can see which game they are in and can, at any time, return to the menu by pressing exit
Some level of personalization:				
<i>Can users set their own system, session, file, and screen defaults?</i>	1	0	0	There are customisation features in the application
Process Confirmation:				
<i>When a user's task is complete, does the system wait for a signal from the user before processing?</i>	1	0	0	After a task is complete, the user has to press 'next' before continuing in the application
<i>Are users prompted to confirm commands that have drastic, destructive consequences?</i>	1	0	0	Message when clicking exit between levels : are you sure you want to go back to the menu? You will lose your progress
Undo/Cancellation:				
<i>Can users easily reverse their actions? Also found as "Do function keys that can cause serious consequences have an undo feature?" and "Is there an "undo" function at the level of a single action, a data entry, and a complete group of actions?"</i>	1	0	0	There are no actions that has serious consequences. If they do go back to menu, they will lose their progress within that game. However, this game can easily be performed again. Therefore, there is nothing with serious consequences.
<i>Can users cancel out of operations in progress?</i>	1	0	0	Users can cancel out of operation, but will lose their progress
Menus Control:				
<i>If the system has multiple menu levels, is there a mechanism that allows users to go back to previous menus?</i>	1	0	0	User can go back to previous menu. It is not integrated in the prototype, but will be in the final system.
<i>Are menus broad (many items on a menu) rather than deep (many menu levels)?</i>	1	0	0	The greatest depth of the menus is two

Heuristic	Yes	No	N/A	Comment
<i>If users can go back to a previous menu, can they change their earlier menu choice?</i>	0	0	1	Users can change their earlier menu choice when going back to an earlier menu
4. Consistency and Standards				
<i>Design Consistency:</i>				
<i>Are attention-getting techniques used with care?</i>	1	0	0	Icons or buttons that are more important have a brighter color and a bigger shape
<i>Intensity: two levels only</i>	1	0	0	There are no more than 2 hierarchy levels
<i>Color: up to four (additional colors for occasional use only)</i>	1	0	0	The main application only uses three colors, with other colours occasionally used for buttons
<i>Are there no more than four to seven colors, and are they far apart along the visible spectrum?</i>	1	0	0	There are no more than 4 to 7 colours used within the application
<i>Sound: soft tones for regular positive feedback, harsh for rare critical conditions.</i>	0	0	1	There are no sounds used within this prototype
<i>If the system has multipage data entry screens, do all pages have the same title?</i>	1	0	0	The pages within the same game have the same title
<i>Do online instructions appear in a consistent location across screens?</i>	1	0	0	The instructions for the games are always on the same place on the screen
<i>Have industry or company standards been established for menu design, and are they applied consistently on all menu screens in the system?</i>	1	0	0	There is consistency among menu design
<i>Are there no more than twelve to twenty icon types?</i>	1	0	0	There are no more than 20 icon types
<i>Has a heavy use of all uppercase letters on a screen been avoided?</i>	1	0	0	No use of uppercase letters
<i>Is there a consistent icon design scheme and stylistic treatment across the system?</i>	1	0	0	Consistent icon design scheme has been used
<i>Naming convention consistency:</i>				
<i>Is the structure of a data entry value consistent from screen to screen?</i>	1	0	0	Data entry value structure is consistent across screens

Heuristic	Yes	No	N/A	Comment
Are system objects named consistently across all prompts in the system?	1	0	0	All system objects that have the same function have the same name
Are user actions named consistently across all prompts in the system?	1	0	0	All users actions are named consistently across the system
Menus/Tasks consistency:				
Are menu choice lists presented vertically?	1	0	0	Menu choices are horizontal on the main page, but are vertical when selected in list, so somewhat pass
If "exit" is a menu choice, does it always appear at the bottom of the list?	0	0	1	Never part of the list
Are menu titles either centered or left-justified?	1	0	0	Menu titles are left-justified
Are menu choice names consistent, both within each menu and across the system, in grammatical style and terminology?	1	0	0	Menu choices names are consistent across the screens
Does the structure of menu choice names match their corresponding menu titles?	1	0	0	All menu items are linked to a page with same title
Does the menu structure match the task structure?	0	0	1	There is no clear task structure that the menu structure
When prompts imply a necessary action, are the words in the message consistent with that action?	1	0	0	Necessary prompts include that the user must go forward "next" or back "exit". This is used consistently
Functional goals consistency:				
Where are the website goals? Are they well defined? Do content and services delivered match these goals?	1	0	0	Goal is defined in information
Does the look & feel correspond with goals characteristics contents and services of the website?	1	0	0	Colors used are proven to be nice for elderly people. Moreover, the exercises are presented in a gaming fashion to promote cognitive exercises to be fun. So look and feel corresponds
Is the website being updated frequently?	0	0	1	No updates within the prototype

Heuristic	Yes	No	N/A	Comment
System Response:				
<i>Is system response after clicking links predictable?</i>	1	0	0	Links in system are well labeled and predictable
<i>Are nowhere links avoided?</i>	1	0	0	No links avoided
<i>Are orphan pages avoided?</i>	1	0	0	No orphan pages avoided
Orientation:				
<i>About constraining orientation: users tend to switch orientation when an impasse occurs and, if the application does not support them, their flow is going to be disrupted, and they are going to wonder why it is not working.</i>	0	0	1	In this prototype, orientation cannot be changed. However, the design should be able to change orientation and allow for it.
<i>Navigation (horizontal and vertical) must be consistent across orientations. Some applications use a different navigation direction in the two orientations; for instance, they use horizontal navigation in landscape and use vertical navigation in portrait.</i>	0	0	1	In this prototype, orientation cannot be changed. However, the design should be able to change orientation and allow for it.
<i>Inconsistent content across orientations: "Same content," "Keep location," and "If a feature is only available in one orientation, inform users".</i>	0	0	1	In this prototype, orientation cannot be changed. However, the design should be able to change orientation and allow for it.
5. Error Prevention				
<i>Accidental activation (lack of back button)</i>	1	0	0	Always a back button, only continue when answer is correct
<i>Are menu choices logical distinctive and mutually exclusive?</i>	1	0	0	In general, menus are mutually exclusive, the support information is included in two places in order to make it easily findable by the user
<i>Are data inputs case-blind whenever possible?</i>	0	0	1	Not applicable for the prototype
<i>Does the system warn users if they are about to make a potentially serious error?</i>	1	0	0	System shows when entry is wrong. It warns that progress will be lost when going back to the menu

Heuristic	Yes	No	N/A	Comment
<i>Do data entry screens and dialog boxes indicate the number of character spaces available in a field?</i>	1	0	0	Game does not want to give hints , therefore the line does not indicate how many numbers should be inputted
<i>Do fields in data entry screens and dialog boxes contain default values when appropriate?</i>	0	0	1	There are no default values applicable for the fields
Fat-finger syndrome:				
<i>Touchable areas are too small. Research has shown that the best target size for widgets is 1 cm × 1 cm for touch devices.</i>	1	0	0	Widgets are large
<i>Crowding targets: another fat-finger issue that we encountered frequently is placing targets too close to each other. When targets are placed too close to each other, users can easily hit the wrong one.</i>	1	0	0	Targets are placed a good distance from one another.
<i>Padding: although the visible part of the target may be small, there is some invisible target space that if a user hits that space, their tap will still count.</i>	1	0	0	Widgets include some padding
<i>When several items are listed in columns, one on top of another (see the time example below), users expect to be able to hit anywhere in the row to select the target corresponding to that row. Whenever a design does not fulfil that expectation, it is disconcerting for users.</i>	0	0	1	There are no columns
<i>Do not make users download software that is inappropriate for their phone.</i>	0	0	1	Users do not have to download any software
<i>JavaScript and Flash do not work on many phones do not use them.</i>	0	0	1	Not integrated within the prototype

Heuristic	Yes	No	N/A	Comment
6. Recognition Rather than Recall				
<i>Memory Load Reduction:</i>				
<i>The task flow should start with actions that are essential to the main task. Users should be able to start the task as soon as possible.</i>	1	0	0	Starting the game is the main task and can be easily found
<i>The controls that are related to a task should be grouped together and reflect the sequence of actions in the task.</i>	1	0	0	User is automatically guided through sequence of tasks within the application
<i>High levels of concentration are not necessary and remembering information is not required: two to fifteen seconds.</i>	1	0	0	Only thing user needs to remember is word for the recall game, but that is the purpose of the game and not part of the user interface
<i>Are all data a user needs on display at each step in a transaction sequence?</i>	1	0	0	All the data is present on screen when user needs it
<i>If users have to navigate between multiple screens, does the system use context labels, menu maps, and place markers as navigational aids?</i>	1	0	0	Progress bar shown during game and within level
<i>After the user completes an action (or group of actions), does the feedback indicate that the next group of actions can be started?</i>	1	0	0	After completion, user interface shows if next level is unlocked or if the user needs to wait, both are indicated making it clear to the user
<i>Are optional data entry fields clearly marked?</i>	0	0	1	No optional data fields
<i>Do data entry screens and dialog boxes indicate when fields are optional?</i>	0	0	1	No optional data fields
<i>Is page length controlled?</i>	1	0	0	Page length is short, confined to screen
<i>General visual cues:</i>				
<i>For question and answer interfaces, are visual cues and white space used to distinguish questions, prompts, instructions, and user input?</i>	1	0	0	Visual cues of boxes indicate user input
<i>Does the data display start in the upper-left corner of the screen?</i>	1	0	0	Starts from left top screen

Heuristic	Yes	No	N/A	Comment
<i>Have prompts been formatted using white space, justification, and visual cues for easy scanning?</i>	1	0	0	Prompts are easy to read
<i>Do text areas have “breathing space” around them?</i>	1	0	0	Text has breathing space
<i>Are there “white” areas between informational objects for visual relaxation?</i>	1	0	0	Space has been left between informational objects
<i>Does the system provide visibility; that is, by looking, can the user tell the state of the system and the alternatives for action?</i>	0	0	0	Status bars, shades for buttons, home page also shows status bar.
<i>Is size, boldface, underlining, color, shading, or typography used to show relative quantity or importance of different screen items?</i>	0	0	0	Headings and subheadings are used. Text that comes up is bold. Sizing is also adjusted to importance.
<i>Is color used in conjunction with some other redundant cue?</i>	1	0	0	Color is not the only visual means by which options or links are identified
<i>Is there good color and brightness contrast between image and background colors?</i>	1	0	0	Good use of contrast
<i>Have light, bright, saturated colors been used to emphasize data and have darker, duller, and desaturated colors been used to deemphasize data?</i>	0	0	1	Not applicable
<i>Is the visual page space well used?</i>	1	0	0	Content is across space, easily visible
Input/output data:				
<i>On data entry screens and dialog boxes, are dependent fields displayed only when necessary?</i>	0	0	1	No text data entry screens
<i>Are field labels close to fields, but separated by at least one space?</i>	0	0	1	No text data entry screens
Menus:				
<i>Is the first word of each menu choice the most important?</i>	1	0	0	Menu choices are mostly one word
<i>Are inactive menu items grayed out or omitted?</i>	0	0	1	No inactive menu items

Heuristic	Yes	No	N/A	Comment
<i>Are there menu selection defaults?</i>	0	0	1	Menu selection defaults not applicable
<i>Is there an obvious visual distinction made between “choose one” menu and “choose many” menus?</i>	0	0	1	No choose many menus
Navigation:				
<i>Use breadcrumbs on sites with a deep navigation structure (many navigation branches). Do not use breadcrumbs on sites with shallow navigation structures.</i>	1	0	0	Only breadcrumbs are progress bar, no other breadcrumbs are needed within the application/prototype
7. Flexibility and Efficiency of Use				
Search:				
<i>A search box and navigation should be present on the homepage if your website is designed for smartphones and touch phones.</i>	0	0	1	Not a website
<i>The length of the search box should be at least the size of the average search string. We recommend going for the largest possible size that will fit on the screen.</i>	0	0	1	No search function
<i>Preserve search strings between searches. Use autocomplete and suggestions.</i>	0	0	1	No search function
<i>Do not use several search boxes with different functionalities on the same page.</i>	0	0	1	No search function
<i>If the search returns zero results offer some alternative searches or a link to the search results on the full page.</i>	0	0	1	No search function
Navigation:				
<i>Use links with good information scent (i.e. links which clearly indicate where they take the users) on your mobile pages.</i>	0	0	1	No textual links (only buttons), buttons are clear
<i>Use links to related content to help the user navigate more quickly between similar topics.</i>	1	0	0	The help pages are customised to the game and can all be visited on the home page

Heuristic	Yes	No	N/A	Comment
8. Aesthetic and Minimalist Design				
<i>Recognizable application icons to be found in the crowded list of applications.</i>	1	0	0	Icons are recognisable and often used in other applications
<i>Fitt's Law: the time to acquire a target is a function of the distance to and size of the target.</i>	1	0	0	Target size is large
<i>Is only (and all) information essential to decision making displayed on the screen?</i>	1	0	0	All information needed is available on the current screen of the user
<i>Are field labels brief familiar and descriptive?</i>	0	0	1	No field labels
<i>Are prompts expressed in the affirmative and do they use the active voice?</i>	1	0	0	Prompts are affirmative (e.g. next, back, etc.)
<i>Is layout clearly designed avoiding visual noise?</i>	1	0	0	No visual noise
Multimedia Content:				
<i>Getting rid of Flash content.</i>	0	0	1	No flash content
<i>Carousels: avoid using animated carousels but if they must be used users should be able to control them.</i>	0	0	1	No carousels
<i>Do not use image sizes that are bigger than the screen. The entire image should be viewable with no scrolling.</i>	0	0	1	No large images
<i>For cases where customers are likely to need access to a higher resolution picture initially display a screen-size picture and add a separate link to a higher resolution variant.</i>	0	0	1	No high resolution needed
<i>When you use thumbnails make sure the user can distinguish what the picture is about.</i>	0	0	1	No thumbnails used
<i>Use captions for images that are part of an article if their meaning is not clear from the context of the article.</i>	0	0	1	No images
<i>Do not use moving animation.</i>	0	0	1	No moving animation

Heuristic	Yes	No	N/A	Comment
<i>If you have videos on your site offer a textual description of what the video is about.</i>	0	0	1	No videos
<i>Clicking on the thumbnail and clicking on the video title should both play the video.</i>	0	0	1	No thumbnails
<i>Indicate video length.</i>	0	0	1	No video
<i>Specify if the video cannot be played on the user's device.</i>	0	0	1	No video
<i>Use the whole screen surface to place information efficiently: “Popovers for displaying information restricts size of frame where information will be shown” and “Small modal views present the same size constraints”.</i>	1	0	0	Popovers are on the screen and take a good amount of space
Icons:				
<i>Has excessive detail in icon design been avoided?</i>	1	0	0	No excessively detailed icons
<i>Is each individual icon a harmonious member of a family of icons?</i>	1	0	0	One icon family
<i>Does each icon stand out from its background?</i>	1	0	0	Icon stands out
<i>Are all icons in a set visually and conceptually distinct?</i>	1	0	0	Conceptually and visually distinct icons
Menus:				
<i>Is each lower-level menu choice associated with only one higher level menu?</i>	1	0	0	Each menu only has one parent
<i>Are menu titles brief, yet long enough to communicate?</i>	1	0	0	Menu titles are brief and explain well
Orientation:				
<i>Desktop websites have a strong guideline to avoid horizontal scrolling. But for touch screens, horizontal swipes are often fine.</i>	0	0	1	No swiping

Heuristic	Yes	No	N/A	Comment
<i>Navigation:</i>				
<i>Do not replicate a large number of persistent navigation options across all pages of a mobile site.</i>	1	0	0	Only navigation options that are necessary in game are shown in game mode
<i>9. Help Users Recognize, Diagnose, and Recover from Errors</i>				
<i>To signal an input error in a form, mark the textbox that needs to be changed.</i>	1	0	0	Error is indicated for which letter is wrong
<i>10. Help and Documentation</i>				
<i>Focus on one single feature at a time. Present only those instructions that are necessary for the user to get started.</i>	1	0	0	Only necessary instructions are given, more instructions can be found through 'help'
<i>Are online instructions visually distinct?</i>	1	0	0	Instructions through text and visually
<i>Do the instructions follow the sequence of user actions?</i>	1	0	0	Instructions follow sequence
<i>If menu choices are ambiguous does the system provide additional explanatory information when an item is selected?</i>	0	0	1	No ambiguous menu choices
<i>Is the help function visible for example a key labeled HELP or a special menu?</i>	1	0	0	Special menu and help button
<i>Is the help system interface (navigation presentation and conversation) consistent with the navigation presentation and conversation interfaces of the application it supports?</i>	1	0	0	Consistent with the navigation presentation. Moreover, help only shown where necessary
<i>Navigation: is information easy to find?</i>	1	0	0	Information findable
<i>Presentation: is the visual layout well designed?</i>	1	0	0	Design has a good and clear visual layout
<i>Conversation: is the information accurate complete and understandable?</i>	1	0	0	Good information on errors and easy help instructions

Heuristic	Yes	No	N/A	Comment
<i>Is the information relevant? It should be relevant in the following aspects: goal-oriented (what can I do with this program?) descriptive (what is this thing for?) procedural (how do I do this task?) interpretive (why did that happen?) and navigational (where am I?)</i>	1	0	0	Help is available throughout the pages and specific help is available for the relevant game when on the game pag
<i>Is there context-sensitive help?</i>	0	0	1	No in-app support other than the help function. There is information on how to contact the company when problems occur . Not applicable for this prototype.
<i>Can the user change the level of detail available?</i>	0	0	1	Not applicable
<i>Can users easily switch between help and their work?</i>	1	0	0	Help can be accessed during the game and no work is lost
<i>Is it easy to access and return from the help system?</i>	1	0	0	Easy to access and return since it can be opened during the gam and closed during the game
<i>Can users resume work where they left off after accessing help?</i>	1	0	0	Users do not lose progress after accessing help
<i>If a FAQs section exists are the selection and redaction of questions and answers correct?</i>	0	0	1	No FAQ
11. Skills				
<i>Do not use the word “default” in an application or service; replace it with “Standard,” “Use Customary Settings,” “Restore Initial Settings,” or some other more specific terms describing what will actually happen.</i>	1	0	0	No default
<i>If the system supports both novice and expert users, are multiple levels of error message detail available?</i>	0	0	1	No difference between level of users within the prototype
<i>If the system supports both novice and expert users, are multiple levels of detail available?</i>	0	0	1	No difference between level of users within the prototype
<i>Are users the initiators of actions rather than the responders?</i>	1	0	0	Actions are always initiated by the users

Heuristic	Yes	No	N/A	Comment
<i>Do the selected input device(s) match user capabilities?</i>	1	0	0	In-app keyboard with clear functionality and easy to use buttons
<i>Are important keys (e.g., ENTER, TAB) larger than other keys?</i>	1	0	0	Next and back are larger than other buttons
<i>Does the system correctly anticipate and prompt for the user's probable next activity?</i>	0	0	1	Application does not anticipate or prompt user's next activity
12. Pleasurable and Respectful Interaction				
<i>Input Data:</i>				
<i>Users dislike typing. Compute information for the users. For instance, ask only for the zip code and calculate state and town; possibly offer a list of towns if there are more under the same zip code.</i>	0	0	1	No personal address information needs to be provided.
<i>Be tolerant of typos and offer corrections. Do not make users type in complete information. For example, accept "123 Main" instead of "123 Main St."</i>	0	0	1	No input fields require information that could be incorrectly added.
<i>Save history and allow users to select previously typed information.</i>	1	0	0	Saved progress after completing a game. Not within a game, but this is based on motivating a user to finish the game which would help them achieve higher cognitive stimulation.
<i>Use defaults that make sense to the user.</i>	1	0	0	Defaults have been set to elderly people, which is the target group
<i>If the application does not store any information that is sensitive (e.g., credit card), then the user should definitely be kept logged in (log out clearly presented).</i>	1	0	0	User logged in, no credit card or other payment details and/or addresses
<i>Minimize the number of submissions (and clicks) that the user needs to go through in order to input information on your site.</i>	1	0	0	On button for settings that allows customisation for everything
<i>When logging in must be done, use graphical passwords at least some of the time, to get around typing.</i>	0	0	1	User stays logged into the application

Heuristic	Yes	No	N/A	Comment
<i>Do not ask people to register on a mobile phone; skipping registration should be the default option.</i>	1	0	0	No need for registration, adding a caretaker is optional
<i>When logging in must be done, have an option that allows the user to see the password clearly.</i>	1	0	0	User stays logged into the application
Shopping:				
<i>When you present a list of products, use image thumbnails that are big enough for the user to get some information out of them.</i>	0	0	1	Products cannot be bought within the application.
<i>On a product page, use an image size that fits the screen. Add a Link to a higher resolution image when the product requires closer inspection.</i>	0	0	1	Products cannot be bought within the application.
<i>Offer the option to email a product to a friend.</i>	0	0	1	Products cannot be bought within the application.
<i>Offer the option to save the product in a wish list.</i>	0	0	1	Products cannot be bought within the application.
<i>On an e-commerce site, include salient links on the homepage to the following information: locations and opening hours (if applicable), shipping cost, phone number, order status, and occasion-based promotions or products.</i>	0	0	1	Not an e-commerce site.
Banking and transactions:				
<i>Whenever users conduct transactions on the phone, allow them to save confirmation numbers for that transaction by emailing themselves. If the phone has an embedded screen-capture feature, show them how to take a picture of their screen.</i>	0	0	1	In-app purchases have not been activated
13. Privacy				
<i>For multiuser devices avoid being permanently signed in on an application.</i>	0	0	1	No multiuser

Heuristic	Yes	No	N/A	Comment
<i>If the application does store credit card information it should allow users to decide if they want to remain logged in. Ideally when the user opts to be kept logged in he/she should get a message informing of the possible risks.</i>	0	0	1	No credit card has been linked to an account
<i>Are protected areas completely inaccessible?</i>	1	0	0	There are no completely protected areas within the application.
<i>Can protected or confidential areas be accessed with certain passwords</i>	1	0	0	No confidential areas
<i>Is there information about how personal data is protected and about contents copyright?</i>	1	0	0	Not personal data because not connected to any person. Pure game element.