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RESEARCH REPORT ON VIRTUAL REALITY DOLPHIN EXPERIENCE

A research on stress reducing effects of virtual reality dolphin experience in students with pre-exam pressure

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Research report in the context of LDM430VNAO2

Finishing Thesis Research

In collaboration with Van Hall Larenstein University of Applied Sciences and The Dolphin Swim Club

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Preface

Being fourth year animal management students, we have had to tackle performance pressure and stress for years. Preparing for exams while attending lectures and writing multiple essays per module, brought the pressure of performing greatly under a high time- and workload demand. Trying to balance a social/personal life with our extensive academic workload has caused us stress and in some occasions made us push our mental and physical wellbeing to second place. Especially during the exam periods. Looking back, as our journey at Van Hall Larenstein University of Applied Sciences nears the end, we would have loved to have an outlet of relaxation and a distraction from all the stress factors of our daily life.

With the development of technology over the years, easy and effective solutions to help students deal with the stress that accompanies the high demands of college life have been invented. One method that has been used to improve the short-term symptoms of mental health problems is the use of virtual reality. While research has been done on the effects of a virtual reality dolphin experience for mental health patients and pain relief, there are still many implications that have been undiscovered. Speaking from experience, having used the VR-glasses as a part of our minors, we believe that one target group that could benefit greatly from this virtual reality dolphin experience is students with exam stress.

With this research we got to use multiple data collection methods and devices that went with them. We got to gain experience in setting up our own research and learn about the legislation and privacy issues that accompany a research containing people as the sample group. We hope to have contributed to an industry where cruelty-free work with animals is prioritized and expanded its possibilities for usage by proving it to be useful for a previously unsearched target group.

We would like to thank our client “The Dolphin Swim Club” and Marijke Sjollema for entrusting us with this project and Van Hall Larenstein University of Applied Sciences for providing us with all the necessary equipment. We would like to thank our first and second supervisors, Susan Ophorst and Corine Oomkes, for guiding us through writing our finishing thesis and always giving us helpful feedback. Lastly, we would like to thank Polyanna Kramer for coming on as our independent supervisor and being flexible and positive in this process.

Shiva Jalalizadeh
Birthe van Neuß

Leeuwarden, 16 February 2022

Abstract

Numbers of stress-related issues have been rising within the world population during the last decade. One demographic that is heavily affected is college and university students. High pressure and expectations have been causing severe health issues and a decrease in performance for many students. The highest stress levels are experienced during examination periods. Finding easy and affordable solutions to help students deal with their stress is necessary. The purpose of this research is to examine to what extent a virtual reality dolphin experience can have a decreasing effect on a student's pre-exam stress levels in the Netherlands.

To answer the research question, *"To what extent does a student in the Netherlands undergo a decrease in pre-exam stress during a virtual reality dolphin experience?"*, an experiment was conducted where students experienced a seven minute virtual reality dolphin session shortly before their exams. The experimental group encountered the dolphin swim in a 360° setting and the control group was presented with the virtual reality image of a cinema where the dolphins were watched on a 2D screen. The effects were measured by a visual analogue scale where students rated their perceived stress levels before and after the experience. This resulted in an absolute and relative VAS-score which was in turn used to measure the mean self-perceived exam-stress reduction for the control group and the experimental group. There was no significant difference in the mean decrease in absolute or relative VAS-scores between the experimental group and the control group, however there was a significant difference from 0 for both. During the experience the students heart rate was measured and these measurements were later translated into heart rate variability and stress index. There was no significant difference found in the mean stress index between the experimental group and the control group. Finally, the body language of the students experiencing a virtual swim with wild dolphins was observed and counted with the help of an ethogram and score sheet. The experimental group showed less stress-related behaviors than the control group.

The analysis of the visual analogue scale was done using GLM to test whether there is a significant difference between the experimental and control groups in terms of reduction in VAS-score. The analysis of the heart rate sensors, was done using LMM to test whether there is a significant difference between the experimental and control groups in terms of their stress index in different time periods. The analysis of the score sheet was done using a Negative Binomial Regresssion within GLM and tested whether there is a significant difference between the experimental and control groups in terms of the number of stress behaviors they performed during the VR-session.

Of the participating students, 97% showed little to no signs of stress-related behaviors during the session. Additionally, heart rate variability data shows that the stress index increases significantly from the first time period towards the other three time periods. This increase could be explained by positive emotional arousal. The main conclusion is; even though no significant difference of self-perceived stress reduction was found between the control group and the experimental group, this research still proves that the virtual reality dolphin experience, whether 360° or 2D, **does** help students in the Netherlands with decreasing their self-perceived pre-exam stress levels.

Lastly, limitations of this research were; a low number of different fields of studies among the control and experimental groups and the missing information on which aspect of the virtual reality dolphin experience caused the difference in stress before and after the session. It is advised that in a follow up research the diversity of the control variable "study" will be more various and equally divided among the experimental group and the control group. Also, adding interview questions to determine whether or not the experience has been encountered as positively emotionally arousing by the students could improve a follow up study.

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1 Introduction

1.1 Problem Description

Stress has been a recurring and extremely rising phenomenon within the world population. So much so that stress has been predicted to be “the health epidemic of the 21st century" by the World Health Organisation (Fink, 2016). Important to note is that the word ‘stress’ is often used in a negative sense. But stress itself is only the body’s response to a changing stimulus or so called ‘stressor’ (González-Valero, Zurita-Ortega, Ubago-Jiménez, & Puertas-Molero, 2019). Positive stress (eustress) is defined as “a positive psychological response to a stressor, as indicated by the presence of positive psychological states” (Parker & Ragsdale, 2015). It is energizing, motivating and allows people to face everyday events (Aschbacher, et al., 2013). Negative stress (distress) on the other hand is defined as a negative reaction to a stressor which is manifested through negative psychological states (Parker & Ragsdale, 2015) which in turn increases vulnerability to suffering from anxiety disorders and depressive symptoms (González-Valero, Zurita-Ortega, Ubago-Jiménez, & Puertas-Molero, 2019). Within distress it is also important to distinguish between acute stress and chronic stress. Chronic stress is defined as a prolonged threatening or challenging circumstance that disrupts daily life and continues for an extended period with a minimum of one month. In comparison, acute stress is known as a short-term event-based exposure to threatening or challenging stimuli that evokes a psychological and/or physiological stress response, such as giving a public speech or writing an exam (Crosswell & Lockwood, 2020). A famous quote from Hans Selye, a renowned researcher who developed a stress theory, goes: *“It’s not stress that kills us, it is our reaction to it”* (Shreedevi, 2013).

An example for Hans Selye’s words would be two students who are faced with the exact same problem but react to it in completely different ways. While one sees it as a challenge and is motivated to find a solution (eustress), the other one can have a meltdown, feel anxiety, and have a blackout in the next exam (distress) which causes even more stress afterwards. These two students with the exact same stimuli show how different reactions can cause completely different stress levels. So, the main difference between eustress and distress is only how the situation is perceived by the person confronted with the changing stimuli (Shreedevi, 2013).

The effects of negative stress on the emotional and physical wellbeing of humans can be devastating. In a recent study in the US, over 50% of respondents said that stress has a negative impact on their work productivity. Between 1983 and 2009, stress levels increased by 10% to 30% across all demographic groups in the US (Fink, 2016). An excess amount of stress can disrupt the logical thought process. The body uses a lot of its energy and that can cause a black-out which can be explained by the humans’ “freeze” response. It has been scientifically proven that stress has a shrinking effect on the prefrontal cortex which is the area of the brain responsible for memory and learning. This can prevent people from performing at their optimal cognitive level (Bernstein, 2016).

One demographic that has been highly affected by immense stress levels are students. The ‘Anxiety and Depression Association of America’ has found that students are prone to feel overwhelmed by the act of trying to balance school, work, family, and friends while simultaneously trying to figure out what to do with the rest of their lives (ADAA, 2021). Very high stress levels can also affect the work efficiency of students and can further lead to poor academic performances and possible dropouts (Grace, 1997).

Stress levels can be measured by the heart rate variability of a person. It is proven that occupational (work-related) stress decreases the heart rate variability and leads to decreased performance. A low heart rate variability indicates stress while a higher heart rate variability indicates that the body is better able to deal with stress. Also, a high heart rate variability indicates that the autonomic nervous system is functioning optimally. Optimally in the sense that the sympathetic and parasympathetic

systems work well together. The sympathetic nervous system activates the fight or flight response during a threat or perceived danger, and the parasympathetic nervous system restores the body back to a state of calm (Järvelin-Pasanen, Sinikallio, & Tarvainen, 2018).

Studies have also shown that a decreased heart rate variability is associated with an increased risk of chronic disease and flawed cognitive function (Prinsloo, Derman, Lambert, & Rauch, 2013). Confirming this, university students who experienced stressful events in their life, were also the ones who reported poorer health outcomes and a lower quality of life (Damush, Hays, & DiMatto, 1997). Besides the long-term stressors such as described above, students are also exposed to acute stress factors such as exam stress. Stress is especially high during the exam periods because the pressure to succeed and the fear of failure are extraordinarily intense (Kumari, 2014). Furthermore, the decreased wellbeing of students and the possible outcomes of lower grades and higher study dropouts can also have a negative cascade effect on the universities, as well as a possible influence on the future employers, the government, and the health care system. This can also create a shortage of highly qualified workers on the labour market. Especially in countries where educational credentials are extremely important for recruitment into the labour market like Germany and Denmark (Schnepf, 2017).

In recent years the same kind of health developments have become true for students in the Netherlands. There have been signs that mental and psychological complaints among students in the Netherlands, especially stress and fear, have increased. Many young students find it difficult to cope with the ever-growing expectations and changing environments nowadays. This is accompanied by the fear of the financial consequences of dropping out, switching, or quitting their studies. This causes high performance pressure (Kumari, 2014).

The Radboud University in Nijmegen has conducted a survey in May 2017 to figure out how severe this problem is amongst their students. The participation in this survey was 22.1%. Out of these participants an alarming 62% have much or very much stress complaints and 60% experience pressure (van Huisseling, et al., 2018). Similar results appeared during research conducted at the University of Tilburg. Eighty percent of their students who filled out the survey, suffer from stress, depression, or anxiety. This has been shown in a well-being survey among 1,700 Tilburg University students (Kuipers R. , 2019). Additionally, the 'Landelijke Studenten Vakbond (LSVb)' has carried out research into the psychological complaints of students in higher education. For this research, a survey was held (N = 1,110) combined with interviews. No less than 49% of students report having or have had mental health problems which can be developed or worsened by too much stress (Kopp, Stauder, Gyärgy, Janszky, & Skrabski, 2018). Also, national statistical research has found that there has been a decrease in the student's psychological wellbeing in the last years. In 2019, 24.7% of Dutch students had anxiety and depression symptoms. A year later, when Covid-19 was also in full swing in the Netherlands, the proportion was suddenly 5 percent higher, and the numbers are growing. The most reported complaints were depression (clinical and non-clinical), stress and fatigue. All in all, the most common factors that put pressure on the student are performance pressure, study pressure, financial pressure, high expectations of oneself, the combination of study and work, CV building and balancing a social life while studying (de Boer, 2017). This literature shows that action must be taken to help students towards better mental health, which will improve their overall well-being, their academic performance and their value for society including the working market. Implementing successful, stress-lowering strategies can help students to avoid the destructive consequences of excessive stress.

Due to the severity of this problem the Dutch 'National Network of Student Welfare' has decided to act and set up a plan of action to tackle the stress-related problems in students. The goals of this plan of action are creating an inclusive study climate, complete and accessible information for students, good financial support, a low-threshold care in the institutions and continuous attention to (further)

education (de Groot & Siebrecht, 2019). As this plan of action was just set up in 2019, actions on improving current student stress levels are only at its infancy.

Dutch Universities see this problem as urgent, and therefore have started to plan interventions to lower the student's long-term stressors and prevent mental illnesses. These preventions include, having student advisors, counsellors, and school psychologists as well as buddy systems. The University of Tilburg also wants to train their staff to detect the signs of stress in students earlier (Visschedijk, 2020). Radboud University offers a program of five 2-hour meetings, led by a student psychologist on their website for students that feel like they can't cope with the stress anymore (van Huisseling, et al., 2018). While increasing awareness in this problem amongst students is good, it is important to note that the steps that have been taken by the universities and networks so far, have only been focusing on chronic stress and stress prevention. For example, the most frequently mentioned reasons for stress have been 'performance pressure' (de Groot & Siebrecht, 2019). While it is important to take measurements to prevent such high-performance pressure, it is also important to find easy and effective solutions to help students lower their already existing stress levels, especially in high pressure periods such as the exam weeks. While there are many ways of tackling acute stress, one method that has been used to improve the short-term symptoms of mental health problems with great success is the use of medical virtual reality (Brennan, et al., 2019). Virtual reality, or VR for short, is often described as the representation and simultaneous perception of an apparent reality and its physical properties in a real-time computer-generated, interactive virtual environment (Sook Yoh, 2002). Medical VR means the usage of the VR-technology for medical purposes (Riener & Harders, 2012).

The Dolphin Swim Club is the first company in the Netherlands that started using a virtual reality dolphin experience to relieve the symptoms of people suffering from pain, depression, anxiety disorders and psychoses (Brennan, et al., 2019). The dolphin swim club is the client the research is done for. They invented the medical dolphin VR-software to provide a cruelty-free alternative for dolphin-assisted therapies with captive dolphins. Because the effects of this intervention on students experiencing exam stress have not yet been proven or researched, The Dolphin Swim Club would like to find out what its effects are on students during a stressful period. Given the previous successes regarding research on the effect of mental health issues, virtual reality dolphin experience could pose a great opportunity to reduce exam stress in students as well.

Since this is a relevant issue in the current student population and the negative effects of distress on health and academic performance are severe, this topic requires further attention and research. In this research the extent to which the VR-dolphin experience can influence the pre-exam stress in students is investigated. Within this research the word 'stress' means acute distress. While stress can be observed in an individual through many different symptoms, this research will be focusing on the physical and physiological symptoms for acute stress. A few physical symptoms that can be observed within an individual can include but are not limited to involuntary twitching or shaking, headaches, nausea, muscle aches, trouble sleeping, fatigue, flushed skin, and clenched teeth (Cohen, 2019). A few physiological symptoms can include galvanic skin response, blood pressure, respiratory rate and heart rate variability (HRV) (Costaldo , Montesinos, Melillo , James, & Pecchia, 2019).

A virtual reality experience session specifically with dolphins has been chosen because dolphins are believed to bring greater wellbeing and relaxation to individuals. The human fascination with these marine mammals has been huge during the last decades and only increased with the classical movie 'Flipper' in 1963. A study in 2001 suggested that swimming in the ocean with wild dolphins has increased the participant's wellbeing as well as decreased anxiety (Webb & Drummond, 2015). With the use of a dolphin experience greater effects than other animals might have, are expected. This is due to the fascination people have had with this marine mammal species for the last decades.

Since the resulting data won't be reliable if the effect of the dolphins in the program and the VR-experience itself is tested at the same time, within this research the focus will be on the effects of the 360° VR-experience. Further research will be necessary to determine if it is the wild dolphin footage that is helpful in decreasing stress levels.

In conclusion, to tackle the global and urgent problem of rising stress levels and decreasing mental health in students, this research will investigate whether and to what extent VR-dolphin experience can have a positive effect on student's stress levels.

1.2 Purpose Of The Research

The aim of the study is to gain insight into the stress reducing effects of virtual reality dolphin experience in students with pre-exam pressure through quantitative research. Using the findings of this study it will be determined, to what extent the virtual reality dolphin experience helps in decreasing pre-exam stress.

1.3 Research Questions

To what extent does a student in the Netherlands undergo a decrease in pre-exam stress during a virtual reality dolphin experience?

a. To what extent are visible signs of stress detected during a VR-dolphin session for students experiencing pre-exam stress?
b. To what extent does a VR- dolphin session cause students to perceive a decrease in their pre-exam stress?
c. To what extent does a VR-dolphin session affect the heart rate variability of a student experiencing pre-exam stress?

1.4 Hypothesis

In order to shed light on the positive effects of virtual reality dolphin experience and its possible use in decreasing pre-exam stress, students in their exam-periods will be investigated. In order to be able to answer all three sub-questions, hypotheses were formulated for each of them.

a. It is expected that during a virtual reality dolphin experience session little (under 10 stress-related behaviors out of the 42 recording moments) to no stress-related behaviors will be exhibited by a student's body language. Thus, the expectation is that the student's don't experience stress while they are in the virtual reality session.
b. It is expected that a virtual reality dolphin experience session will cause students to perceive a decrease in their pre-exam stress.
c. It is expected that a virtual reality dolphin experience session will cause an increase in the heart rate variability of a student with pre-exam stress. Thus, the expectation is that the students will undergo a biological decrease in stress throughout the virtual reality experience session.

Apart from these hypotheses that answer the research questions it is also expected that factors such as gender, age, study, and belief in the VR-experience will have an influence on the extent of decrease in pre-exam stress.

1.5 Definitions

Explained below, are some terms used in this research proposal. These explanations are specific to this research and put in own words.

Biofeedback: Biological information gathered via heart rate sensors that show the student's bodily response to the virtual reality dolphin experience.

Ethogram: The table used as part of a behavioral research where stress-related behaviors are described by noting behavioral elements of an observable action with an extensive explanation.

Stress: In this research the word stress is used for acute distress which is a negative reaction/feeling that is short term and event based that students experience closely before their exam, causing; behavioral changes in the body and a perception of discomfort.

Virtual reality: 360^{o} imagery that shows wild dolphins swimming at the coast of Hawaii and can be watched through glasses with additional sound.

Visual analogue scale: A scale bar where the marks given by the students show their perceived pre-exam stress before and after the VR-session.

2D dolphin experience: The virtual reality image of a cinema where the dolphins were watched on a 2D screen by the control group.

360^{o} dolphin experience: The virtual reality image of an ocean full of dolphins in a 360^{o} setting where the experimental group could virtually experience swimming with dolphins in their natural habitat.

2 Materials & Methods

This materials & methods chapter explains what has been used in this research and how the research has been conducted, from the initial set up and data collection to the final data analysis and reaching of results. In this chapter, the type of research, the targeted population and sample group used, the research design, the types and process of data collection, the data preparation, analysis and finally the list of materials have been described.

2.1 Research type

This research is used to test the theory that virtual reality dolphin experience could have a positive impact on students by lowering their pre-exam stress. The results obtained through the data collection methods are of numeric value which makes the research of quantifiable nature. The three data collection methods being: an ethogram with corresponding score sheet, a visual analogue scale and a heart rate sensor with companion app produced results that were expressed in numbers. Thus, the process of collecting and analyzing numerical data makes this a quantitative research (Streefkerk, 2021).

To collect quantitative data, operationalization, where abstract concepts are turned into observable and quantifiable measures was used (Streefkerk, 2021). In this study the abstract concept that is being measured is negative emotional arousal in the form of stress. This was translated to quantifiable data through self-rating of stress levels. To obtain these stress levels, the observers used an ethogram and filled out a score sheet for the behavioral aspect while the students used a visual analogue scale to rate their perceived stress. Additionally, during the virtual reality session a heart rate sensor was used to measure heart rate variability throughout the experience.

These three methods, when combined, helped to deduce the effect a virtual reality dolphin experience has on the students and to what extent there exists a relationship between these two variables. After establishing this relationship, it is possible to generalize the results to wider student populations, assuming that the students studying at Van Hall Larenstein and NHL Stenden universities of applied sciences are representative of the general student population. The reliability of the sample used for this research is calculated in the next heading, “research population”.

2.2 Research population

According to the Association of Universities (VSNU), the most recent studies, conducted in 2020, shows that on October 1, 2020, the total number of students registered at Dutch universities for the 2020-2021 academic year was 327,300 (Vereniging van Universiteiten, 2020). Since this population is very large in size and geographically dispersed across the whole country, it was chosen to use a sample group to test the hypotheses. The sample group used in this research consists of students between the ages of 19 and 27, attending Van Hall Larenstein and NHL Stenden universities of applied sciences in Leeuwarden and experiencing pre-exam stress. The results obtained from this research are generalized to this group and used to draw conclusions about them. Since every country has a different education system and therefore different academic demands the study and the results are addressing this demographic specifically (Gorard & Smith, 2007).

This research was promoted with posters at school and online *(appendix A)*. Any students that met the requirements of participation, being:

- Student must have an exam in period 1,
- Student experiences exam stress (from moderate to severe), were able to participate.

The representativeness of the data obtained in a research is very important for its reliability. The larger the sample, the greater the chance that the data found will be representative of the whole population covered by the study and the smaller the chance of errors due to the sampling (Garssen & Hornsveld, 2017). Therefore, it was important to determine the sample size needed to ensure a significant outcome of the research. In order to draw conclusions about the entire student population of The Netherlands, an experimental group and a control group was made.

To determine the total sample size for this research, the power analysis was used. The power analysis involves four parameters, namely: effect size, sample size, significance, and statistical power. This analysis is used to determine one of these four parameters given the value of the other three. In this case the sample size was needed. The G*Power 3 program was used to make this calculation. The minimum power allowed for the power analysis was 0.80 (Brownlee, 2020). The goal was to find out how many test subjects are needed to achieve a minimum power of 0.80. After filling out the necessary parameters and keeping the minimum power of 0.80 in consideration, it was calculated that a sample size of 34 is necessary for this research. This sample consists of 17 people in the control group and 17 people in the experimental group. The students were distributed randomly into these groups so that personal relations or preferences didn't have effect on their virtual reality experience. This sample size represents the minimum number of students necessary for this research. Any additional applicants were allowed to take part as well to increase the representativeness of the sample.

2.3 Research design

The research design used for this bachelor thesis is correlational research. This design was chosen because it helped determine the existence of or the extent to which virtual reality dolphin experience has an influence on the reduction of pre-exam stress (Curtis, Comiskey, & Dempsey, 2016). This research design was used to determine how strongly these two variables are related. In this design the virtual reality dolphin experience is the independent variable and stress is the dependent variable. Additionally, control variables were taken into consideration to see if the effects of the virtual reality dolphin experience differ within the sample group. The control variables that could have an impact on the stress reducing effects of the virtual reality dolphin experience were established as: gender, age, study, belief in the virtual reality experience and stress levels before the VR-session (Monteiro, Balogun, & Oratile, 2014).

To obtain the correlational data, three types of data collection methods were used:

1. Observation using an ethogram and score sheet,
2. Visual analogue scale,
3. Biofeedback using a heart rate sensor and companion app.

These methods were used to gather quantitative data and each data collection method is linked to one of the sub-questions.

To answer: *"To what extent are visible signs of stress detected during a VR-dolphin session for students experiencing pre-exam stress?"*, an ethogram and score sheet were used. While the ethogram helped demonstrate the presence of stress-related behaviors, by using the score sheet it was made possible to see which (if any) stress-related behaviors were being displayed every 10 seconds.

The method of observation was chosen because it allows the researcher to document behavior without having to rely on the student's willingness to make an effort to execute an action such as answering a questionnaire (Kawulich, 2012). In this research, the students didn't have to physically exert themselves to perform during the data collection. They were seated in a quiet and relaxed setting where their behavior was observed by the researchers with minimum influence.

Additionally, the observation method allowed an objective representation of what people do since you can directly see what people do rather than relying on what people say they did. While in other methods such as interviews the researcher is dependent on the information provided by the participant, with the observation method the researcher relies on his/her own senses which increases reliability (Kawulich, 2012).

After seeing if there is any stress-related behavior, the next step was determining the extent to which this stress is reduced in the student's own perception, during a virtual reality dolphin experience session.

To answer: *"To what extent does a VR-dolphin session cause students to perceive a decrease in their pre-exam stress?"*, a visual analogue scale was used *(appendix B)*. The visual analogue scale demonstrates how the student's feel their stress levels have changed after the VR-session. With the scale, it could be deducted what the percentage of stress reduction was for the students that took part in the virtual reality dolphin experience. The deduction of this percentage helped build on the data obtained from the ethogram and corresponding score sheet. While the score sheet demonstrates the presence of stress-related behaviors, the visual analogue scale shows the extent of self-perceived exam-stress reduction.

The visual analogue scale in itself also provides a valuable and relevant addition to this research. Ultimately it is how people perceive stress that affect their behavior and performance. Even though there can be individual differences in how a person perceives stress the common thing is that when stress is perceived negatively or becomes excessive, it can affect academic performance, for example during an exam (Rafidah, et al., 2009).

The visual analogue scale was chosen as a research method because it is widely used as an instrument to assess subjective experiences. The scale correlates with the intensity of stress and is sensitive to changes in its intensity. Additionally, the ease of use and the minimum demand of the visual analogue scale allows the students to stay in the after-effects of the VR-experience for a longer time and not fall back to the stress they were experiencing before the VR-session due to a bombarding of questions from the researchers (Briggs & Closs, 1999).

In addition to stress indicated through observation and perception, biological data was collected to increase the reliability of the research. To answer: "*To what extent does a VR-session affect the heart rate variability of a student experiencing pre-exam stress?"* biofeedback was collected using a heart rate sensor. The Polar Verity Sense optical heart rate sensor is a device that views and records heart rate information that can be seen in real time or after the data collection. This device is placed on the arm where it measures the heart rate over time. It is connected to a companion app called Polar Flow which saves the heart rate for the time the device is on one's arm. The app demonstrates the beats per minute (bpm) and changes in the heart rate over time in a graph, which allowed for the deduction of heart rate variability during the virtual reality dolphin experience (Polar Global, 2021).

Heart rate variability is the variation in time between consecutive heart beats and can be influenced by stress reactions, relaxation, and emotional reactions. Relaxing activities increase heart rate variability since the heart will start beating more slowly and therefore the time between consecutive heart beats get longer. The opposite can be said for the heart rate variability in times of stress. Due to rapid beating of the heart during times of stress the heart rate variability decreases. So, the heart rate variability is inversely proportional to the heart rate (Karim, Hasan, & Ali, 2011).

Heart rate variability can in turn be used to measure stress index. Baevsky's stress index (SI), measured in the Kubios software programme (explained further in chapter 2.5) is a geometric measure of heart

rate variability reflecting cardiovascular system stress. High values of stress index indicate reduced heart rate variability and high sympathetic cardiac activation or in other words a high heart rate. So while the stress index is inversely proportional to heart rate variability it is directly proportional to heart rate (Kubios, 2022). It was expected that the heart rate variability would increase in the students going through the virtual reality dolphin experience, subsequently meaning that the stress index would be going down.

The method of biofeedback was chosen because it can show immediate changes in the functioning of the autonomic nervous system. In biofeedback, it is possible to observe one's biological data, in this case heart rate variability, with the help of various instruments attached to one's body. The feedback shown on the companion app helped monitor the changes of the autonomic nervous system and allowed the researchers to comment on the relationship between what is being done at the moment of data collection and the effect this action has on the body (Andrada, 2021). Therefore, this method allowed the researchers to; see how the student's body reacted to the virtual reality dolphin experience and deduct whether or to what extent this experience had an effect on decreasing exam stress.

Even though a lot of different physiological signals have been used in existing literature to detect stress, examples would be galvanic skin response, blood pressure, respiratory rate, and also electrocardiogram (ECG), the signal used in this research, being heart rate variability (HRV), is one of the most studied methods for assessing mental stress in our present day (Costaldo , Montesinos, Melillo , James, & Pecchia, 2019). Therefore it has been chosen as a valid and reliable method to measure biofeedback in this research.

In conclusion, the three research methods were combined to validate or discredit each other on the way to answering the main research question in the most reliable way. The combination of observation, perception and bodily response made this a thorough research.

To make this research design more clear the following conceptual model was made:

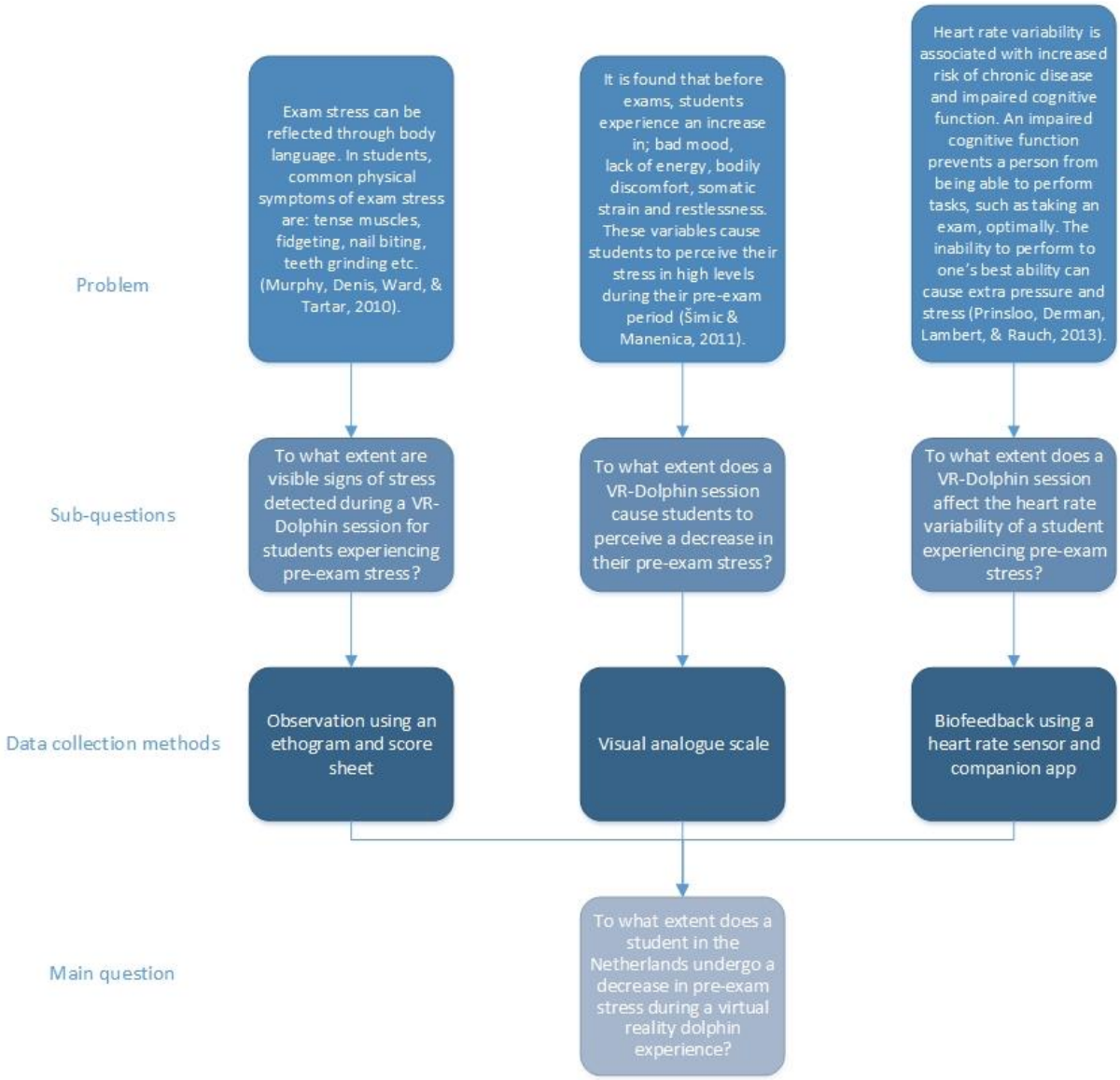


Figure 1 Conceptual model research

2.4 Data collection

The data collection days of this research took place in the exam week, week 44, of Van Hall Larenstein and NHL Stenden universities of applied sciences. This data collection was done from the 1st of November to the 5th of November. A single quite room, the dolphin room at Van Hall Larenstein University, was designated for the data collection days. It was important that the students could go through the virtual reality dolphin experience in a quiet place so that they are not distracted by outside noises or pulled out of the experience abruptly, hereby causing an increase in the students stress or an obstacle to their relaxation. Also, to promote optimal relaxation swivel chairs were used in the quiet rooms. This way the students could easily look around without having to constantly turn their neck or whole body in the chair. This increases the amount of comfort the students experience during the virtual reality dolphin experience. An additional list of materials can be seen in *appendix C.*

When the students came into the quiet room, they were asked to fill out and sign a consent form *(appendix D)* and read a participant information sheet *(appendix E)*. While the participation information sheet gave information about the research and what is expected from the students, the consent form asked for permission to use their information in our research and stated the risks

associated with the virtual reality experience. These document were initially mailed to the interested students upon registration so that they would also have enough time to read it before the data collection days. Additionally, a hygiene protocol *(appendix F)* was present in the quiet room for the researchers and the students who wanted to read it.

In the quiet room, for both the experimental group and the control group, there were VR-glasses and heart rate sensors that the students needed to put on for the virtual reality experience. The control group, watched the same wild dolphin video with the VR-glasses but then in a virtual cinema on a 2D screen. This made it so that the only difference between the two groups was the 360° virtual reality, which allowed the observers to comment on the effect of the entire virtual reality dolphin experience as opposed to watching a 2D wild dolphin video. The virtual reality experience took 7 minutes and after that the students got the chance to calmly come out of the session. The heart rate sensors and VR-glasses were removed, and the students were allowed to take time to come back to real life. The step-by-step plan of the data collection process can be seen in *appendix G.*

5 minutes after the virtual reality, the students were handed the visual analogue scale *(appendix B)* on how they perceived the experience and how their perceived stress levels differed before and after the VR-session. A VR-session can cause dizziness, disorientation, eye soreness etc. in different severities. Therefore the 5 minutes reserved post-VR-session, gave students the chance to take the time they needed to deal with or come back from these possible side effects (Fagan, 2018).

During the session the stress-related behaviors of the students were scored using an ethogram *(appendix H)* and a score sheet *(appendix I)*. The behaviors stated in the ethogram were closely monitored during the virtual reality session and scored every 10 seconds with the instantaneous time sampling method. In order to be able to do this quickly, abbreviations were used on the score sheet. The abbreviations are described in the ethograms. The ethogram in *appendix H* is based on the book "What everybody is saying" by Joe Navarro and Marvin Karlins (Navarro & Karlins, 2008). The score sheet based on the researcher's observations supported by the visual analogue scale that the students filled out and the biological heart rate variability measurements, formed the data necessary to answer the research questions.

Since the observers were scoring different students individually, clear agreements were made on when to consider an observation as a behavior from the ethogram. To increase inter-rater reliability the observers practiced beforehand with volunteers and checked to see if the way they score behaviors match. This is called an inter-observer test. The observers scored the behaviors of the volunteers simultaneously and compared their results at the end of the VR-session. After that, it was discussed why one observer did or did not score an action as a behavior and how these controversial actions should be scored in future sessions. Following these practice sessions, the ethogram was adjusted where necessary and the inter-observer test was repeated until both observers scored behaviors in the same way.

2.5 Data preparation and analysis

As previously described in the "data collection" chapter, three types of data collection methods were used. The score sheet, visual analogue scale and heart rate variability all answer different sub-questions and therefore needed to be prepared and analyzed separately.

2.5.1 Score sheet

The information required from the observation method, i.e. the ethogram and score sheet, was the number of stress-related behaviors. At the end of the data collection the number of stress behaviors

on the score sheet were counted per person and added to SPSS. No further preparations were needed for this data before it was put in Generalized Linear Models.

With all of the following models (made for each data collection method seperately), the gender variable was included as a control variable since it was believed that males might have a harder time expressing emotion (Higgins, Duxbury, & Lyons, 2010) and since the females and males were spread equally across the control and experimental groups so it was reliable for use in the data-analysis step. However, since there was only 1 person in the entire sample group that indicated that they don't believe in the benefits of VR-experience, belief in the VR-experience wasn't included in any of the models. Also, since there was only 1 person not studying animal management in the experimental group, study wasn't included in the models either. Because of this for both belief in the VR-experience and study variables, no interaction could be tested between them and the grouping variable being control/experimental group. For the age variable we could distinguish two different groups, therefore a categorization was made in two different classes: the students aged 21 and above (21+) and the students under the age of 21 (21-). Additionally, VAS_{before} was used as a control variable during the analysis of the score sheet to test whether a student's stress level before starting the VR-dolphin experience could have an impact on the number of stress-related behaviors they display during the VR-session. VAS_{before} was also used as a control variable during the analysis of the heart rate sensors, to test whether a student's stress level before the VR-dolphin experience can have an impact on the changes in a student's stress index in different time periods. Interactions between the control variables (age category, gender, VASbefore) and the group variable (control/experimental group) were tested.

For the analysis of the score sheet, Negative Binomial Regresssion within the Generalized Linear Models was used to test whether there is a significant difference between the experimental and control groups in terms of the number of stress behaviors performed during the VR-dolphin experience session. Negative Binomial Regression was chosen because this method of analysis is used for modelling count variables (UCLA, 2021). Generalized Linear Models can be used to analyze count data, such as the number of stress behaviors during a VR-session, but the count data are often highly skewed so the assumption of normality of residuals is violated. To account for this overdispersion the Negative Binomial probability distribution needs to be used within GLM (Kuipers H. , 2021).

Within the GLM the distribution was specified as *Negative Binomial*, the link function was specified as *Log* and *Estimate value* was marked. Following this the variables/interactions previously mentioned in the introductory paragraph (age category, gender, VASbefore) were deleted one by one(backwards selection) to achieve a model with the lowest AIC. To determine the best model, the model with the lowest AIC was trying to be found since the lower the AIC the better the model. After we obtained the final model, this model was validated using the homogenity-, independence-, temporal/spatial correlation-, and extreme outliers tests. The requirements of these tests were met. The final model is presented in a tabel in the results chapter.

2.5.2 Visual analogue scale

The visual analogue scale that can be seen in appendix B contained two marks where the students put down their perceived stress levels before and after the VR-dolphin experience. These marks had no numeric value. The VAS-scores were calculated manually with a ruler and translated to percentages. The data used for SPSS was the increase or decrease in VAS-scores, if there was any.

The decrease in VAS-scores were measured in two ways. Initially, their percentage of perceived stress after ending the VR-dolphin experience (VAS_{after}) was subtracted from their percentage of perceived stress before the start of the VR-dolphin experience (VAS_{before}). This is called the absolute VAS-score. The equation used for the absolute VAS-score ($VAS_{absolute}$) is shown below:

$$VASbefore\ -VASafter\ = VASabsolute$$

Secondly, the percentage of perceived stress before the start of the VR-dolphin experience (VAS_{before}) was divided by the absolute VAS-score ($VAS_{absolute}$) (see above how this was calculated) and multiplied by 100. This is called the relative VAS-score. The equation used for the relative VAS-score ($VAS_{relative}$) is shown below:

$$\frac{VASbefore}{VASabsolute} \times 100\ = VASrelative$$

The $VAS_{relative}$ was calculated because it was believed that a highly stressed person would be more prone to stress reduction than someone who already isn't experiencing a lot of stress at the start of the experiment. With this in mind, it was believed that the $VAS_{relative}$ would give a more accurate representation of pre-exam stress decrease in students (Can, et al., 2020).

For the analysis of the visual analogue scale, GLM was used to test whether there is a significant difference between the experimental and control groups in terms of reduction in VAS-score. GLM was chosen because this method of analysis is used to determine whether the means of two or more groups differ. In this case these two groups are the experimental group and the control group, and their difference conveys whether the decrease in a student's perception of stress overtime is actually linked to the 360° virtual reality dolphin experience. Additionally, GLM allows the inclusion of control variables and corrects the model for them when calculating the mean stress decrease for both the experimental and control groups. Simultaneously, GLM deduced whether the control variables being gender and age category had an influence on the mean decrease in stress (Fox, 2015).

Next, a univariate analysis(single test) was performed for each independent variable separately via GLM and the variables whose significance of the univariate test were P<0.25 were selected (Hosmer, Lemeshow, & Sturdivant, 2013). Following this preselection, the variables that weren't statistically significant (p>0.05) were deleted one by one(backwards selection). Next, we added two interaction terms to the model to see if these interactions are significant (p<0.05) (Hosmer, Lemeshow, & Sturdivant, 2013). This was done seperately for the variables between which interactions could be expected. The interaction terms that were set against the group variable (control/experimental group) were age category and gender. After we obtained the final model, this model was validated using the interdependence of residuals, test of normality, test of equality of error variances and the independence of the residuals from the predicted values. The requirements of these tests were met. The steps described in the paragraphs above were executed in the same way for both the absolute and the relative VAS-scores. The final models are presented in tabels in the results chapter.

After the GLM was used to test whether there is a significant difference between the experimental and control groups in terms of reduction in mean VAS-score, the one-sample T-test was used to see if this mean decrease significantly deviates from 0. The final models of the one sample T-tests are represented as tabels in the results chapter.

2.5.3 Heart rate variability

The heart rate variability was measured using a Polar Verity Sense optical heart rate sensor and companion app called Polar Flow. The companion app was opened on the laptop where the session could be exported to Excel. In Excel the time of the VR-dolphin experience session and heart rate (HR) measured each second were demonstrated. The heart rate was translated to respiratory rate (RR) which is the heart rate interval in milliseconds. The RR interval and HR are inversely proportional (Goldberger, Johnson, Subacius, Ng, & Greenland, 2014). The formula seen below, shows how many

milliseconds the RR interval measures and this provides information that can be used to calculate heart rate variability:

$$\frac{60000}{HR} = RR$$

After the RR per millisecond was calculated, this data was uploaded to a computer software called Kubios. Kubios is a software that supports the Polar Verity Sense optical heart rate sensors and provides accurate and detailed heart rate variability (HRV) analysis for short- and long-term measurements (Kubios, 2021). The RR data transformed from the HR in Excel was copied to a text document and this text document was opened in the Kubios software. Consequently, this software produced lots of information, including a graph showing the RR over time and most importantly the stress index.

Different time periods could be specified on this graph and the stress index was measured separately for each of these time periods. It was decided that 4 time periods would be used to be able to follow the change in stress throughout the VR-dolphin experience. For each person (ID), time period 1,2,3 and 4 were specified, where each time period measures a 1 minute and 45 second window. The reason intervals were chosen is that in this way instead of measuring the stress index across the entire session we can follow the changes in the stress index over time and hereby comment on, if or how the course of the session has an impact on the stress indexes. The shorter the interval the better since it increases the number of time periods and data that can be used to observe the changes over the session in a more specific and detailed way. However, more than 4 time periods could not be specified in our case since a shorter time interval wouldn't accurately measure the stress index of a given time in the Kubios software programme.

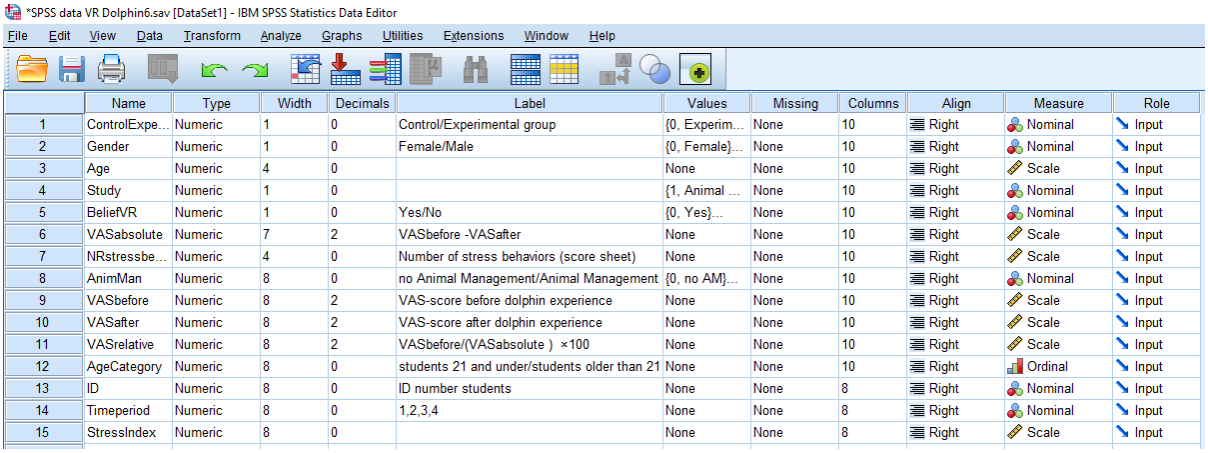
For the analysis of the heart rate sensors, LMM was used to test whether there is a significant difference between the experimental and control groups in terms of their stress index in different time periods during a VR-dolphin experience session. The reason the linear mixed model is chosen is because this method allows the analysis of dependent data. In the following model the dependency is caused due to repeated measurements that are taken on the same subject. This is called subsampling. The repeated measurements are the different stress indexes measured during the 4 time periods for each individual person (ID). Subsampling using Linear Mixed Models (LMM) allows the inclusion of repeated measurements and correct analysis of the individual data for each ID, whereas an analysis in GLM would be incorrect since the samples would be taken independently and not categorized per ID (Kuipers, 2021). This analysis allows a wide variety of correlation patterns to be modeled in a clear way. Also, the LMM can handle uneven spacing of the data points when it comes to repeated measurements which can be the case for the changing heart rate variability levels (Seltman, 2018).

Additionally, the LMM allows the use of both fixed and random effects in the same analysis. In this case the random effects are the students so the ID, the fixed effects are the grouping variable (control/experimental group), control variables (gender, age category and VAS_{before}), the interactions and the 4 time periods. This method allows the investigation of whether or not these fixed effects have an influence on the changing of the stress indexes over time and whether there is a significant difference within groups (Seltman, 2018).

Within LLM subjects was specified as *ID*, repeated was specified as *Time Period* and and the repeated covariance type was specified as *AR(1)* (Seltman, 2018). Following this the variables/interactions that were not significant ($p>0.05$) were deleted one by one(backwards selection) to achieve a model with the lowest AICC. To determine the best model, the model with the lowest AICC was trying to be found since the lower the AICC the better the model (Seltman, 2018). Pairwise comparisons were made for

control/experimental group, time periods and gender using Sidak. After we obtained the final model, this model was validated using the test of linearity-, absence of collinearity between the predictors, test of homoscedasticity, absence of influential points (outliers), and the normality of residuals. The requirements of these tests were met. The final models are presented in tabels and a column chart in the results chapter.

The final codebook in SPSS, with all the above mentioned data can be seen in figure 2 below.



	Name	Type	Width	Decimals	Label	Values	Missing	Columns	Align	Measure	Role
1	ControlExpe...	Numeric	1	0	Control/Experimental group	{0, Experim...	None	10	Right	Nominal	Input
2	Gender	Numeric	1	0	Female/Male	{0, Female}...	None	10	Right	Nominal	Input
3	Age	Numeric	4	0		None	None	10	Right	Scale	Input
4	Study	Numeric	1	0		{1, Animal ...	None	10	Right	Nominal	Input
5	BeliefVR	Numeric	1	0	Yes/No	{0, Yes}...	None	10	Right	Nominal	Input
6	VASabsolute	Numeric	7	2	VASbefore -VASafter	None	None	10	Right	Scale	Input
7	NRstressbe...	Numeric	4	0	Number of stress behaviors (score sheet)	None	None	10	Right	Scale	Input
8	AnimMan	Numeric	8	0	no Animal Management/Animal Management	{0, no AM}...	None	10	Right	Nominal	Input
9	VASbefore	Numeric	8	2	VAS-score before dolphin experience	None	None	10	Right	Scale	Input
10	VASafter	Numeric	8	2	VAS-score after dolphin experience	None	None	10	Right	Scale	Input
11	VASrelative	Numeric	8	2	VASbefore/(VASabsolute) ×100	None	None	10	Right	Scale	Input
12	AgeCategory	Numeric	8	0	students 21 and under/students older than 21	None	None	10	Right	Ordinal	Input
13	ID	Numeric	8	0	ID number students	None	None	8	Right	Nominal	Input
14	Timeperiod	Numeric	8	0	1,2,3,4	None	None	8	Right	Nominal	Input
15	StressIndex	Numeric	8	0		None	None	8	Right	Scale	Input

Figure 2 Codebook VR-dolphin data

3 Results

The following results chapter presents the final outputs obtained from SPSS for each of the sub-questions and their corresponding hypotheses. These outputs are factually described and supported by tables and figures. The results of; the observation, visual analogue scale, and biofeedback methods are discussed seperately in subchapters and each subchapter will link the results to the subquestion it is meant to answer (each subchapter is named based on the method used and the information collected through its use). The results will then be compared to the expected results which are the hypotheses.

3.1 Observation: visible signs of stress

The ethogram and score sheet that recorded the stress behaviors observed during the VR-dolphin experience were used to answer the following sub-question: *"To what extent are visible signs of stress detected during a VR-dolphin session for students experiencing pre-exam stress?".* It was expected that during a virtual reality dolphin experience session little (under 10 stress-related behaviors out of the 42 recording moments) to no stress-related behaviors would be exhibited by a student's body language. Thus the expectation was that the student's don't experience stress while they are in the virtual reality session.

During the observation of students in the VR-dolphin experience it was seen that 97% of the students showed little (under 10) to no signs of stress-related behaviors. 62% of the entire sample group showed 0 stress-related behaviors throughout the whole session. Only 1 person showed mild stress (between 10 and 20) with 11 stress-related behaviors during the VR-dolphin experience. To determine whether or not it was the 360° VR-dolphin experience that had an impact on the number of stress-related behaviors that the students exhibited, a negative binomial regression was conducted within Generalized Linear Models (GLM) to compare the number of stress-related behaviors displayed by the experimental group and the control group.

There was a significant difference between the number of times the experimental group displayed stress-related behaviors per session (0.47 ± 0.26) and the number of times the control group displayed stress-related behaviors per session (2.95 ± 1.49); (X^2 (1, N = 34) = 5.2, p = 0.023). The number of stress-related behaviors decreases with a factor of 0.159 (95% CI 0.033-0.772) for the experimental group. Additionally, it was found that none of the control variables and interactions with group variables were statistically significant. The final model for the negative binomial regression can be seen below in table 1:

Table 1 Final model Negative Binomial Regression

Test of Model Effects of Number of Stress Behaviors

Source	X^2	*df*	*P*
Intercept	0.223	1	0.637
Control/Experimental group	5.200	1	0.023
Age Category	3.026	1	0.082

3.1.1 Partial conclusion – Observation

To answer, *to what extent visible signs of stress are detected during a VR-dolphin session for students experiencing pre-exam stress,* it can be said that 97% of the students showed little (under 10) to no signs of stress-related behaviors and that there was a significant difference between the number of times the experimental group displayed stress-related behaviors per session and the number of times

the control group did so, with the experimental group showing less stress-related behaviors in comparison.

3.2 VAS-score: perception of pre-exam stress

The virtual analogue scale and the VAS-score that was deducted out of it, is used to answer the following sub-question: *"To what extent does a VR-dolphin session cause students to perceive a decrease in their pre-exam stress?"*. It was expected that a virtual reality dolphin experience session **will** cause students to perceive a decrease in their pre-exam stress and thus this decrease would be reflected in their VAS-score. Initially, their VAS-score was measured as an absolute VAS-score.

A univariate analysis was conducted within Generalized Linear Models (GLM) to compare the mean decrease in absolute VAS-scores between the experimental group and the control group. There was not a significant difference in the mean decrease in absolute VAS-scores between the experimental group (26.26 ± 16.46) and the control group (24.68 ± 15.1); (F(1;32)) = 0.084; p = 0.773). The final model of the absolute VAS-scores obtained using GLM can be seen below in table 2:

Table 2 Final model absolute VAS-scores

Test of Between-Subjects Effects of absolute VAS-scores

Source	*df*	*Type III SS*	*MS*	*F*	*p*
Corrected Model	1	21.062[a]	21.062	0.084	0.773
Intercept	1	22053.454	22053.454	88.441	0.000
Control/Experimental	1	21.062	21.062	0.084	0.773
Error	32	7979.441	249.358		
Total	34	30053.957			
Corrected Total	33	8000.503			

[a] R Squared = 0.003 (Adjusted R Squared = - 0.029)

Following this, a one-sample t test was conducted separately for the experimental and control groups, to deduce whether the mean decrease in absolute VAS-scores for both groups significantly differ from 0. There were 2 outliers who showed no decrease in stress at all but other than that there was a strong significant difference between the mean decrease in absolute VAS-scores for the experimental group (M = 26.26, SD = 16.46; t(16) = 6.58, p<0.001), the mean decrease in absolute VAS-scores for the control group (M = 24.68, SD = 15.1; t(16) = 6.74, p<0.001), and 0. Additionally, it was found that none of the control variables and interactions with group variables were statistically significant.

After seeing that there was no significant difference in the mean decrease in absolute VAS-scores between the control and experimental groups, their VAS-score was measured as a relative VAS-score.

A univariate analysis was conducted within GLM to compare the mean decrease in relative VAS-scores between the experimental group and the control group. Again, there was not a significant difference in the mean decrease in absolute VAS-scores between the experimental group (39.41 ± 21.44) and the control group (40.38 ± 19.82); (F(1;32)) = 0.019; p = 0.892). The final model of the relative VAS-scores obtained using GLM can be seen below in table 3:

Table 3 Final model relative VAS-scores

Test of Between-Subjects Effects of relative VAS-scores

Source	*df*	*Type III SS*	*MS*	*F*	*p*
Corrected Model	1	7.998[a]	7.998	0.019	0.892
Intercept	1	54105.200	54105.200	129.936	0.000
Control/Experimental	1	7.998	7.998	0.019	0.892
Error	32	13639.684	426.420		
Total	34	67752.883			
Corrected Total	33	13647.682			

[a] R Squared = 0.001 (Adjusted R Squared = - 0.031)

Following this, a one-sample t test was conducted separately for the experimental and control groups, to deduce whether the mean decrease in relative VAS-scores for both groups significantly differ from 0. There were 2 outliers who showed no decrease in stress at all but other than that there was a strong significant difference between the mean decrease in relative VAS-scores for the experimental group ($M = 39.41$, $SD = 21.44$; $t(16) = 7.58$, $p<0.001$), the mean decrease in absolute VAS-scores for the control group ($M = 40.38$, $SD = 19.82$; $t(16) = 8.4$, $p<0.001$) and 0. As is the case with absolute VAS-scores, it was found that none of the control variables and interactions with group variables were statistically significant for the relative VAS-scores. The final models resulting from the One-Sample T test for the control and experimental groups can be seen below in tables 4 and 5:

Table 4 Final model mean comparison experimental group

One Sample Test for the Experimental Group

					% 95 CI	
	t	*Df*	*p (2-tailed)*	*MD*	*LL*	*UL*
VASabsolute	6.578	16	0.000	26.25529	17.7938	34.7168
VASrelative	7.577	16	0.000	39.40647	28.3815	50.4315

Table 5 Final model mean comparison control group

One Sample Test for the Control Group

					% 95 CI	
	T	*Df*	*p (2-tailed)*	*MD*	*LL*	*UL*
VASabsolute	6.741	16	0.000	24.68118	16.9198	32.4426
VASrelative	8.401	16	0.000	40.37647	30.1880	50.5649

3.2.1 Partial conclusion – VAS-score

To answer, *to what extent a VR-dolphin session causes students to perceive a decrease in their pre-exam stress,* it can be said that for both the experimental and the control groups the mean decrease deviated from 0, when measured as absolute VAS-scores as well as relative VAS-scores, which means that there is a significant decrease in stress. However there was not a significant difference in the mean decrease in absolute or relative VAS-scores between the experimental group and the control group, so this decrease is the same for both groups.

3.3 Biofeedback: heart-rate variability

The biofeeedback device(heart-rate monitor) measuring heart rate variability throughout the VR-dolphin experience was used to answer the following sub-question: *"To what extent does a VR-dolphin session affect the heart rate variability of a student experiencing pre-exam stress?".* It was expected that a virtual reality dolphin experience session will cause an increase in the heart rate variability of a student with pre-exam stress. Thus the expectation was that the student's undergo a biological decrease in stress throughout the virtual reality experience session. The heart rate variability was used to measure the stress index across different time periods (stress index was the measurement used in SPSS for the data analysis).

A repeated measures analysis was conducted within Linear Mixed Models(LMM) to compare the mean stress index for the experimental group (M = 28.75, SE= 1.28) and the control group (M = 28.09, SE = 1.28). There was not a significant difference in the mean stress index between the experimental group (28.75 ± 16.46) and the control group (28.09 ± 15.1); (F(1;28.47) = 0.146; p = 0.706).

However, it was found that there is a significant difference in the mean stress index between time period 1 (M =25.2, SE=1.18), and time periods 2 (M = 29.36, SE= 1.18), 3 (M = 29.58, SE= 1.18) and 4 (M = 29.54, SE= 1.18); (F(3;55.43) = 6.32; p = 0.001) for both groups. In period 1 the stress index of the students is the lowest and increases gradually throughout the VR-dolphin experience. This was modeled in the column chart below:

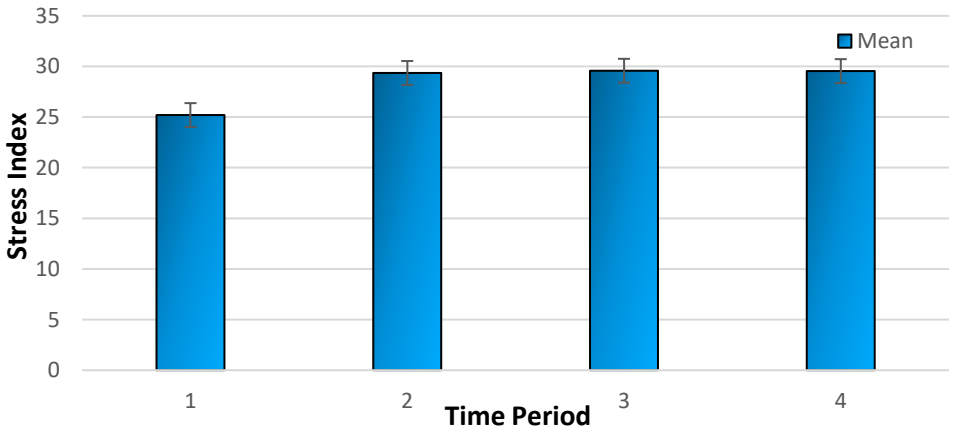


Figure 3 Mean Stress Indexes For Different Time Periods

Taking the control variables into account within this LMM test, it was found that there is a significant difference in the mean stress index of males (M = 26.03, SE = 1.56) and females (M = 30.8, SE = 1.05); (F(1;28.47) = 6.50; p = 0.016). The mean stress indexes for males and females show no significant change across different time periods or for experimental and control groups. The final model of the stress indexes obtained using LMM can be seen below in table 6:

Table 6 Final model LMM Stress Index

Type III Tests of Fixed Effects of Stress Index

Source	*Numerator df*	*Denominator df*	*F*	*p*
Intercept	1	28.946	918.711	0.000
Control/Experimental	1	28.469	0.146	0.706
TimePeriod	3	55.430	6.317	0.001
Gender	1	28.469	6.496	0.016

3.3.1 Partial conclusion - Biofeedback

To answer, *to what extent a VR-dolphin session affects the heart rate variability of a student experiencing pre-exam stress,* it can be said that there was no significant difference found in the mean stress index between the experimental group and the control group. However, it was found that there is a significant difference in the mean stress index between time period 1 and time periods 2, 3, and 4. Finally for the control variable gender it was found that there is a significant difference in the mean stress index of males and females. Females have a higher mean stress index in comparison to males.

4 Discussion

The discussion chapter distinguishes a methodic discussion and a results discussion. In the methodic discussion the validity and reliability of the study and its design are discussed. This included a discussion of the external factors that influenced this study. The methodic discussion also includes the three different types of measurements and their reliability. In the results-discussion, explanations and interpretations were given to the results. The influences that the data had on the results and the data analysis were discussed. Additionally, the limitations and possible implications of the research were discussed in order to make suggestions for further research.

4.1 Methodic discussion

During the design of this research, choices were made on how to set-up and structure the research. One of these choices was randomly distributing the students into the control and experimental groups. Later, it stood out that due to this random distribution the "study" control variable wasn't divided equally across the control and experimental groups. Even though none of the control variables (except females and males in the HRV measurements) have been proven to have a significant effect within this research, the diversity of students among the control and experimental groups were limited. While the experimental group mostly consisted of animal management students, the control group mostly consisted of other studies. It is possible that, an even distribution of this demographic could lead to different results. It can be said that there might be a factor of preference and that this has influenced the results since a person who likes and is familiar with animals might get more relaxed during such an experience (Beetz, Uvnäs-Moberg, Julius , & Kotrschal, 2012). While this research is able to comment on the benefits of the 360° virtual reality experience by making a distinction between a 2D wild dolphin video and an immersive 360° experience, having mainly animal management students in the experimental group, prevents us from being able to comment on whether a predisposition to animals could also have an effect on the benefits of this experience.

Following the data collection, other limitations were discovered in the methods that were used for this research. For example, the reliability of the VAS-score could be seen as problematic, because there have been verbal interactions with the participants before and after the virtual reality dolphin experience. Both researchers had been talking to the students in a friendly way, explaining and making small talk. This social interaction could have possibly influenced the participants stress level, especially during an isolated time like Covid-19 (Elmer, Mepham, & Stadtfeld, 2020). The experienced stress through this social interaction could have become higher or lower as well as stayed neutral, depending on the participants prior experiences and sociability. The influence would have mainly been within the starting stress level of a student, prior to the experience (Murphy, Franklin, & Tsang, 2020). However, the data on the starting stress levels of the participants show that around 76**%** of the students still started with a high perceived stress level of above 50%. So, the conversations that were made with the student's before they filled out their initial VAS-scores, had minimal to no influence on them meeting the requirements of having moderate to severe stress for this research.

The next data collection method used in this research, namely the ethogram, was also accompanied with some limitations. The ethogram has been marked based on a ten second interval. Within the timeframe of these ten seconds there could have been potential moments where the student's body-language showed stress-related behaviors. However, due to the 10-second interval that would have not been captured by the researcher. This could lead to low reliability of the behavior assessment as the representation of how much stress-related behavior was actually expressed would not be accurate. This however, did not seem to be an issue within this research, as very few students showed any stress-related behaviors at all and those who did express it did not have it so frequently that significant

amounts would have been missed within these ten seconds. So, it can be said the reliability of this data collection method is high (Jones, et al., 2017).

Another problem that has been encountered due to scoring behavior with an ethogram is that stress behaviors are generalized in an ethogram. Adaptability to stress and a person's attitude in a stressful situation is very much an individualistic matter (Rafidah, et al., 2009). So, the reaction to the VR-experience and the stress behaviors shown during, might have an individual expression in the individual student. Distinctions were made on when to consider a behavior stress-related but even then, it is possible that behaviors that have been labeled as stress behaviors might not be performed out of stress by the student but another reason. To minimize this as much as possible within this research, the stress-related behaviors were backed up by scientific sources and only the ones which have been proven as universal signs for stress in the past were included in the ethogram and scored during data collection. However, this does not take away the personal aspect in which a student might show stress (Brent, 2003). Another limitation of this method could have been that behaviors that weren't included in the stress behavior list, because they were researched as relaxation behaviors, could have actually been coping behaviors. A coping behavior is performed to intentionally regulate an emotional response, which means they could have also been stress-related and performed to relax one's self (Orgilés, et al., 2021). It is unsure what kind of effect the exclusion of coping behaviors had on the outcomes in this research but seeing as there was almost no specific body language performed, other than relaxed sitting, the effects are believed to be minimal to nonexistent.

The reliability of the ethogram was ensured before it was used on the data collection days. The fact that two different researchers viewed and scored the students behavior in a random distribution of student-researcher, helps the data to not be biased by one person. When two or more researchers score the behavior, it is less likely to be misinterpret. It was made sure that the two researchers interpret and score behavior in the same way by using an inter-observer test. Performing the inter-observer test brought some differences in scoring of behavior to the surface. To make sure these differences are adjusted, when to consider an action as a specific stress-related behavior was discussed. More information on how inter-rater reliability was maintained can be found in chapter 2.4, data collection.

The heart rate variability data was considered to be highly reliable because it has been measured by two Polar Verity Sense smart watches which measured and recorded the heart rate of a student every second. Previous research that has been carried out on the smart watches used in this research show that it is a reliable source to measure HR (Bodell, et al., 2021). The translation of this extensive data of each student's heart rate has been done by calculating the RR to then be able to get the HRV and the stress index with the help of the Kubios software program. The formula used to translate HR into RR is reliable since it has been retrieved from a scientific paper (Goldberger, Johnson, Subacius, Ng, & Greenland, 2014). Additionally, the translation of RR to HRV and stress index is also a reliable method that has been used in several different researches regarding stress, such as the "Kubios HRV – Heart rate variability analysis software" article by Tarvainen et al. (Tarvainen, Niskanen, Lipponen, Ranta-aho, & Karjalainena, 2014).

The reliability of the time frame of seven-minutes of recording the HR is high. Several studies have shown that during long- and short-time recordings the HRV features change consistently during mental stress and present therefore a reliable method to detect stress. This is true for laboratory settings as well as real life scenarios (Can, Chalabianloo, Ekiz, & Ersoy, 2019). After splitting the seven-minute time frame into four sections, to be able to see an upward or downward trend in stress, the time period has become very short. This could be a potential reliability issue. The researcher R. Costaldo has concluded in his study that six ultra-short time periods from less than five minutes are a reliable source for

measuring HRV. This however has not been researched for four ultra-short time periods therefore it would have been more reliable to use six time periods instead of four (Costaldo , Montesinos, Melillo , James, & Pecchia, 2019). This also would have led to more data available for the system to compare. However, the time frame of seven-minutes could not have been split by six accurately within the Kubios software so the decision to use four time periods couldn't be adjusted in this research. Even though six time periods would have been optimal, the four time periods used in this research are still reliable.

Finally, there are a few aspects that could have been thought about prior to the data collection and carried out differently in the process. Firstly, the experience itself and putting on the VR-glasses for the first time could have been stressful (distress) or exciting (eustress) which would have both been measured by the smart watches as a change in the stress index (Li, Cao, & Li, 2016). If it would have been asked if people had a VR-experience before in their life and a distinction was made between those who were and those weren't familiar with this process, it could have been considered as a control variable to be able to see if the effect of the rise in stress levels during the first period was due to the unfamiliarity of the experience. Additionally, there could have been data collections performed in different exam periods, to be able to see if students get desensitized to the experience over time and whether the effects are still consistent or if the effect wears off over time. This, however, was not possible within this research due to the limited time frame of five months. Since only one exam week was used to collect data for this research, the effect of desensitization and the possible influence of repeated measurements can't be discussed. This does not affect the reliability of these findings but rather is an improvement for future research.

4.2 Results discussion

During the observation of students in the VR-dolphin experience it was seen that 97% of the students showed little (under 10) to no signs of stress-related behaviors. 62% of the entire sample group showed zero stress-related behaviors throughout the whole session. It was found that the number of stress-related behaviors decreases with a factor of 0.159 for the experimental group. This means that the experimental group showed a significantly less amount of stress-related behaviors than the control group during the VR-experience. It has been observed that the experimental group exhibited more movement in general. This could be due to the interactive 360° experience. Students moved in their chair, moved their heads, and tried to grasp things. These were non-stress related behaviors and can be interpreted as excitement and being fully immersed in the experience. This can also be connected to a flow state. The positive psychologist Mihaly Csikszentmihalyi describes flow as a state of complete immersion in an activity. Which could explain why stress-related behaviors weren't as often exhibited in the experimental group as in the control group, as it is logical that when you are fully immersed in an experience you cannot be in a state where you show physical sign of stress as your body is so distracted with what is happening (Csikszentmihalyi, 2014). This can also explain why the number of stress-related behaviors were so low in everyone. The only difference would be that the level of immersion in the 360° is a deeper and more intense one than the 2D. This has been observed by the researchers themselves as well as communicated by the students. Also, recent research has proven that a 360° VR-environment was accompanied by greater positive emotional arousal than in its 2D counterpart (Tian, Hua, Zhang, Yingjie, & Yang, 2021). This can explain why the experimental group had a higher amount of movement in general and a lower amount of stress-related behaviors. This could also indicate a possible higher stress reduction within the 360° experience in opposition to the 2D experience.

Through the visual analogue scale, it was found that the control group and the experimental group, both had a significant difference in their VAS-scores. Which means both groups started with a significantly higher self-perceived stress level than after their two individual experiences. This means that both dolphin experiences, the 360° and the 2D versions, have a significant lowering impact on a student's self-perceived stress level before their exams. However, because there is no significant difference between the control and experimental group, the effect is not coming from the 360° VR-experience as anticipated at the beginning of this research. It could be said that even though the consciously perceived reduction of stress didn't show a significant difference between the 2D and 360° experience, the student´s may unconsciously reflect this significant difference in their stress-related behaviors as explained in the previous paragraph. From the personal feedback our participants voluntarily gave us it appears that the positive effect could also possibly be brought about by the special circumstances of the virtual reality experience itself, meaning both the 360° and the 2D experience, and the distraction that a unique experience like this offers.

Additionally, the relaxing sound in both experiences could have had a positive influence on the student's stress level. The researcher Timothy Onosahwo Iyendo has found that music has a positive impact on medical treatments. Positive impacts that were found included; calming and relaxing the patients, reducing blood pressure and heart rate, evoking positive emotions as well as decreasing the levels of anxiety and stress (Iyendo, 2016). Another possibility that seems very plausible is the therapeutic effects of dolphins as they are proven to have a relaxing effect on a human's psyche (Webb & Drummond, 2015). In this research it was found that the control and experimental groups showed no difference in their VAS-scores which means that the difference for the consciously perceived reduction of stress does not lie in the experience being provided in 2D or 360°. This could be because the 2D experience where the students sat in a virtual reality cinema was too similar to the 360° VR-experience. A limitation of this research is the missing information on which aspect of the VR-experience has caused the difference in self-perceived stress before and after the VR-dolphin experience. With this research it is possible to say that the VR-experience has an effect on students self-perceived exam stress, but it is not possible to say why exactly this effect is occurring. Both of the above described aspects of the virtual reality could be a possible explanation as to why the VR-experience caused a significant decrease in stress. Further research would be necessary to establish what exactly the cause of stress reduction is.

According to the heart rate variability data it was found that the stress index was at its lowest in period 1 and increased gradually throughout the VR-dolphin experience, showing a significant difference between time period 1 and time periods; 2, 3 and 4. This increase in stress index is the opposite of what was expected in the beginning of this research. A possible explanation for this increase could be that this is a case of positive emotional arousal. The watch cannot differentiate between eustress and distress because the stress that is being measured is on a physiological level while the differentiation of eustress and distress occurs on a psychological level (Le Fevre, Kolt, & Matheny, 2006). The research of Le Fevre, Kolt and Matheny (2006) shows that a particular stress is distinguished as eustress or distress based on the individual's perception of the intensity of the stimulus and on the perception of its other characteristics such as its controllability and desirability. In this research the physiological change would be the raising heart rate, which is what the watches were recording. So, it could be said that the watches measured the excitement of the students or in other words, their eustress. Eustress is a positive experienced stress of an individual which enhances motivation and focus (Dua, 2018). This thesis is supported by the positive and significant results from the VAS-scores that all students, except two outliers, felt less stressed after the experience.

The reason the stress index was significantly lower in the first time period in comparison to the other three time periods could be that in the first time period only a few dolphins were seen due to the intro of the video which includes a black screen with The Dolphin Swim Club logo and a calm ocean scenery.

As the video continues more and more dolphins come into view. It was observed by the researchers that as the VR-session progressed the students showed more excitement which would also support the possibility that the increase in stress index could be caused by positive emotional arousal in this research. Additionally, the students started to move their body more in the last three time periods to be able to see the dolphins swimming all-around. Movement overall (non-stress related) automatically leads to a higher heart rate which could also explain why the student's stress index gradually increased (Rennie, Rowsell, Jebb, Holburn, & J., 2000). This leads to the conclusion that biological data alone is insufficient for measuring stress. The biofeedback results alone wouldn't have been reliable in this research since the interpretation of biological data is highly dependent on the context of the situation and an individual's perception.

Another insight of this research was that there was a significant difference in the stress index between females and males. Females had a higher stress index during both types of the experience in comparison to the participating male students, which would mean that the males experienced less stress during the 360^{o} VR and 2D experience than the females. This could be explained by the conditioning that most males have gone through in their life of not easily showing emotions, not perceiving stress as fiercely as females do and the need to be more capable when dealing with stressful situations (Higgins, Duxbury, & Lyons, 2010). A lot of past research has shown that females experience higher stress levels and also have a greater vulnerability to stress than males do (Sandanger, Nygård, Sørensen, & Moum, 2014). This could be an explanation for the results showing that females had a significantly higher stress index than the males within this research. However, if we take the previous discussion point into consideration and assume that a high stress index implies excitement and positive emotional arousal, than the significant difference between males and females could be explained by females having a higher sensitivity to emotions in general. Females are more emotionally intense and expressive than males (Timmers, Fischer, & Manstead, 1998), so the significant difference in stress index between males and females could also be explained by female's having a higher susceptibility to stimuli causing emotional response.

5 Conclusion

Through the results and discussion, answers can be given to the following research question:
''To what extent does a student in the Netherlands undergo a decrease in pre-exam stress during a virtual reality dolphin experience?'' and the accompanying sub-questions:

a. To what extent are visible signs of stress detected during a VR-dolphin session for students experiencing pre-exam stress?
b. To what extent does a VR-dolphin session cause students to perceive a decrease in their pre-exam stress?
c. To what extent does a VR-dolphin session affect the heart rate variability of a student experiencing pre-exam stress?

Students experience a significant decrease in their perceived pre-exam stress after a virtual reality dolphin experience. This is true for the experimental group as well as for the control group.

a. Small amounts of stress behaviors were detected during a VR-dolphin experience session for students experiencing pre-exam stress. As little as 3% of the students were expressing stress-related behaviors. This shows that the students were generally relaxed during the sessions. With the experimental group showing significantly less signs of stress-related behaviors than the control group.
b. The students in the control group as well as the experimental group had a significant decrease in their perceived pre-exam stress during the VR-dolphin experience session.
c. The heart rate variability of a student experiencing pre-exam stress was affected by the VR-dolphin experience in both the control and experimental group, in a way that the HRV decreased whereas the stress index increased significantly from period one towards the other time periods.

Even though no significant difference of self-perceived stress reduction was found between the control group and the experimental group, this research still proves that the virtual reality dolphin experience, whether 360° or 2D, **does** help students in the Netherlands with decreasing their self-perceived pre-exam stress levels. Additionally, this is a good baseline to do further research to find out what exactly has caused the significant difference in stress levels of the students.

6 Recommendations

This chapter consists of practical recommendations and recommendations for follow-up research.

This study has revealed that using a dolphin VR-experience is an effective and advisable tool to reduce a student's perceived pre-exam stress during an examination period. Therefore, it is recommended for colleges and universities to purchase VR-glasses including the dolphin VR-software and start a program in their facility where students get to experience VR-dolphin sessions shortly before their exams. This will decrease the students perceived stress levels prior to an exam and with that they might possibly also have a better outcome on tests, as a study in 2010 has found that higher academic stress is associated with lower grades (Akgun & Ciarocchi , 2010).

The glasses could be a valuable addition to a college or universities repertoire to help their students fight against increasing stress levels during an examination period. One person to supervise the usage of the VR-glasses would be enough. If the student is provided with a quiet environment, the VR-experience will do the rest.

An alternative for colleges and universities who don't have many financial resources could be setting up a screen to provide a 2D experience. An advantage of this alternative could be that multiple students could participate in this 2D experience at the same time. However, additional research would need to be done to find out whether there is a difference between the 2D effect with the glasses on and the 2D effect without glasses, measured individually and in a group.

Recommendations for a follow up research:

- In follow-up research there should be a strict and clean handling of the participants caried out in a neutral way with a positive attitude and with little human interaction, to eliminate the possible influence of the researchers and to make sure that the same results are achieved.
- There should be a bigger variety of age groups, study's (particularly non-animal related studies) and a bigger quantity of students to make the data more reliable.
- Scientific studies that should follow are, research where the dolphin VR gets compared with another animal VR and one without the music to test if either of these factors were contributing to the perceived stress reducing effects on the students.
- For follow-up research, it would be advised to perform interviews with questions after the experience where the participants can state if they found the 360° VR positively or negatively emotionally arousing, to potentially support this research's hypothesis that a 360° VR is increasing the HRV through positive emotional arousal rather than negative stress.
- It is advised, for a follow up research to ask students the question of whether they've had prior VR-experience. If possible, it would be better to have sufficient representatives for students with and without prior VR-experience equally divided across the control and experimental groups to be able to see if the factor of previously having experienced a VR-dolphin session has an impact on the results.
- To be able to say if the positive stress reducing effects in students in this research were driven by the unfamiliarity and the excitement of this experience, it is advised to have multiple data collection moments in a follow up research. Three to four exam periods could be used to let the same group of students experience the VR-dolphin sessions prior to their exams. This should be done to detect whether or not a desensitization process is or isn't happening over time.

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Appendix

Appendix A: Poster for Free VR-Dolphin Experience

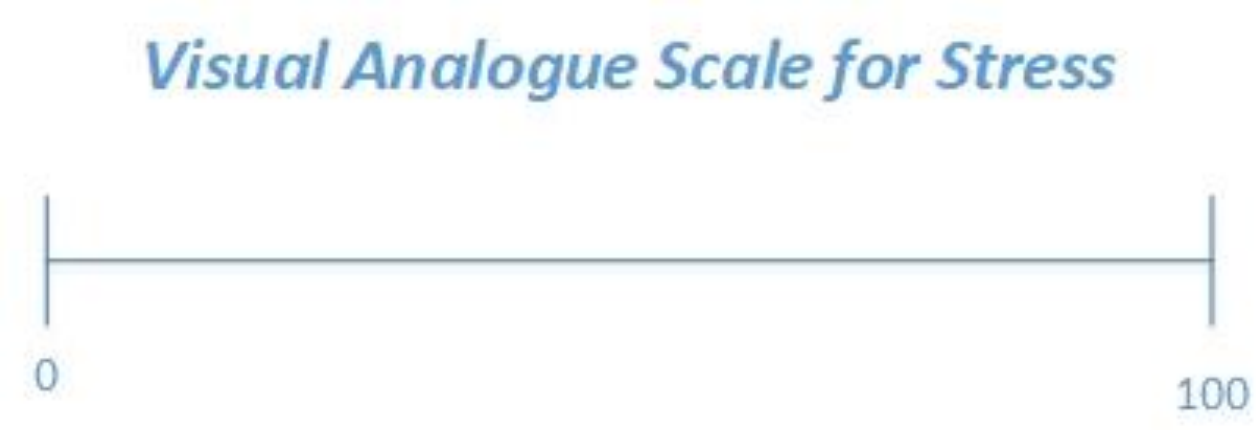
Appendix B: Visual Analogue Scale

Gender:

Age:

Study:

Belief in the VR-experience:



Appendix C: List of Materials

- 2 VR-glasses
- 2 Polar Verity Sense – optical heart rate sensors
- Biofeedback app – Polar Flow
- Kubios HRV
- SPSS
- Visual analogue scale
- Ruler
- Ethogram and score sheet
- Clipboard
- Pens
- Posters for applicants
- Consent form
- Participant information sheet
- Hygiene protocol *(appendix F)*
- Disinfecting gel for hands
- Wet wipes to clean VR-glasses
- 2 Swivel chairs
- 2 Normal chairs
- Quiet room

Appendix D: Consent Form for Virtual Reality Dolphin Experience

This personal data consent form is based on the GDPR. Which is the **EU General Data Protection Regulation.** The data collection form in our research is the express consent method. Where we ask for consent, the students understand the questions and make a genuine choice. This informed consent form is based on the template by University Twente (BMS Ethics Committee & Human Research Ethics TU Delft, 2018).

Consent Form for Virtual Reality Dolphin Experience

YOU WILL BE GIVEN A COPY OF THIS INFORMED CONSENT FORM

	Yes	No
Please tick the appropriate boxes		
Taking part in the study		
I have read and understood the study information dated [01/11/2021]. I have been able to ask questions about the study and my questions have been answered to my satisfaction.	○	○
I consent voluntarily to be a participant in this study and understand that I can refuse to answer questions and I can withdraw from the study at any time, without having to give a reason.	○	○
I understand that taking part in the study involves my personal information (such as sex, age, study, behavior, and heart rate) being stored on a hard drive. Names will not be saved. The heart rate is being measured by a non-invasive sport bracelet (Polar Verity Sense). It is being collected to see if the VR has a relaxing effect on the participant's heart rate and heart rate variability.	○	○
Risks associated with participating in the study		
I understand that taking part in the study involves the following risks: some participants might experience nausea, dizziness, disorientation, loss of spatial awareness, eye soreness and seizures through the use of the VR-glasses. (We advise that you don't participate in the research study if you have a history of epilepsy or brain injury.)	○	○
Use of the information in the study		
I understand that information I provide will be used for a bachelor thesis within Van Hall Larenstein University of Applied Sciences, The Dolphin Swim Club Leeuwarden, and possible publications in a journal or other third parties for research purposes only.	○	○
I understand that personal information collected about me that can identify me, such as my name, will not be shared beyond the study team.	○	○
Future use and reuse of the information by others		
I give permission for the personal data that I provide, such as the Visual Analogue Scale (self-assessment scale) and the behavior observations, to be archived on a hard drive in a locker so it can be used for future research and learning. Access restrictions that apply to the data are commercial use. The data will be safely guarded, and names will be removed as an anonymization process.	○	○

Signatures

_____	_____	_____
Name of participant [printed]	Signature	Date

I have witnessed the accurate reading of the consent form with the potential participant and the individual has had the opportunity to ask questions. I confirm that the individual has given consent freely.

_____	_____	_____
Name of witness [printed]	Signature	Date

Study contact details for further information:

Bibi van Neuss, bibi.vanneuss@hvhl.nl

Shiva Jalalizadeh, *shiva.jalalizadeh@hvhl.nl*

Contact information for questions about your rights as a research participant

If you have questions about your rights as a research participant, or wish to obtain information, ask questions, or discuss any concerns about this study with someone other than the researcher(s), please contact the Examencommissie of the Faculty of Van Hall Larenstein, by examencommissie.dm-kzm@hvhl.nl

Appendix E: Participant Information Sheet

This sheet has been made based on the template provided by the University of Sheffield (The University of Sheffield, 2022).

Participant Information Sheet

Research Project Title

The effect of the virtual reality dolphin experience on students with pre-exam stress.

Invitation

You are being invited to take part in this research project. Before you decide to do so, it is important you understand why the research is being done and what it will involve. Please take time to read the following information carefully. Ask questions if anything you read is not clear or if you would like more information. Take time to decide whether or not to take part.

What is the project's purpose?

This research project aims to investigate to what extent a virtual reality dolphin experience (using VR-glasses) has a positive effect on the stress students experience before their exams. This is the first research project of its kind. But the project builds on research previously carried out by the University of California in San Diego, United States of America and has been designed to allow further research on this topic. The previous research has found great results by using VR-dolphin experience to treat the symptoms of people suffering from pain, depression, and anxiety disorders.

Why have I been chosen?

You have been chosen because as a student of Van Hall Larenstein you have indicated that you experience moderate to severe stress in your pre-exam period, and this makes you a candidate to participate in our research.

Do I have to take part?

It is up to you to decide whether or not to take part. If you do decide to take part, you will be able to keep a copy of this information sheet and you should indicate your agreement to the informed consent form. You can still withdraw at any time. You do not have to give a reason.

What happens when I take part?

You will be asked to sign the informed consent form about your personal data and set a mark on a stress scale to help us determine with which stress levels you participated in the study. After that we will put a sport bracelet on your arm to be able to measure your heart rate and heart rate variability to see if there are biological signs of relaxation in your body. Then you will be provided with virtual reality glasses and a 7-minute wild dolphin experience. This will take place in the room Va011 or Va012 at Van Hall Larenstein University. During the experience you will be able to observe dolphins swimming in the oceans like you are right in the water with them. During this experience one of the researchers will be present in the room with you. The researcher is present during your experience to be able to assist you in case you have any questions or experience problems and to observe your body language for signs of stress. Afterwards you will make another mark on the same scale to let us know how much/little stress you feel in that current moment. The whole process will take about 15 minutes.

What do I have to do?

Arrive 10 minutes before your time slot at Va011 or Va012 and participate in the research as described above.

Please come without make-up on your face, as the virtual reality glasses will cover parts of your face and can get dirty otherwise.

What are the possible disadvantages and risks of taking part?

Participating in the research is not anticipated to cause you any disadvantages or discomfort. However, some participants might experience nausea, dizziness, disorientation, loss of spatial awareness, eye soreness and seizures through the use of the VR-glasses. We advise that you don‘t participate in the research study if you have a history of epilepsy or brain injuries.

What are the possible benefits of taking part?

You might experience less to no stress at all after taking part in the virtual reality dolphin session.

Will my taking part in this project be kept confidential?

All the information that we collect about you during the course of the research will be kept strictly confidential. You will not be identifiable in any reports or publications. Data collected may be shared in an anonymised form to allow reuse by the research team and other third parties. These anonymised data will not allow any individuals or their institutions to be identified. For more information, please refer to the informed consent form.

Will I be recorded, and how will the recorded media be used?

You will not be recorded in any digital way.

What will happen to the results of the research project?

The results of the research will be used for the researcher’s bachelor thesis and possibly published later. You will not be identified in any report or publication. If you wish to be given a copy of any reports resulting from the research, please ask us to put you on our circulation list.

Who is organizing and funding the research?

The VR-glasses are funded by the Dolphin Swim Club Leeuwarden and the facilities are provided by Van Hall Larenstein University of Applied Sciences.

Contacts for further information

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Thank you for taking part in this research.

Appendix F: Hygiene Protocol

Hygiene Protocol

For the VR-Dolphin Experience Research

To ensure the hygienic safety of our research the following measures will be taken. The two researchers will take a corona test before week 9 to ensure that no infection with the corona virus is present. In week 9 every participant needs to disinfect their hands right when they enter the room. The pen they use to sign the informed consent form will be disinfected after every participant. Right after the VR-dolphin experience the VR-glasses will be disinfected with special wipes. The researchers will take any change of corona guidelines from the government into account and will change the hygienic protocol accordingly if necessary.

In the following will be a bullet point checklist to enable an easy check if everything has been taken care of before, during and after the research:

Prior to the data collection:

- Corona test for researcher at the end of week 8
- Two hand disinfectant sprays have been placed, one in each room
- Special disinfectant wipes are present for the students to wipe their faces with and for the material used on the data collection days
- Check Corona-Guidelines again in week 8 and the beginning of week 9

During the data collection:

- Disinfect VR-glasses after every use
- Disinfect pen after every use

After the data collection:

- Make sure everything is disinfected and saved securely
- Bins with wipes are emptied

Appendix G: Data collection process step-by-step plan

1. The experimental group and the control group students are ushered into a quiet empty room and seated in swivel chairs.
2. The experimental group and the control group are given a participation information sheet to read and a consent form to fill out and sign.
3. The experimental group and the control group get a paper with a scale on it. They are asked to put a mark on the scale somewhere between 0 and 100 to show how high they would say they are experiencing their stress.
4. The experimental group and the control group will be shown how the VR-glasses work and explained how it starts and how the session unfolds.
5. The experimental group and the control group will get the Polar Verity Sense heart rate sensors around their arm and these sensors will be set to record heart rate data.
6. The control group will be asked to sit and watch the videos of the wild dolphins in 2D using the VR-glasses while the experimental group will sit and watch the same video in 360° for the full virtual reality experience.
7. Each observer will sit across 1 student and score their behaviors on a score sheet while the students are in the VR-session.
8. After the VR-session, the VR-glasses and heart rate sensors are taken off and the students are allowed to take their time to come out of their experience. They can stay seated up to 5 minutes for as long as they feel is necessary.
9. Before they leave both the experimental group, and the control group students will be asked to fill out the scale they got in step 2 again. This time showing how high they are experiencing their stress after the VR-session.

Appendix H: Ethogram for stress-related behaviors in students

Table H1 Ethogram stress students

Type of behavior	Behavior	Code	Description of behavior
Stress			
Head			
	Biting lips	BL	Mouth parted and teeth sinking into the lower lip.
	Tightly shut lips	TSL	Upper and lower lips pressed firmly against each other.
	Fast head turning	FHT	Head moving quickly from side to side or up and down.
Hands			
	Knuckle cracking	KC	Playing with the fingers and producing cracking or popping sounds.
	Playing with your hands	PH	Fingers and hands moving, twisting, forming a knuckle, or stroking an object quickly.
	Nail biting	NB	Placing fingers in the mouth and biting the nails off.
Torso			
	Elevated shoulders	ES	Shoulders held up in the air in a tense posture.
Legs			
	Feet wrap	FW	Wrapping the feet around each other or the legs of the chair quickly and changing it often.

Appendix I: Score sheet for stress-related behavior in time

Table I1 Score sheet, code behavior and time

Time (seconds) / ***Code (behavior)***	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240	250	260	270	280	290	300	310	320	330	340	350	360	370	380	390	400	410	420
BL																																										
TSL																																										
FHT																																										
KC																																										
PH																																										
NB																																										
ES																																										
FW																																										