EFFECTS OF VIRTUAL NATURAL ENVIRONMENT AND MEDITATIVE GUIDANCE TO STRESS REDUCTION IN THERAPEUTIC APPLICATIONS

Ilmari Jyskä

Faculty of Information Technology and Communication Sciences
M. Sc. Thesis
December 2020
ABSTRACT

Ilmari Jyskä: Effects of virtual natural environment and meditative guidance to stress reduction in therapeutic applications.
M.Sc. Thesis
Tampere University
Master's Degree Programme in
December 2020

Previous studies and professional literature suggest that children suffering from severe anxiety could benefit from a relaxation application for therapeutic purposes. This thesis studies the effects of virtual natural environment and meditative guidance to relaxation and stress reduction, with the aim of investigating the suitability of those methods for a therapeutic application.

The study consists of a remote experimental research of a therapeutic meditation application prototype built with Unity. Original implementation of the prototype was built in a research room in Tampere University facilities, but due to the situation with the Covid-19 virus in spring 2020 in Finland, it was not possible to study the effects of it on location, thus the research was conducted remotely with online methods.

This research was done with 20 research participants, and it uses between-subjects design with three levels of independent variables. These variables are three different versions of the prototype; one version was only the audiovisual virtual natural environment with no relaxation instructions, another version included a meditative guidance audio to the virtual natural environment, and the third version was the full version of the prototype, which included a visual stimulus to the meditative guidance in form of an instructive virtual guide character.

Online questionnaires, structured interviews and researcher’s observations during the research situation were used to gather dependent variables and additional data, while online meeting service was used as the research platform, and online video service was used for presenting the prototype.

The results of the research suggest that the use of meditation guidance increases the relaxation effect of the virtual natural environment regarding reported levels of tension. However, no statistically significant difference was found on the reported levels of anxiety and relaxation. Furthermore, a general positive effect was found in all levels of the independent variable, confirming the findings from previous studies which suggest that experiencing a peaceful audio-visual virtual natural environment via computer screen and sound system has a relaxing effect to motivated users.

Key words and terms: Stress reduction, virtual natural environment, guided meditation, remote experimental research, user experience, sound design

The originality of this thesis has been checked using the Turnitin OriginalityCheck service.
Acknowledgements

I would like to express my gratitude to professors Kaija Puura and Markku Turunen for their excellent supervision – 2020 ended up being a rather challenging year to conduct a research, and your support played a fundamental role in this relatively long process.

I would also like to thank Elina Eloranta and Jaana Tikkanen for their contribution to the design and implementation process of the prototype studied in this research, John Mäkelä for his essential help with the Unity project, Elina Korpi-Hyövälti for bringing the meditation guidance alive with her voice, Abraham Braun for providing the original version of the background video, and all research participants for making this research possible.

Last but not least, I would like to thank my family and friends. I know I have been too busy for my own good, and distant at times, but you have always been there for me with your heartwarming support. Kiitos.

Tampere, 8th of December 2020

Ilmari Jyskä
Contents

1 Introduction ............................................................................................................................................... 1

2 Background ............................................................................................................................................... 4
  2.1 The use of virtual reality in psychiatric therapy .............................................................................. 4
  2.2 Sound as a form of therapy ................................................................................................................ 5
  2.3 Mindfulness meditation ....................................................................................................................... 6

3 Prototype design ..................................................................................................................................... 7
  3.1 General information about the design process .................................................................................. 7
  3.2 The virtual natural environment ....................................................................................................... 9
  3.3 The meditation guidance audio ......................................................................................................... 10
  3.4 The virtual guide character ............................................................................................................... 11
  3.5 The prototype application ................................................................................................................. 12
  3.6 Research versions of the prototype: The independent variable ..................................................... 12

4 Research methods .................................................................................................................................. 14
  4.1 Research ethics ................................................................................................................................. 14
  4.2 Participant registration ...................................................................................................................... 15
  4.3 The remote experimental research .................................................................................................. 17

5 Research results ...................................................................................................................................... 24
  5.1 Registration form .............................................................................................................................. 24
  5.2 Pre-research questionnaire ............................................................................................................... 24
  5.3 Observations during the remote experimental research ................................................................... 24
  5.4 PANAS-SF questionnaire ................................................................................................................. 25
  5.5 Research group balance comparison ............................................................................................... 26
  5.6 Current State Of Mind 1 & 2 questionnaires (CSOM1 & CSOM2) ................................................ 27
  5.7 User Experience Questionnaire + .................................................................................................. 29
  5.8 Structured Interview ......................................................................................................................... 30

6 Discussion .............................................................................................................................................. 34
  6.1 Virtual natural environment ............................................................................................................. 34
  6.2 Meditation guidance .......................................................................................................................... 35
  6.3 Virtual guide character ..................................................................................................................... 36
  6.4 Research protocol .............................................................................................................................. 37
  6.5 Answers to the research questions ................................................................................................... 39
7 Conclusion ................................................................................................................. 40
    7.1 Summary of the main findings 40
    7.2 Limitations 41
    7.3 Recommendations 42

References .............................................................................................................43

Appendices
1 Introduction

Psychiatric referrals to children in Finland have been steadily increasing in the 21st century, straining the available health care resources. During the year 2018, 50 756 Finnish children received psychiatric treatment, whereas in 2008 the amount of child patient cases was 34 057 (THL, 2019). Mental disorders decrease the cognitive abilities of children and affect their social relationships negatively, increasing the risk of learning problems and social exclusion in the vital phases growing up, which can ultimately lead to significant expenses to the society in addition to the ethical costs (Kazdin and Blaze, 2011; Sourander et al., 2016). There existed an increasing need for developing new cost-effective and safe methods to psychiatric treatment for children (Happo, 2018) even before the current global stress factor of the corona virus pandemic, which is bound to have a negative impact on children’s mental health. Recent scientific findings offer insight on possible future technological solutions addressing this issue.

Being in a real natural environment has been found to cause psychological health benefits. Especially forest environment seems to offer clear positive effects to mental health. Positive effects of nature, and especially green areas, include stress recovery, relaxation and empowerment (Nielsen & Hansen, 2007; Lee et al., 2014). Several recent studies suggest that also the use of virtual natural environments has significant potential in the area of psychological healthcare. A review by White et al. (2018) concluded that while real natural environments are preferred, virtual natural solutions are a viable alternative for therapeutic purposes and offer possibilities in psychiatric and medical care, but the risks, benefits and cost-efficiency should be carefully assessed, and the effects of such solutions should be measured in a scientifically valid manner.

Meditation programs has been found to have positive effects on mental health, reducing multiple negative dimensions of psychological stress. In their review and meta-analysis of the subject, Goyal et al. (2014) concluded that while clinicians should be aware of the positive effects of meditation, further research on the topic is needed to determine the possible role of meditation in mental health therapy. The positive effects of meditation are likely to be linked to conscious breathing and mindfulness, which form the fundamental basis for most meditation exercises. Zaccaro et al. (2018) stated in their
review that slow breathing techniques have a potential to increase the level of relaxation and feeling of comfort, while reducing the feelings of anxiety and depression. This implies strong potential for therapeutic applications.

However, no previous studies have addressed the issue of combining guided meditation exercise to virtual natural environment with the intent of comparing the effects to plain virtual natural environment. This thesis is based on hypothesis that if both virtual natural environment and meditation exercises can have positive effects to psychological wellbeing, the combined effect of the two is likely to be also positive and plausibly stronger than the effects of a plain virtual natural environment.

In late 2019, a group of Tampere University Human-Technology Interaction MDP students designed a prototype of a therapeutic relaxation application for children with mental disorders in collaboration and supervision of experts from emotion regulation research group of Tampere University MED-department. The writer of this thesis, Ilmari Jyskä, was a member of the student group. The prototype application is based on visual and auditory mindfulness and guided meditation in virtual natural environment, and it uses a virtual guide character to support the auditory meditation guidance dialog. The prototype is an attempt to provide a new additional tool for psychiatric treatment for children suffering from stress and anxiety.

This thesis presents an experimental research to evaluate the effects of this prototype, and the aim of it is to provide tentative answers on whether the methods used in the prototype could provide new cost-effective tools for psychiatric health care for children. More importantly, it tries to justify future research on the subject with an improved version of the prototype studied in this thesis. If the methods used in the prototype are effective, more research is highly recommended, as an effective digital therapeutic solution could reduce the strain on public health care resources.

Special attention is given to sound design aspects of the research, as sound is a powerful and common tool for influencing emotions in media productions (Görne, 2019), and the writer of this pro gradu, Ilmari Jyskä, is a BA in Film and Television with several years of professional working experience as a sound designer.
First research question to be answered by this study is to verify the result of prior studies:

1. Does virtual natural environment stimulus have effect on stress reduction?

If the virtual natural environment of the prototype causes stress reduction, it is important to measure the effect of it in order to be able to evaluate the possible additional effect caused by meditation exercise, which forms the second research question:

2. Does virtual meditative guidance in virtual natural environment have an additional effect on stress reduction?

Furthermore, as the experimental research in this thesis was eventually conducted remotely via internet connection due to the situation with SARS-CoV-2 in Finland, it presents one way to conduct an experimental research remotely, and provides an insight on participant experiences of remote experimental research conducted with the help of an online meeting service and other relevant online tools. Although remote methods are unlikely to surpass traditional research methods in reliability and scientific validity, they offer flexible and accessible ways to participate in experimental research. The third and last research question is:

3. What are the general characteristics of a research participant experience regarding the remote methods used in this research?

In the following chapters this paper first goes through current scientific background of the topic. It is followed by description of the prototype design process, before continuing to description of the experimental research conducted, which is covered in chapters Research Methods and Research Results. Discussion chapter discusses the results of this study, and the paper ends in Conclusions chapter, which summarizes the main findings, states the limitations of the study, and offers recommendations for future research.
2 Background

This chapter presents the current scientific background of this thesis, and the aim is to provide more information to the subjects presented in the introduction chapter.

It is divided into three parts, first going through the use of virtual reality solutions in psychiatric therapy, before focusing on sound as a form for therapy, and ending the chapter with a brief look on mindfulness meditation.

2.1 The use of virtual reality in psychiatric therapy

Virtual reality applications can be powerful and cost-effective tools in psychiatric treatment because the user experience of patients can be replicated, tested and modified in safe virtual environment. According to the review by Maples-Keller et al. (2017), VR therapy solutions can be an effective form of therapy in a variety of mental disorders, including post-traumatic stress disorder (PTSD), obsessive-compulsive disorder (OCD), phobias, social anxiety disorder and generalized anxiety disorder. Perhaps the most common method of using VR as a form of therapy is virtual reality exposure therapy (VRE), which is based on emotional processing theory, in which emotional memories are considered as information structures regarding the stimuli, responses, and meaning. In exposure therapy, the patient is presented a triggering stimulus in a safe virtual environment, where the amount of exposure can be controlled without compromising the immersion of the stimulus. The goal of these virtual interventions in VRE is to activate and modify these information structures by presenting scenarios that trigger the source of anxiety but also present incompatible information to the existing information structures, facilitating emotional processing. First research to suggest the effectiveness of VRE was published in 1995 by Rothbaum et al., who studied using VRE as a treatment for acrophobia. Since then, VRE has been used to treat a variety of mental disorders, one example being the therapy for veterans with combat-related PTSD.

As technology has advanced, more subtle options to use virtual reality in psychiatric therapy have emerged, and VR solutions have also been used effectively to induce relaxation and reduce stress. Pizzoli et al. (2019) states that VR solutions is an evolving technology, with improving technology offering increased immersion and AI solutions paving way for more engaging and even personalized VR experiences. Pizzoli presents two main methods for achieving relaxation: stress reduction by relaxing VR stimuli, and
emotional regulation by interaction with VR contents, and suggests that the two approaches can and often should be used in combination to achieve the best results.

Ojala et al. (2019) used a virtual natural environment experienced via TV screen to study stress recovery in office environment, and the method was found to be easy and cost-effective solution to produce positive effects in stress recovery and relaxation. The results from Ojala’s study suggests that VR glasses or large projections are not necessarily needed in order to present virtual natural experiences with positive effects.

In their conference paper RelaWorld: Neuroadaptive and Immersive Virtual Reality Meditation System (2016), Kosunen and his colleagues presented their study of a delicate VR implementation of a mindfulness meditation exercise. They concluded that the system, which was based on neurofeedback, was regarded by the research participants as more effective than traditional mindfulness exercise. However, the study did not compare the meditation exercises to the effects of the VR environment.

2.2 Sound as a form of therapy

Music and certain soundscapes have been widely accepted to having potential to positively influence the mental health and mood. Music activates the rewarding system of human brains, and music therapy can be used to treat depression and to help relieve pain (Pitkäniemi et al., 2020). Natural soundscapes have also been found to have stress relieving effects. Sound stimuli can trigger pleasant (or unpleasant) memory structures, but even more importantly, a steady natural soundscape can help human mind to relax, as the hearing ability cannot be switched off, and a pleasant soundscape can cover other more unnerving sounds. The calming effect of natural sounds, such as birds singing or gentle waves hitting the shore, is also genetically imprinted to human brains via evolution (Thoma et al., 2018, Parkkinen et al., 2020).

A pilot study by Annerstedt et al. (2013) studied the effect of sounds in a virtual reality forest by conducting an experimental research where stress recovery was studied with between subjects -design in three different virtual environments. One environment was a virtual forest with congruent sounds, whereas others were the same virtual forest without sounds, and a control group of no virtual forest at all. The study was conducted on healthy
Swedish males, aged 21-56, and its main finding was that sound was essential in producing the effect of stress recovery. The group that experienced the environment with sound showed improved stress recovery in comparison to the other groups. The silent nature experience did not work for stress recovery, and some participants even reported uncertainty or unpleasantness, stating that they anticipated that something scary might appear. The calming effect of sound is missing, and visual stimuli alone is too open for interpretations for therapeutic purposes.

2.3 Mindfulness meditation

Meditation is thousands of years old practice of training attention and awareness to achieve a mentally clear and emotionally calm and stable state. It is commonly thought that meditation can significantly reduce stress and anxiety, as well as enhance peace, perception and general well-being.

In clinical trial Bhasin et al. (2018) found that mindfulness meditation had clear positive measurable effects on research participants during an eight-week period. Genes that regulate inflammation, circadian rhythms and glucose metabolism had caused a meaningful decrease in the research participants’ blood pressures, which is an indication of a stress-reducing effect.
3 Prototype design

The main focus of this thesis is the remote experimental research, and this chapter gives only a short summary of the design process with the aim of providing background information about the prototype.

![Figure 1](image)

**Figure 1.** Physical implementation of the prototype in a research room of the Arvo building of Tampere University. Photos are from the work-in-progress phase of the implementation process.

3.1 General information about the design process

The design and implementation process of the prototype studied in this research started in September 2019 and ended in April 2020. The project started as a course assignment in the Tampere University course Human-Technology Interaction Project Work, an advanced course supervised by Markku Turunen, professor from Tampere University Faculty of Information Technology and Communication Sciences. This main phase of design process was done as a group work and in collaboration with professor Kaija Puura from the Emotional Regulation (EMORE) research group of Tampere University MED-department. Members of the student project group were Ilmari Jyskä, Elina Eloranta and Jaana Tikkanen, all second year MDP in HTI students, and the group also received help from John Mäkelä, Tampere University employee and Unity specialist. After the course ended in January 2020, the prototype design was further developed by Jyskä with guidance from Mäkelä, Turunen and Puura.

It was agreed that the project group would produce a prototype that can be used with three different settings for research purposes. One operating setting would include only the virtual natural environment, another would include scripted meditation guidance to the virtual natural environment, and one version would also include a virtual guide character.
to help users focus to the meditation guidance. It was noted that while the project group had a relatively good skillset for producing the first two versions, the project group lacked experience regarding issues related to virtual character animation.

The student project group operated in a democratic manner and no project manager or leader was appointed. The first months of the design process was based on literature review and brainstorming sessions, with various course and project related meetings supporting the progress. The design progress was iterative, producing several different early development versions of the prototype with the help of video production tools. Eventually, Unity 3D development platform was used to produce a working prototype application, and the physical version prototype was implemented to a research room in the Arvo building of Tampere University Kauppi campus. The project group was responsible for producing a working prototype software, based on a script by written by Puura, while technical implementation and engineering of the room was done by Tampere University technical staff. The target user group of the prototype was set to children of age 6-17, who are suffering from severe anxiety.

Most of the design and implementation work was ready when the course ended and the student project group assignment was finished in a seminar in 23th of January 2020, but at this time it was already agreed that the project will be continued as the master’s thesis work of Jyskä. The development of the prototype was continued by Jyskä until the final physical version of the prototype was ready for research with participants in March 2020.

Final changes to the design were forced by the corona virus pandemic, as the closing down of Tampere University facilities canceled the plan to test the physical prototype in Arvo building. This caused major changes to the research protocol and made it mandatory to redesign the presentation of the prototype for remote research participants. As the size of the screen, internet connection and general operating platform were no longer balanced between the participants, it was decided that video versions of the prototype made from the final version of the Unity project would best serve the changed research situation, which caused some fine-tuning to the visual elements of the prototype.

For more detailed understanding of the design process, it is necessary to focus on four main priorities of the prototype development:

- Production of the virtual natural environment
- Production of the meditation guidance audio
• Software development of the prototype application
• Production of the virtual guide character

3.2 The virtual natural environment

The original target platform for audiovisual virtual natural environment design was the research room in Kauppi campus. Visual presentation of the virtual natural environment was to be projected to a circa 3m x 3m white screen in the room with two full-HD projectors, allowing a total resolution of 2160 x 1920 pixels for the projected image. This was the target resolution for the visual side of virtual natural environment development. The room had two high-quality loudspeakers installed to both sides of the screen, calibrated to produce high quality stereo sound to the location of the user. The room had also atmospheric and adjustable lighting, and gentle green light for the room was chosen to support the virtual natural environment.

During the design process Tikkanen and Eloranta focused on visual appearance of the virtual environment, while Jyskä focused on producing a suitable audio landscape for the environment. The project group set out to implement two different environments to the prototype, a beach and a forest. Visual design team searched various video libraries for high quality 4K nature videos with still camera picture and a place for the virtual guide character in the middle of the picture, as there were no real possibilities to produce a new video with our resources and deadline. Although suitable and available high-resolution video for both the beach and the forest scenario were found in December 2019, the group decided to focus on the forest scenario as other tasks required more attention. Final version of the virtual natural environment was based on looping a relatively short high-quality video of a relaxing looking forest. The longer looped version was carefully prepared by Eloranta, and the project group estimated the result as suitable for prototype and research purposes. The virtual natural environment was essentially a 6-minute realistic forest video with still point-of-view camera and 2180 x 1920 resolution.

In April 2020 the new research protocol required to change the target resolution to standard full-HD 1080p (1920 x 1080 pixels). Camera perspective and virtual character location was changed to better suit the new screen dimensions. The research version of the prototype was essentially a screen capture of the prototype application.

Sound design regarding the virtual forest environment was based on a stereo recording from the countryside of Raasepori, Finland. It was recorded by Jyskä with Zoom H6 in
June 2016 on a small road between a meadow and a forest, at around 6am in the morning on a sunny summer day. Jyskä cleaned, edited and mixed the raw recording with Protools 10 software, and produced a 6-minute stereo audio file of continuous pleasant nature ambience for this prototype. The main element of the sound file is the singing of Finnish summer birds, and no cars or other sounds of artificial nature are audible.

3.3 The meditation guidance audio

Initial version of the script for the meditation guidance dialog in the application was written by Puura. The script was based on breathing and mindfulness exercise, and it consisted of six different phases:

1. Introduction to the exercise
2. Setting the body posture
3. Conscious slow breathing
4. Relaxing the body
5. Relaxing the mind
6. Returning to normal mental state

Audio production of the dialog was Jyskä’s responsibility. Elina Korpi-Hyövälti, 32 years old woman at the time of the recordings, was selected to be the voice actor for the prototype, mainly due to practical reasons. Korpi-Hyövälti was skilled and available, her voice was evaluated to be pleasant, and she was motivated to contribute to the project without any financial gain. This made it possible to record the first demo version of the dialog soon after receiving the first version of the script. This first audio versions of the script were recorded by Korpi-Hyövälti herself using a standard smartphone as a recorder, while Jyskä provided instructions for microphone placement and artistic guidance to the tone of voice via social media messages. The resulting raw dialog audio was cleaned and edited with ProTools 10 software by Jyskä. This first version of the dialog was made only for demonstration and development purposes, and the resulting sound quality was estimated to be well sufficient for this phase.

The demo version helped the project group to evaluate the script and dialog rhythm, and after analyzing the demo, improved version of the script was done in collaboration with Puura. The revised script was recorded with Korpi-Hyövälti in Tampere University facilities by Jyskä and Tikkanen. Zoom H6 portable recorder was used as the recording equipment, and several takes of the script was recorded. This material was used to
produce the final version of the mediation guidance audio with ProTools 10 software. Most of the work regarding meditation guidance audio was finished in January 2020 when the group work ended, but Jyskä did minor improvements to the dialog material during spring 2020, while working on the Salsa asset of Unity, which produced the lip sync of the virtual guide character. Although the audio was well sufficient for humans, the asset proved to be picky, and several syllables of the dialog needed to be further clarified for the asset to work properly. At times this caused a slight decrease in the quality of the dialog sound. Final timing of the meditation guidance dialog was done using the Unity Timeline asset.

Final version of the meditation guidance audio was ready in April 2020.

3.4 The virtual guide character

The virtual character design and animation to support meditation guidance dialog was initially considered to be of lower priority than the other development categories, due to lack of resources and limited time. However, as the project progressed well on schedule in other development categories, more focus was allocated to virtual guide character design. Eventually, two virtual characters were designed, first being a 2D bunny character of the early prototype versions, and the second being the 3D human virtual character of the prototype studied in this research. The production of the virtual characters took considerable amount of time and effort, and all group members were equally invested in the process during the group work phase. After the project work course ended, Jyskä continued the animation work of the 3D virtual guide character until March 2020.

The final version of the guide character performs instructive gestures from the script and features a lip sync animation according to the dialog. It was implemented with the help of Tampere University Unity specialist John Mäkelä to Unity 3D development environment. Adobe Fuse was used to create the 3D model of the virtual character, and Adobe Mixamo was used to create animations for the model. The reasoning behind the selected method was that Adobe Fuse provided free and adjustable 3D models for the character, and the model could be animated in Adobe Mixamo with free animation packages. Unity Timeline was used to control the animations in sync with the meditation guidance audio, and Salsa asset could be used to provide lip sync for the guide.
3.5 The prototype application

Unity 3D was the main platform used to build the prototype. Coding of the prototype was done by Jyskä and Tikkanen with significant help from Mäkelä. The animations prepared in Adobe Mixamo were used to animate the character in Unity Timeline, which served as the basis of the prototype application code. Unity Version 2018.3.14f1 was used as it was known to work with the selected production methods. The resulting application has a virtual natural environment playing in the background, while virtual guide character performs gestures in align with the audio instructions of the meditation guidance.

The application design included an interactive timeline, which would have made it possible to control the progress of the meditation exercise according to user behavior. However, because of both practical reasons and research purposes the prototype application was implemented with a linear timeline.

After the course ended in January 2020, the development was continued by Jyskä as the prototype still had some known and significant flaws. Final version of the prototype for testing in the research room was ready in March 2020.

3.6 Research versions of the prototype: The independent variable

Prototype application design ensured that three different research versions could be easily produced by removing elements from the full version. All three different versions produced for the research had equal length and the same virtual natural environment.

1. **Full version**, including virtual guide character and meditation guidance
2. **No virtual guide character**, meditation guidance dialog included
3. **Only virtual natural environment**, no meditation guidance

![Figure 2. Screenshots from the research versions of the prototype.](image-url)
In March 2020 the situation with the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) in Finland caused the premises of Tampere University to close down from students and visitors, which forced to cancel the idea of testing the physical version of the prototype.

After rewriting the research protocol according to the new situation, the prototype entered the last phase of the development process. As the only viable option to test the prototype was via remote testing, it was decided that the prototype will be tested remotely via online video service. This final development phase was done in April 2020 by Jyskä, and it included changing the target resolution to standard 1920 x 1080 pixels, (Full HD, 1080p), changing the camera perspective and virtual character location to better suit the new screen dimensions, and some additional fine-tuning to the animations and rhythm of the guidance.

Encoding video versions out of the Unity project faced some difficulties, as it turned out that the timeline recorder asset in Unity caused audio corruptions and sync problems to the dialog while encoding the videos. As the problem could have been based on Unity version used, or caused by the lip sync asset, and there was no guarantee that other recording assets would work any better, a different approach was tried. OBS Studio software was used to capture video and audio of the screen while running Unity builds. Resulting video files lacked some color information and some sharpness of the picture was lost, but it was considered as being the best solution with available resources and timeframe. Captured video files were edited and color corrected in DaVinci Resolve, and the final results were uploaded to YouTube. Video files suffered further quality losses in YouTube, but the end-result was considered of high enough quality for prototype testing purposes. However, it was noted that the videos must be viewed in HD 1080 resolution, as the picture became notably blurry in lower resolutions.
4 Research methods

This chapter contains a detailed description of the research methods used to study the prototype design in relevance to the research questions. The study was conducted as a remote experimental research with between-subjects design with three prototype versions. Reasoning behind the research design was that in order to be able to measure the effect of meditative guidance accompanied by virtual environment stimulus, it is mandatory to observe the effect of plain virtual environmental stimulus in the research setting. Furthermore, this research design offers insight on how using a virtual guide character affects the effect of meditation guidance. The main language used in the research was Finnish, and all English translations for this paper are done by the researcher.

4.1 Research ethics

Although the target group of the prototype is children suffering from stress and anxiety, it would be highly unethical to test this first prototype on actual child patients. This research used volunteer adult participants interested in the topic, in order to get preliminary results on the effects of the prototype, and to pave way for possible future research with children.

Reducing stress and anxiety as a topic requires great care and protection of participant privacy is critically important. This need for privacy is even stronger in remote online research situations. To ensure that no data breach could be traced to the research participants, an ID number was given to each participant upon registration, and all further questionnaires filled during the research included only the ID number as the identifier, and only the researcher had the means to connect the ID number to the background information about the participant.

No video or audio recording was captured during of the research situation – all observations and interview data was recorded by writing by the researcher during the research situation. The decision to not record the research situation was based on two reasons. It was done not only to further ensure the privacy of the participants, but also and perhaps even more importantly, to create a feeling of safety and trust to the
participants, who knew they were being observed via their webcams during the research situation.

Research participants were informed several times during the research about their right to cancel the experiment at any point without any consequences. The goal of the ethics in this research was that all participants would feel safe and appreciated, regardless of their experience with the prototype. The research aimed for equality regarding participant experience, and the research followed a written script in most of the communication between the researcher and the participant, only exceptions being unexpected technical or practical problems during the research.

4.2 Participant registration

The remote experimental research was conducted with 20 Finnish adult participants in May 2020. The participants were recruited by sending a letter of invitation via Tampere University intranet, as well as invited from a pool of research participants gathered by EMORE research group. Letter of invitation included a link to an online registration form, using Google Forms as the platform for the first direct contact between the researcher (Ilmari Jyskä) and the research participants. Both the letter of invitation and the online registration form included basic information about the research. The target group for research participants was native Finnish adults with good English language skills. It was specifically stated that the research participants do not need to identify themselves as anxious persons.

The registration form collected the following information:

- Name
- E-mail
- Phone number
- Gender (Male/Female/Other)
- Age
- Normal eyesight (Yes/No)
- Normal hearing (Yes/No)
- Additional information / wishes regarding contact time (optional)

The registered research participants were then contacted by the researcher via telephone within a week from the initial registration. Before the call, the participant was given a three-digit participant ID number. The call was scripted in order to maintain professional impression.
During the phone call, research participants verified their interest to participate in the research, and a schedule for the actual research was agreed upon, and additional information about the research to participants was delivered - including how privacy issues are taken care of during the research, and their right to cancel their participation at any time. Some information was deliberately left untold, like the between subjects-design of the research and other details of the research protocol. At the end of the call, participants were asked if they had any questions, and more information was provided as needed.

After each phone call, the verified research participant was invited to a Microsoft Teams meeting according to the schedule agreed upon during the phone call, using the e-mail address given in the initial registration. The invitation included instructions for the research situation and contact details of the researcher, along with the participant ID number, and a link to pre-research information questionnaire for research participants in Google Forms.

The pre-research questionnaire was made with Google Forms, and it collected the following data:

- Participant ID number
- How anxious do you feel yourself? (Likert scale from 0 to 10)
- How worried are you about the covid-19 virus? (Likert scale from 0 to 10)
- Do you practice mediation or yoga? (Yes/no)
- Do you have an attention deficit disorder? (Yes/no)

This pre-research data was used to divide the research participants to three groups with as good balance as was practically possible. This process was done during the research and with limited amount of information regarding the final number or attributes of research participants.

First participant registration to the research arrived circa one hour after the letter of invitation was released in Tampere University intranet in 7th of May 2020, and the last registration arrived in 21st of May 2020. The remote experimental research meetings in Microsoft Teams were conducted between 14th of May to 28th of May 2020. Each registration was successful in providing a remote experimental research participant.
4.3 The remote experimental research

Researcher used two laptop computers to manage the research situation. Laptop A was used to run the Microsoft Teams application and connect directly with the research participant. Laptop B was used for observing and verifying the incoming data in Google Forms, and also provided the script for the research situation along with data input questionnaire for researcher, which was also produced with Google Forms. All the research forms started with the question about research participant ID number, including the researcher’s data input questionnaire. This procedure caused all the .cvs files from the questionnaires to be in identical order, all beginning with timestamp and participant ID number, which made data verification and combination easy and effortless.

In addition, a physical paper with first name, phone number, research date and time, and group selection was prepared for each research participant. This was used for making additional notes and simple calculations during the video call, in addition to providing fast access to contact information in case of problems. These papers were stored in privacy of the researcher’s home, before being shredded after the research.

4.3.1 Researcher’s data input questionnaire

The questionnaire was built on top of the script of the experiment, making it possible to follow the script and input data during the experiment from the same page. The questionnaire included the script, and this solution was aimed to make both the research situation and data analysis as smooth as possible. Following questions were included in the questionnaire:

- Participant ID
- Time of the experiment
- Does participant use headphones? (Yes/No)
- Independent variable (Group)? (Group1/Group2/Group3)
- Observations during the prototype testing (Open field)

Structured interview:

- Q1: “Did you experience technical problems during the playback of the video?”
  o Open field
- Q2: “What is the size of the screen of the computer you are using?”
  o Small/Normal/Large
- Q3: “Can you imagine yourself being interested of using a similar product at some point in the future?”
  o Yes/No
• Q4: “Is there something else you wish to say about the prototype?”
  ○ Open field

• Q5: “Have you ever participated in a research before this one?”
  ○ Yes/No

• Q6: “How was your experience in this remote research setting?”
  ○ Positive/Neutral/Negative + Open field

4.3.2 Starting the research situation

Meetings in Microsoft Teams were not recorded in order to keep the situation as comfortable as possible. However, participants were asked to keep their webcam and microphone open through the experiment, as means to observe the test situation. Webcam feed of the researcher was closed during the test situation, but it was opened after the data collection period of the experiment. Microphone of the researcher was turned on except when the participant was watching the video of the prototype.

Once live connection between the participant and the researcher was established in Microsoft Teams, the researcher verified from the participant that the connection was working properly. Possible technical problems were solved if observed. If participant’s camera was turned off, researcher asked participant to open it while going through the introduction phase of the video call.

During the introduction, participants were welcomed to the experimental research and noted that the video call will not be recorded. They were briefed about the structure and estimated length of the research situation, and informed about the data collection methods (questionnaires, observations, interview), as well as reminded of the anonymity and privacy aspects of the research, and about their right to end and cancel their participation to the research at any point without consequences. At the end of the introduction phase the participants were asked if they had any questions before continuing with the research.

After the introduction, a technical test was done to verify that the prototype can be tested. An advertisement of Tampere University Computer Sciences programmes was used as a neutral test video. Participants received a link to YouTube video in Microsoft Teams message window and were asked to open the link and verify that it can be viewed in full-screen mode in 1080p HD resolution, without any disruptions or reduced quality to the sound or picture. In case there was some technical problems, the researcher tried to solve them with the participant before continuing with the experiment. As soon as the
participant confirmed that the test video was playing in full-screen mode and with HD resolution, the technical test was considered passed and the experiment continued.

In case a participant had not returned the pre-research questionnaire before the experiment, he/she was asked to do so at this point. This was a rare occasion, and it happened only with one research participant.

4.3.3 PANAS-SF questionnaire

The participant was first given a link in Teams to an English language version of the PANAS-SF questionnaire implemented in Google Forms. Although the research was conducted mainly in Finnish, it seemed practical to use the English version of the PANAS-SF as no official Finnish translation of it exists. All official texts were included in the questionnaire, accompanied by short instructions in Finnish.

The questionnaire started with participant ID question, and it was followed by the 20 official questions of PANAS-SF questionnaire. PANAS-SF uses 5-point Likert scale with labels. As Google Forms doesn’t support labelling each point in the scale, instructions and each PANAS-SF question included an additional line of text which stated the labels: "1. Very slightly of not at all - 2. A little - 3. Moderately - 4. Quite a bit - 5. Extremely". This information was collected in order to gain trustworthy insight to the mindset of the research participants, to verify the balance between the research groups, and to study possible correlations that might occur with other research data.

Before starting to answer to the questionnaire, the participant was encouraged to ask for a translation if any of the terms in the questionnaire seemed unfamiliar.

Translations and additional explanations for each emotion was prepared from combining information from Cambridge Dictionary, Sanakirja.org and Google Translate. Most of the research participants asked for a translation to one or two emotions, and these answers were provided by reading from this prepared document.

When the participant was ready with the questionnaire, the researcher verified that the answers had arrived in Google Forms, and verified that the correct participant ID number was being used, before moving on to the next task.
4.3.4 Current State Of Mind 1 questionnaire (CSOM1)

After the PANAS-SF questionnaire, the participant was asked to answer to a unique questionnaire prepared for this experiment, called Current State Of Mind 1 (“Tämänhetkinen oloilasi 1”). A copy of this questionnaire can be found from Appendix 1 of this paper.

The first question in the questionnaire asked participant ID number, and the rest included 3 Likert scales (0-10) regarding three feelings the prototype targets: Anxiety (“Ahdistuneisuus”), Tension (“Jännityneisyys”) and Relaxation (“Rentoutuneisuus”), and it was used to report the current subjective emotions the participant is experiencing during the experiment.

This information, in combination with data from Current State of Mind 2 questionnaire (CSOM2), is considered as the main meter for the effect of the prototype. The idea of the questionnaires was derived from the VAS (Visual Analog Scale) questionnaires. The largest possible number of different points (11) in Likert scales in Google Forms can be achieved by using the scale 0-10.

The questionnaire instructed the participant to give their subjective self-measurement of their current state of mind, and the participant was verbally instructed to answer quickly and with their initial feeling without thinking too much about it.

When the participant was ready with the questionnaire, the researcher verified that the answers had arrived in Google Forms, and verified that the correct participant ID number was being used, before moving on to the next task.

4.3.5 The Independent variable: Using the prototype

The participant was given a link to a YouTube video of the prototype according to the research group he/she was appointed to. The design chapter of this document includes the details of preparations for this task. The three different versions of the prototype were:

- GROUP 1: FULL VERSION
- GROUP 2: NO VIRTUAL GUIDE CHARACTER
- GROUP 3: ONLY NATURE

The participant was verbally prepared and instructed to watch a 6-minute YouTube-video of the prototype, asked to make sure the video opens in full screen mode and with HD resolution, and instructed to focus on the video and aim for relaxation.
When the video started playing, the researcher muted his microphone, unless some technical problems could be observed. During the 6-minute time period of participant watching the video, the researcher made observations about the research situation and participant behavior, with the main focus on participant’s eyes and analyzing from sounds whether there were external disturbances. In addition, the participant’s answers to CSOM1 questionnaire was checked at this point, and the researcher also filled the following questions from the researcher’s data input questionnaire:

- Does participant use headphones? (Yes/No)
- Independent variable (Group)? (Group1/Group2/Group3)
- Observations during the prototype testing (Open field)

After the participant reported having finished watching the video, he/she was given the next task.

4.3.6 Current State Of Mind 2 questionnaire (CSOM2)

After watching the video, the participant was asked to answer to the Current State Of Mind 2 questionnaire (CSOM2), which was identical to the questionnaire CSOM1, but saved the results to a different file. The participant was again asked to answer quickly and with their initial subjective feeling without thinking too much about it. The possible changes between the CSOM1 and CSOM2 questionnaires was the main meter in this experiment.

When the researcher could see the answer from the participant, the participant was given the next task.

4.3.7 User Experience Questionnaire + (UEQ+)

The participant was informed that this is the last and rather long questionnaire, and that the language is again English due to UEQ+ being a widely used modular UX questionnaire with no official Finnish translations. However, it should be noted that there does exist an unofficial Finnish translation of the UEQ+, but the decision to use the English version was done because of poor quality of the translation.

During research preparations, careful consideration was used to select five most fitting categories from the category selection in UEQ+ for evaluating the prototype. The implementation of the questionnaire was done in Google Forms.
This research uses the following categories of UEQ+:

- Attractiveness
- Efficiency
- Usefulness
- Value
- Visual Aesthetics

4.3.8 Structured Interview

After the UEQ+ questionnaire, structured interview was conducted with the participant with following questions. During the interview, researcher entered the answers to the data to researcher’s data input questionnaire with Laptop B. Most of the questions were designed to have simple answers, except comments about the prototype and about the experience.

Q1: “Did you experience technical problems during the playback of the video?”

Researcher’s data input questionnaire had an open field for problem reports, but the aim was to get a Yes/No answer. Any technical problems would likely affect the results, and this information was collected to ensure the integrity of the experiment.

Q2: “What size is the screen of the computer you are using?”

Researcher’s data input questionnaire had a Likert scale of 1. Small, 2. Medium, 3. Large for this. Anything below 13” was considered small, 13”-20” was considered normal and anything beyond that was considered large. For practical reasons, participants didn’t need to answer the exact size of the screen if they didn’t tell it straight away. If participant didn’t know the screen size, they were asked whether the screen size is small like in a tablet or small laptop, normal screen like in most of the laptop computers, or would they consider their screen large.

Rationale behind the question was to ensure that if the screen size would affect the results, it could be detected.

Q3: “Can you imagine yourself being interested of using a similar product at some point in the future?”

Researcher’s data input questionnaire had a Yes/No answer to this.
**Q4: “Is there something else you wish to say about the prototype?”**

As the video was not recorded, the answer to this question was written live during the interview by the researcher. If the participant answered a relatively long answer, the aim was not to copy every word the participant says, but rather to record the essence of the response. In cases of any possible misinterpretation, researcher verified the written version of the answer from the participant verbally.

**Q5: “Have you participated in a research before this one?”**

Rationale for this question was to provide means to measure if previous experience from being a research participant affects the general participant experience of this remote experimental study. The next question further clarifies the idea.

**Q6: “How was your experience in this remote research setting?”**

The aim of this question was to provide two types of data. First of all, the aim was to find how did the participant rate the experience in Likert scale Positive-Neutral-Negative, and secondarily to provide any further comments about the research protocol. Researcher’s data input questionnaire had two different question lines to fill during this point, one for the 3-point scale and another one with text field for possible comments.

Longer answers were interpreted and recorded with the same method as in Q4. In case of any possible misinterpretation about the nature of the answer, the researcher asked the participant how they rated the experience in the scale positive-neutral-negative.

### 4.3.9 Debriefing and ending the experiment

After the interview, participant was told that the data collection phase was over, and more informal debriefing started with the researcher opening his webcam feed and greeting the participant again. During the debriefing the participant was given further information about the study, and the between subject design of the research was revealed to the participant. Participants were told which group they belonged to, and participants in Groups 2 and 3 were offered a chance to test the full version on their free time after the research by providing them a link if requested. Before ending the video call in Teams, participants were provided a possibility to ask any questions or tell more about their experience.
5 Research results

This chapter presents the findings of the study. Findings are presented in similar order as the methods were presented in the chapter Research methods. Further discussion of the results can be found in the Discussion chapter. Additional research data can be found from the appendices part of this thesis.

5.1 Registration form

The gender division of the research participants was notably uneven, with 19 of the participants being female and only one being male. Because of this, it was decided that no gender comparison would be done while analyzing the results. Mean participant age (SD) in this research was 28.6 (6.0) years. No detailed background information was collected from the participants, but the participants were likely to be mostly of academic background due to selected invitation methods. All research participants reported having normal hearing ability. 19 participants reported normal eyesight. The participant who reported abnormal eyesight was later evaluated to having a sufficient eyesight for being considered normal in this experiment.

5.2 Pre-research questionnaire

19 research participants answered to the questionnaire before the remote experimental research, while one participant answered to it in the early phase of the research meeting. Mean self-reported level of anxiousness (SD) was 6.1 (1.9), while mean self-reported level of worry regarding Covid-19 (SD) was 5.4 (2.0). Nine research participants stated practicing meditation or yoga, and three participants stated having an attention deficit disorder.

5.3 Observations during the remote experimental research

The remote experimental research online meetings lasted circa 20-30 minutes each if no problems were encountered. A total of eight research participants encountered some kind of technical problem during the preparation phase of the experiment. These technical problems included dysfunctional headphones (3), dysfunctional microphone (2), browser related problems with YouTube video or audio (2), and a problem with webcam (1). In one case the researcher couldn’t get the participant’s microphone to function properly, so a phone connection was used to have audio input from the research situation. In another case the participant was instructed to restart the computer to solve a problem, which
caused a major delay due to automatic operating system updates. In this most extreme example, the meeting lasted a bit over 100 minutes from the initial starting time, exceeding the reserved 90-minute time slot. Luckily this was the last meeting of that research day, and the delay didn’t cause significant problems. Most of the technical problems were solved within minutes. Furthermore, one participant had forgotten the research meeting and was first contacted via phone, which caused a 30-minute delay as the participant was not on location at the time of the call.

15 of the participants used headphones, while five participants did not. Reasons for not using headphones included unsolvable related technical problems, and not having any functional headphones available. All research situations could be considered as calm and not having any significant external disturbances. The presence of additional persons in the research location could be detected with four of the participants (three via audio, and one via video), but no direct disturbances could be observed by the researcher, and all research participants appeared to be fully focused to the research.

Two research participants encountered a problem during the prototype testing phase of the experiment. One research participant accidentally opened the prototype video multiple times simultaneously. The researcher noticed this in the early seconds of the prototype testing from the confused facial gesture of the participant, and verified this from the audio feed, before interrupting the experiment and instructing the participant to close other windows and restart the video. In other case, the participant’s internet connection proved to be poor, and it resulted in disruptions and eventually to a very low video resolution during the prototype testing. However, this was not observed during the prototype testing, but was later revealed during the interview phase of the research.

5.4 PANAS-SF questionnaire

Mean PANAS Positive Affect score regarding all of the research participants (SD) was 31.25 (7.99), while mean Negative Affect score (SD) was 28.65 (4.04). Mean sum of the Positive and Negative Affect scores (SD) was 2.60 (9.31). PANAS-SF sum and self-reported anxiousness in pre-research questionnaire was found to be moderately negatively correlated, \( r(18) = -.55, p < .05 \). No statistically significant correlation was found when studying PANAS-SF sum and self-reported worry of Covid-19, \( r(18) = -.13, p = .57 \).
5.5 Research group balance comparison

Research participants were divided to three research groups according to the pre-research questionnaire information. Microsoft Excel was used as a tool to evaluate the balance while deciding the group for each research participant. This balance comparison also includes information about headphone usage, although there was no prior knowledge of the functionality of each participant’s technical setup.

5.5.1 Research group 1: Full prototype

RG1 had seven participants with the mean age (SD) of 26.9 (8.1). Three participants practiced meditation or yoga, and one had an attention deficit disorder. Mean level of self-reported anxiety (SD) was 6.29 (1.58), while mean level of worry regarding Covid-19 (SD) was 5.71 (2.37). Mean PANAS Positive Affect (SD) was 29.14 (9.15), while mean PANAS Negative Affect (SD) was 28.86 (2.57). Five participants had their eyes closed at times and open at times during the prototype testing, while one participant kept eyes open during the whole prototype testing, and one participant tested the prototype with eyes mainly closed. Four participants used headphones, while three did not.

5.5.2 Research group 2: No virtual guide character

RG2 had seven participants with the mean age (SD) of 29.9 (3.0). Three participants practiced meditation or yoga, and one had an attention deficit disorder. Mean level of self-reported anxiety (SD) was 6.00 (2.14), while mean level of worry regarding Covid-19 (SD) was 5.00 (1.60). Mean PANAS Positive Affect (SD) was 32.57 (6.97), while mean PANAS Negative Affect (SD) was 28.29 (4.30). Majority of the participants (5) kept their eyes mainly closed during the experiment, and two participants had their eyes open at times, and closed at times during the experiment. No participants kept their eyes fully open during the prototype testing. Five participants used headphones, while two did not.

5.5.3 Research group 3: Only nature

RG2 had six participants with the mean age (SD) of 29.2 (5.1). Three participants practiced meditation or yoga, and one had an attention deficit disorder. Mean level of self-reported anxiety (SD) was 6.00 (2.08), while mean level of worry regarding Covid-19 (SD) was 5.50 (1.89). Mean PANAS Positive Affect (SD) was 32.17 (7.31), while
mean PANAS Negative Affect (SD) was 28.83 (4.98). All participants kept their eyes fully open during the prototype testing, and all participants used headphones.

5.6 Current State Of Mind 1 & 2 questionnaires (CSOM1 & CSOM2)

Among all research participants, mean answers to CSOM1 questionnaire (SD) were Anxiety 4.30 (2.79), Tension 4.60 (2.09), and Relaxation 4.85 (1.56). Three participants stated their initial level of anxiety being 0, making positive effect measurement impossible regarding anxiety. Luckily the distribution of participants with zero initial anxiety was even between the research groups, each group hosting one of them. All participants had a measurable answer regarding Tension and Relaxation, meaning that both positive and negative changes were possible.

Similarly, mean answers to CSOM2 questionnaire (SD) were Anxiety 2.85 (2.67), Tension 2.85 (2.39), and Relaxation 6.70 (1.90). The changes to mean values between CSOM1 and CSOM2 in all three categories suggests a clear general positive effect among all research groups, but they also show that some negative effects were also observed. Mean effects (SD) were Anxiety -1.45 (2.01), Tension -1.75 (1.81), and Relaxation +1.85 (2.08). A total sum of effect was calculated with a simple formula: Anxiety (CSOM1-CSOM2) + Tension (CSOM1-CSOM2) + Relaxation (CSOM2-CSOM1). Among all participants this mean total effect (SD) was +5.05 (5.01).

Dependent T-Tests confirmed a significant decrease to the values of anxiety t(18) = -3.1, p < .01 and tension t(18) = -4.2, p < .01, and a significant increase to the relaxation t(18) = 3.9, p < .01 among all participants. This is a clear indication that the virtual natural environment, the element present in all research groups, had a reducing effect to stress-levels.

5.6.1 Research Group 1: Full version (RG1)

Mean answers to CSOM1 (SD) were Anxiety 4.43 (3.06), Tension 4.57 (1.99), and Relaxation 4.57 (1.18), while mean answers to CSOM2 (SD) were Anxiety 2.86 (2.10), Tension 1.57 (1.05), and Relaxation 7.43 (1.18). Mean effects (SD) were Anxiety -1.57 (1.18), Tension -3.00 (1.07), and Relaxation +2.86 (1.36). Mean total effect (SD) was +7.43 (2.32), and the total effect was positive among all seven research participants.
5.6.2 Research Group 2: No virtual guide character (RG2)

Mean answers to CSOM1 (SD) were Anxiety 3.57 (2.06), Tension 4.57 (1.68), and Relaxation 5.57 (1.18), while mean answers to CSOM2 (SD) were Anxiety 2.86 (2.95), Tension 3.57 (2.61), and Relaxation 6.57 (1.84). Mean effects (SD) were Anxiety -0.71 (2.81), Tension -1.00 (2.27), and Relaxation +1.00 (2.56). Mean total effect (SD) was +2.71 (6.78), and the total effect was positive to five of the participants, while two participants reported negative effects (total effect sums -5 and -7), which were confirmed during the interviews. A large variance can be observed from the results. Also, when comparing the levels of Anxiety, Tension and Relaxation from CSOM1 between research groups, RG2 has significantly lower mean initial level of Anxiety, and a significantly higher mean initial level of Relaxation, than RG1 and RG3.

5.6.3 Research Group 3: Nature only (RG3)

Mean answers to CSOM1 (SD) were Anxiety 5.00 (3.00), Tension 4.67 (2.56), and Relaxation 4.33 (1.97), while mean answers to CSOM2 (SD) were Anxiety 2.83 (2.91), Tension 3.50 (2.63), and Relaxation 6.00 (2.31). Mean effects (SD) were Anxiety -2.17 (1.21), Tension -1.17 (0.90), and Relaxation +1.67 (1.60). Mean total effect (SD) was +5.00 (3.32), and the total effect was positive to five of the participants, while one participant indicated a slightly negative effect (-1) which was confirmed during the interview.

5.6.4 One-way between subjects ANOVA

One-way between subjects ANOVA was conducted to compare the effect of meditation guidance to perceived level of anxiety, tension and relaxation in a virtual natural environment in audiovisual guidance (RG1), audio guidance (RG2) and no meditation guidance (RG3) conditions.

There was no statistically significant effect of meditation guidance to the perceived levels of anxiety, tension or relaxation at the p < .05 level for the three conditions. The test results are as follows: Anxiety [ F(2, 17) = 0.80, p = .465 ], Tension [ F(2, 17) = 2.94, p = .080 ] and Relaxation [ F(2, 17) = 1.42, p = .270 ].
5.6.5 Independent Samples T-Test between RG1 and RG3

The ANOVA results regarding tension were close to being statistically relevant, and RG2 had mixed data, so a T-Test was conducted to compare the effect of meditation guidance to perceived levels of anxiety, tension and relaxation in a virtual natural environment in audiovisual guidance (RG1) and no meditation guidance (RG3) conditions. There was a significant effect of audiovisual meditation guidance to the perceived level of tension at the p < .05 level for the two conditions \( F(1, 11) = 9.30, p = .011 \). No statistically significant effect was found to the perceived level of anxiety or relaxation. This means that meditation guidance with virtual guide character seems to further reduce the level of tension experienced, in addition to the stress-reducing effects of the virtual natural environment.

5.7 User Experience Questionnaire +

This section presents the general results from UEQ+ questionnaires. Further analysis can be found from the Discussion chapter.

**Figure 3.** UEQ+ results as mean values and standard deviations per research groups in each category

When comparing the mean scale values of the research groups, it can be noted that all mean values are positive. Participants in RG3 reported the most positive experience in
almost all scales. All groups reported a clearly positive experience regarding the scales “Attractiveness”, “Efficiency” and “Usefulness”.

There is a clear difference between RG1 and both RG2 and RG3 in the scales “Value” and “Visual Aesthetics”. This indicates a clear visual problem in the virtual guide character of RG1.

Detailed results of UEQ+ questionnaires can be found from Appendix 2.

5.8 Structured Interview

Q1: “Did you experience technical problems during the playback of the video?”

18 research participants reported no technical problems. One participant in RG1 reported problems related to slow internet connection and changed to a significantly lower resolution while watching the prototype video. One participant in RG3 initially reported a technical problem, but after a follow up question it was verified that the participant just noticed the looping cycle of the virtual natural environment video.

Q2: “What is the screen size of the computer you are using?”

6 participants reported a small screen, while 13 participants reported their screen size as normal. 1 participant stated that the screen was rather large.

Q3: “Can you imagine yourself being interested of using a similar product at some point in the future?”

All 20 research participants answered yes to this question.

Q4: “Is there something else you wish to say about the prototype?”

17 research participants gave more information about the prototype as an answer to this question, while three (3) participants, all from RG3, didn’t have anything to add.

Research Group 1: Full version

All 7 participants commented something about the prototype. Main finding was that the facial appearance of the virtual guide character was problematic. Three participants stated that they felt the guide character was a bit disturbing, while two participants gave neutral statements indicating they didn’t pay much attention to the virtual character. Adjectives used to describe the virtual character included “outo”
(strange), “pelottava” (scary), and “häiritsevä” (disturbing), and two participants pinpointed this problem to the face or eyes of the guide.

“The virtual guide looked somewhat disturbing, especially the face or the eyes - somehow just didn’t seem to fit this program. The soundscape was pretty nice, but the guide was not that successful part of this.” (Participant, 45 years)

“The character was a bit strange, and I decided to keep my eyes closed as I suspected I would not relax while watching the guide.” (Participant, 25 years)

Two of the participants gave only general positive comments regarding functionality and indicated interest over the possibility of using the product again at some point in the future.

“I can imagine myself using the product again, it was actually quite efficient. Pretty functional, it did relax my mind.” (Participant, 18 years)

Two participants gave positive statements regarding the sound design of the prototype, while one participant stated not liking the vocal style or tone of voice of the dialog, and one participant didn’t like how the word “virkistyä” (refresh oneself) was used in the dialog.

“I felt it was a bit childish to my taste, but I liked the dialog in general. The content of the dialog was working, but the tone of voice was not fully pleasing.” (Participant, 25 years)

One participant stated being pleased with the length of the mediation exercise in the prototype, while another participant stated that the exercise advanced too quickly, and relaxation was hard because of it. One participant also included a positive remark about background scenery to the answer.

Research Group 2: No virtual character

All 7 participants had something to say about the prototype. The findings from this group are more related to the sound design and dialog than in RG1, as a total of 6 participants commented something regarding sounds. Most of the comments were about the dialog.

Three of the participants found the dialog sound and tone to be pleasant, while one participant specifically stated that the dialog sound was annoying. Furthermore, one participant stated that the sound of the dialog was OK, but that it could have been clearer.
“The sounds were pleasant, both the forest and the female voice.” (Participant, 25 years)

“The dialog voice was pleasant, and it’s rhythm was suitable.” (Participant, 30 years)

“I didn’t like the voice, it made me feel like someone is talking to a child.” (Participant, 28 years)

The contents of the dialog received some mixed comments. One participant enjoyed that the breathing was not as much a focus point in the dialog as it is in some other similar services, as breathing can also be a source of anxiety. Another participant stated that there was a bit too much talking, and that the instructions were a bit unclear. One participant told that the breathing sound in the dialog was unnerving, and another participant stated that it was irritating when the dialog said “you are now feeling relaxed”, when in reality the participant didn’t experience that.

“Quite a bit of talking. At some point I didn’t know whether to breathe using my mouth or not. I like simple instructions, and I didn’t always know what to do. That’s the only negative thing I can think of, otherwise it seemed to be good.” (Participant, 34 years)

One comment stated that the relaxation exercise was a bit short, and that the participant had experienced both better and worse relaxation videos. One participant also noticed that the background video was looping and stated that it made it difficult to focus to the exercise. One participant couldn’t really focus at all to the prototype, and stated it being a common problem with similar services after a hard week.

**Research Group 3: Only Nature**

Only three out of six participants had something to say about the prototype. Two of them stated liking the sounds of nature, while another one of the two would have wanted to also see some of the contents of the audio background, mainly some of the birds. One participant also complained about the picture resolution, which was less than expected.

Two of the participants stated they would have wanted to choose the virtual environment themselves, and one specifically told that the forest with birds is personally an unpleasant location, but even this less ideal location the prototype managed to cause relaxation and the idea was pleasing.

"I think the soundscape is especially important in this, and it worked really well. I was disappointed with the quality of the picture, it didn’t seem to be HD. I would have wanted
to choose the environment including the sounds myself. This felt visually static, and I feel like it could have used a bit more action. I would have liked to also see what I heard: swans and cranes.” (Participant, 34 years)

"Forest and singing of birds is certainly relaxing for most of the people, but personally I don’t enjoy being in the woods and bird singing annoys me. Some other video than one with a forest would have worked better. However, the idea was nice, and it managed to relax me even though the environment was not ideal for me.” (Participant, 27)

Q5: “Have you participated in a research before this one?”

11 research participants stated having some kind of previous experience in being a research participant, while 9 participants said no. Several participants asked whether non-academic and commercial researches count as research experience or not, and any kind of experience was counted as having previous experience.

Q6: “How was your experience in this remote research setting?”

19 research participants indicated positive feelings towards the research setting, while one participant stated that the experience was neutral. No participants indicated negative feelings towards the research. The most common adjectives used in the answers were “helpo” (easy), “mukava” (pleasant/nice), and “toimiva” (working/functional), each appearing in five different responses. Four participants gave statements indicating they would prefer this method over laboratory studies due to convenience.

“Quite succesful. It worked very well, and during the whole experience there was a feeling of everything progressing effortlessly. The remote experiment made my participation possible, as I wouldn’t have participated if it would have required me to arrive to some physical research room.” (Participant, 45 years)

“The thought of camera being on and situation being observed was lurking a bit in the back of my mind, but it (the research protocol) worked quite well.” (Participant, 29 years)

“Pretty pleasant and easy. Simple and straightforward process.” (Participant, 30 years)

“It was pretty normal. It was not anything special. My state of relaxation dropped a bit because I expected more of myself.” (Participant, 27 years)
6 Discussion

This chapter includes discussion of the research findings and compares those to relevant literature and recent scientific findings presented in the Introduction and Background chapters. Discussion chapter is divided to five subsections. It begins with analysis of the four fundamental areas of the research, including the virtual natural environment, meditation guidance, virtual guide character and research protocol. After discussing the critical elements, the chapter proceeds to answer the research questions.

6.1 Virtual natural environment

The results of this study regarding virtual natural environment are in line with the results of Ojala et al. (2019), offering further proof that virtual natural environments can be useful in reducing stress and anxiety and increasing the level of relaxation in the target. It should be noted that both the prototype studied and the research by Ojala et al. used forest environment as the virtual natural background, and it remains unknown whether any calm virtual natural environment, for example mountains or beach, would have similar effects. However, individual differences might affect how chosen environments work, as some research participants did state that they would have liked to choose the environment they were in, and one participant specifically mentioned a forest as a generally unpleasant location.

The research used standard computer displays of various sizes, and no statistically meaningful difference caused by the screen size could be observed from the results. However, standard sizes of the screen offer only little variation, and it is possible that visually more immersive presentations, like the physical implementation of the prototype in the research room, could alter the effects of virtual natural environment, plausibly towards a stronger effect.

The sound design of the prototype in this study was done by a sound design professional with several years of working experience. Soundscape of the virtual natural environment is in a fundamental role in creating the immersive atmosphere. Most of the participants in research groups RG1 and RG2 relied mostly on their hearing ability to experience the virtual nature, as they kept their eyes mostly closed. This indicates that the visual element is not fundamentally necessary in creating the relaxing effect of virtual natural
environment, as long as the audio landscape is of high enough quality. Interestingly, in the group RG3 with no meditation guidance audio, all participants kept their eyes open during the whole prototype testing phase, which indicates that users are likely to keep their eyes open unless given a verbal permission to close them. Another likely cause for this phenomenon is that the research participants had knowledge of being observed and wanted to focus to the prototype with all of their senses.

UEQ+ results of the research groups indicate that the plain virtual natural environment of RG3 produced the most positive user experience for the participants, especially regarding value and visual aesthetics. It is important to note that although RG1 reported a more positive total effect in the CSOM1 & CSOM2 questionnaires, it performed more poorly regarding the user experience.

In order to understand why the virtual natural environment had a positive effect to the mental state of research participants, it is important to note that the hearing ability of humans cannot be shut down at will, as it is the main alarm channel of human brains. It is active even when asleep, constantly analyzing changes in the sound environment. Hearing ability is most active in silence, which can lead to small sounds disturbing the level of relaxation of an individual. Steady natural soundscapes can free human cognitive resources as they can be used to fill the silence with information that causes low amounts of cognitive load. Natural soundscapes like sounds of a river flowing or waves of the ocean have been found to have a relaxing effect in several researches. (Thoma et al., 2017, Parkkinen et al., 2020)

6.2 Meditation guidance

When comparing the research data of the groups with meditation guidance, RG1 and RG2, to the data of RG3, it needs to be considered that RG2 had two clearly negative results, and interviews revealed that both were at least partially caused by an unpreferred tone or style of the meditation guidance audio. However, it is impossible to evaluate whether the prototype version of RG1 would have worked any better for these two participants, as both versions have identical dialog audio. What can be stated from the results is that the preferred style of the meditation guidance dialog can vary between users and user groups, and an unpreferred style can cause undesirable effects to the stress and relaxation levels of a user. One way to counter this issue is to include several different
meditation guidance presentation styles to the application, possibly targeting several different user groups.

Meditation guidance script of the prototype studied was written by professor of child psychiatry Kaija Puura, and the script presented the dialog to mindfulness and breathing exercise to a target group of children suffering from anxiety. As the research participants were all adults, it is understandable that several research participants stated that they did not like the style of the dialog, mainly claiming it to be too childish for their taste. Even so, 12 out of 14 participants in RG1 and RG2 reported a positive effect on their stress and relaxation levels.

To provide further analysis on the difference between meditation guidance in virtual natural environment in RG1 and RG2 and plain virtual natural environment of RG3, it is justified to remove the two participants with negative total sum of measurable effects from RG2. When comparing the positive effects in RG1 and RG2 to the effects in RG3, it can be noted that the prototype versions with meditation guidance seem to have a stronger effect on reducing tension and inducing relaxation, while regarding the level of anxiety the results are fairly similar. The decrease in the level of anxiety in RG3 was slightly larger than in RG1 or RG2.

**6.3 Virtual guide character**

Research results regarding the virtual guide character indicate that while the measured effect of the prototype was strongest in RG1, the user experience of RG1 was also the worst, and several participants complained that the virtual guide character was somewhat disturbing. This effect was already noticed during the development phase of the prototype, and it was at least partially caused by the Salsa asset which produced the lip sync of the virtual guide character, as it changed the expression of the character. However, the problem was not considered to be large enough to cancel the prototype testing with the virtual character. In hindsight, it can be said that the lip sync was most likely not as important part of the end-result to justify the reduction in user experience.

It can be stated that the facial animation of the virtual guide character caused *uncanny valley effect* (Mori, 2012) within the research participants, and it is likely that the results
The uncanny valley effect refers to eerie feelings caused by imperfect presentation of emotions by a character that resembles a human being.

The results of this study imply that virtual guide character can help users focus on the meditation guidance, but great consideration should be practiced when designing the virtual character for any target group. The easiest way to avoid falling to the uncanny valley is designing a nonhumanoid virtual guide character, for example an animated cartoon character.

6.4 Research protocol

The protocol for this research was a combination of remote online methods, between-subjects experimental research design, and a user experience study. Participant interviews revealed a subjective evaluation of the protocol from participant viewpoint. The protocol was found to be easy, pleasant and suitable for the task. One participant reported feeling slightly uneasy due to being observed, but still found the experience positive. One participant was clearly nervous during the research, but reported a positive experience regarding the research, and stated that external influences caused the distress.

It should be noted that even while majority of the research participants conducted the research from their homes, one sided webcam observation didn’t seem to bother the participants too much. Some participants had to be asked to open their webcams, but it can be stated that all participants quickly accepted the observation as part of the research. Elements that might contribute to the trust towards the research situation include general online behavior norms of 2020, friendly but professional communication with the participants, researcher being already a familiar voice as all participant registrations were confirmed via a phone call, and knowledge of the fact that the research situation was not recorded. Several participants stated that they felt safe as the researcher was observing and helping with technical issues.

Technically, the combination of e-mails, phone calls, Microsoft Teams meeting, Google Forms, YouTube and scripted research dialog was found to be effective for this type of research. However, Google Forms has limited tools for creating questionnaires, especially regarding numerical Likert scales, and YouTube is a very limited platform for presenting
the prototype, being suitable only for passive and linear presentation without any technological interaction. The method of contacting the participant first via scripted phone call was an effective form of scheduling the research and creating a positive connection with the participant, and pre-research questionnaire was a very significant factor in creating the balance between the research groups before the actual research situation. Microsoft Teams was a suitable and reliable platform for conducting a remote research. One of the main technical findings of this research was that technical problems are somewhat common in remote researches, and that the problems are mostly related to audio or internet connection problems. This requires some preparations, flexibility and quick adaption from the researcher, but none of the technical problems encountered resulted in a disqualified research participant.

As participants faced the computer screen most of the times, facial expressions were easy to observe. This was useful at times, even though the research didn’t directly collect facial expression data except the information on whether the participant kept their eyes open or closed. For example, researcher could provide additional instructions when the facial expression of the participant revealed frustration or confusion. Audio feed from the participant’s computer was very useful in estimating the external disturbances. The webcam provided only a limited view to the research situation, but microphone provided a broader sound image of the location. Although remote observation via participant’s webcam and microphone does not deliver the same amount of information as observations conducted in laboratory conditions, the audiovisual feed from participant’s computer provided good means to study the participant reactions and possible external disturbances.

Data collection via online questionnaires provides a fast and efficient way to save data directly to a raw database. It is highly recommended to identify the individual participants with a simple data identifier, especially when using multiple questionnaires. Participant ID number used in this research was found to be useful when combining different data tables and analyzing the research results. It also tackles the main privacy issue of online research data. Even in the unlikely case of a data breach, the participant ID does not reveal the identity of the participant. However, online questionnaires do not offer the same precision as laboratory conditions or other methods when collecting the data.
6.5 Answers to the research questions

6.5.1 Does virtual natural environment stimulus have effect on stress reduction?

The results indicate a clear decrease to the level of anxiety and tension, and a clear increase to the level of relaxation when comparing the total results from CSOM1 and CSOM2. This research confirms the positive effect on stress reduction previously found in other recent studies – virtual natural environment stimulus has an effect on stress reduction.

6.5.2 Does virtual meditative guidance in virtual natural environment have an additional effect on stress reduction?

Virtual meditative guidance has a number of factors than can affect the results, including the visual presentation of the guidance, the script, rhythm and sound of the guidance dialog, and user preferences. Results from RG1 and RG3 indicate a statistically meaningful decrease to the perceived level of tension caused by virtual meditative guidance with virtual guide character, but the sample population is too small to draw definite conclusions. No significant effect was found regarding anxiety and relaxation.

6.5.3 What are the general characteristics of a research participant experience regarding the remote methods used in this research?

The methods used in this research provided a positive research participant experience. Participant interviews revealed a clear general positive attitude towards the research protocol, regardless of their previous experiences in the field of research. Most common words used to describe the research experience included easy, pleasant and functional, and this kind of remote setting seemed to be preferred over laboratory studies due to convenience.
7 Conclusion

This research set out to study whether meditative guidance in a virtual natural environment has an effect on stress-reduction, and it conducted a remote experimental research of therapeutic application prototype with 20 research participants. The aim was not only to replicate the effect of stress-reduction of previous studies by using a virtual natural environment, but also to inspect on whether meditation guidance can offer additional stress-reducing effects when used in a virtual natural environment. In addition, as the research protocol was forced to use innovative remote methods due to the SARS-CoV-2 pandemic, the aim was to also study the general research experience of research participants.

This chapter presents a summary of the main findings and compares those to the research objectives, before stating the limitations of the study and recommendations for further research.

7.1 Summary of the main findings

Principal findings of this thesis add weight to the statement that virtual natural environments can have positive effects on stress reduction and relaxation, even when experienced via normal computer screen. The effect does not seem to necessarily require eyesight, indicating an auditory origin of the phenomena. Therefore, sound design seems to be an essential element in providing a pleasant and immersive functional experience.

Furthermore, combining guided meditation to virtual natural environment is likely to further decrease the level of tension, but no significant effect was found regarding subjective feelings of anxiety or relaxation. User experience can highly vary depending on individual personality, taste and previous experience, especially regarding presentation style of the meditation guidance. Having a virtual guide to visually present the meditation exercise can increase the positive effect, but great care needs to be put on the character design, as poor design can also reduce the user experience.

Conducting a study with the remote methods used in this research is likely to produce a positive research participant experience, but the methods can be directly recommended only for studying passive audio or audiovisual material with motivated users. It is notable
that one-sided video surveillance via webcam seemed to be well-tolerated in a remote research setting.

As the research objectives were to confirm the stress-reducing effect of virtual natural environment, to study the effect of meditation guidance in virtual natural environment to stress-reduction, and to evaluate the participant experience in relation to the research methods used, it can be stated that the research objectives were fully met.

The results of this study offer new tentative information regarding the effect of meditation guidance in virtual natural environment, indicating that meditation guidance can offer additional tension reducing effects to the stress-reducing effects of virtual natural environments.

7.2 Limitations

The study was conducted with adult research participants, whereas the prototype studied was designed for a target user group of children suffering from anxiety. Therefore, it should be noted that the results of this study only state the effect on adult users. Although it is plausible that the methods studied, meditation guidance in a virtual natural environment, would be effective for children suffering from anxiety, the results of this research cannot be used to confirm it in any way. Furthermore, the research participants tested a prototype designed for children, which causes a mismatch between the target user group and actual users in the research, and this can affect the results negatively.

The gender division of research participants was highly unbalanced, as all except one participant stated their gender as female. Any possible effect of gender to the research results remains unknown.

The sample size of this research was too small for any definite conclusions regarding the effect of meditation guidance. Furthermore, only subjective data was collected regarding the effects of the prototype, which limits the validity of the results. The remote research protocol used prevented objective measurements such as measuring the heart-rate variable of the participants. In addition, the effect of the remote research protocol to the subjective data collected during the study remains unknown – it is possible that the
positive experience regarding the research itself could affect the subjective measurements of the prototype studied.

The virtual guide character was somewhat poorly implemented to the prototype due to lack of available resources, which might affect the results regarding meditation guidance negatively. However, as the results regarding the meditation guidance were already positive or neutral, this only indicates that an improved guide design could have potential to further improve the results.

7.3 Recommendations

In order to verify the study findings regarding the effects of meditation guidance in virtual natural environment to stress-reduction, more research with larger sample sizes and objective measurements is recommended. Regarding the therapeutic application studied in this research, as the effects were positive, further research can be recommended. However, before proceeding to conduct an experimental research with the target user group, children suffering from anxiety, the virtual meditation guide character should be redesigned – more abstract character design is recommended.

Sound design seems to be an essential element in creating the relaxation effect of virtual natural environment, and therefore it is highly recommended to use a professional sound designer for creating the soundscape of a relaxation application. Furthermore, as the stress-reducing effect of virtual natural environment seems to be closely connected to the auditory sense, more research should be conducted on the possibilities of using sound design as a mind-altering element in therapeutic applications.

Furthermore, the results of the participant interviews indicate a clear demand for similar services, as all participants reported being interested of using a similar service in the future, regardless of their experience with the prototype studied. More research and future innovations with similar therapeutic applications can be generally recommended.
References


Tilastoraportti : 42/2019


Current State of Mind questionnaire (CSOM)

A visual presentation of the CSOM questionnaire in its original language (finnish).
**Appendix 2**

Detailed UEQ+ results of RG1, RG2 and RG3

Color coding of the results done by the researcher while analyzing the results.

### Research Group 1 - Mean and Standard Deviation per Scale and per Item

<table>
<thead>
<tr>
<th>Scale</th>
<th>Mean</th>
<th>Variance</th>
<th>Std. Dev.</th>
<th>N</th>
<th>Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attractiveness</td>
<td>4.46</td>
<td>0.84</td>
<td>0.93</td>
<td>6</td>
<td>3.70 - 5.22</td>
</tr>
<tr>
<td>Efficiency</td>
<td>4.46</td>
<td>0.84</td>
<td>0.93</td>
<td>6</td>
<td>3.70 - 5.22</td>
</tr>
<tr>
<td>Usability</td>
<td>4.00</td>
<td>1.00</td>
<td>1.00</td>
<td>5</td>
<td>3.00 - 5.00</td>
</tr>
<tr>
<td>Value</td>
<td>4.88</td>
<td>0.73</td>
<td>0.85</td>
<td>5</td>
<td>4.10 - 5.66</td>
</tr>
<tr>
<td>Visual Aesthetics</td>
<td>4.31</td>
<td>0.84</td>
<td>0.92</td>
<td>6</td>
<td>3.58 - 5.04</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Scale</th>
<th>Mean</th>
<th>Variance</th>
<th>Std. Dev.</th>
<th>N</th>
<th>Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attractiveness</td>
<td>4.46</td>
<td>0.84</td>
<td>0.93</td>
<td>6</td>
<td>3.70 - 5.22</td>
</tr>
<tr>
<td>Efficiency</td>
<td>4.46</td>
<td>0.84</td>
<td>0.93</td>
<td>6</td>
<td>3.70 - 5.22</td>
</tr>
<tr>
<td>Usability</td>
<td>4.00</td>
<td>1.00</td>
<td>1.00</td>
<td>5</td>
<td>3.00 - 5.00</td>
</tr>
<tr>
<td>Value</td>
<td>4.88</td>
<td>0.73</td>
<td>0.85</td>
<td>5</td>
<td>4.10 - 5.66</td>
</tr>
<tr>
<td>Visual Aesthetics</td>
<td>4.31</td>
<td>0.84</td>
<td>0.92</td>
<td>6</td>
<td>3.58 - 5.04</td>
</tr>
</tbody>
</table>

### Research Group 2 - Mean and Standard Deviation per Scale and per Item

<table>
<thead>
<tr>
<th>Scale</th>
<th>Mean</th>
<th>Variance</th>
<th>Std. Dev.</th>
<th>N</th>
<th>Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attractiveness</td>
<td>4.46</td>
<td>0.84</td>
<td>0.93</td>
<td>6</td>
<td>3.70 - 5.22</td>
</tr>
<tr>
<td>Efficiency</td>
<td>4.46</td>
<td>0.84</td>
<td>0.93</td>
<td>6</td>
<td>3.70 - 5.22</td>
</tr>
<tr>
<td>Usability</td>
<td>4.00</td>
<td>1.00</td>
<td>1.00</td>
<td>5</td>
<td>3.00 - 5.00</td>
</tr>
<tr>
<td>Value</td>
<td>4.88</td>
<td>0.73</td>
<td>0.85</td>
<td>5</td>
<td>4.10 - 5.66</td>
</tr>
<tr>
<td>Visual Aesthetics</td>
<td>4.31</td>
<td>0.84</td>
<td>0.92</td>
<td>6</td>
<td>3.58 - 5.04</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Scale</th>
<th>Mean</th>
<th>Variance</th>
<th>Std. Dev.</th>
<th>N</th>
<th>Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attractiveness</td>
<td>4.46</td>
<td>0.84</td>
<td>0.93</td>
<td>6</td>
<td>3.70 - 5.22</td>
</tr>
<tr>
<td>Efficiency</td>
<td>4.46</td>
<td>0.84</td>
<td>0.93</td>
<td>6</td>
<td>3.70 - 5.22</td>
</tr>
<tr>
<td>Usability</td>
<td>4.00</td>
<td>1.00</td>
<td>1.00</td>
<td>5</td>
<td>3.00 - 5.00</td>
</tr>
<tr>
<td>Value</td>
<td>4.88</td>
<td>0.73</td>
<td>0.85</td>
<td>5</td>
<td>4.10 - 5.66</td>
</tr>
<tr>
<td>Visual Aesthetics</td>
<td>4.31</td>
<td>0.84</td>
<td>0.92</td>
<td>6</td>
<td>3.58 - 5.04</td>
</tr>
</tbody>
</table>
### Research Group 3 - Mean and Standard Deviation per Scale and per Item

Here means for the scales (mean across all items in a scale), standard deviations and confidence intervals are calculated. The mean values are transformed from a ±1 to ±3 range to a ±3 to ±1 range to be compatible with the reporting format of the original studies.

#### Mean and Confidence Interval per Scale

<table>
<thead>
<tr>
<th>Scale</th>
<th>Mean</th>
<th>Variance</th>
<th>Std. dev.</th>
<th>N</th>
<th>Confidence</th>
<th>Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attractiveness</td>
<td>2.44</td>
<td>3.41</td>
<td>1.86</td>
<td>6</td>
<td>6.00</td>
<td>1.90 - 7.70</td>
</tr>
<tr>
<td>Usability</td>
<td>2.42</td>
<td>3.31</td>
<td>1.85</td>
<td>6</td>
<td>6.00</td>
<td>1.90 - 7.70</td>
</tr>
<tr>
<td>Value</td>
<td>1.80</td>
<td>1.73</td>
<td>1.31</td>
<td>6</td>
<td>6.00</td>
<td>1.90 - 7.70</td>
</tr>
<tr>
<td>Visual Aesthetics</td>
<td>2.59</td>
<td>3.42</td>
<td>1.86</td>
<td>6</td>
<td>6.00</td>
<td>1.90 - 7.70</td>
</tr>
</tbody>
</table>

#### Mean and Confidence Interval per Item

<table>
<thead>
<tr>
<th>Item Left</th>
<th>Item Right</th>
<th>Mean</th>
<th>Variance</th>
<th>Std. dev.</th>
<th>N</th>
<th>Confidence</th>
<th>Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Efficient</td>
<td>2.35</td>
<td>3.43</td>
<td>1.85</td>
<td>6</td>
<td>6.00</td>
<td>1.90 - 7.70</td>
<td></td>
</tr>
<tr>
<td>颠簸性</td>
<td>2.56</td>
<td>3.63</td>
<td>1.87</td>
<td>6</td>
<td>6.00</td>
<td>1.90 - 7.70</td>
<td></td>
</tr>
<tr>
<td>性感</td>
<td>2.39</td>
<td>3.67</td>
<td>1.85</td>
<td>6</td>
<td>6.00</td>
<td>1.90 - 7.70</td>
<td></td>
</tr>
<tr>
<td>舒适</td>
<td>2.58</td>
<td>3.43</td>
<td>1.86</td>
<td>6</td>
<td>6.00</td>
<td>1.90 - 7.70</td>
<td></td>
</tr>
</tbody>
</table>

#### Mean Importance Ratings (see Data: Importance)

<table>
<thead>
<tr>
<th>Scale</th>
<th>Mean</th>
<th>Variance</th>
<th>Std. dev.</th>
<th>N</th>
<th>Confidence</th>
<th>Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attractiveness</td>
<td>2.53</td>
<td>3.47</td>
<td>1.85</td>
<td>6</td>
<td>6.00</td>
<td>1.90 - 7.70</td>
</tr>
<tr>
<td>Usability</td>
<td>2.51</td>
<td>3.31</td>
<td>1.85</td>
<td>6</td>
<td>6.00</td>
<td>1.90 - 7.70</td>
</tr>
<tr>
<td>Value</td>
<td>1.53</td>
<td>1.62</td>
<td>1.27</td>
<td>6</td>
<td>6.00</td>
<td>1.90 - 7.70</td>
</tr>
<tr>
<td>Visual Aesthetics</td>
<td>2.55</td>
<td>3.42</td>
<td>1.86</td>
<td>6</td>
<td>6.00</td>
<td>1.90 - 7.70</td>
</tr>
</tbody>
</table>

### Visual Aesthetics

- Efficient
- 颠簸性
- 性感
- 舒适
- 2.35
- 2.56
- 2.39
- 2.58

### Visual Aesthetics

- Efficient
- 颠簸性
- 性感
- 舒适
- 2.35
- 2.56
- 2.39
- 2.58