02.07.20

UNIVERSITY OF TWENTE.

Stress Reduction during Bronchoscopy using a Virtual Reality Head Mounted Display with Nature Stimuli

Nicole Thomasson

University of Twente
BMS Faculty
Department of Psychology

Supervisors: Dr. Marcel Pieterse, Dr. Thomas van Rompay

Abstract

Introduction: Nature has been shown to have a positive effect on stress reduction and patient recovery in medical settings. However, most literature has focused predominantly on the use of physical nature stimuli in hospital settings, such as murals or plants, or auditory stimuli, such as nature sounds or music. In addition, few studies have focused on using these stimuli for endoscopic procedures, like bronchoscopies. Considering a lack of focus on the possibilities of new technologies, such as Virtual Reality (VR), the aim of this study was to investigate whether VR has an effect on stress and whether this effect is stronger in highly anxious individuals. Secondly, this study aimed at researching the effect of soft-fascinating stimuli, which are stimuli that effortlessly attract our attention, on stress-reduction during bronchoscopy.

Method: This study used a quasi-experimental, between-group design with VR as an independent variable and stress and arousal as dependent variables, in the form of self-reported data and physiological data. The sample consisted of 32 individuals (N=32). 19 participants were part of the experimental condition, of which 10 took part in the low soft-fascination condition and 9 in the high soft-fascination condition. 13 participants took part in the control condition. A virtual reality head-mounted device (HMD), called RelaxMaker, was used for participants in the experimental conditions.

Results: A general linear model with repeated measures was used to investigate the role of stress at baseline on the effect of VR on stress reduction. Significant effects were found for the main effect of time and condition. No significant effects were found for the interaction of baseline stress on the effect of VR on time on heart rate. However, visual analyses indicated an adverse effect of VR on stress reduction in patients that were overly anxious before the procedure. Next to that a Kruskal-Wallis test has shown that soft-fascinating stimuli might have a relaxing effect on the perceived discomfort of a patient after insertion of the bronchoscope.

Discussion: This study had low statistical power, therefore, research with a bigger sample size is recommended. In addition, future research should make use of modern VR technology with moving pictures. At last, the effect of pain on stress in this context should be further investigated.

Introduction

Many medical diagnostic procedures are stressful for patients undergoing them. One of the most invasive diagnostic procedures is a bronchoscopy (Poi, Chuah, Srinivas & Liam, 1998). A bronchoscopy is a medical procedure in which the airways and lungs are inspected for abnormalities. During this procedure, a bronchoscope is inserted through the mouth or the nose of the patient and is guided towards the lungs in order to get an endoscopic view of the airways.

Bronchoscopy is often regarded as a being highly stressful for patients. Poi et al. (1998) reported that 61% of patients who undergo bronchoscopy feel anxious before or during the procedure. Anxiety activates the sympathetic nervous system which can be observed in many physiological responses, such as the increase of the heart-rate, the increase of blood pressure, a heightened respiratory rate or a heightened level of skin conductance (Korhan, Khorshid & Uyar, 2011).

Several specific fears have been identified that cause bronchoscopy patients to be anxious. The most prevalent fear is the fear of pain that the procedure may cause (Poi et al., 1998). Next to that, patients are also afraid of breathing difficulties, oropharyngeal irritation, the bronchoscopy findings and sedation (Tetikkurt et al., 2014; Poi et al., 1998).

High levels of anxiety prior and during bronchoscopy can lead to several complications during the procedure. First, heightened levels of anxiety and stress prior to bronchoscopy lead to more feelings of discomfort in the patient during bronchoscopy, making the procedure seem even more stressful (Mitsumune, Senoh & Adachi, 2005). In addition, high levels of anxiety prior to bronchoscopy can interfere with the procedure and can cause intolerance to bronchoscopy. This might eventually elongate the diagnostic process for patients, which leads to more stress due to a longer period of uncertainty regarding a possible diagnosis (Tetikkurt et al., 2014). Furthermore, heightened levels of anxiety during bronchoscopy can cause a higher requirement for sedation due to a more intense sensation of pain (Bytzer & Lindeberg, 2007).

In order to reduce pain during the procedure, anesthesia and sedation are frequently used. This medication, however, can lead to side effects such as cardiovascular instability, respiratory depression and hypotension (Chadha, Kulshrestha & Biyani, 2015). Therefore, it would be favorable to reduce anesthesia as much as possible and use non-pharmacological interventions to decrease stress and pain in patients.

Several studies have been conducted regarding how to reduce pain, stress and anxiety prior to and during bronchoscopies in a hospital setting without anesthesia and sedation. One way of doing so has been listening to music during the procedure (Tam, Lo & Hui ,2016; Nilsson, Unosson & Rawal, 2005). However, the reported effectiveness of music during bronchoscopy varies greatly per study (Colt, Powers & Shanks, 1999).

A second way of reducing pain and stress for bronchoscopy patients has been the use of nature in a hospital setting (Diette et al., 2003). Moreover, the positive effects of nature are valid for both direct and indirect interactions with nature (Keniger, Gaston, Irvine & Fuller, 2013). The fact that indirect interactions with nature show similar psychological benefits compared to direct interactions with nature is promising for closed environments, such as hospitals. Several studies with indirect nature interactions in medical settings have been carried out. Ulrich (1984) reported that patients with a window-view on nature used less medication for pain relief and had shorter recovery times in the hospital. Another study, in which patients were looking at a mural showing a natural environment and listening to nature sounds during the procedure has been effective in reducing pain for bronchoscopy patients (Diette et. al, 2003). Moreover, in a study by Ulrich et. al (1991), participants first watched a stressful video and afterwards watched a video with either a natural environment or an urban environment. The results indicate that participants who watched the nature video recovered faster from stress than the participants who watched the urban video. Finally, in a study by

Dijkstra, Pieterse and Pruyn (2008), participants were asked to imagine themselves being hospitalized with a legionella diagnosis. Afterwards, they had to look at a photo that either showed a hospital room with a painting of an urban environment or a hospital room decorated with plants. Participants watching the photo with plants reported lower levels of anticipated stress than participants watching the photo with the urban environment painting. Hence, research indicates that nature might have a pain- and stress-relieving effect in medical settings.

There are two prevalent theories that explain how nature stimuli might influence stress reduction. The first is the Attention Restoration Theory (ART) (Kaplan & Berman, 2010). ART is based on the assumption that individuals have limited cognitive resources that need to be restored once these resources are used completely. Kaplan and Berman (2010) distinguish between two types of attention that would have an influence on an individual's level of cognitive resources. The first type of attention is involuntary attention. This type of attention does not deplete cognitive resources as it occurs spontaneously when an individual sees something exciting, for example something that moves or something that seems strange in the individual's environment (Kaplan & Berman, 2010). The second type of attention is directed attention. Directed attention is used when an individual needs to pay attention to something in his environment that is not naturally exciting to him. Directed attention is an important resource for planning, learning or dealing with stress and is therefore important for reaching one's goals (Kaplan & Berman, 2010). As opposed to involuntary attention, directed attention is a process that takes mental effort as it does not occur automatically. Consequently, it would be directed attention that causes cognitive depletion. Once the resources for directed attention have been used, it needs to be restored before it is available to the individual again. It has been shown that the use of involuntary attention is able to restore the capacity for directed attention (Kaplan & Berman, 2010). According to Kaplan and Berman (2010), nature is particularly able to trigger involuntary attention and can therefore restore capacity for directed attention because it oftentimes is a form of soft fascination. Soft fascinating stimuli are gentle stimuli that attract our attention in a non-demanding way (Kaplan & Berman, 2010). It still allows for reflection. It stands in contrast to hard fascination that demands an individual's full attention and uses the resources of directed attention.

A second theory that aims at explaining stress reduction through nature stimuli is the Stress Reduction Theory (SRT) by Ulrich (1883; 1991). It suggests that by looking at vegetation, water or other elements of nature, we start to feel more positive emotions and feel less stressed. According to Ulrich (1983), nature makes us feel better because it is more aesthetically pleasing to us and therefore leads to increased positive affect compared to urban environments. Especially for individuals who feel stressed, nature tends to increase positive affect and reduce arousal, therefore decreasing levels of stress (Ulrich, 1983). In contrast to ART, Ulrich (1983) claims that "feelings, not thoughts, come first in environmental encounters, and the observer's initial feeling reaction shapes subsequent cognitive events".

The two theories on how natural environments reduce feelings of stress mainly differ in causality. In ART, the effect of nature on stress is more indirect. Nature helps to restore attentional resources and these resources can be used by the individual to deal with acute stress. This is, however, more indirect compared to SRT, as the freed attentional resources are not predestined to be used for stress reduction by the individual. Other cognitive processes besides stress reduction and relaxation also draw from these resources. In SRT, recovering from stress means recovering from psychophysiological stress. In this theory, nature has been said to increase positive affect and therefore simultaneously lowers stress levels in a direct causal way. Nevertheless, both theories show a consensus in the fact that nature is perceived to be able to reduce stress in individuals.

A third mechanism, that might explain how stress can be reduced is distraction from the stressor. This mechanism does not necessarily determine nature as the direct cause of stress reduction, nature is rather one way of many to reach lower stress-levels. The main idea of distraction as a mechanism to reduce stress is, that by diverting the attention of the patient away from the stressful experience towards a more pleasant experience, stress levels are lowered (McCaul & Malott, 1984).

As technology has advanced, the possibilities of implementing both extensive distraction and natural environments in hospitals have increased. One example of new technology in hospital settings is the use of Virtual Reality (VR). VR glasses are especially interesting for the medical sector because of its reachable degree of high immersion that allows patients to feel as if the virtual environment was real and allows them to forget about their surroundings (Hoffman et. al, 2011). This state might be especially beneficial during procedures where patients usually experience heightened levels of stress that can be linked to the hospital environment or when patients experience high levels of pain. Hoffman et al. (2011) used VR distraction on patients experiencing acute burn pain during the cleaning of their wounds. Patients reported 35-50% less pain during this procedure, when they were distracted by VR. However, the distraction did not consist of nature stimuli.

The virtual environment that the patient finds himself in has been shown to play a role in recovery and stress reduction. Several virtual environments have been tested for this. Valtchanov, Barton and Ellard (2010) reported that only VR-glasses that show natural environments have been found to activate the parasympathetic nervous system and therefore decrease levels of stress and increase levels of positive affect. Moreover, Annerstedt et. al (2013) have found indications that the visual nature stimuli need to be accompanied by acoustic nature sounds in order to decrease stress.

The findings of Valtchanov, Barton and Ellard (2010) suggest that soft-fascination might play a role in effectively lowering stress in patients. As was previously mentioned, soft fascinating stimuli are gentle stimuli that attract our attention in a non-demanding way and still allow for reflection (Kaplan & Berman, 2010). Soft-fascinating elements can be found in nature, for example in the movement of trees or water (Felsten, 2009). Therefore, when capturing nature on photo or film, the nature scenes can vary to the extent in which they are softly fascinating. As this study builds on, amongst others, the previous studies of Rupert (2018), Boekel (2018) and Jansen (2017), more information on the effect of soft-fascination in this specific research setting can be found in these studies.

Even though existing literature provides insight into the relationship between stress and natural environments in virtual reality, not a lot of research has focused on this relationship in the case of bronchoscopy. Research that has been done on the topic of stress and bronchoscopy has been either inconclusive and not focused on nature stimuli, such as in the case of listening to music during the procedure (Colt, Powers & Shanks, 1999), or it has been focusing on physical nature stimuli, such as murals with nature pictures or physical plants in a hospital room, as opposed to virtual stimuli (Diette et. al, 2013; Dijkstra, Pieterse & Pruyn, 2008). Consequently, the existing research only gives a general idea about whether nature stimuli can lower stress, but it does not give enough insight into this relationship in a medical setting or more specific: in the setting of a bronchoscopy, nor does it focus a lot on the use of VR.

Present study

This present study is unique and holds several benefits compared to previous research in the field. First, the study uses a combination of self-reported data as well as physiological data to measure the stress levels that patients experience. Second, the use of a VR head-mounted display leads to higher levels of immersion. Consequently, the patient feels more present in the virtual environment he is watching and has a feeling of truly being in nature, compared to when the real medical environment is altered. Nevertheless, the VR head-mounted display differs from regular VR glasses as it still allows for contact with the medical staff during the procedure. This is possible due to the fact that the part of the device the patients look at is thin and there is no physical screen. Instead, beamer-technology is used to project the images straight into the eyes of the patient. Therefore, patients are able to look below the images, see the real medical environment and communicate with medical staff. Next to that, the videos do not move with the patients' head, as it is the case with standard virtual reality glasses. This is, in order to not disturb the procedure. Since the bronchoscope is inserted through the nose or mouth of the patient, moving the head could lead to procedural complications.

Eventually, this study is a continuation of previous research on stress reduction during bronchoscopy with the help of Virtual Reality (Jansen, 2017; Boekel, 2018; Rupert, 2018; Te Mebel, 2019; Fischer, 2019). In the latest study, no significant effects were found for the effect of VR nature videos on physiological measurements of stress. Nevertheless, there were indications that a moderator effect might be found for a subgroup of the population, namely patients reporting high arousal and stress before the start of the procedure. Therefore, this study aims at answering the question whether patients who report higher stress levels prior to bronchoscopy experience a proportionally greater decline in stress levels with the help of VR and nature stimuli than patients who report low levels of stress prior to bronchoscopy. Next to that, it aims at finding out whether patients watching high soft-fascinating videos in VR experience less stress compared to patients watching low soft-fascinating videos in VR or patients not using VR.

In the context of this study, it is hypothesized that:

H1: Patients who report high levels of stress prior to bronchoscopy show a significantly greater decline in heart rate in the VR condition than in the control condition compared to patients with low levels of stress prior to bronchoscopy.

H2: Patients who watch the high soft-fascinating video show a significantly greater decline in heart rate than patients who watched the low soft-fascinating video or patients who did not make use of the VR device.

H3: Patients who watch the high soft-fascinating video show significantly lower self-reported stress-levels than patients who watched the low soft-fascinating video or patients who did not make use of the VR device.

Method

Design

The previous studies of Jansen (2017), Boekel (2018), Rupert (2018), Te Mebel (2019) and Fischer (2019) mark the foundation of this study. In those studies, a quasi-experimental, between-group design was used with VR as an independent variable and stress and arousal as dependent variables, in the form of self-reported data and physiological data.

Participants

In the studies, 32 individuals participated (N=32) of which 25 were male and 7 were female. The age of the participants ranged from 43 to 87 with a mean age of 68.8 (SD= 11.85). 19 participants were part of the experimental condition, of which 10 took part in the low soft-fascination condition and 9 in the high soft-fascination condition. Further, 13 participants took part in the control condition. Participants for the experimental groups were recruited from March 2017 until July 2018 and participants for the control group were recruited from March until July 2019. They were selected based on their willingness to participate. All participants were approached by the researchers and had undergone the bronchoscopy at the Medisch Spectrum Twente (MST) in Enschede, Netherlands. Exclusion criteria were a reduced vision of more than -5 myopic, the use of anesthesia and insufficient mastery of the Dutch language. Participants that were recruited for the experimental condition were also alternately assigned to the low soft-fascination condition or the high soft-fascination condition.

Materials and Instruments

Virtual Reality. A virtual reality head-mounted device (HMD), called RelaxMaker was used for participants in the experimental conditions. The RelaxMaker contains two LCD displays with 1280x720 pixels, a 98" screen, 26° sight and an aspect ratio of 16:9, 24-bit RGB colors (Beter door Beeld, 2018). It also incorporates headphones that transmit the sounds of the nature videos to the participants.

Image: RelaxMaker (n.d.)

The RelaxMaker makes use of static images with moving elements. Therefore, unlike many VR glasses, the perspective of the video does not move when the person moves his head. This is to ensure, that the medical procedure will not be hindered. Since the bronchoscope is inserted through the nose or mouth of the patient, moving the head could lead to procedural complications. Moreover, the screens are small enough for the patient to look above or below it, in order to communicate with medical staff.

Nature imagery. Two videos were displayed on the RelaxMaker. One using low soft-fascinating elements and one using high soft-fascinating elements. The video high on soft-fascination showed more movement of water and trees in the foreground than the video on low soft-fascination. Moreover, in the low soft-fascination video, there were less nature sounds. More information on the videos and the SF-conditions can be found in Rupert (2018) and Boekel (2018).

Physiological measurements of stress. An Empatica E4 wristband was used to measure heartrate as a physiological indicator for stress. This device contains a sensor that makes use of the principle of Photoplethysmography (PPG) in order to measure a continuous heart-rate. With this technique, the absorption of light in the tissue is measured. This depends on the amount of blood that is in the capillaries at that time. As the heart forces waves of blood into the capillaries of the skin, this leads to a higher absorption of light that can be measured. These fluctuations in absorption are representative of the heartbeat of the person (Allen, 2007). This way, the Empatica E4 is able to provide real-time physiological data (Empatica, 2020).

Self-reported measurements of stress. Three different questionnaires were used as part of a pre- and post-test structure with a follow-up. All questionnaires were written in the Dutch language. In the first questionnaire that was administered before the bronchoscopy, the participant's stress level was measured, thereby differentiating between Mood and Arousal. Arousal was measured by the item: "How nervous/restless or relaxed/calm do you feel at this moment?". Mood was measured by the item: "What is your mood at this moment?". Both items could be answered on a 7-point scale ranging from very bad (1) to very good (7) or ranging from nervous/restless to relaxed/calm (Hardy & Rejeski, 1989). No data has been gathered on the validity of the scales.

The second questionnaire that was administered after the bronchoscopy makes use of the same items for measuring stress. In addition to that, discomfort was measured using the Discomfort Insertion Scope with one item: "How pleasant or unpleasant was the insertion of the bronchoscope?". Afterwards, the Discomfort After Insertion Scale with the item: "How pleasant or unpleasant was the bronchoscopy after the insertion of the bronchoscope?" was used. Both items were answered on a 10-point scale ranging from very unpleasant (1) to very pleasant (10). Third, the Experienced Pain Relief scale was used with the item: "How good or bad did the sedation work in relieving pain during the bronchoscopy?". The item was answered on a 10-point scale ranging from "very bad, the procedure was very painful (1) to very good, the procedure was not painful at all (10). Lastly, the tension dimension of the Profile of Mood States short form (POMS-SF) was used in order to measure perceived stress (Baker, Denniston, Zabora, Polland & Dudley, 2002). Participants had to indicate how nervous, panicky, tense, restless, anxious and insecure they felt on a 5-point scale ranging from absolutely not (0) to very strong (4).

The third questionnaire was administered one week after the bronchoscopy. It also contains the two items on stress, as well as the items from the Discomfort Insertion Scope, the Discomfort After Insertion Scale and the Experienced Pain Relief scale, that were also used in the post-test. One item was added to this questionnaire compared to the second. It focused on how the participant would feel about future bronchoscopies: "Imagine you had to undergo another bronchoscopy, how much would you dread that?". This item was answered on a 7-point scale, ranging from "I dread very much" (1) to "I do not dread at all" (7).

Procedure

Participants were informed about the research in beforehand by the MST. On the day of the scheduled appointment for a bronchoscopy, participants were approached by the researcher in the waiting room of the MST and were provided more information on the research and had the opportunity to ask questions. Patients that were willing to participate signed an informed consent.

In the treatment room, patients were first informed by the doctor about the general procedure of the bronchoscopy. Afterwards, the Empatica E4 was applied at the participant's wrist and participants filled out the pre-test. Next, the throat of the participants was sedated.

After sedation, the RelaxMaker was administered to participants in the experimental condition and the bronchoscope was inserted. Exact moments of insertion and exertion were timed by the researcher. After exertion of the bronchoscope, the RelaxMaker was taken off. Approximately 5 minutes after the bronchoscopy, patients were asked to fill in the post-test.

A week after the bronchoscopy, patients were asked to fill in the follow-up questionnaire.

Data analysis

Before performing statistical analyses, the two datasets of the questionnaires and the physiological data of Te Mebel (2019) were merged into one dataset. Afterwards, statistical analyses were performed. All statistical analyses were conducted using IBM SPSS Statistics version 26.0.

Stress at baseline. In order to investigate the role of stress before bronchoscopy on the VR intervention, the two items “baseline mood” and “baseline arousal” that were answered by the participants before undergoing bronchoscopy, were made binary into “high” and “low”. Therefore, a median split was performed on these items to identify the cut-off score. A general linear model (GLM) for repeated measures was used to compare the three different measurements of heart-rate (before intubation, at insertion of the bronchoscope and during bronchoscopy, after passing the vocal cords) between the control and nature group, as well as between the participants that score high or low on mood. In addition, the interaction effects (time*VRcondition, time*baselinemood, time*VRcondition*baselinemood) were computed. A separate but similar GLM was used for baseline arousal.

Soft-fascination. In order to investigate the second and third hypothesis, that participants who watch the high soft-fascinating video show a significantly greater decline in heart rate and self-reported measures of stress than participants who watched the low soft-fascinating video or participants who did not make use of the VR device, a variable “SF” was computed to categorize participants into the three conditions (control, low SF, high SF). For analyzing the physiological data, a GLM for repeated measures was used to compare the three measurements of heart-rate between the three SF-conditions. Furthermore, the self-reported measurements were analyzed. The items of the POMS-SF, the Discomfort Insertion Scope and Discomfort After Insertion Scale were tested for normal distribution. Afterwards, an ANOVA was used to determine whether the means on the mentioned items are significantly different for the low SF-, high SF- and control-condition. When an unequal distribution was found, a Kruskal Wallis test was used to test whether the means were significantly different.

Results

The final sample consisted of 29 participants. Three participants were excluded due to a large number of missing data points in the questionnaires or physiological measurements. Therefore, the final sample consisted of 11 participants in the control group and 18 participants in the experimental group, of which 9 belonged to the high SF condition and 9 to the low SF condition. A descriptive overview of the sample can be found in Table 1.

Table 1.
Means and standard deviations of age and gender per condition.

Condition	**Age**		**Gender**	
	M	SD	Male	Female
Control	71,4	8,1	72,7%	27,3%
High SF	68,0	14,8	77,8%	22,2%
Low SF	67,4	13,4	77,8%	22,2%
Total	69,1	11,9	75,9%	24,1%

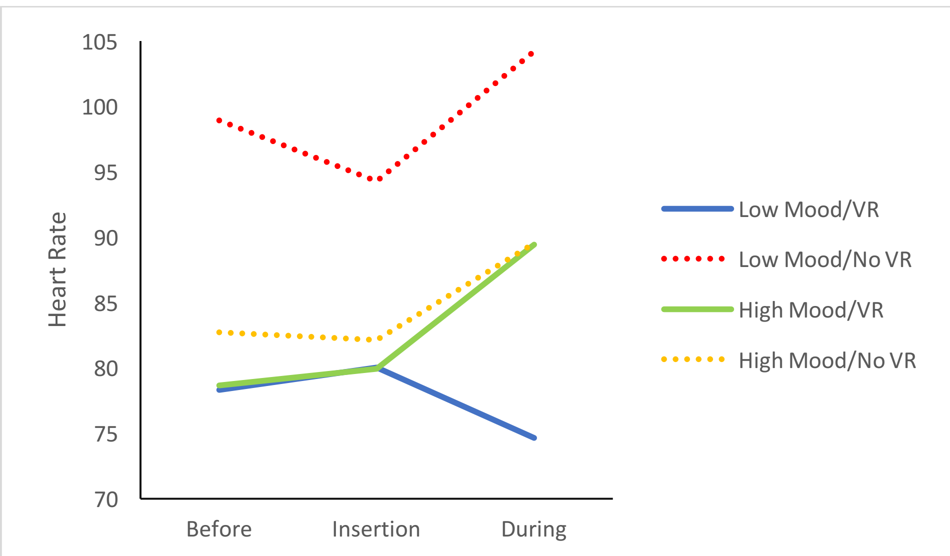
Stress at baseline

The two items "baseline arousal" and "baseline mood" that were measured in the first questionnaire before the start of the bronchoscopy were made binary using a median split. For baseline arousal, answers of 5 or higher on the Likert scale were considered as high, whereas answers below 5 were considered as low. For baseline mood, answers of 5.5 or higher were considered as high and answers below 5.5 were considered as low.

Afterwards, data has been analyzed using a general linear model for repeated measures with a within-subjects factor of time, composed of three measurements of heartrate, and between-subject factors of condition and baseline mood. Mauchly's test indicated that the assumption of sphericity had not been violated ($X^2(2)$=.97, *p*=.694). A significant main effect for VR-condition on heart rate was obtained F(1,25)=4.513, *p*=.044, η_p^2=.153. Heart rate in the VR condition was significantly lower (*M*= 80.161) than in the control condition (*M*=91.958), as can also be seen in Figure 1. The main effect of Baseline mood on heart rate, as well as the main effect of time on heart rate were not significant.

Figure 1

Heart Rate over Time for VR and Control Condition with High Arousal or Low Mood prior to Bronchoscopy



The two-way interaction of baseline mood on the effect of VR-condition on heart rate was non-significant, however, marginal F(1,25)=3.044, *p*=.093, η_p^2=.109. The tendency of the effect is in the direction that participants with a low baseline mood and used VR had a lower heart rate (*M*=77.65) than participants with a low mood in the control condition (*M*=99.14), participants in a high mood in the control condition (*M*=82.69) and participants in a high mood in the VR condition (*M*=84.77). This is again visible in Figure 1. When taking a closer look at the graph, it becomes clear that during bronchoscopy, low mood-patients in the VR condition show a decline in heart rate and patients in the control condition show an increase of almost the same factor after the point of insertion. This is in line with the first hypothesis. In addition, it is shown that patients who were in the high mood/ VR condition had a lower heart rate before insertion than patients who were in the high mood/ no VR condition. At the time of insertion, the heart rate of high mood patients in the control condition has decreased, whereas in the VR condition, it has increased. During the bronchoscopy, the heart rate in both VR- and control condition seems to be similar for high-mood patients, meaning that the heart rate of patients in the VR condition has increased more than the heart rate of patients in the control condition.

The two-way interactions of time and VR-condition, as well as time and baseline mood, were non-significant.

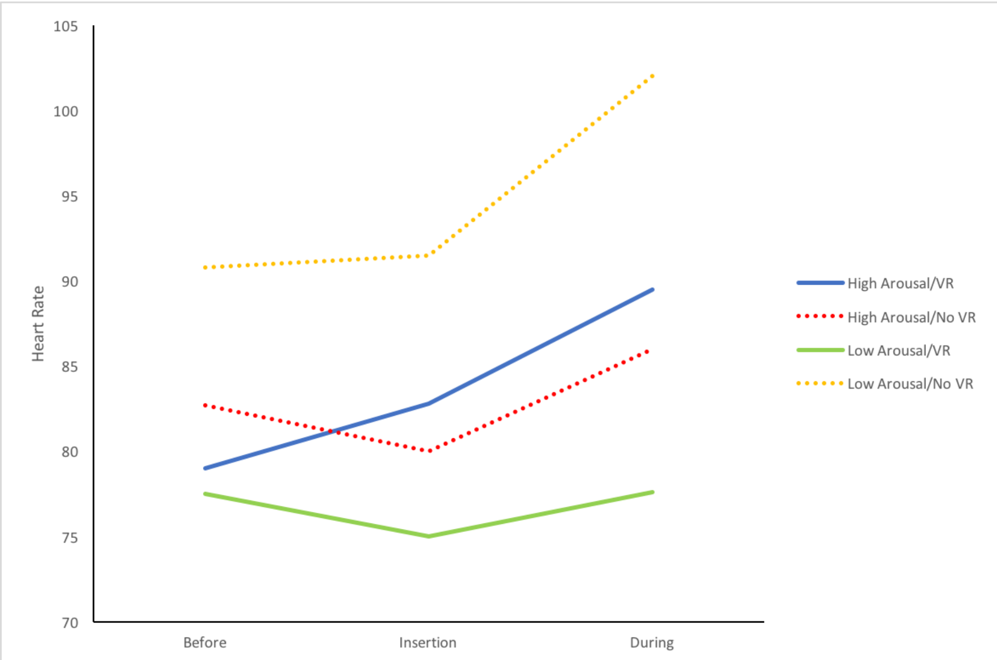
Next to the mentioned main effects and two-way interaction effects, no three-way interaction effects were found. Therefore, the first hypothesis was not supported by the data on baseline mood, as no within-subjects interaction effect of baseline mood on the effect of VR on time on heart rate (time*VRcondition*baselinemood) was found.

A similar general linear model was used for baseline arousal. Mauchly's test indicated again that the assumption of sphericity had not been violated ($X^2(2)$=.929, *p*=.415). The results show a significant main effect of time on heart rate F(2,50)=5.124, *p*=.009, η_p^2=.170.

Heart rate was significantly lower before insertion (*M*=82.55) and at insertion (*M*=82.460) than after insertion (*M*=89.13). This is visible in Figure 2. The main effects of VR-condition and baseline arousal were non-significant.

Figure 2

Heart Rate over Time for VR and Control Condition with High Arousal or Low Arousal prior to Bronchoscopy



Moreover, there was a significant effect for the two-way interaction of baseline arousal and VR-condition on heart rate, which was independent of time $F(1,25)=4.466$, $p=.045$, $\eta_p^2=.152$. Heart rate was overall lower in participants in the VR and low arousal condition (*M*=76.69) than in participants in the VR and high arousal condition (*M*=84.19), participants in the control and high arousal condition (*M*=83.12) and participants in the control and low arousal condition (*M*=94.86), as can also be seen in Figure 2.

When taking a closer look at the graph and analyzing the course of heart rates of patients over the three points in time, it shows that, patients who reported to be more aroused prior to bronchoscopy and were in the VR condition, on average, had a lower heartrate before bronchoscopy than high arousal-patients in the control condition. At the time of insertion, however, their heart rate increased, whereas the heart rate of the high arousal-patients in the control condition dropped. Moreover, also during bronchoscopy the average heart rate of high arousal patients in the VR condition seemed to be higher. This is against the first hypothesis that patients with high stress-levels prior to bronchoscopy show a greater decline in stress with the help of VR. At the time of insertion, the heartrate of the low-arousal patients in the VR condition decreases slightly, whereas in the control condition it seems to remain stable. During bronchoscopy, the heart rate of low-arousal patients in both conditions increases. However, in the VR condition, it only increases to the same level as before the procedure, whereas in the control condition the average heartrate seems to increase more.

Lastly, no significant effects were found for the three-way interaction of baseline arousal, VR condition and time on heart rate $F(2,50)=.083$, $p=.920$. Therefore, the first hypothesis was also not supported by the data on baseline arousal.

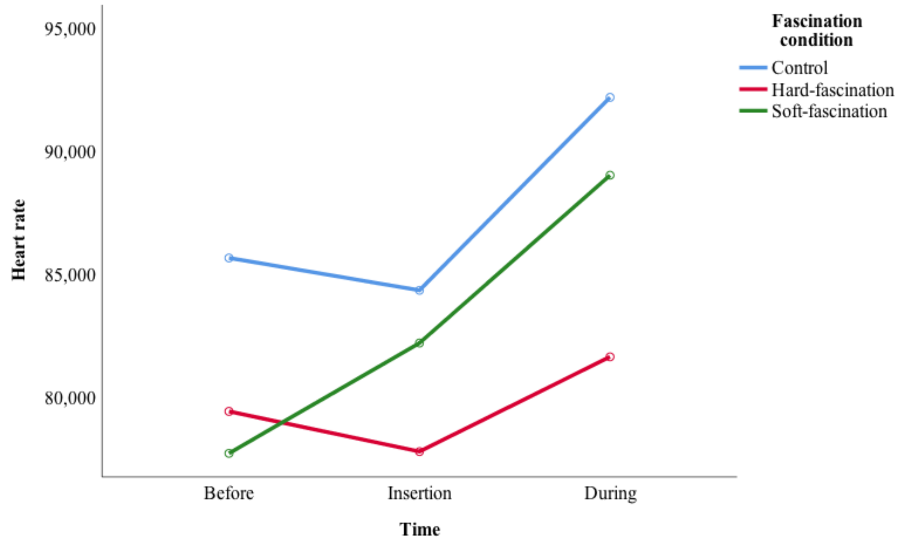
Thus, a positive main effect of VR on heart rate and time on heart rate was found, next to a two-way interaction effect of baseline arousal and VR-condition, independent of time and a marginal confirmatory interaction effect of baseline mood and VR-condition on heart rate. However, the two interaction effects point into opposite directions. In addition, counter to expectations, no significant within-subjects interaction effects involving time were found, meaning that there was no difference in decline of heart rate per participant over time in the different groups. This argues against the first hypothesis. A trend that was found by visual analyses of the graphs, is that patients in the control condition in all cases started with a higher average heart rate than patients in the VR condition, and subsequently, all experienced a decline in heart rate at the point of insertion, followed by a vast increase in heart rate during bronchoscopy. This trend therefore confirms the reported main effect of time in all conditions. No trend in heart rate was found for the VR condition, nor was there a visual difference between low-stress patients (low arousal, high mood) and high-stress patients (high arousal, low mood).

Soft fascination

In order to investigate whether participants who watch the soft-fascinating video show a significantly greater decline in heart rate than participants who watched the hard-fascinating video or participants who did not make use of the VR device, a general linear model for repeated measures was used with a within-subjects factor of time and a between-subject factor of soft-fascination (SF), consisting of three groups (control, low SF and high SF). The assumption of sphericity had not been violated ($X^2(2)=.923$, $p=.369$). As was previously mentioned, the results show a significant effect of time on heartrate $F(2,52)=5.459$, $p=.007$, $\eta_p^2=.174$. Heart rate was significantly higher after the insertion of the bronchoscope (*M*=87.61) than before insertion (*M*=80.91) and during insertion (*M*=81.42). No significant effects were found for time*SF. In Figure 3, the main effect of time on heart rate becomes visible. In all groups, heart rate rises significantly after insertion. The figure also shows that the trend for the effect of soft-fascination on heart rate seems to be going in the opposite direction of the hypothesis, as the heart rate of patients watching the high-soft fascinating video increases steeper than the heart rate of patients watching the low soft-fascinating video. The physiological data, therefore, does not support the second hypothesis.

Figure 3

Heart Rate over Time for Soft-Fascination-, Hard-Fascination- and Control Condition



Afterwards, the self-reported data of the POMS-SF, the Discomfort Insertion Scope and the Discomfort After Insertion Scale were checked for normality. As only the total scores of the POMS-SF met the normality assumption, as well as the homogeneity assumption, a one-way between-subjects ANOVA was carried out with this item to compare the effect of soft-fascination on the participants' stress levels in the control condition, the low soft-fascination condition and the high soft-fascination condition. As can be seen in Table 2, it was concluded that there is no significant difference in the total scores of the POMS due to the SF condition.

Table 2

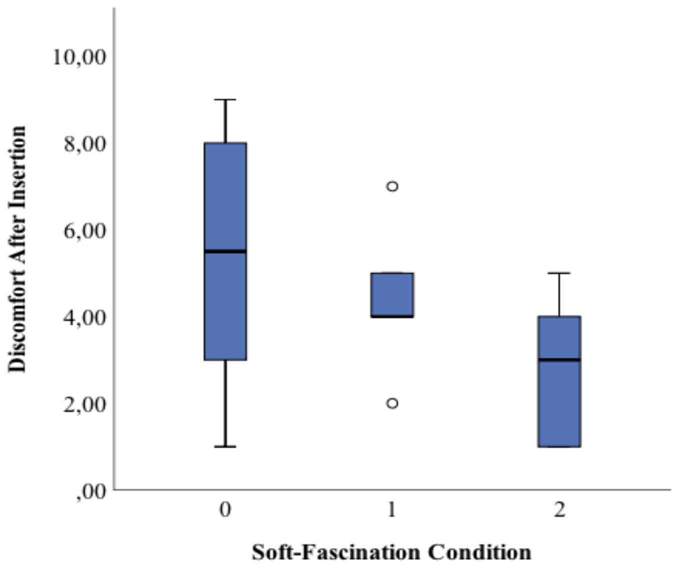
One-Way Analysis of Variance of Total Score POMS by SF-condition

	df	SS	MS	F	*p*
Between-groups	2	104.253	52.127	1.403	.265
Within-groups	25	928.711	37.148		
Total	27	1032.964			

For the items that did not have a normal distribution, a Kruskal-Wallis test was performed. Results show that discomfort during insertion of the bronchoscope is not significantly affected by soft fascination, $H(2)=.350$, $p=.839$. Discomfort after the insertion of the bronchoscope was closer to significance, $H(2)= 5.536$, $p=.063$ and showed that the mean for discomfort after insertion for patients in the high soft-fascinating condition was lower (M=3.0) than for patients in the low soft-fascinating condition (M=4.0) and the control condition (M=5.5), as can be seen in Figure 4.

Figure 4

Discomfort After Insertion for Control-, Low Soft-Fascination and High Soft-Fascination Condition

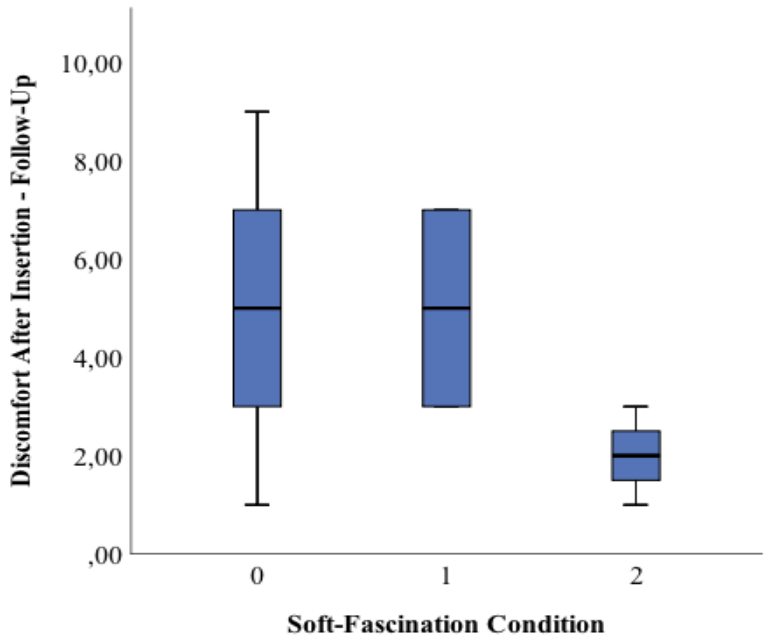


Note. 0= Control, 1= Low Soft-Fascination, 2= High Soft-Fascination

Though only marginally significant, this trend is in line with the expectations. In addition, also the follow-up of discomfort during and after insertion has not been significantly affected by soft fascination. However, again for discomfort after insertion, it is closer to significance, H(2)= 5.178, p=.075. Also in this case, patients in the high soft-fascinating condition reported experiencing lower discomfort after insertion (*M*= 2.0) than patients in the low soft-fascinating condition (*M*=5.0) and patients in the control condition (*M*=5.0), as can be seen in Figure 5. This again, is in line with the third hypothesis.

Figure 5

Discomfort After Insertion Follow-Up for Control-, Low Soft-Fascination and High Soft-Fascination Condition



Note. 0= Control, 1= Low Soft-Fascination, 2= High Soft-Fascination

Discussion

The aim of this research was to provide insights into the effects of VR on stress in the context of a bronchoscopy, while focusing on physiological effects, such as an increase of heart rate, as well as psychological effects, such as perceived distress during the procedure and one week after the procedure. In addition, the study aimed at investigating the role of soft-fascinating stimuli for stress-reduction in this specific setting.

Stress at baseline. It was hypothesized that exposure to VR nature simulation would primarily benefit patients undergoing bronchoscopy with high anticipatory stress. However, when analyzing the physiological data, no significant differences in decline in heart rate were found for the four groups (High Stress/VR, High Stress/No VR, Low Stress/VR, Low Stress/ No VR). Significant effects were only found for VR condition on heart rate, time on heart rate and the two-way interaction of VR-condition and baseline arousal on heart rate. It was shown that patients in the VR-condition had a significantly lower heart rate than patients in the control condition. This is in line with the expectations. However, the graphs also show that the lower heart rate of patients in the VR-condition was already present before insertion. The fact that patients in the control condition started with a higher heart rate than patients in the VR condition and subsequently experience a decline might indicate an effect of anticipation of pain that is moderated by the researcher telling the participant about being in the VR condition. It could therefore be, that when participants heard, that they would be using VR, it had a relaxing effect on them, making them underestimate the pain and stress, which is why afterwards at insertion heart rate increases. This can be due to the expectations participants have from using VR. It is possible that participants already anticipated that VR would distract them, when in fact at insertion they were disappointed by the real effect it had on them. This effect has been described in literature as the “nocebo effect”, which describes the occurrence of negative symptoms after using a certain substance or treatment and is introduced by certain psychological mechanisms such as expectations (Webster, Weinman &

Rubin, 2016). In contrast, it might be that participants who are not told to use the VR, do not experience this effect and subsequently naturally overestimate the pain and stress that is linked to the procedure. This is why it might be that they experience a decline in heartrate at the point of insertion. However, these assumptions should be treated carefully, as no significant effects were found and the possibility exists that there was a simple natural difference in baseline heart rates in the two groups. The latter seems more likely, as the sample size and therefore statistical power was low in this study.

Moreover, the significant main effect of time on heart rate shows that overall stress levels rise in all groups during the course of the procedure. This effect can be explained by the invasiveness of the procedure. As was explained before, bronchoscopy is oftentimes considered a very stressful procedure for patients due to various, oftentimes personal, reasons. Although the use of VR aims at reducing stress and anxiety in patients undergoing this procedure, it is understandable that the situation in which the patients find themselves, is still new, unknown and therefore potentially frightening. This nervousness eventually leads to an elevated heart-rate over time, starting especially around the time of insertion of the bronchoscope. This effect of time on heart rate therefore does not contradict the hypothesis that VR might lower stress-levels in certain individuals during bronchoscopy. As the heart rate of all participants rise, it is necessary to look into whether the heart rate of patients in the VR condition rises slower than patients in the control condition.

Contrary to the expectations, however, no significant effects were found for the three-way interaction of time, VR-condition and baseline arousal or the three-way interaction of time, VR-condition and baseline mood. Therefore, the first hypothesis needs to be rejected.

Interestingly, in the two conditions high arousal and low mood, that both indicate high baseline stress and in which a decline in heart rate over time was expected in the VR condition, the expected effect was rather visible in the control condition. In both, the high arousal/ No VR condition and the low mood/ No VR condition, the heart rate of patients dropped at the point of insertion and only increased to approximately pre-bronchoscopy levels, not higher, unlike in the VR condition where, especially in the high arousal/ VR condition, heart rate rises to a seemingly higher level (see Figure 1). These findings indicate that there is a possibility that, against all expectations, the use of VR is counter-productive in the case of patients with high stress at baseline.

Similar findings have been already made by McCall and Malott (1984), who proposed that methods of distraction turn from superior to inferior when a certain pain threshold is reached. It is possible that this also accounts for a certain stress threshold or for nature as a distracting stimulus. Nevertheless, it might be interesting to investigate the role of pain in the context of bronchoscopy.

Overall, however, these findings are in line with existing literature on stress reduction via VR distraction. Most studies investigating this relationship found positive results for the effect of VR distraction on stress during an invasive procedure (Schneider, Prince-Paul, Allen, Silverman & Talaba, 2004; Allan, Danforth & Drabman, 1989; Diette et al., 2003). This current study similarly found a significant main effect of VR on heart rate, showing that overall VR might be a useful tool in stress reduction in medical settings. In addition, however, this study shows that distraction might not be as effective for every patient. To be precise, VR-distraction has proven to be less effective for patients who are already highly stressed before the procedure. More research on the effect of anxiety on the effectiveness of VR-distraction for lowering stress-levels in medical settings is advised.

Soft fascination. It was hypothesized that patients who watch the high soft-fascinating video show a significantly greater decline in heart rate than patients who watched the low soft-fascinating video or patients who did not make use of the VR device. However, no significant effects were found regarding this hypothesis.

In addition, it was hypothesized that patients who watch the high soft-fascinating video show significantly lower self-reported stress-levels than patients who watched the low soft-fascinating video or patients who did not make use of the VR device. Although no significant effects were found, tendencies towards this hypothesis were visible, in the direction that patients felt less discomfort after the insertion of the bronchoscope when they watched the video high in soft-fascination. The difference between the control group and the low-soft fascination group was minimal. Though non-significant, the tendencies that the results of this study display, are in line with literature on soft-fascination (Kaplan, 1995).

In addition, these results can be linked to the Attention Restoration Theory. According to this theory, attention capacities are restored when attending to soft-fascinating nature stimuli. Higher capacities for directed attention would then be able to help to cope better with stress. In this research, it was shown that patients watching the video high in soft-fascination perceived less discomfort after insertion of the bronchoscope than other patients. It is possible, that these patients were able to restore more attention due to the effects of the high soft-fascinating video. Nevertheless, research with more statistical power might be useful to clarify this effect.

Strengths and limitations. One of the strengths of the study was the combined use of physiological data and self-reported data for the measurement of stress, giving a clearer picture into the changing stress levels of patients. Moreover, the use of physiological measurements of heart rate with the Empatica E4 allowed to see the full development of the heart rate at any point in time during the bronchoscopy. Therefore, certain events, such as complications during the procedure, could be marked and taken into consideration when analyzing the data.

Nevertheless, this study was also confronted with some limitations. One important limitation is the low statistical power of the study. Due to the small sample size, the chances that the statistical analyses detected the true effects between the different variables are reduced. Unfortunately, due to the global pandemic of Sars-Cov-2, it was not possible to recruit more participants for the control group, as was planned in beforehand. Non-Covid related procedures were widely put on hold during the peak of the epidemic in the Netherlands, which led to the fact that less bronchoscopies were carried out. In addition, the Medisch Spectrum Twente in Enschede had decided to pause most research activity in the hospital for the time being, which made it impossible for the researchers to gather new data.

A second limitation of the study is the outdated technology. During to the long period of data collection over three years, major technological developments have taken place. Whereas, the RelaxMaker was a relatively advanced and new VR tool in medical settings in 2017, over the years, the HMD itself has changed, as well as VR technology in general has majorly advanced. However, in order to preserve the internal validity of the study, no new VR technology could have been used for new data collection. One example of a limitation of the HMD used in this study is the fact that it does not move with the patients head but is steady. This is unlike most VR devices today and makes the high degree of immersion and the related feeling for users of being in a realistic realm, that is usually praised in modern VR, questionable for the Relaxmaker. Consequently, this leads to an unclear picture, of what the possibilities of today's VR technology could really mean for the medical sector.

Another technical constraint was the occasionally detected inaccuracy of the Empatica E4. As was described by Fischer (2019), the E4 occasionally lost signal and did not report the heart rate consistently at all times. This makes it questionable, whether all increases and decreases of heart rate were detected reliably. Studies on the validity of the E4 show that the device is able to detect average heart-rate reliably over a longer period of time. However, for "short-lived stressors", such as sudden anxious responses, validity is lower (Van Lier et al., 2019). In this study, the stressor is rather short-lived, as heart-rate is only monitored in the specific moment of the stressor, in this case the bronchoscopy, instead of over the course of for example a whole day.

Another limitation is the different working style of doctors. As was already mentioned by Te Mebel (2019), doctors have different protocols, working styles and communication strategies that could have an impact on stress levels of patients. It might for example make a difference for patients how a doctor communicated the risks of the procedure, whether he or she stays present during the whole procedure or is absent at some points or whether complications occurred during the procedure. As all individuals involved in the procedure are different, natural empathy or antipathy and personal preferences might bias the levels of stress that a patient experiences during the bronchoscopy.

Practical implications. Based on these results, there are several practical implications on the use of VR-distraction with soft-fascinating stimuli in clinical practice. First, this study has shown that VR-distraction is not beneficial for every patient. For patients that are overly anxious before the start of the bronchoscopy, it is advised to not use VR-distraction, as the immersive effect of VR may have an adverse effect on the stress-levels of patients. The use of VR in a medical setting goes along with a potential feeling of loss of control of the real situation. This can be beneficial, as individuals can immerse themselves into another, less stressful, situation via VR. However, for patients who already dread the loss of control linked to the procedure itself, the loss of control of the VR might add up to the levels of stress. Eventually, this makes the bronchoscopy more uncomfortable for these individuals.

Secondly, when VR-distraction is used on a patient that was less anxious before bronchoscopy and responds well to the device, it is advised to use soft-fascinating videos, meaning videos with high soft-fascinating elements, such as flowing water, moving clouds or moving trees (Kaplan, 1995). This study has shown indications, that only the soft-fascinating videos might make a difference in perceived stress and discomfort for bronchoscopy patients. This was the case for the post-test but also the follow-up two weeks later.

Future research. Future research is recommended in order to be able to say more about the effects of virtual reality and nature stimuli on stress during bronchoscopies. One recommendation is to use modern VR devices with high resolution that guarantee high levels of immersion. This is recommended because it was doubted whether the fixed images of the

Relaxmaker truthfully portray the power of virtual reality. In addition, a larger sample size is recommended in order to increase statistical power and obtain trustworthy effects. Moreover, as the results of this study carefully point towards an opposed effect of VR on anxious patients, it would be interesting to look more into the direct contrast between effects of ambient nature exposure in contrast to virtual nature exposure. Lastly, individual protocols of medical staff regarding the bronchoscopy and the use of the VR device should be tried to align and carried out as similar as possible in order to reduce biases.

References

Allen, J. (2007). Photoplethysmography and its application in clinical physiological measurement. *Physiological measurement*, *28*(3), R1. https://doi.org/10.1088/0967-3334/28/3/R01

Allen, K. D., Danforth, J. S., & Drabman, R. S. (1989). Videotaped modeling and film distraction for fear reduction in adults undergoing hyperbaric oxygen therapy. *Journal of Consulting and Clinical Psychology, 57*(4), 554–558. https://doi.org/10.1037/0022-006X.57.4.554

Annerstedt, M., Jönsson, P., Wallergård, M., Johansson, G., Karlson, B., Grahn, P., ... & Währborg, P. (2013). Inducing physiological stress recovery with sounds of nature in a 250. doi:10.1016/j.physbeh.2013.05.023

Baker, F., Denniston, M., Zabora, J., Polland, A., & Dudley, W. N. (2002). A POMS short form for cancer patients: psychometric and structural evaluation. *Psycho-Oncology: Journal of the Psychological, Social and Behavioral Dimensions of Cancer*, *11*(4), 273-281. https://doi.org/10.1002/pon.564

Boekel, I. (2018). *Psychological and physiological effects of virtual nature environments on well-being of bronchoscopy patients* (Bachelor's thesis, University of Twente). Retrieved from http://essay.utwente.nl/75170/

Bytzer, P., & Lindeberg, B. (2007). Impact of an information video before colonoscopy on patient satisfaction and anxiety-a randomized trial. *Endoscopy*, *39*(08), 710-714. DOI: 10.1055/s-0032-1308859

Chadha, M., Kulshrestha, M., & Biyani, A. (2015). Anaesthesia for bronchoscopy. *Indian journal of anaesthesia*, *59*(9), 565. doi: 10.4103/0019-5049.165851

Colt, H. G., Powers, A., & Shanks, T. G. (1999). Effect of music on state anxiety scores in patients undergoing fiberoptic bronchoscopy. *Chest*, *116*(3), 819-824. https://doi.org/10.1378/chest.116.3.819

Diette, G. B., Lechtzin, N., Haponik, E., Devrotes, A., & Rubin, H. R. (2003). Distraction therapy with nature sights and sounds reduces pain during flexible bronchoscopy: A complementary approach to routine analgesia. *Chest*, *123*(3), 941-948. https://doi.org/10.1378/chest.123.3.941

Dijkstra, K., Pieterse, M. E., & Pruyn, A. (2008). Stress-reducing effects of indoor plants in the built healthcare environment: The mediating role of perceived attractiveness. *Preventive medicine*, *47*(3), 279-283. https://doi.org/10.1016/j.ypmed.2008.01.013

Felsten, G. (2009). Where to take a study break on the college campus: An attention restoration theory perspective. *Journal of environmental psychology*, *29*(1), 160-167. https://doi.org/10.1016/j.jenvp.2008.11.006

Fischer, O. M. (2019). *Creating virtual nature environments during bronchoscopy, on the reduction of stress and discomfort, by using a RelaxMaker* (Bachelor's thesis, University of Twente). Retrieved from https://essay.utwente.nl/78111/

Hardy, C. J., & Rejeski, W. J. (1989). Not what, but how one feels: the measurement of affect during exercise. *Journal of sport and exercise psychology*, *11*(3), 304-317. https://doi.org/10.1123/jsep.11.3.304

Hoffman, H. G., Chambers, G. T., Meyer III, W. J., Arceneaux, L. L., Russell, W. J., Seibel, E. J., ... & Patterson, D. R. (2011). Virtual reality as an adjunctive non-pharmacologic analgesic for acute burn pain during medical procedures. *Annals of behavioral medicine*, *41*(2), 183-191. https://doi.org/10.1007/s12160-010-9248-7

Jansen, E. M. M. (2017). *Effects of nature on stress and anxiety during invasive diagnostic procedures: using virtual reality environments* (Bachelor's thesis, University of Twente). Retrieved from https://essay.utwente.nl/72911/

Kaplan, S. (1995). The restorative benefits of nature: Toward an integrative framework. *Journal of environmental psychology*, *15*(3), 169-182. Retrieved from https://willsull.net/la270/LA_270_Readings/LA_270_Readings_files/Kaplan%201995.pdf

Kaplan, S., & Berman, M. G. (2010). Directed attention as a common resource for executive functioning and self-regulation. *Perspectives on psychological science*, *5*(1), 43-57. https://doi.org/10.1177/1745691609356784

Keniger, L. E., Gaston, K. J., Irvine, K. N., & Fuller, R. A. (2013). What are the benefits of interacting with nature?. *International journal of environmental research and public health*, *10*(3), 913-935. https://doi.org/10.3390/ijerph10030913

Korhan, E. A., Khorshid, L., & Uyar, M. (2011). The effect of music therapy on physiological signs of anxiety in patients receiving mechanical ventilatory support. *Journal of clinical nursing*, *20*(7-8), 1026-1034. https://doi.org/10.1111/j.1365-2702.2010.03434.x

McCaul, K. D., & Malott, J. M. (1984). Distraction and coping with pain. *Psychological bulletin*, *95*(3), 516. https://psycnet.apa.org/doi/10.1037/0033-2909.95.3.516

Mitsumune, T., Senoh, E., & Adachi, M. (2005). Prediction of patient discomfort during fibreoptic bronchoscopy. *Respirology*, *10*(1), 92-96. https://doi.org/10.1111/j.1440-1843.2005.00642.x

Nilsson, U., Unosson, M., & Rawal, N. (2005). Stress reduction and analgesia in patients exposed to calming music postoperatively: a randomized controlled trial. *European journal of anaesthesiology*, *22*(2), 96-102. https://doi.org/10.1017/S0265021505000189

Poi, P. J., Chuah, S. Y., Srinivas, P., & Liam, C. K. (1998). Common fears of patients undergoing bronchoscopy. *European Respiratory Journal*, *11*(5), 1147-1149. DOI: 10.1183/09031936.98.11051147

Rupert, K. L. M. (2018). *The effects of nature on physiology and phenomenological experienced stress and anxiety during bronchoscopy: using an HMD* (Bachelor's thesis, University of Twente). Retrieved from http://essay.utwente.nl/75133/

Schneider, S. M., Prince-Paul, M., Allen, M. J., Silverman, P., & Talaba, D. (2004). Virtual reality as a distraction intervention for women receiving chemotherapy. *Oncology nursing forum, 31*(1).DOI: 10.1188/04.ONF.81-88

Tam, W. W., Lo, K. K., & Hui, D. S. (2016). The effect of music during bronchoscopy: a meta- analysis. *Heart & Lung*, *45*(2), 86-94. https://doi.org/10.1016/j.hrtlng.2015.12.004

Te Mebel, L. (2019). *The effect of a Virtual Nature Environment on the Experience of Bronchoscopy Patients, Measured by Psychological and Physiological Measurements* (Bachelor's thesis, University of Twente). Retrieved from https://essay.utwente.nl/78155/

Tetikkurt, C., Yasar, I., Tetikkurt, S., Yılmaz, N., Kara, B. Y., Yavuz, R., & Disci, R. (2014). Role of anxiety on patient intolerance during bronchoscopy. *Journal of Advances in Medicine and Medical Research*, 2171-2180. https://doi.org/10.9734/BJMMR/2014/6907

Ulrich, R. S. (1983). Aesthetic and affective response to natural environment. In *Behavior and the natural environment*(pp. 85-125). Springer, Boston, MA. https://doi.org/10.1007/978-1-4613-3539-9_4

Ulrich, R.S. (1984). View through a window may influence recovery from surgery. Science 224; 420-421.

Ulrich, R. S., Simons, R. F., Losito, B. D., Fiorito, E., Miles, M. A., & Zelson, M. (1991). Stress recovery during exposure to natural and urban environments. *Journal of environmental psychology*, *11*(3), 201-230. https://doi.org/10.1016/S0272-4944(05)80184-7

Valtchanov, D., Barton, K. R., & Ellard, C. (2010). Restorative effects of virtual nature settings. *Cyberpsychology, Behavior, and Social Networking*, *13*(5), 503-512. https://doi.org/10.1089/cyber.2009.0308

Van Lier, H. G., Pieterse, M. E., Garde, A., Postel, M. G., de Haan, H. A., Vollenbroek-Hutten, M. M., ... & Noordzij, M. L. (2019). A standardized validity assessment protocol for physiological signals from wearable technology: Methodological underpinnings and an application to the E4 biosensor. *Behavior research methods*, 1-23. https://doi.org/10.3758/s13428-019-01263-9

Webster, R. K., Weinman, J., & Rubin, G. J. (2016). A systematic review of factors that contribute to nocebo effects. *Health Psychology*, *35*(12), 1334. https://psycnet.apa.org/doi/10.1037/hea0000416

Appendix

Pre-Test, Post-Test and Follow-up Questionnaires

Vragenlijst

Deelnemer code: [ ]

MST UNIVERSITEIT TWENTE. Beter door Beeld

Voorafgaand aan de bronchoscopie

Algemene vragen

1. **Wat is uw geslacht?**
   - ❑ Man
   - ❑ Vrouw

2. **Wat is uw geboortedatum?**

   Dag Maand Jaar

   [ ][ ] - [ ][ ] - [ ][ ][ ][ ]

Wat is uw stemming op dit moment?
Omcirkel het cijfer dat het best weergeeft hoe uw stemming op dit moment is.

Heel slecht	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Heel goed**

De volgende stelling meet hoe ontspannen/kalm ofwel gespannen/onrustig u zich voelt.
Omcirkel het cijfer dat het best weergeeft hoe u zich voelt op dit moment.

Ik voel me op dit moment:

Gespannen, onrustig	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Ontspannen, kalm**

<u>Na de bronchoscopie</u>

Wat is uw stemming op dit moment?
Omcirkel het cijfer dat het best weergeeft hoe uw stemming <u>op dit moment</u> is.

Heel slecht	1	2	3	4	5	6	7	Heel goed

De volgende stelling meet hoe ontspannen/kalm ofwel gespannen/onrustig u zich voelt.
Omcirkel het cijfer dat het best weergeeft hoe u zich voelt <u>op dit moment.</u>
Ik voel me op dit moment:

Gespannen, onrustig	1	2	3	4	5	6	7	Ontspannen, kalm

Hoe prettig of onprettig vond u het inbrengen van de bronchoscoop?
Omcirkel het cijfer dat het beste bij uw ervaring past.

Zeer onprettig	1	2	3	4	5	6	7	8	9	10	Zeer prettig

Hoe prettig of onprettig vond u het verloop van de bronchoscopie na het inbrengen van de bronchoscoop?
Omcirkel het cijfer dat het beste bij uw ervaring past.

Zeer onprettig	1	2	3	4	5	6	7	8	9	10	Zeer prettig

Hoe goed of slecht werkte de verdoving die u heeft gekregen tegen pijn tijdens de bronchoscopie? Omcirkel het cijfer wat het meest van toepassing is voor u.

Zeer slecht, ik vond de procedure erg pijnlijk	1	2	3	4	5	6	7	8	9	10	Zeer goed, ik vond de procedure niet pijnlijk.

Hieronder staat een aantal woorden die verschillende emoties en gevoelens beschrijven.
Geef bij elk woord aan in hoeverre het beschrijft hoe u zich voelde tijdens de bronchoscopie.
Gebruik de volgende schaal en zet het kruisje in het vakje dat van toepassing is.

---

[0] = absoluut niet [1] = zwak [2] = matig [3] = sterk [4] = heel sterk

[1] [2] [2] [4] [4]

1. ZENUWACHTIG

2. PANIEKERIG

3. GESPANNEN

4. RUSTELOOS

5. ANGSTIG

6. ONZEKER

UNIVERSITEIT TWENTE.

Vragenlijst: een week na de bronchoscopie

Deelnemer code:

Als u nu terugdenkt aan de bronchoscopie, kunt u dan aangeven hoe uw stemming was op dat moment?
Omcirkel het cijfer dat het best weergeeft hoe uw stemming tijdens de bronchoscopie was.

Mijn stemming tijdens de bronchoscopie was:

Heel slecht	1	2	3	4	5	6	7	Heel goed

De volgende stelling meet hoe ontspannen/kalm ofwel gespannen/onrustig u zich voelde.
Omcirkel het cijfer dat het best weergeeft hoe u zich tijdens de bronchoscopie voelde.

Ik voelde me tijdens de bronchoscopie:

Gespannen, onrustig	1	2	3	4	5	6	7	Ontspannen, kalm

Stel dat u nogmaals een bronchoscopie zou moeten ondergaan, hoe erg ziet u daar dan tegenop?
Omcirkel het cijfer dat het beste bij uw gevoel past.

Ik zie er heel erg tegenop	1	2	3	4	5	6	7	Ik zie er helemaal niet tegenop

Hoe prettig of onprettig vond u het inbrengen van de bronchoscoop?
Omcirkel het cijfer dat het beste bij uw ervaring past.

Zeer onprettig	1	2	3	4	5	6	7	8	9	10	Zeer prettig

Hoe prettig of onprettig vond u het verloop van de bronchoscopie na het inbrengen van de bronchoscoop?
Omcirkel het cijfer dat het beste bij uw ervaring past.

Zeer onprettig	1	2	3	4	5	6	7	8	9	10	Zeer prettig

Hoe goed of slecht werkte de verdoving die u heeft gekregen tegen pijn tijdens de bronchoscopie? Omcirkel het cijfer wat het meest van toepassing is voor u.

Zeer slecht, ik vond de procedure erg pijnlijk	1	2	3	4	5	6	7	8	9	10	Zeer goed, ik vond de procedure niet pijnlijk.