The Effects of Instruction on At-Home Use of the Virtual Reality Environment 'Walk in Nature'

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Abstract

Instruction is an important factor that can influence a person's learning process of how to use Virtual Reality (VR). Instruction is especially beneficial to people who need to learn how to use VR on their own, such as for an e-health intervention like the Walk in Nature (WiN). Because of this, the current study aims to investigate what the effect is of adding instructions to the WiN on usability, self-guided use and knowledge retention. 25 students from the University of Twente participated in the study, who were assigned to either the control group (N = 12) or the instruction group (N = 13). The instruction group received multi-modal instruction within and outside of the VR-environment, while the control group received paper-based instruction and the instructions that were already present within the environment. The dependent variables were measured with the System Usability Scale (SUS), an observation scheme and a knowledge test. It was found that the instruction group had significantly higher scores on the SUS and observation scheme, indicating a better usability and self-guided use for this group. Knowledge retention was high in both conditions and no significant differences were observed between the two conditions. These results may indicate a relationship between usability, self-guided use and reaction time, and may point towards a design flaw in the knowledge test. Furthermore, the findings provide insight into the benefits of adding multi-modal instruction to e-health and VR interventions and make a contribution to the currently limited body of research on instruction for VR-environments.

Keywords: virtual reality, instruction, usability, self-guided use, knowledge retention

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Introduction

Instruction is an important part of people's experiences when learning something new. It can come in many different forms, such as a teacher or a booklet, and can be defined as the guidance and directions people are given in order to teach them how to do something. Good quality and informative instruction can help people in their learning process, but bad quality instruction, or the complete absence of instruction, can also hinder learning (Kunter et al., 2013; Weinert et al., 1989). This makes instruction an influential factor on learning new skills. Considering this, instruction could also influence the learning process of how to use Virtual Reality (VR). Virtual Reality refers to a technology that allows people to have an interactive and immersive experience in a 3D computer-generated environment (Abbas et al., 2023). Most of the time, VR users wear a Head Mounted Display (HMD), or headset, to experience this virtual environment (Abbas et al., 2023). VR is generally known for its use in video gaming, but it can be used for all sorts of purposes, including military training, medical education and the treatment of PTSD and anxiety disorders, especially phobias (Côté & Bouchard, 2008; Tassinari et al., 2022).

Another one of these purposes is providing care to people within their homes. A lot of people need long-term care and support, such as those with chronic illnesses, and since VR can be used independently when and where it suits you, it could be a valuable tool to support these needs. Within this context, patients will benefit from effective instruction, as they may need help with finding out what they are supposed to do during the use of a VR intervention, or how they are supposed to do it. Furthermore, by using VR independently without any outside help, people are also able to take on a more active role in their treatment or care. This independent, often called 'self-guided', learning has been found to result in better learning than when access to instruction is controlled by someone else, and results in increased motivation due to being more actively involved in the learning process (Brydges et al., 2009; Chiviacowsky & Wulf, 2005; Wulf et al., 2005). Self-guided use may also be influenced by the quality of instruction people are given, since giving instructions has been found to increase skill retention in a self-guided learning environment (Brydges et al., 2009).

Besides this, instruction is also important to the usability of a VR intervention. Usability refers to the ease in which a technology can be used by a person, and it can be measured in different ways (Bareišytė, 2021; Zhang et al., 2020). It is an important part of assessing whether an intervention provides a good experience to its users. While research on the influence of instruction on usability is scarce, what studies have found is that effective instruction increases the ease in which an user can accomplish a task and decreases the amount of errors users make (Dunham et al., 2020; McBreen & Savage, 2020). This indicates that effective instruction could be an important influence on the usability of a VR intervention.

Effective instruction in a VR intervention can be given both within the virtual environment the users find themselves in, and before or after they put on the HMD. The goal of both of these instructions is to give the user guidance on how to perform a task. Therefore, VR instruction should be divided into two main forms: instruction within the VR environment and instruction outside of the environment.

Instruction Within the VR Environment

Within a VR environment, multiple types of instructions are possible that all involve different senses: verbal instruction, visual instruction, and tactile/haptic instruction (Cooper et al., 2018). Verbal instructions are the instructions given through audio played during the simulation. This can be done through a virtual character, a video of a person, or a disembodied voice. Visual instructions are demonstrations and explanations shown visually to the user. One study with an immersive VR environment made the distinction between two types of visual instructions: 'annotation' and a 'virtual tutor' (Lee et al., 2019). Annotation consists of gestures and spatial anchors in the form of virtual objects such as a 3D text, arrows, and circles surrounding objects (Lee et al., 2019). The virtual tutor consisted of a virtual character that demonstrated to the user what they had to do (Lee et al., 2019). When comparing these, they found that annotation was generally more effective in bringing across what the user had to do than demonstration via a virtual tutor (Lee et al., 2019). However, the virtual tutor was found to be more effective in a stretching exercise that involved imitating the movements of the tutor (Lee et al., 2019). Lastly, tactile instruction refers to everything that can be felt by the user through the technology provided to them. Due to practical and financial constraints, this type of instruction is often not prioritized when creating VR environments, and therefore less commonly in use (Cooper et al., 2018).

Combinations of different types of instructions, or multi-modal instructions, can occur as well. An example of this is when an object in the environment that needs to be picked up by the user is glowing, and when the user comes close to it, the controller starts vibrating. This uses a combination of both visual instruction, namely the glow emitting from the object, and tactile instruction, in the form of a vibrating controller. There are certain benefits to combining these types of instructions. For example, Hecht et al. (2007) found that combining types of signals increased the reaction times of users in a detection exercise, with a combination of visual, audio and haptic signals being the most effective. A study by Meyer et al. (2005) confirms this, as they also found that presenting information in more than one modality causes faster and more accurate reactions. Multiple studies into interface design also found that using different types of cues leads to an improved performance on tasks, increased user satisfaction, and a decreased cognitive workload (Cooper et al., 2018; Jia et al., 2011; Lee et al., 2013; Oviatt et al., 2004; Shi et al., 2007).

Based on these findings, using a combination of verbal, visual, and tactile instruction would be the most effective in instructing users on what they should do. However, when this is not possible, using more than one type of instruction and using different types of cues together is still more effective than using only one modality. Furthermore, whether annotation or a virtual tutor should be chosen for the visual instruction depends on the type of task: a virtual tutor is preferable on tasks where the user should physically imitate movements, while annotation is generally preferable for other tasks.

Instruction Outside of the VR Environment

The instruction outside of the VR environment is the instruction that takes place when the user does not have the HMD on. This type of instruction is most often given through texts, pictures or videos. Text-based instruction and paper-based instruction are similar to each other, however text-based purely uses texts, while paper-based can also involve the use of pictures. Generally, the more specific and precise text-based instructions are, the more effective they are (Stein & Bransford, 1979). Mayer (2002) proposed that users learn better when corresponding words and pictures are presented near each other. Mayer (2022) also proposed that removing irrelevant details from instruction helps users learn better. By making the text understandable and only adding relevant details, the reader's interest to read the text is maintained. Another way to improve text-based instruction is by showing participants what the goal and importance of the VR intervention is, as this makes them more engaged with the environment (Chen & Teh, 2013). Furthermore, using visual representations in instruction helps users better understand what they need to do (Chen & Teh, 2013). This indicates that using paper-based instructions with a combination of text and pictures is more effective than merely using text-based instruction.

Besides this, signalling can be used to make an instructional text more understandable (Richter et al., 2016). With signalling you provide the reader with cues that indicate the structure of the text, which helps the reader to organize information (Richter et al., 2016). Examples of this would be typographical cues, colour coding, enumerations, repetitions and headings (Richter et al., 2016). Signalling is especially helpful for readers who do not have a lot of prior knowledge on a topic (Richter et al., 2016).

Video-based instruction includes videos that have both visuals and audio (Noetel et al., 2021). Videos are able to reduce the cognitive load of instruction, as users are able to pause, rewind and fast-forward the video (Noetel et al., 2021). Cognitive load can be further reduced by limiting the length of the video to under six minutes (Afify, 2020). This reduction of the cognitive load then leads to a better retention of the learned knowledge (Afify, 2020). Lastly, when comparing video- and text-based instruction to each other, video-based instruction seems to be more effective (Buch et al., 2014; Donkor, 2010).

To conclude how effective these instruction outside of the VR environment are compared to instruction within the environment, a study by Jasche et al. (2021) is relevant, since this investigated different instructions within Augmented Reality (AR) and compared this to paper-based instruction outside of the environment. AR is similar to VR, as in AR computer-generated images are overlayed on a view of the real world, which is often done through a HMD (Jasche et al., 2021). This study found that paper-based instructions had a larger variance in task completion time compared to instructions within the AR environment (Jasche et al., 2021). This was due to the paper instructions often being less easy to interpret (Jasche et al., 2021). Furthermore, they found that participants made the least amount of errors on tasks when the instructions within the AR environment were supplemented with recorded video demonstrations (Jasche et al., 2021). These findings suggest that paper-based instructions are less effective than instruction within a VR environment, but that instruction becomes more effective when instruction within a VR environment is combined with video-based instruction outside of the environment.

‘Walk in Nature’ Intervention

A case to which the instruction in- and outside of the environment can be applied is the Walk in Nature VR intervention. This VR environment is aimed at people with chronic fatigue and started its development in 2021 with the objective of creating a tool that can increase subjective vitality and decrease the stress levels of its users (Korporaal, 2023). Subjective vitality refers to a positive feeling of being alive and energetic and consists of both a physical health and a psychological aspect (Theodorou et al., 2023). By increasing the subjective vitality of its users, a VR environment like Walk in Nature can cause several benefits, most notably, improving physical, emotional, and social well-being, decreasing psychological and physical stress, and decreasing anxiety. In addition to this, VR environments displaying nature, and specifically displaying a forest, have been found to increase subjective vitality within only five minutes of use (Mattila et al., 2020; Plante et al., 2006). Because of this, the decision was made for this environment to be completely based in a forest.

The interventions consists of three exercises that all take place within this same forest environment: the butterfly task, the breathing tree task, and the yoga task. In the butterfly task users are placed in a tunnel made of plant-filled garden arches with butterflies scattered all around. The users then have to move around the room and reach out to touch the butterflies one by one, after which they will fly away towards the tunnel exit. During the breathing tree task users are standing in front of a tree while a voice is talking to them and guiding them on when to breathe in and out. As the users progress in this exercise, the tree expands in size and increases its saturation from grey to bright green. Lastly, during the yoga task a virtual yoga instructor demonstrates, one by one, several different yoga movements to the user, such as side bends and the chair pose. The user is then asked to try these movements out for themselves. During this instruction, an audio cue in combination with a visual cue is playing to remind the user when to breathe in and when to breathe out. (Bareišytė, 2021)

Figure 1

The Butterfly Exercise

Figure 2

The Yoga Exercise Including the Breathing Bubble

Since subjective vitality consists of both a physical health aspect and a psychological aspect, the included exercises in the environment are aimed at improving either of these aspects (Korporaal, 2023). The butterfly task is aimed at improving the physical well-being of the users, the breathing tree task is aimed at improving psychological well-being, and the yoga task is aimed at improving both physical and psychological well-being, and thus focusing on subjective vitality as a whole.

The first study conducted on this VR environment by Bareišytė (2021) had two phases that discussed different relevant aspects of the study. In the first phase, presence, immersion and user experience were the focus of the study, which were all measured as different aspects of the usability of the intervention. Based on these measurements, Bareišytė (2021) found that some adjustments in usability would be needed in order for the environment to be used in the future. Besides these findings, it was also not possible to let the participants use the environment self-guided as every task in the environment was initiated by the researcher.

In the second phase of the study by Bareišytė (2021), the focus was on subjective vitality and stress. This is similar to a succeeding study on the environment that was conducted by Korporaal (2023) that investigated whether the exercises implemented in the previous study influenced the effectiveness of the environment compared to a simple nature environment without exercises. This study focused on subjective vitality, energy, tension, and stress, and did not aim to test the usability of the intervention (Korporaal, 2023). It showed there was no difference in effectiveness between the condition that contained the exercises compared to the condition without any exercises (Koporaal, 2023).

Current Instructions

The current instructions present in the Walk in Nature intervention consist of both the instructions given by the researcher and the instructions within the VR simulation.

In the study by Korporaal (2023), the researcher helped with putting on the VR-headset and controller and explained that they would check if the cable of the headset is not in the way of the participant. During the simulation, the researcher explained the buttons on the controllers which were necessary for the exercises. They also instructed the participants on where to stand in the room so that there was enough space to correctly perform the exercises. Because the tasks and environment had to be manually changed, participants also had to close their eyes in between every exercise change. During the exercises, the researcher answered questions from the participants and gave extra instructions. After all exercises were completed, the researcher also concluded by instructing the participants to take off the controllers and headset. (Korporaal, 2023)

The current instructions within the simulation include the explanations of what to do during the exercises. During all of the exercises, visual instruction is present in the form of brief text on which buttons need to be pressed. Additionally, during the breathing tree task, users receive text instruction on pressing the button while breathing in and holding their breath. Besides this, verbal instruction was given as well in the form of an audio cue that indicates when the user should breathe in or out. During the yoga task, visual instruction is present in the form of a virtual yoga teacher who demonstrates to the user on how to do different yoga poses. Visual instruction is also present in this exercise due to the 'breathing bubble': a circle that increases and decreases in size and shows the text "breathe in" and "breathe out" depending on if the user is supposed to be inhaling or exhaling in that moment. This bubble is used in combination with the same audio cue that was being played during the breathing tree task.

Figure 3

Instruction Given During the Butterfly Exercise

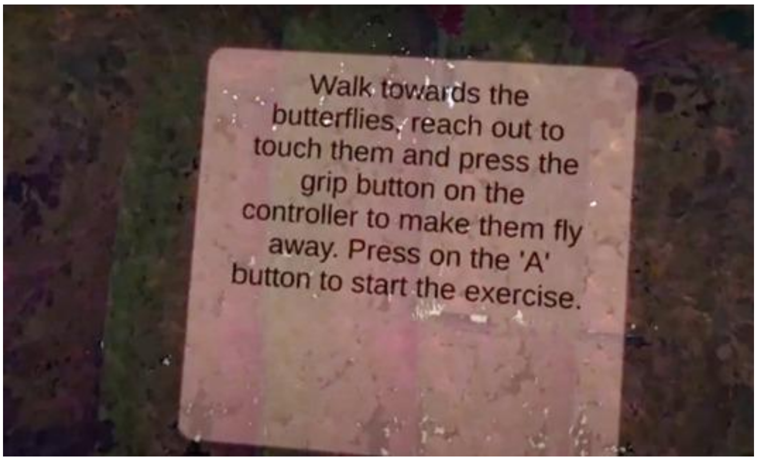

Figure 4

Instruction Given During the Yoga Exercise

Despite this, there is still instruction missing from the WiN intervention that is necessary for users to use the intervention independently. Firstly, as in a situation where users would have to use the WiN intervention on their own there would be no researcher present to help them, the instruction that was previously given by the researchers should be replaced with instruction fit for self-guided use. This means that instruction should be included on how to set up the VR technology, where to stand in the room in order to provide enough space, how to start the simulation, and when the users should close their eyes. If users are unfamiliar with VR, they will also need instructions on how to use the controllers.

As of now, there is also no instruction on what to do if the user experiences trouble during the exercise. If the user is not pressing the right buttons or not progressing in the exercise, there is no further explanation given within the simulation on what the user should be doing. In order to prevent users from experiencing trouble during the exercises, more detailed explanations of how to perform the exercise should be given, as they are quite brief within the current instruction, especially for the yoga task. Lastly, in the present intervention there is nothing to indicate the end of the simulation, which means that there is instruction missing on when the headset can be put off again.

From this, it is apparent that in the current condition of the Walk in Nature environment, there is still a lot missing concerning instruction. Therefore, a proposed solution would be to add new instruction to the intervention according to the earlier mentioned findings. Within the VR environment, this would mean that the current text-based instruction will be made more concrete. An example of this would be replacing sentences such as “Press the button on your thumb” with “Press button B”. In addition to this, since a combination of visual, audio and haptic instruction is shown to be ideal, these forms should be combined as much as possible within the environment. Means to do this would for example be to combine textual instruction with audio instruction, and to add a vibration in the controller once the right button is pressed.

Concerning the instruction outside of the environment, multi-modal instruction consisting of a video demonstration and brief paper-based instruction seems the most effective. Within the paper-based instruction, users should be told what the goal and relevance of the WiN intervention is. Furthermore, signalling should be present and irrelevant and complicated details should be avoided as much as possible. Within the video tutorial, instruction should then be included on how to set up the VR technology, how to use the controllers, where to stand in the room, how to start the simulation and when the user should close their eyes.

Present Study

In order to investigate whether these proposed added instructions would have any value to the Walk in Nature intervention being self-guided by users, they should be compared to a baseline that consists of the current instructions in combination with paper-based instruction, as previous findings have found this to be the least effective type of instruction (Buch et al., 2014; Donkor, 2010; Jasche et al., 2021). Furthermore, as this study aims to find out more about the usability of the intervention and the ability of users to use the intervention independently at home, both aspects should be measured. Therefore the research question of this current study is:

"What is the effect of using multi-modal instruction with the 'Walk in Nature' VR intervention on the usability and self-guided use compared to a group receiving only paper-based instruction?"

Besides this, previously mentioned findings indicate that the use of different types of cues with the VR-environment and video-based instruction outside of the VR-environment reduces the cognitive load of users and increases their knowledge retention (Afify, 2020; Cooper et al. 2018; Noetel et al., 2021; Oviatt et al., 2004; Shi et al., 2007). Therefore, a second research question is formulated:

"What is the effect of multi-modal instruction with the 'Walk in Nature' VR intervention on the knowledge retention of users, compared to purely paper-based instruction?"

Methods

Participants

25 students from the University of Twente participated in the study. The ages of the students ranged from 20-24 (M = 21.6, SD = 1.0). 15 were female and 10 male. They were recruited through convenience sampling, by using the Test Subject Pool in SONA systems of the BMS department of the University of Twente, and by asking students who knew the researchers directly. The inclusion criteria of the study were that participants have to be proficient in English and 18 years or older. People with medical conditions and sensitivities that can be aggravated by Virtual Reality were excluded from the study. The research was approved by the Ethics Committee of the University of Twente (request number 240588). The informed consent that was written also corresponds with the guidelines of the Committee, and was signed by all participants prior to participation.

Materials

For this study, the Walk in Nature (WiN) VR intervention was used and given to the participants through the Oculus Quest 2 HMD. The headset was connected with a powerlink cable to a Dell Alienware laptop. The Oculus computer app was used to connect the laptop and the HMD to each other. The location of the experiment was the Ravelijn building at the University of Twente, as this is a controlled environment in which there was enough room for participants to use the WiN environment and for the researchers to be present as well. The data gathered from the participants was analysed with the statistical tool RStudio, version 4.1.1.

Participants had to fill out an online questionnaire in Qualtrics. This questionnaire contained a knowledge test on the instruction given to the participant and questions on the experiences of the participant with the intervention. Additionally, this questionnaire was also used for the informed consent and to gather demographic information. Further information on the demographic questions and other elements within the questionnaire can be found in the Measures section of this thesis.

An observation scheme was used to assess the participants' ability to use the intervention independently. More information on this scheme can also be found in the Measures section. Besides this, participants were given an instruction sheet that contained instructions on how to use the WiN intervention. This instruction sheet differed based on whether the participant was part of the instruction or control group. The instruction within the VR environment also differed depending on what group the participant was assigned to. An overview of the instructions as they were before this research, together with what the instructions entail within the two conditions of this study, can be found in Table 1.

Table 1

Overview of the Current Instructions and the New Instructions in Both Groups

	Current		**Control Group**		**Instruction Group**	
	Instruction type	*Medium*	*Instruction type*	*Medium*	*Instruction type*	*Medium*
Instructions outside of VR			Visual Instruction	Paper-based instruction (Instruction sheet – Long)	Visual instruction, Verbal instruction	Paper-based instruction (Instruction sheet – Short), Video-based instruction including Voiceover audio
Butterfly Task	Visual instruction	Annotation (Textbox at start)	Visual instruction	Annotation (Textbox at start)	Visual instruction, Verbal instruction	Annotation (Textbox at start), Voiceover audio
Breathing Tree	Visual instruction, Verbal instruction	Annotation (Textbox at start), Voiceover audio				
Social Yoga	Visual instruction, Verbal instruction	Annotation (Textbox at start, Breathing bubble), Virtual tutor (Yoga instructor and students), Voiceover audio (Short)	Visual instruction, Verbal instruction	Annotation (Textbox at start, Breathing bubble), Virtual tutor (Yoga instructor and students), Voiceover audio (Short)	Visual instruction, Verbal instruction	Annotation (Textbox at start, Breathing bubble), Virtual tutor (Yoga instructor and students), Voiceover audio (Long)

Control Group

The control condition received the current instruction that was already present within the “Walk in Nature” environment before this research. In addition, they received a double-sided A4 paper including the instructions described in Table 2. On this paper, one picture was included of what a VR controller looks like with an overview of the buttons present on it. This instruction sheet can be found in Appendix B. The instructions that were given within the VR-environment, were the following:

Butterfly task. At the start of this exercise there is a textbox with instructions containing the text: “Walk towards the butterflies, reach out to touch them and press the grip button on the controller to make them fly away. Press the ‘A’ button to start the exercise”. After the user presses the button, the exercise starts and there is no further instruction present during this.

Social yoga task. At the start of this exercise there is a textbox with the instruction: “Press the ‘A’ button to start.” After the user presses the button to start the exercise, a voiceover audio on how to do the yoga exercises immediately starts playing without introduction. This is the short form of the audio.

Instruction Group

The experimental condition also received an A4 paper, but theirs had briefer instructions on only steps 1 and 2 (see Table 2). In addition to this, it had instruction in the form of a video-based tutorial in which steps 3 to 7 were demonstrated to the participant while a voiceover audio further explained what was happening in the video. Participants could access this video on their phones by following a QR-code on the bottom of the A4 paper. The instruction sheet for the instruction group can be found in Appendix C. Researchers had an extra laptop with them in case the QR-code did not work for any of the participants. Besides the A4 paper and video-tutorial, the instruction group also received additional instruction during the VR-simulation in the form of audio instruction and clearer text instruction within the VR environment. These instructions were the following:

Butterfly task. At the start of the exercise there is a textbox with instructions containing the text: “Walk towards the butterflies, reach out to touch them and press the grip button on the controller to make them fly away. Press the ‘A’ button to start the exercise”. A voiceover audio also says the same text as is present in the textbox. After the user presses the button, the exercise starts and there is no instruction present during this.

Social yoga task. At the start there is a textbox with the instruction: “Breathe in and out and move according to the instructions of the yoga instructor. You can check how to do the movements by looking at the other participants next to you. Press the ‘A’ button to start the exercise.” After the user presses the button to start, the breathing bubble appears and a voiceover audio of 2 minutes starts playing in which the voice explains what the purpose is of the exercise, why the breathing bubble is there and how the user should perform the yoga exercises (i.e. imitate the yoga instructor in front of you and the other students next to you, and follow what the voiceover audio says). After this introduction audio is done, the yoga instructor and students (visual instruction) start doing the yoga movements and a voiceover audio talks the user through on what to do. After all the yoga movements are done, the voiceover audio now tells the user to focus on their breathing and ends the session. This is the long form of the audio.

Table 2

Steps of Instruction Given to Participants Outside of VR-Environment

	Step
1.	Description of goals and importance of the intervention (Chen and Teh, 2013)
2.	Brief description of what happens during the simulation
3.	How to turn the VR-headset on
4.	How to set up barriers in the VR environment
5.	Adjusting VR-headset to fit on the head of the participant
6.	How to hold the controllers
7.	Explaining buttons on the controllers.

Measures

In order to measure the perceived usability of the WiN intervention, the System Usability Scale (SUS) was used as a measurement. This is a scale with ten items that are all based on a 5-point Likert scale, ranging from “1” or “Strongly disagree” to “5” or “Strongly agree”. The default word “system” was replaced with the word “VR intervention” in all of the questions.

Because this thesis was a joint project with another bachelor student who was investigating the attitudes of participants regarding the WiN VR environment, in the questionnaire there were also three open questions added and questions which were based on the Unified Theory of Acceptance and Use of Technology 2 (UTAUT2). All questions from this model were used, except for the ones regarding ‘Price Value’ and ‘Social Influence’, since these are not relevant within this intervention. The UTAUT2 is measured through a 5-point Likert scale, and the total score is calculated by taking the sum of the scores given on the Likert scale (1 to 5), and can range from 18 to 90. Through measuring the attitude of the participants regarding the intervention, more can also be found out about their general experience with it.

Demographic Characteristics

There were in total seven demographic questions asked of the participants. The first demographic question was “Please ask the researchers what your participation number is and fill it in below.” This was an open entry box that participants were supposed to fill in with their assigned participation number. Participants in the control group were assigned the numbers 101 to 112, while the participants in the instruction group were assigned the numbers 201 to 213.

The second question was “Please indicate your age”. This was answered with an open entry text box in which participants could type a number without decimals between 18 and 100.

The third question was “Please indicate your gender”, which could be answered with the options “Male”, “Female”, “Non-binary / Third gender”, and “Prefer not to say”.

The fourth question was “Please indicate your nationality”, which could be answered with the options “Dutch”, “German”, and “Other, namely:”. The last option had an open entry text box attached to it.

The fifth question was “How often do you use VR?”, which could be answered with the options “Never”, “I have tried it once”, “I have tried it a few times”, “1-5 hours a week” and “5+ hours a week”. If participants answered with one of the last two options, they were shown a new additional question: “If you indeed use VR, for what purpose?”. This question could be answered with the options “Personal enjoyment”, “Mental health”, “Physical health”, “Education” and “Job/Business”, from which participants could choose one or more options.

The last question was “What social media do you use?”. This could be answered with the options “Instagram”, “X”, “Facebook”, “Threads”, “Snapchat”, “TikTok”, “Youtube”, “Reddit”, “Tumblr” and “Pinterest”, from which participants could choose one or more options.

Observation scheme

Besides this, in order to measure the self-guided use, an observation scheme was created. This observation scheme is divided into the following three behaviours: “Participant is able to adjust the VR-headset independently”, “Participant is able to hold the controllers correctly and independently”, and “Participant is able to press the right buttons during the simulation independently”. Participants could get a maximum of four points on the first two behaviours, and three points on the last behaviour. The highest total score participants could get was 11. The scheme can be found in Appendix A, including all of the criteria.

Knowledge Test

Lastly, participants were tested on their knowledge retention after using the VR-environment via a knowledge test in the questionnaire that asked the participants to put the steps of connecting the VR-headset to the laptop and setting up the barriers within the VR environment in the right order. The amount of mistakes made on each test were then calculated to form the scoring on the knowledge tests. This meant that zero was the highest score on the tests and that the maximum amount of mistakes that could be made was 8 on the first knowledge test, and 5 on the second.

Design

For this research, an experimental design was used. Participants were randomly allocated to one of two conditions: the control condition, or the experimental condition, which is the instruction group. The independent variable of this study was Added Instruction, which is dichotomous with the answers “Yes” and “No”. The outcome measures / dependent variables were the scores on the SUS, the scores on the first (“How do you connect the VR-headset to the laptop? Please put the steps in the right order.”) and second knowledge tests (“How do you set-up the barriers within the VR environment? Please put the steps in the right order.”), the UTAUT2, the total score of the observation scheme, and the score on each part of the observation scheme: “Participant is able to adjust the VR-headset independently” (AH), “Participant is able to hold the controllers correctly and independently” (HC), “Participant is able to press the right buttons during the simulation independently” (PB).

Procedure

In order to participate in the research, participants could select a day and time slot in which they were available. They were then invited to the exact location of the study. When participants arrived, the researchers first discussed possible ethical issues and confidentiality. After this, the participants were asked to fill in the first part of the questionnaire including the informed consent and demographic questions. When participants completed this, they would receive a brief explanation of the set-up of the VR headset from the researcher. At this point, participants in the instruction group were handed an additional set of instructions that they had to follow on their own.

Following this, all of the participants proceeded with trying out the tasks in the "Walk in Nature" environment. This included the butterfly and social yoga task, since the breathing tree task was unable to be used. After the butterfly task was done, a researcher manually switched the environment to the social yoga task. All participants were asked to close their eyes here, since there was no smooth transition between the scenes and this may have led to nausea in the users. After finishing the tasks, participants were asked to fill out the rest of the questionnaire on the provided laptop. Subsequently, the study was concluded by thanking the participants for their time and asking them if they had any remaining questions.

Data Analysis

First, unnecessary columns in the dataset were removed, such as those containing the informed consent, the start date and end date of the questionnaire, and the location of the participants, since all questionnaires were conducted at the same place. As multiple numeric variables were classed as characters by RStudio, these were changed to numeric. After this, Cronbach's alpha was calculated on the SUS and UTAUT scores in order to make sure that the results are reliable and that the variables can be measured against each other. Following this, descriptive statistics were conducted on all of the outcome measures to give a general impression of the data. This includes the means and standard deviations for both the instruction and control group. The means for the SUS score and total observation score were calculated to answer the first research question. To answer the second question, the means on both of the knowledge tests were calculated.

Prior to performing any statistical tests, it was checked if the assumptions of independence, homogeneity of variance and normality were met. This was necessary to see if parametric statistical tests could be performed to answer the research questions. The Pearsons' Chi-square test was used to determine if the data meets the independence assumption. The Shapiro-Wilk test was conducted on each dependent variable to test the normality assumption of the data. The homogeneity of variances assumption was tested with the Fligner-Killeen test, as not all data was normally distributed and this test is more robust against departures from normality.

To answer the first research question "What is the effect of using multi-modal instruction with the 'Walk in Nature' VR intervention on the usability and self-guided use compared to a group receiving only paper-based instruction?", t-tests were conducted that compared the scores on the SUS and observation scheme between the control group and instruction group. The Welch two-sample t-test was chosen specifically, because the homogeneity of variance assumption was not met.

Subsequently, in order to answer the second research question "What is the effect of multi-modal instruction with the 'Walk in Nature' VR intervention on the knowledge retention of users, compared to purely paper-based instruction?", another Welch t-test was conducted that compared the mistakes on the first and second knowledge test between the control group and instruction group.

The script that was used in RStudio can be found in Appendix D.

Results

Descriptive Statistics

For the categorical demographic variables of both groups, descriptive statistics are shown in Table 3. From this, it can be seen that most participants selected that they had tried VR once, with n = 5 in the instruction group and n = 2 in the control group, or had tried it a few times, with n = 6 in the instruction group and n = 8 in the control group. Besides this the most used social media platforms were Instagram and YouTube, which both had n = 12 in the instruction group and n = 10 in the control group.

Table 3

Demographics of Participants in the Instruction and Control Group

	Instruction (N=13)	Control (N=12)
Age (years)	21.9 (1.14)	21.3 (0.87)
Gender		
Male	7 (53.8%)	3 (25%)
Female	6 (46.2%)	9 (75%)
Nationality		
Dutch	6 (46.2%)	5 (41.7%)
German	5 (38.4%)	4 (33.3%)
Other	2 (15.4%)	3 (25%)
How often do you use VR?		
Never	1 (7.7%)	2 (16.7%)
I have tried it once	5 (38.4%)	2 (16.7%)
I have tried it a few times	6 (46.2%)	8 (66.7%)
1-5 hours a week	1 (7.7%)	0 (0%)
What Social media do you use?*		
Instagram	12 (92.3%)	10 (83.3%)
Snapchat	7 (53.8%)	5 (41.7%)
TikTok	3 (23.1%)	8 (66.7%)
YouTube	12 (92.3%)	10 (83.3%)
Reddit	3 (23.1%)	4 (33.3%)
Pinterest	5 (38.5%)	7 (58.3%)

Note. As the variable Age is numeric, the mean of this is shown and the standard deviation in brackets. The other variables in this table show the number of participants who selected an option, with in brackets the percentage that this is of the total group sample.

** Participants could select multiple options on this question. The answers 'X', 'Facebook', 'Threads' and 'Tumblr' are not mentioned here, since only 1 participant or less chose these options.*

On the two demographic questions, “How often do you use VR?” and “If you indeed use VR, for what purpose?”, participants could select multiple options. As only one person chose the option 1-5 hours a week, they were only shown the follow-up question, “If you indeed use VR, for what purpose?”, which they answered with “Education”. Due to this, this question was not further analysed.

Table 4

Descriptives of the Control and Instruction Group and p-values of Welch T-test

	Control		Instruction		T-test	
	M	SD	M	SD	t	p
Knowledge test 1 Mistakes	1.3	1.2	1.9	1.1	-1.11	.280
Knowledge test 2 Mistakes	0.8	0.6	0.9	0.7	-0.37	.717
SUS Total score	65.6	16.3	79.6	16.2	-2.15	.042
UTAUT Total score	57.0	8.8	58.9	12.3	-0.435	.668
AH Observation score	3.5	0.6	3.7	0.5	-0.52	.611
HC Observation score	3.4	0.6	3.7	0.4	-1.10	.282
PB Observation score	2.1	0.8	2.7	0.5	-2.27	.038
Total Observation score	9.0	0.8	9.9	0.8	-2.77	.011

Note. AH = adjusting headset, or “Participant is able to adjust the VR-headset independently”. HC = holding controllers, or “Participant is able to hold the controllers correctly and independently”. PB = pressing buttons, or “Participant is able to press the right buttons during the simulation independently”.

To answer both research questions, descriptives in the form of means and standard deviations were also taken from the dependent variables, which can be found in Table 4. To find out what the effect of multi-modal instruction in the WiN is on the usability and self-guided use compared to the control group, it was found that the mean of the SUS score was M = 65.6 in the control group and M = 79.6 in the instruction group. The means of the total observation score were M = 9.0 for the control group and M = 9.9 for the instruction group. To find out what the effect is of multi-modal instruction in the WiN on the knowledge retention of users compared to the control group, it was found that the mean of the amount of mistakes made on the first knowledge test was M = 1.3 for the control group and M = 1.9 for the instruction group. Furthermore, on the second knowledge test, the mean amount of mistakes was M = 0.8 for the control group and M = 0.9 for the instruction group.

Testing of Assumptions

In order to find out what tests could be performed on the data to answer the research questions, the assumptions of independence, normality and homogeneity of variances were tested. Results of the Pearson's Chi-square test were $\chi^2(984,\ N = 25) = 315.7,\ \text{p} = 1.$ This indicates that the independence assumption is met, as $p > 0.05$. The Shapiro-Wilk test gave $p < 0.05$ for all dependent variables except for the SUS score ($p = 0.391$), the UTAUT score ($p = 0.466$), and the total observation score ($p = 0.057$). Therefore these 3 variables are normally distributed and the rest is not, meaning that the normality assumption is not met. Lastly, the Fligner-Killeen test gave $p > 0.05$ on all variables except for the PB observation score, meaning that the data has unequal variances and the assumption of homogeneity of variances is not met.

Welch Two Sample T-test

As the assumptions of normality and homogeneity of variances were not met, the Welch Two Sample t-test was used to answer both research questions by testing if there were significant differences between the instruction and control group on the SUS score, the observation scores, and both of the knowledge tests. The t-test found that participants in the instruction group scored significantly higher on the SUS compared to the control group, $t(22.81) = -2.15$, $p = 0.042$. The instruction group also scored significantly higher on the total score of the observation scheme, $t(22.89) = -2.77$, $p = 0.011$. Furthermore, the instruction group had significantly higher scores on the Pressing Buttons component of the observation scheme, $t(15.42) = -2.269$, $p = 0.038$. These results all indicate a significant difference in favour of the instruction group. The variables of the knowledge tests, and the AH and HC scores, all did not have significant differences between the instruction and control group. The t- and p-values of the t-tests can be found in Table 4.

Discussion

The purpose of this study was to investigate whether adding multi-modal instruction to the Walk in Nature intervention would have any added value for the usability and self-guided at-home use of the intervention compared to using only paper-based instruction and the instruction that was already present within the VR environment. Furthermore, it wanted to find out what the effect of adding multi-modal instruction is on the knowledge retention of users. This research found that multi-modal instructions improved perceived usability and self-guided use of the intervention compared to only paper-based instructions. In particular, users were better at pressing the correct buttons during the VR-simulation when they participated in the group that received multi-modal instructions. Moreover, the usability is considered good for the group that received multi-modal instructions, while it is considered sufficient for the group that received purely paper-based instruction.

To answer the second research question, this study found that the addition of multi-modal instruction did neither increase or decrease the knowledge retention of users and that knowledge retention was high in both conditions. There were no differences between the two conditions for both of the knowledge tests about mistakes regarding connecting the HMD to the laptop and setting up the barriers of the VR-environment.

The findings of the first research question indicate that using a combination of verbal and visual instruction results in higher usability and self-guided use than just using visual instruction. These findings are in line with the studies done by Hecht et al. (2007) and Meyer et al. (2005), which both indicated that using more than one type of instruction caused faster and more accurate reaction times. An improved reaction time indicates that users had less problems with following the instruction, and since ease of use is an important part of usability that was also investigated with the SUS, usability and reaction time may have a relationship with each other. Additionally, an increased ease of use means that an intervention will also be easier for a user to use on their own, which indicates that self-guided use has a positive relationship with usability and may have an indirect relationship with reaction time as well.

Besides this, the findings of this study suggest that video-based instruction is combination with brief paper-based instruction also results in a higher usability and self-guided use than purely using paper-based instruction. This is in line with previous research done by Buch et al. (2014) and Donkor (2010), who both also found that that video-based instruction was more effective than text-based.

One explanation for the results of the second research question may be that the use of video-based instruction and multiple different types of cues indeed does not cause a decrease in cognitive load and increase in knowledge retention. However, this does not seem very likely as this would contradict earlier findings (Afify, 2020; Cooper et al. 2018; Noetel et al., 2021; Oviatt et al., 2004; Shi et al., 2007). Therefore, an alternative explanation may be that there was a design flaw in the knowledge test that made the test easier for the control group than for the instruction group. The knowledge test consisted of two enumerations that participants had to put in the right order, and the control group was shown these exact enumerations on the paper when they got the instruction (see Appendix B). Instead of this, the instruction group was shown a video that contained the same information, but had every number of the enumeration shown one by one. This means that the control group had seen the full enumerations before and could easily read through them a few times, while the instruction group did not have such an overview and would have had to rewind the video.

Strengths and Limitations

The study has shown to have several strengths. The first strength was that the experimental conditions were successfully implemented by keeping the conditions across the two groups the same as much as possible. Moreover, through randomly assigning participants to a group, a quite similar distribution of demographics across the two groups is achieved, which increases the reliability of the results and the generalizability of the results to the general population of university students. This was especially the case for age, nationality and social media use. Another strength of this study was the choice to utilize an observation scheme instead of a questionnaire to test the self-guided use. As this study was a joint project with another student, the questionnaire given to participants was already on the longer side, and adding another measure to this would result in more rushed and unreliable answers due to the participants losing interest (Sharma, 2022). Thus, the observation scheme made sure that the questionnaire was kept shorter, which results in a lower non-response rate and higher reliability in the answers of the participants (Sharma, 2022).

However, the study also has several limitations that should be taken into account. Firstly, during the conducting of the experiment, a few participants experienced technical difficulties. Namely, sometimes the cable that connected the HMD to the laptop got disconnected, this meant that some participants were interrupted and had to do an exercise over. Moreover, the sound did not work for two participants, and because of this they had to either also start over the exercise or do the exercise with no sound. As this impacted these participants' experiences with the intervention, this may have had an influence on the results.

Another limitation of the study is that the sample size of 25 participants was relatively small. This decreases the reliability of the study and means that the study has a limited generalizability to the general population. Furthermore, another aspect that limits the generalizability of this research is that it is specifically focused on the WiN intervention. Therefore no certain conclusions can be made on what the outcomes would be of a similar study with a different VR-environment.

A last point to consider is that multiple types of instruction have been added to the WiN intervention for the instruction group. The study had only one intervention group to which multiple types of instruction were added, and due to this, it is unclear which specific part of the instruction in the intervention was responsible for the increases in usability and self-guided use in the instruction group.

Implications and Future Recommendations

Due to the significant results found on the usability and self-guided use in the instruction group, this study provides a valuable addition to the further development of the Walk in Nature VR-environment as an intervention that can be utilized by users in their homes. Furthermore, this study provides an insight into the benefits of adding multi-modal instruction to VR and other e-health technologies. Future studies into e-health interventions can make use of the findings of this study and potentially expand upon it. Furthermore, as there are currently only a very small amount of studies done on instruction for VR interventions and environments, this study will be a useful contribution to the limited body of research within this domain.

For future research that will elaborate on the current study, a recommendation would be to investigate which part of the instruction that the instruction group received was effective in increasing the usability and self-guided use of the WiN intervention in comparison with paper-based instruction. To test this, a future study could keep the same control condition, but use multiple intervention conditions, instead of one intervention group, that all add one type of instruction to the control condition.

As this study concludes that there may be a potential relationship between reaction time, usability and self-guided use, a further recommendation would be to test if there are actually relationships between these concepts in a future study.

Another recommendation for future research is based on the earlier mentioned potential design flaw in the knowledge test that made the test easier for the control group. In case a knowledge test like the one used in this study will be utilized in a future study, it would be recommended to make adjustments to the test. One possibility for adjustment would be to make the knowledge test into open questions. This will make sure that participants are judged on the basis of their retention and understanding of the knowledge, and not on their ability to recall the order of an enumeration, and thus increase the validity of the test. Furthermore, by doing it in this manner, it prevents the participants from being influenced by the order of responses that is already there before they interact with it (Tsang et al., 2017).

A last recommendation for future studies would be to investigate the impact of adding tactile/haptic instruction on the usability, self-guided use and knowledge retention of the WiN intervention. Due to practical and time constraints, it was not possible to incorporate tactile instruction into the VR-environment of the current study. However, previous research findings do suggest that a combination of visual, verbal and tactile cues causes faster and more accurate reaction times (Hecht et al., 2007; Meyer et al., 2005). Additionally, other research found that using multi-modal cues increases performance on tasks and decreases cognitive load (Cooper et al., 2018; Jia et al., 2011; Oviatt et al., 2004; Shi et al., 2007) Because of this, it would be worthwhile to investigate combinations of instructions with tactile instruction further within the context of the Walk in Nature intervention, and what kind of impact this would have on the usability, self-guided use and knowledge retention of VR-environments in general.

All things considered, while simple paper-based instruction and the current instructions present in the Walk in Nature environment do lead to a good usability, self-guided use and knowledge retention, the usability and self-guided use of the intervention can be improved by the addition of multi-modal instruction. Because of this, multi-modal instruction is considered an integral part of creating easy to use VR-environments and other e-health interventions that people can use independently in their own homes.

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Appendix A

Observation/Coding Scheme

Participant nr.:

			Score
Participant is able to adjust the VR-headset independently			
The sliders on the straps of the back of the head are adjusted. ***(1 point)***	Participant does not adjust sliders on the back of the head. ***(0 points)***		
Participant moves the headset around on their head. ***(1 point)***	Participant does not move headset around on their head. ***(0 points)***		
Top strap that goes over the head is centred ***(1 point)***	Top strap that goes over the head is not centred ***(0 points)***		
Participant does not ask researcher for help regarding adjustment of headset. ***(1 point)***	Participant asks researcher for help once regarding adjustment of headset. ***(½ point)***	Participant asks researcher for help 2 or more times regarding adjustment of headset. ***(0 points)***	
Participant is able to hold the controllers correctly and independently			
Participant rests their thumb on top of the controller (near the X/A buttons) ***(1 point)***	Participants does not rest their thumb on top of the controller. ***(0 points)***		
Participant rests the rest of their hand on the back of the controller, with their index finger on the trigger, and their middle finger on the grip button. ***(1 point)***	Participant rests the rest of their hand on the back of the controller, but the index and middle finger are not on the supposed buttons. ***(½ point)***	Participant does not rest their hand on the back of the controller. ***(0 points)***	
Participant puts wristbands around their arms. ***(1 point)***	Wristbands are not used by the participant. ***(0 points)***		
Participant does not ask researcher for help regarding the controllers. ***(1 point)***	Participant asks researcher for help once regarding the controllers. ***(½ point)***	Participant asks researcher for help 2 or more times regarding the controllers. ***(0 points)***	
Participant is able to press the right buttons during the simulation independently			
'A' button was only used when the participant was supposed to. ***(1 point)***	'A' button was pressed wrongly once ***(½ point)***	'A' button was pressed wrongly 2 or more times ***(0 points)***	

Grip button was only used when the participant was supposed to. ***(1 point)***	Grip button was pressed wrongly once ***(½ point)***	Grip button was pressed wrongly 2 or more times ***(0 points)***	
Participant does not ask researcher for help regarding finding the right button(s). ***(1 point)***	Participant asks researcher for help once regarding finding the right button(s). ***(½ point)***	Participant asks researcher for help 2 or more times regarding finding the right button(s). ***(0 points)***	
		Total Score	

Appendix B

Instruction Sheet Control Group

The Walk in Nature (WiN) environment is a Virtual Reality environment developed for improving the well-being of its users and decreasing their stress and anxiety, with its effects being shown in a previous study. Because of this, the WiN intervention could be a useful tool when people are dealing with things such as chronic fatigue. The goal of this current study is to investigate how the WiN environment can be applied to an at-home situation where the user would have to use it completely independently. For this purpose, we are investigating the experiences of users with the intervention and how instructions influence these experiences.

When you put on the VR-headset, you will experience a simulation of a nature environment that includes the default starting environment and 2 tasks. The researchers will be manually switching you between these tasks, so please close your eyes when this happens in order to prevent nausea. The VR-headset can be put off again after the last task, the yoga exercise, is finished.

During the entire duration of this study, it is important that you imagine yourself in the following scenario:

You were provided with a VR-intervention called the 'Walk in Nature' and were asked to try it out at-home with the aim of using it regularly, for example for improving your physical movements. When you open the box you have been given, you see the following: a VR-headset with controllers, a cable, a charger, a laptop, and this instruction sheet. You now have to set-up and start using the intervention completely on your own, with the help of the instruction sheet.

Instructions on the use of the VR intervention

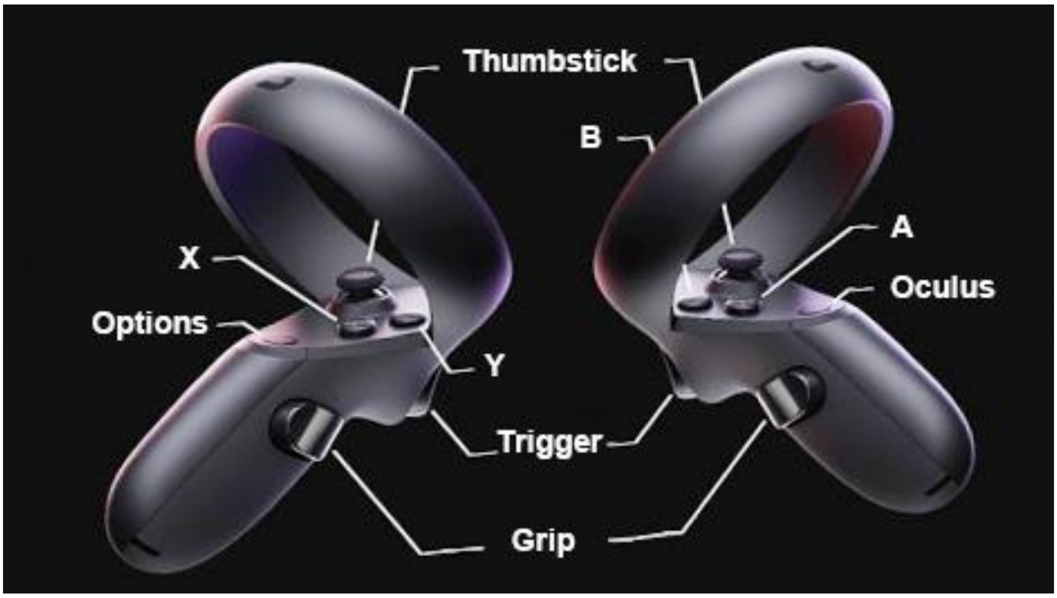
*When there is a * symbol before a heading, you do not have to follow these steps. However, it is important that you read through it all and try to remember it as you would need to for a situation such as the scenario mentioned above. Therefore take your time when reading.*

Adjusting the fit of the headset

The VR-headset should sit on your head tightly so that it remains in place, but it should also feel comfortable. Therefore, you can adjust it with the sliders on the straps that are on the back of your head. To tighten the headset, move the sliders away from the centre and each other. To loosen the headset, move the sliders towards the centre and each other. After this is done, gently move the headset around on your head until the image on the screen in front of your eyes is clear. Lastly, make sure that the top strap that goes over your head is centred when being put on.

Controllers

The picture on the next page gives a good overview of the buttons present on the controller. During the Walk in Nature, only the 'A' button and Grip buttons are used. Your hands should be on the controller with your thumb near the 'X' / 'A' buttons and your index finger on the Trigger button. The rest of your hand should be at the back of the controller, with your middle fingers on the Grip button. Make sure you put your hands through the wristbands of the controller before you start playing.



*** Turning on the VR-headset**

The VR-headset can be turned on by pressing and holding the button on the right side of the headset for a few seconds.

*** Connecting the VR-headset to the laptop[1]**

In order to connect the headset to your laptop, you have to do the following steps:

1. Download the Meta Quest app on your PC or laptop and open the software after the installation.
2. Connect the Link cable to the VR-headset. Make sure the cable doesn't get stuck between the headband.
3. Connect the other end of the cable to your PC or laptop and click 'Continue' on the screen of your laptop.
4. Put on your Meta Quest VR headset and go to your system settings via the menu.
5. Scroll down and choose Quest Link.
6. Toggle on the switch next to 'Quest Link'.
7. Click on 'Launch Quest Link'. Then, click on the 'Launch' button.
8. Click on 'Enable'.

*** Setting up the barriers within the VR environment**

In order to set-up the barriers of the VR-environment, also called the Guardian, that prevent you from walking into objects, you need to do the following steps:

[1] Text of this part is taken from Coolblue (2024), with some adjustments.

1. Make sure to clear the space you are playing in. Remove anything in your surroundings that could hinder you when playing
2. Press the gear button on the right bottom corner of your screen within VR to go to the Settings menu
3. At the Quick Actions tab, Click on ‘Guardian’.
4. Select either "Stationary" or "Roomscale".
5. Follow the on-screen instructions to set up your Guardian.

Appendix C

Instruction Sheet Instruction Group

The Walk in Nature (WiN) environment is a Virtual Reality environment developed for improving the well-being of its users and decreasing their stress and anxiety, with its effects being shown in a previous study. Because of this, the WiN intervention could be a useful tool when people are dealing with things such as chronic fatigue. The goal of this current study is to investigate how the WiN environment can be applied to an at-home situation where the user would have to use it completely independently. For this purpose, we are investigating the experiences of users with the intervention and how instructions influence these experiences.

When you put on the VR-headset, you will experience a simulation of a nature environment that includes the default starting environment and 2 tasks. The researchers will be manually switching you between these tasks, so please close your eyes when this happens in order to prevent nausea. The VR-headset can be put off again after the last task, the yoga exercise, is finished.

During the entire duration of this study, it is important that you imagine yourself in the following scenario:

You were provided with a VR-intervention called the 'Walk in Nature' and were asked to try it out at-home with the aim of using it regularly, for example for improving your physical movements. When you open the box you have been given, you see the following: a VR-headset with controllers, a cable, a charger, a laptop, and this instruction sheet. You now have to set-up and start using the intervention completely on your own, with the help of the instruction sheet.

The QR Code below will bring you to an instruction video on how to use the VR intervention. You do not have to follow the last three steps, however, it is important that you try to remember the information as you would need to for a situation such as the scenario mentioned above. Therefore take your time when watching.

Or use this link: *https://youtu.be/Cs2E6krCsxk*

Appendix D

R-script

```
library(tidyverse)
library(ggplot2)
library(vosonSML)
library(tidytext)
library(topicmodels)
library(SnowballC)
library(igraph)
library(RColorBrewer)
library(wordcloud)
library(ltm)
library(dplyr)
library(stringr)
library(stringi)
library(foreign)
library(janitor)
library(vctrs)
library(glue)
library(reshape2)
library(readr)
library(readxl)
library(psych)

# Open and view data
setwd("C:/Users/carme/Desktop/Rfiles")
file.choose()
data <- read_excel("Dataset Thesis.xlsx")

view(data)
```

```
str(data)

# Clean up data (remove unnecessary columns and rows)
data <- data[-c(1), ]
data <- data[-c(2, 3, 5:11, 16:20, 31:43)]

#Change character variables to numeric where relevant
data$Age <- as.numeric(data$Age)
data$K1_Mistakes <- as.numeric(data$K1_Mistakes)
data$K2_Mistakes <- as.numeric(data$K2_Mistakes)
data$SUS1 <- as.numeric(data$SUS1)
data$SUS2 <- as.numeric(data$SUS2)
data$SUS3 <- as.numeric(data$SUS3)
data$SUS4 <- as.numeric(data$SUS4)
data$SUS5 <- as.numeric(data$SUS5)
data$SUS6 <- as.numeric(data$SUS6)
data$SUS7 <- as.numeric(data$SUS7)
data$SUS8 <- as.numeric(data$SUS8)
data$SUS9 <- as.numeric(data$SUS9)
data$SUS10 <- as.numeric(data$SUS10)
data$PE1 <- as.numeric(data$PE1)
data$PE2 <- as.numeric(data$PE2)
data$PE3 <- as.numeric(data$PE3)
data$EE1 <- as.numeric(data$EE1)
data$EE2 <- as.numeric(data$EE2)
data$EE3 <- as.numeric(data$EE3)
data$EE4 <- as.numeric(data$EE4)
data$FC2 <- as.numeric(data$FC2)
data$HM1 <- as.numeric(data$HM1)
data$HM2 <- as.numeric(data$HM2)
```

```
data$HM3 <- as.numeric(data$HM3)
data$HT1 <- as.numeric(data$HT1)
data$HT2 <- as.numeric(data$HT2)
data$HT3 <- as.numeric(data$HT3)
data$HT4 <- as.numeric(data$HT4)
data$BI1 <- as.numeric(data$BI1)
data$BI2 <- as.numeric(data$BI2)
data$BI3 <- as.numeric(data$BI3)
data$OBS_Total <- as.numeric(data$OBS_Total)

# Creating dataset intervention group
data_interv <- data[c(5, 6, 7, 8, 9, 12, 14, 16, 18, 19, 22, 23, 25),]

# Creating dataset control group
data_control <- data[c(1, 2, 3, 4, 10, 11, 13, 15, 17, 20, 21, 24),]

# Descriptive statistics - Demographics
data %>% summary(data)
data_interv %>% summary(data_interv)
data_control %>% summary(data_control)

data_interv %>% map(sd)
data_interv %>% tabyl(Gender)
data_interv %>% tabyl(Nationality)
data_interv %>% tabyl(Experience_VR)

data_control %>% map(sd)
data_control %>% tabyl(Gender)
data_control %>% tabyl(Nationality)
data_control %>% tabyl(Experience_VR)
```

```
# Descriptive statistics - Social media use
data_interv %>% tabyl(Instagram)
data_interv %>% tabyl(X)
data_interv %>% tabyl(Facebook)
data_interv %>% tabyl(Threads)
data_interv %>% tabyl(Snapchat)
data_interv %>% tabyl(TikTok)
data_interv %>% tabyl(Youtube)
data_interv %>% tabyl(Reddit)
data_interv %>% tabyl(Tumblr)
data_interv %>% tabyl(Pinterest)

data_control %>% tabyl(Instagram)
data_control %>% tabyl(X)
data_control %>% tabyl(Facebook)
data_control %>% tabyl(Threads)
data_control %>% tabyl(Snapchat)
data_control %>% tabyl(TikTok)
data_control %>% tabyl(Youtube)
data_control %>% tabyl(Reddit)
data_control %>% tabyl(Tumblr)
data_control %>% tabyl(Pinterest)


#Reverse even (i.e. negatively worded) items on SUS scale for calculating Cronbach's alpha
reverse <- data[c(24, 26, 28, 30, 32) ]
keys <- c(-1, -1, -1, -1, -1)
reverse <- reverse.code(keys, items = reverse, mini = 1, maxi = 5)
reverse_SUS=as.data.frame(reverse)
```

```
data['SUS2'] <- reverse_SUS['SUS2-']
data['SUS4'] <- reverse_SUS['SUS4-']
data['SUS6'] <- reverse_SUS['SUS6-']
data['SUS8'] <- reverse_SUS['SUS8-']
data['SUS10'] <- reverse_SUS['SUS10-']

# Reliability - Dependent variables
SUS_score <- data[c(23:32)]
PE_score <- data[c(33:35)]
EE_score <- data[c(36:39)]
FC_score <- data[c(40)]
HM_score <- data[c(41:43)]
HT_score <- data[c(44:47)]
BI_score <- data[c(48:50)]
AH_score <- data[c(54:57)]
HC_score <- data[c(58:61)]
PB_score <- data[c(62:64)]
OBS_total_score <- data[c(54:64)]

#Cronbach's alpha of multiple item scores to test internal consistency / reliability
# -> if alpha is sufficient, the score with multiple items will be merged into one variable
cronbach.alpha(SUS_score)
cronbach.alpha(PE_score)
cronbach.alpha(EE_score)
cronbach.alpha(HM_score)
cronbach.alpha(HT_score)
cronbach.alpha(BI_score)
# a > 0.6 on all of them, with all, except HT_score (0.612), a > 0.85

#### Descriptive statistics - Dependent variables
```

```
## Total score UTAUT (sum of scores on variables)
data$UTAUT_Total <- data$PE1 + data$PE2 + data$PE3 + data$EE1 +
            data$EE2 + data$EE3 + data$EE4 + data$FC2 +
            data$HM1 + data$HM2 + data$HM3 + data$HT1 +
            data$HT2 + data$HT3 + data$HT4 + data$BI1 +
            data$BI2 + data$BI3

## Total score SUS (  SUS = ((X-1)+(5-X)) * 2.5  )
# Make sure to reload dataset to reset the even reversed questions
data$SUS_Total <- (((data$SUS1 - 1) + (data$SUS3 - 1) + (data$SUS5 - 1)
            + (data$SUS7 - 1) + (data$SUS9 - 1)) + ((5 - data$SUS2)
            + (5 - data$SUS4) + (5 - data$SUS6) + (5 - data$SUS8)
            + (5 - data$SUS10))) * 2.5

## Total score AH, HC, and PB
data$AH_Total <- data$OBS_1 + data$OBS_2 + data$OBS_3 + data$OBS_4

data$HC_Total <- data$OBS_5 + data$OBS_6 + data$OBS_7 + data$OBS_8

data$PB_Total <- data$OBS_9 + data$OBS_10 + data$OBS_11

# Make Total scores numeric
data$SUS_Total <- as.numeric(data$SUS_Total)
data$UTAUT_Total <- as.numeric(data$UTAUT_Total)
data$AH_Total <- as.numeric(data$AH_Total)
data$HC_Total <- as.numeric(data$HC_Total)
data$PB_Total <- as.numeric(data$PB_Total)

## Means and standard deviations of Intervention and Control group
summary(data_interv)
```

```
data_interv %>% map(sd)

summary(data_control)
data_control %>% map(sd)
data %>% map(sd)

# Dataset with only the dependent variables included
data_dep_var <- data[-c(1:16, 19:22, 51:53, 66)]

# Chi-Square Test for independence of data
chisq.test(data_dep_var)

# Shapiro-Wilk test for normality data
shapiro.test(data_dep_var$K1_Mistakes)
shapiro.test(data_dep_var$K2_Mistakes)
shapiro.test(data_dep_var$SUS_Total)
shapiro.test(data_dep_var$UTAUT_Total)
shapiro.test(data_dep_var$AH_Total)
shapiro.test(data_dep_var$HC_Total)
shapiro.test(data_dep_var$PB_Total)
shapiro.test(data_dep_var$OBS_Total)



# Fligner-Killeen test for homogeneity of variances
# After being done with this, reload data_dep_var without PN column
data_dep_var <- data[-c(2:16, 19:22, 51:53, 66)]
data_dep_var <- data_dep_var %>%
  mutate(PN = recode(PN, '101.0' = "control", '102.0' = "control", '103.0' = "control", '104.0' = "control", '105.0' = "control",
                     '106.0' = 'control', '107.0' = 'control', '108.0' = 'control', '109.0' = 'control', '110.0' = 'control',
```

```
'111.0' = 'control', '112.0' = 'control', '201.0' = 'instruction', '202.0' = 'instruction', '203.0' = 'instruction',
'204.0' = 'instruction', '205.0' = 'instruction', '206.0' = 'instruction', '207.0' = 'instruction', '208.0' = 'instruction',
'209.0' = 'instruction', '210.0' = 'instruction', '211.0' = 'instruction', '212.0' = 'instruction', '213.0' = 'instruction'))


fligner.test(K1_Mistakes ~ PN , data = data_dep_var)
fligner.test(K2_Mistakes ~ PN , data = data_dep_var)
fligner.test(SUS_Total ~ PN , data = data_dep_var)
fligner.test(UTAUT_Total ~ PN , data = data_dep_var)
fligner.test(AH_Total ~ PN , data = data_dep_var)
fligner.test(HC_Total ~ PN , data = data_dep_var)
fligner.test(PB_Total ~ PN , data = data_dep_var)
fligner.test(OBS_Total ~ PN , data = data_dep_var)



# Independent / Welch t-test
t.test(data_control$K1_Mistakes, data_interv$K1_Mistakes)
t.test(data_control$K2_Mistakes, data_interv$K2_Mistakes)
t.test(data_control$SUS_Total, data_interv$SUS_Total)
## Significant
t.test(data_control$UTAUT_Total, data_interv$UTAUT_Total)
t.test(data_control$AH_Total, data_interv$AH_Total)
t.test(data_control$HC_Total, data_interv$HC_Total)
t.test(data_control$PB_Total, data_interv$PB_Total)
## Significant
t.test(data_control$OBS_Total, data_interv$OBS_Total)
## Significant
```