INTRODUCTION TO COMPUTATIONAL NEUROSCIENCE
(MTAT.03.291)

FINAL PROJECT

BEST WAYS OF PRODUCING CYBERSICKNESS IN VR

KEVIN KANARBIK

AL WILLIAM TAMMSAAR
# Table of Contents

Introduction .......................................................................................................................... 3

Cybersickness .......................................................................................................................... 4
  Cause and symptoms ........................................................................................................... 4
  Neurological relation ........................................................................................................... 5

Oculus Rift experimentation .................................................................................................... 6
  Previous experiences ............................................................................................................. 6
  Lab experiments .................................................................................................................. 7

Interview .................................................................................................................................. 8

The Virtual Reality Game ....................................................................................................... 10

The Experiment ...................................................................................................................... 12

Conclusion ............................................................................................................................. 13

List of References .................................................................................................................. 14
Introduction

The purpose of the project named „Best ways of producing cybersickness in VR“ is to introduce the idea of cybersickness to the reader and to find ways how to induce cybersickness to people. In today’s world of advanced virtual reality systems cybersickness is becoming a large problem. Scientists are constantly researching newer ways of to prevent people from becoming cybersick.

People are different because of their different individual experiences with virtual reality systems – some people are more susceptible to getting sick and some are not. Different methods are used to cause cybersickness in people and by combining these methods into one specific virtual world. This way we could investigate more thoroughly what makes people more or less susceptible to cybersickness.

This virtual world could also be used to help people adapt to virtual reality so getting sick would not be a issue in the future. The more often the human body is exposed to discomforting situations the quicker it can adapt to these situations.

The project itself consisted of many phases. Firstly the project team investigated different academic articles and research papers regarding cybersickness to have a better understanding of it. Secondly the team experimented with the Oculus Rift DK2 virtual reality system to have an idea what a VR world looks and feels like. Thirdly an interview was conducted with a virtual reality and experimentation expert. The team created a virtual reality video game with Oculus Rift integration. The purpose of the video game is to cause cybersickness in the individuals who play it. Lastly the team created a specific questionnaire, which would be used together with the VR video game to investigate what levels of cybersickness the player experienced.
Cybersickness

Cause and symptoms

Cybersickness is similar to motion sickness because the symptoms are typically the same but instead of being caused by either the movement of a ship, car or plane, cybersickness is caused by exposure to a virtual reality environment. The symptoms of cybersickness include postural instability, discomfort, headache, nausea, stomach awareness, sweating, fatigue, drowsiness, disorientation and so on. The next table shows the main symptoms and the strength of the symptoms based on a study made with different 47 students. The main difference between motion and virtual reality sickness is that the first one is caused by real self motion while cybersickness is caused by the visually-induced perception of self-motion.

The causes for cybersickness are usually related to conflicts between perceptions by different senses like visual, auditory, vestibular and non-vestibular. The conflicts occur when sensory cue information in the VR world is incongruent with what is felt by the body or with

---

2 Kolasinski, E. M. "Simulator sickness in virtual environments (ARI 1027)"
what is expected based on the persons sensory experience and memory.

The occurrences of cybersickness varies between such factors like length of exposure time, the type of virtual reality system used, technical drivers, person’s age, gender and previous experience with VR, the amount the person moved their head within the simulation and other, smaller or undiscovered factors.

**Neurological relation**

Experiments have been conducted to neurologically impaired populations, some of whom display residual equilibrium, balance and orientation difficulties. One specific report by Pugnetii compared 11 neurological patients with 41 non-neurological subjects regarding self-reported prevalence of cybersickness. It was reported that the neurological subjects appeared to be at no greater risk for developing cybersickness than the non-neurological group.  

Also, it is implied that because of the increasing size of the aging population, coupled with age-related cognitive/functional performance, makes investigations into the feasibility of psychological applications with elderly populations more and more important. Research is already being made on the susceptibility for cybersickness and aftereffects on the elderly population (65+). Functional virtual environments which exploit preserved procedural learning abilities in a relatively safe environment could serve to help maintain adequate performance of activities of daily living needed for safe living and functional independence. 

---

4 Giueseppe Riva „Virtual Reality in Neuro-psycho-physiology” pg. 138
5 Giueseppe Riva „Virtual Environments in Clinical Psychology and Neuroscience“ pg. 29
Oculus Rift experimentation

To have greater overall understanding on the positive and negative sides of Virtual Reality, the team conducted hands-on experiments with the VR simulation platform Oculus Rift, which is a virtual reality head-mounted display. We used the Development Kit 2 version. The team protocled their previous experience with virtual reality to have a better understanding of how susceptible to cybersickness the team is.

Previous experiences

Al William Tammsaar had the Oculus Rift at his house from demoing it to high school students at an education convention. He set this Oculus Rift up to play Team Fortress 2 (from here on referred to as TF2). TF2 was one of the first real games to implement VR support and had provided a total of 15 different set-ups of how the Oculus controlled the game.

The one he used the most was a set-up in a way where the mouse was used to move the viewport but the location on the screen where the crosshairs were located was decided by where you were looking on the Oculus Rift.

After attempting some very complex maneuvers in this setup, which involved suddenly jerking the aim down and up, William started to feel mild cybersickness. When he was finished with using the Rift, he took it off and that is when the full brunt of cybersickness hit him - slight headache, mild vertigo, dizziness and strong stomach awareness. This lasted for 6 hours.

---

7 http://en.wikipedia.org/wiki/Team_Fortress_2
From this we concluded that tying the viewport to something else that can manipulate the VR headset rotation is an effective part of creating cybersickness.

Kevin Kanarbik’s first case of cybersickness was with the roller-coaster game Lava Inc, which caused disorientation, dizziness, and vertigo. During the time in the VR world of Lava Inc, Kevin’s body felt like it was sitting still, but his his eyes tricked him into thinking he was moving.

This means that a good way of producing cybersickness is by manipulating the senses to send conflicting and false signals.

**Lab experiments**

Hands-on work was conducted to get a better understanding on virtual reality simulations and the possible uncomfortable effects it can have to the human brain. The team specifically asked for VR video games that are known to make the players sick. Firstly Kevin tried a simple game where the player just needed to move and look around, so the team experimented with manipulation of the viewport by changing where the player looked with the mouse. This caused slight disorientation but not too major. Next Kevin tried the Tron Lightcycle VR video game. After playing for a while he started to experience minor nausea. Lastly an experiment with the classic Lava Inc roller coaster game was conducted but a few changes were made to the game a little bit for research purposes. After a few tweaks the team discovered that the experience was way more nauseating when the moving object (in this case, the roller coaster) was not in view. The more the player was tricked into thinking that he was moving the more terrifying and cybersickening the experience would be.

The team concluded that there might be relationship between how much a video game is in control of the view. This means any viewport hijacking, delayed response also referred to

---

8 [https://share.oculus.com/app/lava-inc](https://share.oculus.com/app/lava-inc)
as lag or similar actions contribute to cybersickness. This was taken into account with the creating of the cybersickness producing VR video game.

### Interview

Because of the lack of experience with Virtual Reality systems, the project team decided to ask an expert about VR worlds and the experiments that have been made with devices that simulate virtual reality. The person we decided to interview was Madis Vasser, who is also the team’s project instructor and his equipment was used to conduct this project. Madis is the head of Psychobus, a pop-science project by psychology students with the goal of introducing the science behind psychology to the public. Madis Vasser often travels to conduct interactive psychological experiments on people and those experiments include virtual reality simulations. The team decided asking 10 questions about Madis’ experience with VR experiments should be sufficient to make our own conclusions.

Question 1: How long have you dealt with Virtual Reality systems and how many experiments have you conducted?

Madis Vasser: I’ve been closely following the field for 1.5 years, hands-on experiences for 1 year. I’ve developed 5 VR experiences since then.

Question 2: Have you ever had to do an experiment that was anyway related to neuroscience?

Madis Vasser: Yes, the change blindness project that deals with human attention and memory.

Question 3: Did you ever come across situations with VR experiments, where the player got cybersickness?

Madis Vasser: It depends on the demo. For some demos (rollercoasters, flying, sudden movements), about 50% get dizzy.

Question 4: What kind of stimuli have you noticed that cause cybersickness most often?

10 [http://www.epsy.org.ee/?page_id=2412](http://www.epsy.org.ee/?page_id=2412)
Madis Vasser: Mostly mismatches with G-forces – taking sharp turns, falling down, fast accelerations, going upside down in VR.

Question 5: Have you noticed a pattern of certain people being more or less susceptible to cybersickness?

Madis Vasser: No, I have not noticed any patterns.

Question 6: Have you yourself ever gotten cybersick even though you probably have a lot of experience in virtual reality simulations?

Madis Vasser: Yes, some particular games get me dizzy every time. And also playing some good games on weak hardware can induce sickness.

Question 7: Why did you come up with this kind of project of finding the best ways of producing cybersickness?

Madis Vasser: VR is a very new situation for the human mind. Research on the topic is still mostly lacking. For example it is not entirely clear why cybersickness occurs or how to prevent it. One solution is to enhance the framerate, but other simpler tricks have also been found, such as including a virtual nose in the experience. These are things that researchers have previously not even thought about. If we can easily find the people who do not get sick from our game, maybe we can find some properties about these people that we can transfer to those who get sick easily.

Question 8: Have you heard about researches conducting similar projects?

Madis Vasser: I don’t know any similar projects that intentionally try to induce cybersickness. Usually this is a by-product of bad design or optimization errors. And usually these experiences are not too bad. So we need a program that is the absolute worst experience to know what „the worst experience“ really means.

Question 9: How will „curing“ cybersickness be beneficial for the modern world?

This would eliminate one of the biggest problems VR currently has and will provide a much more user-friendly experience in VR. Safety is also a factor – with cyber sickness people can hurt themselves in VR or outside of it, as the effects are often long-lasting.
The Virtual Reality Game

After extensive research and experimentation the team recognised a few key factors that might contribute to cybersickness and the three main points are next:

- Viewport tiling and pivoting unrelated to Oculus-based inputs also known as „viewport hijacking“
- Need for the player to move his/her head around a lot during the simulation
- Input lag and/or framerate lag.

The idea for the game was produced:

The Virtual Reality world will have the user following a plane while trying to look at a specific cylinder object within the virtual environment, the more often the player looks at the cylinder the more points the player gathers, these points are displayed in the players screen. It was been noted by several VR enthusiasts, that user interfaces that are directly on the viewport are uncomfortable. Based on this the score is attached directly to the viewport.

When the player is looking at the cylinder, it turns red and when the player is not looking at the cylinder, it turns blue. The plane, which is invisible to the player, will do fast, sharp maneuvers that the camera of Oculus Rift will need to follow. The task is also ever more difficult because the environment has many yellow pillars that obstruct the players view. The team also made it so the player’s visual senses receive different stimuli: the eyes have different viewdistances (this means one eye can see farther than the other) and both eyes are provided with a different color sky.
By trying to control where the player looks, the player will have a nauseating experience. Another factor we added into the VR video game to make the players task more difficult is that the local camera rotation is not directly tied to the rotation of the oculus. The viewport will smoothly follow the oculus rotation, taking about 1 second to fully catch up to the oculus’s rotation.

The idea of the game is to induce cybersickness in people and measure what techniques are best suited to this end. The team wants a large number of people to test the game to see by experimentation how players react to certain situations so perhaps in the future a more thorough virtual reality game, that makes people cybersick might be made. Also this will hopefully give us a sample pool of people who do not suffer from cybersickness and we can try to find out why.
The Experiment

The experiment with a test subject will look like this. First the subject will start playing with the goal of playing for 5 minutes. While playing the subject is asked about how is he/she feeling and the answer again is catalogued. After playing for 5 minutes the subject will have 5 minutes to stand up and walk before he/she answers a questionnaire that the team put together using a similar type\textsuperscript{11}:

\begin{tabular}{|l|c|c|c|c|}
\hline
\textbf{GENERAL DISCOMFORT} & NOT AT ALL & SLIGHTLY & MILD & MODERATE & SEVERE \\
\hline
\textbf{HEADACHE} & & & & & \\
\hline
\textbf{DIZZINESS} & & & & & \\
\hline
\textbf{PERSPIRATION} & & & & & \\
\hline
\textbf{STOMACH AWARENESS} & & & & & \\
\hline
\textbf{VISUAL IMPAIRMENT} & & & & & \\
\hline
\end{tabular}

The subject is also asked about his previous experienced that might perhaps have a relationship to the subject degree of cybersickness.

- Does the subject get seasick?
- Does the subject get nausea from riding a rollercoaster?
- How many hours has the subject been in the Oculus before?
- Has the subject experienced any form of nausea in the past year?
- How often does the subject play video games?

We also ask the subject to send us a message when he feels he has fully recovered from the cybersickness. The duration of the cybersickness is logged.

\textsuperscript{11} http://w3.uqo.ca/cyberpsy/docs/qaires/ssq/SSQ_va.pdf
Conclusion

In conclusion the team can say that the project „Best ways of producing cybersickness“ was a success: after thorough investigation of both research papers on the internet and hands-on experimentation the team has found out a lot what methods and gimmicks could intentionally produce cybersickness. The main concept is that cybersickness is something that naturally occurs in virtual reality game because if there is difference between sensory inputs like **ocular input** and **vestibular input** then the nervous system responds with nausea. This is quite similar to other types of sicknesses that have to do with the human brain being confused like airsickness, seasickness, simulator sickness, ski sickness and space adaptation sickness.

Just by giving a false input for the user of a virtual reality simulation will someway make the subject cybersick and the severity of it is determined by the users previous experience in VR if the users brain has already adapted to possible fictional and deceptive sensory input.

With this project the team discovered not only what the project-goal was, but also the why would there be a need for a cybersickening virtual reality video game. It is necessary to train users to adapt to situations where cybersickness occurs and with that training maybe people will develop almost an immunity to cybersickness. Almost all individuals eventually adapt to motions or situations which initially provoke sickness; continued exposure to a particular nauseogenic environment leads to a gradual reduction in the disorientation and associated symptoms.\(^{12}\)

This project has potential to be improved on. The video game may need more methods implemented to cause cybersickness and experiments need to be done on a large sample pool, for the conclusions to be relevant in improving the simulation.

\(^{12}\) „Motion sickness and perception“ Yardley, L. (1992)
List of References