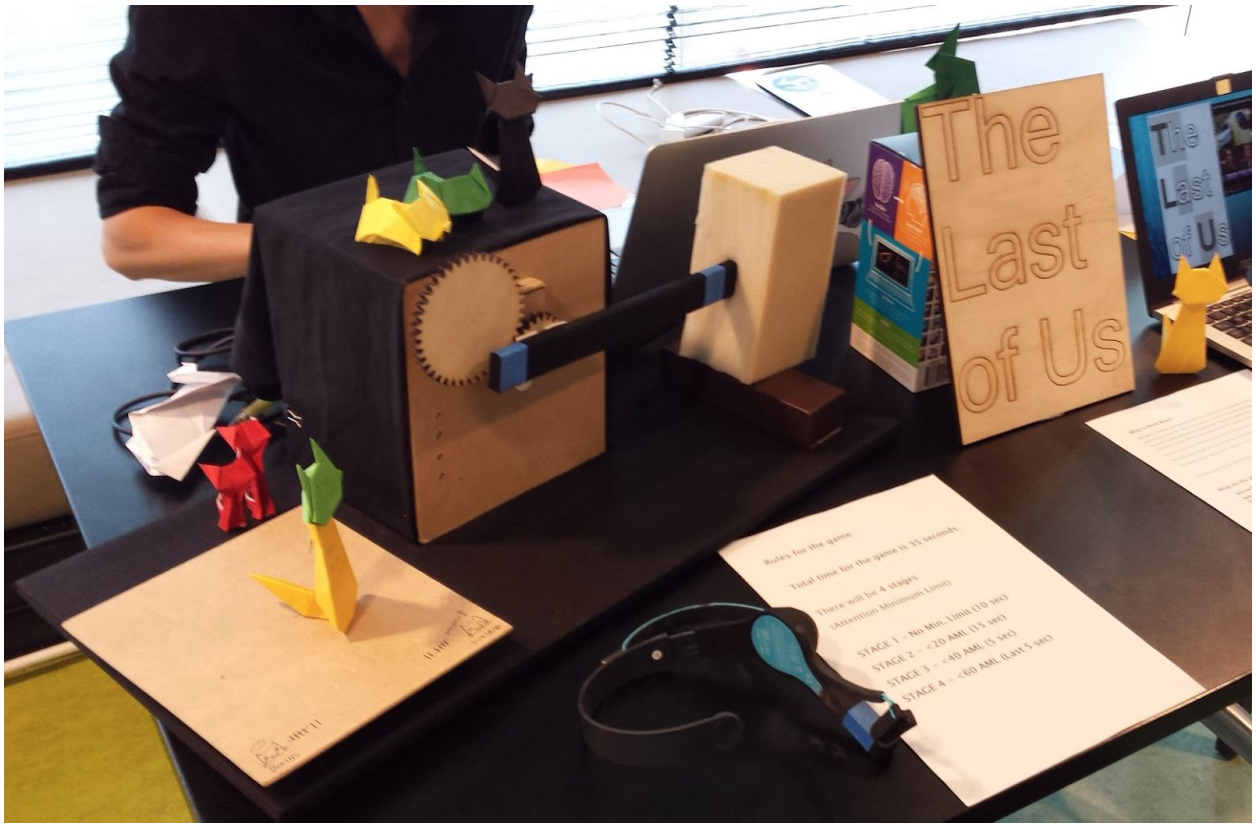


# An Investigation into Brain-Computer-Interaction and Brain Training

*Reflective report on project 'BrainDamage'*

Team TheLastOfUs

# Introduction

Brain training is not something new, it has been around for some time. Nevertheless, this area of science is far from mature, there are still many things we do not know about it, the most popular question currently is about its effectiveness and use. Naturally, to advance a field of science, more research has to be done on it.

In this modern era where personal computing, affordable technology is on the rise, the general populace are empowered in many ways. A person need not go to hollywood to be a film director. The internet, a camera, a laptop, some passion and an average joe is able to create amazing moving pictures and be a YouTube star. This is just one example out of many. This is where BrainDamage comes in, with the affordability of Brain-Computer-Interface (BCI) devices, our goal is to promote awareness as well as training on the topic of Neuroplasticity and Brain Training.

BrainDamage is an interactive installation which uses a BCI device called a MindWave to control a physical hammer which responds to the players Attention levels. The aim of the game is to maintain a high attention level for 35 seconds. Failure to do so would result in the destruction of an object which has emotional impact to the players.

The rest of the report will provide details on background sources, document a detailed design process, discuss observations and reflections about the interactive prototype as well as list the individual achievements attained from this course.

# Background

## *BCI*

Brain-Computer-Interfaces are devices that provides the extraction of brain data that can be interpreted by a computer. The usage of BCI for human computer interaction has been gaining popularity, it provides a novel way to interface with a computer. A sizeable amount of BCI research has been on its utility in helping individuals with disabilities. An example is the use of a BCI for people with amyotropic lateral sclerosis [1]. Another similarly large area of research is into BCI and games. As Nijholt, A., Bos, D. P. O., & Reuderink, B. (2009) suggests, "gamers are early adopters. They are quite happy to play with technology, to accept that great efforts have to be made in order to gain a sometimes minimal advantage, and they are used to the fact that games have to be mastered by training"[2]. Hence, they represent a suitable community for researchers to delve into with BCI.

## *Brain Training*

Brain training the the "improved cognitive function through the regular use of computerised tests"[3]. There has been a rise in the commercial applications of brain training. One of the famous example is Lumosity, a company which develops brain training games to improve cognitive functions such as attention and memory. However, its effective is questionable. Whatever the reasons may be, brain training cannot simply be regarded. Currently, most brain training is presented similar to simple flash based games on the web, with the exception that the gameplay is specifically tailored to improve a specific cognitive function.

### *Emotions*

Humans are creatures of emotions. Emotions play an important role in our everyday lives, and there has been studies regarding the role of emotions in learning and memory. In this context however, emotions play a major role in why we play games. Although this is just one aspect, we play games because it is fun. In our case, we work closely with emotions to persuade certain types of gameplay with our interactive prototype.

## Development of Idea

The original theme we were developing upon was Mood and Emotions. The goal was to develop a system capable of visualising human emotions in an interesting and playful manner, such as emoticons above a person's head in reality. However, as we progressed with experimentation of our available technology to us, our project slowly changes over the weeks till the end result is a pretty drastic change from the original ideas.

Initially, the idea of using the MindWave, which is a simplified EEG headset, was to be able to get emotions from people, however, we discovered that we were limited to obtaining Attention, Meditation and eye blinks from the device. Early ideas for the MindWave were simple ideas such as physical visualisation of the brain data.

Most implementations of BCI are towards its usage for people with disabilities. This led us to think about using the MindWave to provide awareness as well as training on the topic of Neuroplasticity and brain training.

The task of incorporating limitations of technology, themes, as well as purpose, has cumulated into an idea which consists of a physical hammer that responds to brain waves and a game which connects to the players

emotionally. Thus all these converged into our interaction idea. To develop a brain training game, with emotional consequences.

# Gameplay

Brain Damage is a single player game, where a player wears the MindWave headset which transmits the signals to a physical hammer attached to a servo, the hammer moves in accordance to the attention levels of the player. Low to high attention is representation by the hammer's sweeping angle from 0 degrees to 180 degrees. To transform it into a game, a win condition and a lose condition was implemented. The goal of the game was to use your mind to prevent the hammer from hitting the cat for 35 seconds, the first 10 seconds is penalty-free, while the rest of the 25 seconds is divided into:

phase 1: minimum attention limit - 10, duration - 15 seconds
phase 2: minimum attention limit - 20, duration - 5 seconds
phase 3: minimum attention limit - 30, duration - 5 seconds

Should the player's attention drop below the limit, the hammer would smash the cat, resulting in a lose condition.

While the interaction has win and lose conditions, we intend the interaction design to be open ended as well, we do not prohibit players from smashing the cat if it is their intention. In fact, the results were tabulated as the number of cats saved and the number of cats killed. By enabling players to choose either, it enables them to explore the control of the mind in various ways. Each player has his/her own way to focusing their attention, they just have to find what works for them, and this is exactly what the gameplay is allowing them to do.

# Development of Prototype

In the early stages of the prototype testing, we discovered that users are fascinated by the novelty of controlling the physical hammer with their minds, however, there was a lack of pressure on the players. The interaction we want to build into the prototype is to induce stress on the players to save the cat. The two issues that we have was, while the hammer directly correlated to the brain signals, there was minimal stress towards the players as time goes on, hence we implemented a phase system which has minimum limits that increases per phase to make it more difficult for the player. The second issue is the servo that the hammer was attached to was too slow, the emotional impact we were rooting for when the cat gets hit was non-existent. Short of finding another servo which has a higher speed rating, there was no way to increase the speed. A gear system was decided as the solution. By fabricating two new gears, we amplified the speed of the servo by a factor of 2, which enables us to attain the emotional impact we were looking for as the cat gets hit.

## *Level Design*

A major influence on the user experience would be the difficulty of the game. As the game is intended to be more of playful interaction and 'introduction to brain training' than an 'elitist training' at the exhibit, we had to set the difficulty appropriate for first-time players, a wide variety of people (different ages, knowledge, backgrounds) as well as factor in MindWave limitations (inaccuracies). For the MindWave, an attention value of 50 indicates the middle, neither an increased attentiveness or decrease attentiveness. Hence, the minimum limits per phase were implemented as 40, 60 and 80 as it would seem to be logical. However, extensive user testing has led us to settle upon drastically lower level limits of 10, 20 and 30. These values, while may not seem very logical, corresponds very well to the difficulty criteria's explained above.

### *Victim Design & Design Compromises*

Ideally we would have loved to be able to develop a prototype consisting of a real hammer and porcelain cats, as these would no doubt generate a stronger emotional reaction. Unfortunately such a system would result in a wide variety of issues such as safety, cost, availability of hardware parts and etc. Thus the prototype design was settled by compromising and using a lightweight foam hammer and origami paper cats.

During the middle of the development process of the prototype, there were several indicators during user testing and feedback that we should evolve into a multiplayer design. The implementation of multiplayer design would enable us to explore many new interactions between users and game plays, such as two players competing or working together to achieve a goal. While I have thought thoroughly about a few variations on how it could be done, none of them seem viable to fit into our projected timeline due to insufficient manpower from the lack of interest and commitment of team members. Hence, the idea was scrapped at its infancy.

## Evaluation, Observation, Analysis

Although I had serious doubts about the project's success. Exhibit day came and it turned out to be a huge success. The concept of brain-computer-interface certainly captured the attention of the masses, as was demonstrated by the near unwavering stream of participants to our booth. A pleasant observation about using a physical interaction was that it could be easily viewed by other non-participants. We intended BrainDamage to be a single player game but we realise on exhibit day that it does more than that. It brings social elements as well, friends would help/hinder their friend who is participating and would sometimes turn it into a competition. I believe that the social interaction could be a helpful

addition to brain training, the same way social interaction has its place in certain learning situations.

I believe we managed to achieve our original intentions that the prototype would allow players to find their own techniques to alter their attention levels. The first observation is players would ask us what to focus on. We would give them some tips on how they should try. The players would usually perform badly on the first try but on subsequent attemps would show an improvement as they find out what works for them. One of our design students who frequently played with our prototype has developed the ability to accurate change his attention levels. He is now able to kill the cat on demand.

The goal of increasing brain training awareness could be argued to be successful. A rough estimate of 109 participants has been recorded and a significant amount of them requested additional explanation regarding the brainwave topic area as well as details on the MindWave hardware. Frequently, we observed that players would bring their friends and family to our booth to try out the game. I consider this to be a strong indicator of interest and consequently brings about greater awareness about brain training.

An overlooked problem was the feeling of awkwardness or insecurity the players had while wearing the MindWave. The importance of social skills were apparent at the exhibit and we have to thank Mr. Kent for keeping up the hard work throughout the whole period by interacting with participants. The majority of awkward moments were due to the waiting time for the MindWave to connect to the person. Explaining the instructions of the game during this time was important as it helps to set their mind at ease.

The final score of 47 cats killed and 62 cats saved suggests that the level system was appropriate to the general skill level of players at the

exhibit. Another interpretation developed by listening to the frequency of participants questions such as "Can I kill the cat instead" and "Can I have another go to try and kill the cat" demonstrates that the emotional impact is not very strong, as I presume that participants would be more hesitant to destroy a porcelain cat. However, emotional impact is definitely there judging by the reactions of the players as they play.

# Individual Achievements

## *Leadership*

Throughout my career as a design student, I have learn many things regarding team composition, leadership, being a follower, motivations, team chemistry, psychology and much more. Each component important to the success of a team project. While the previous project based works built my knowledge in mentioned areas, it was within this project development which I had to use all previously learnt knowledge to attempt to become an effective leader.

Honest I can't say how I have handled the team was right or wrong. For example, should you angrily scold your teammates when they are not contributing, tell them politely, or ignore it. When you make a decision, you will obtain the experience that comes from the result of making that decision, but you will not know what would happen if you chose another way to tackle the problem. Therefore, I would say that what I have gained in this course was attain more knowledge regarding leadership in practice.

## *Arduino and circuits*

If you were to interested in homemade projects you would encounter many guides which utilize arduino. This was how I came to learn about Arduino. However, I ended up not doing any home projects because of the cost and other reasons. I am glad that I have managed to work with Arduino in this

course and learnt quite a bit about it. I did not manage to master solving all the issues with the project because of the multiple possibility of the source of errors. But i did manage to learn the basics of the hardware and software of Arduino.

## *Hardware and Engineering*

Although my team mate Mr. Kent handled most of the engineering aspects of the course, I have observed and helped out in many areas. The major part I was involved in was the physics of the gears and hammer system.

## *Social Skills*

Learning how to deal with team mates were a small portion of what I have learnt. The biggest impact was on exhibit day when I observed how important a presenter's social skills will be required when demonstrating an exhibit.

## *Overall*

I was involved in almost every single aspect of the project from start to finish with the exception of videos and posters. This has contributed greatly to understanding the whole design process as there were no gaps in my knowledge gained. From brainstorming ideas to prototyping them as well as important details such as Stephen Viller's requirement of sticking with an idea and trying to fix it instead of jumping to a whole new idea. It was a good thing I followed the advice because it resulted in my ability to fix the old system by implementing the gear system.

# Conclusion

Brain Training is an interesting research area which still needs more research to be done. This can be done by providing awareness as well as developing the interest of the public by displaying interactive installations such as BrainDamage. As it is with budding technologies such as virtual reality and motion gestures, brain-computer-interfaces are far from exact, and thus is the major limiting factor in its implementations. Research in this area is important and would most likely prove to be indispensable because it proves a unique mode of input to computers. BCI provides communication channels that do not depend on peripheral nerves or muscles [4]. And thus, opens up a host of new possibilities and ways to interact with technology. I believe this fits into the idea of the field of Design Thinking.

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