The effects of nature on physiology and phenomenological experienced stress and anxiety during bronchoscopy: using an HMD

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Abstract

Background. According to earlier research, patients undergoing a bronchoscopy appear to profit from nature. Nature provides a form of positive distraction from stressful situations. Nature also appears to have restorative effects in that it enables directed attention to rest and recover from depletion of sources, according to the Attention Restoration Theory. Especially nature views with elements that make a nature view soft-fascinating (SF) appear to be beneficial (i.e. water, spaciousness, depth).

Methods. The present research aimed to study the effects of two different nature scenes (high vs. low on SF) on phenomenologically and physiologically experiences of the bronchoscopy with a quasi-experimental 2 (between subjects) x 2 (within subjects) design. The nature scenes were delivered through an HMD, which strengthened a sense of "being there". It was expected that both the nature scenes would lead to a significant improvement of self-reported mood, but also a reduction in self-reported arousal and the physiological parameter mean amplitude of SCRs. Those effects were believed to be stronger for the condition high on soft-fascination compared to the condition low on soft-fascination. The sample consisted of 19 participants in total, of which 10 were allocated to the condition low on SF and 9 to the condition high on SF. The mean age was 61.18 (SD = 13.45). Shortly before, directly after and approximately one week after the bronchoscopy, one questionnaire at a time was filled in by all participants.

Results. Quantitative analyses seemed to show a trend in the reduction of the mean amplitude of SCRs, but the reduction was non-significant. The reduction also did not differ between the two conditions. All quantitative analyses of all self-report constructs showed non-significant results on the main effect of nature and the differences between the conditions. If there were any marginal differences between the two conditions, they were mostly in the direction opposite to expectations (e.g. in favor of low SF). The single-case analyses showed great individual differences, which made it difficult to infer a certain pattern indicative of effectiveness of exposure to nature or a difference between high-SF and low-SF.

Discussion. Because there was no control group, it is uncertain whether the exposure to nature was truly effective or not and therefore it is strongly recommended to include a control group in further research. It would be interesting to emphasize physiology in further studies, because there seems to be a trend that is in line with the expectation that exposure to nature lead to reduction in the mean amplitude of SCRs after insertion of the bronchoscope.

Introduction

Some invasive medical procedures can be anxiety-provoking, uncomfortable and even painful to the patient (Sinatra, 2010). An example of such a procedure is a bronchoscopy. It appears that between 45-60% of patients undergoing a bronchoscopy is anxious before the procedure (Ketata et al, 2011; Barlési et al., 2003; Poi, Chuah, Srinivas & Liam, 1998). The main causes of the anxiety seem to be the pain patients expect to experience, the probability that one will encounter any breathing difficulties and the idea that oropharyngeal irritations may result (Poi et al., 1998). The anxiety patients experience tends to exacerbate the discomfort experienced during the bronchoscopy (Mitsumune, Senoh & Adachi, 2005; Poi et al., 1998). The most reported reason of the discomfort patients experience is pain (Diette, Lechtzin, Haponik, Devrotes & Rubin, 2003; Poi et al., 1998). Despite the fact that patients receive several sedative substances to eliminate the pain, it is still a major exacerbating factor that must be diminished to make a bronchoscopy less uncomfortable. Sinatra (2010) argued that it is important to manage (acute) pain because of other reasons as well, namely that it tends to lead to better outcomes in terms of improved sleep, improved functioning and faster recovery. Diette et al. (2003) advocated for the development of nonpharmacological approaches to improve the pain patients experience during a bronchoscopy. One of the reasons for this is that sedative drugs can result in undesired side effects such as respiratory depression and cardiovascular instability. It can be concluded that it is important to reduce both the anxiety/stress and the pain patients experience before and during a bronchoscopy, and that this must be realized by developing nonpharmacological interventions.

There is converging evidence that certain environments in the hospital support recovery and psychological well-being. Several features appear to make an environment healing, among others are interior design features (e.g. decor and colour), and architectural features (e.g. window with open view; Harris, McBride, Ross & Curtis, 2002). For example, Lohr and Pearson-Mims (2000) found that the presence of plants in a room diminished pain, and Ulrich (1984) described that patients recovered faster when they had a window in their hospital bedroom. However, this effect was only found when the view was a nature one, not when it was an urban view. Lankston, Cusack, Fremantle and Isles (2010) described that visual art containing landscapes or nature scenes contributes to better well-being of patients. Taking this one step further beyond simple environments, Diette et al. (2003) already proposed the use of nature videos during invasive treatments (e.g. a bronchoscopy). The present study is quite similar to this; it emphasizes stress and anxiety reduction in patients undergoing bronchoscopy by means of virtual nature views delivered through an head mounted device (HMD). Bronchoscopy patients undergo a relatively brief medical procedure that is primarily highly stressful and somewhat painful (Poi et al., 1998). When receiving this non-pharmacological intervention, patients will possibly experience less pain and thus be more comfortable during the procedure and therefore require less additional sedation during the bronchoscopy, which in turn tends to enhance well-being (Sinatra, 2010; Diette et al., 2003). Furthermore, patients are likely to relax a little more than they usually would. Because of this, the procedure is expected to run more smoothly which makes it easier for the practitioner to carry out. Eventually it may result in better and quicker performance of the physician.

Restorative effects of nature views

The effectiveness of nature scenes and sounds has been proven successful in both laboratory studies and within a variety of patient settings. Health care environments that foster access to positive distractions are believed to support coping with stress and anxiety, and to promote wellness (Ulrich, 1981; Ulrich, 1991; Diette et al., 2003). Nature thus is more than simple distraction, it involves a positive restorative effect, as will be further explained below. In laboratory research, visual exposure to nature has been shown to lead to significant recovery from stress within 5 minutes (Ulrich, 1981). Furthermore, the same study also took recordings of brain electrical activity and those suggested that individuals were more relaxed during the nature exposures. Diette et al. (2003) list successful results in perioperative care, phlebotomy and burn care. In their own study, they focused on distraction therapy with nature sights and sounds during flexible bronchoscopy. Patients watched a nature mural and listened to a tape with nature sounds through headphones before, during and after the bronchoscopy. On the mural was a little water stream with detailed grass on the foreground and mountains together with more (less-detailed) grass on the background. The nature sounds involved water streaming and bird chirping. Patients in the intervention group were 43% more likely to report pain control (p = .015) and the ability to breathe as being very good to excellent ($p < .05$). Also very promising results emerged in the study of Tanja-Dijkstra et al. (2017). They studied the effects of VR (both urban and nature environments) on patients who underwent dental treatment for filling and/or extraction. It was discovered that patients in the coastal nature VR condition experienced significantly less pain ($p < .01$) and stress (p = .025) than patients who received standard care. Those beneficial effects were not found in the urban VR condition (Tanja-Dijkstra et al., 2017).

The studies cited above, and in particular the last one, suggest that something in nature specifically has restorative effects that can lead to reduced stress and pain experiences. It is suggested that phenomena are involved that go beyond simple distraction. Several possible explanations have been formulated by different researches. A first point of views was given by Koole and Aldao (2016). They simply explain that emotions (such as stress and anxiety) can be self-regulated by deploying attention elsewhere, away from the emotional event/stimuli. In this case, the nature views serve as a means to deploy that attention away from the bronchoscopy. In that way, one can self-regulate the anxiety and stress they experience. The second suggested explanation comes from Ulrich (1984; 1991), which takes the concept of positive distraction a bit further. He said that *"most natural views elicit positive feelings, reduce fear, hold interest and may block or reduce stressful thought, and because they do so, they might facilitate distraction from anxiety and stress"*. He also suggested that modern humans possess a form of readiness to quickly and readily acquire restorative, stress-reducing responses to natural settings, because these responses had survival advantages in the past. The Attention Restoration Theory (ART) of Kaplan (1995) postulates a slightly different, and third, view. Nature's restorative effects are attributed to the fact that it both attracts involuntary attention and limits the need for directing attention (Kaplan & Berman, 2010). Directed attention is found to require effort and to be resource based. In other words, one will become attention-fatigued if the resources are depleted. Involuntary attention, on the contrary, is effortless and is typically employed when something exciting or interesting occurs. According to Kaplan and Berman (2010), nature views contain features that capture attention in an involuntary, bottom-up, and effortless way. Because directed attention is allowed to rest, it is more likely to recover (Kaplan, 1995). This recovered resource is than better capable of coping effectively with the stress, anxiety and pain patients experience. It can be concluded that nature views are restorative in that they elicit involuntary attention, and minimize the requirements to direct attention. However, the bottom-up attention elicited by the nature views must be gentle enough as to not interfere with other thoughts. This phenomenon is referred to as soft-fascination (Kaplan and Berman, 2010). Soft-fascination (SF) is important for the present study, as will be explained below. To conclude, nature is suggested to enable both a special kind of positive restoration (ART) together with distraction that diverts attention from the stressful bronchoscopy procedure and the accompanying pain.

Soft-fascinating nature

Of course, there is huge variety in world's nature and therefore one may ask what the underlying mechanisms are that makes a nature scene most restorative. As has already been mentioned above, SF is a very important feature according to Kaplan and Berman (2010). Several nature elements are believed to contribute to soft-fascination within a scene. Before describing the elements, a short elaboration on the concept of SF will be given. Fascination requires no effort and is a form of involuntary attention (Kaplan, 1995; Tang et al., 2017). SF appears to be especially effective in terms of restoration (Kaplan, 1995). SF can be experienced while walking in certain natural settings. Elements that qualify as SF are for example clouds and the motion of leaves in the breeze. SF allows for reflection on interfering (stressful) ideas and thoughts who can then be put to rest. Hard fascination prevents thinking of other things, which makes it less restorative because reflection cannot occur and therefore attention cannot be put to rest (Kaplan and Berman, 2010). Although there are many elements that make a nature scene soft-fascinating, only two were used for selection of the nature scenes (e.g. spaciousness and subtleness in foreground).

Spaciousness. Western and Eastern societies prefer settings with moderate to high visual depth or openness, because of an evolutionary acquired aversion to spatially restricted settings that could contain hidden dangers and possibly limit any opportunities to escape (Ulrich, 1993). Ulrich, Dimberg and Öhman (in Ulrich, 1993) discovered that autonomic aversive responses, acquired through conditioning, to the high-depth settings were more resistant to boredom compared to settings with low-depth. This suggests that high-depth settings are somewhat more impressive and therefore will hold involuntary attention for a longer period of time.

Subtleness. Nature scenes with subtle moving details on the foreground are rated more fascinating in the study of Jansen (2017). They are believed to facilitate the feeling of presene in the environment. Also Kaplan (1995) described the motion of elements (e.g. leaves, grass) caused by the breeze qualifying as high on SF. Furthermore, people tend to like scenes that are peaceful in nature (Ulrich, 1993), with moving elements such as grass, leaves and water being qualified as indicative of a peaceful area. Lastly, the subtleness of details on the foreground and possibly the movement of grass and leaves may enhance a feeling of presence in the environment.

Nature sounds

Nature sounds are also believed to contribute to the restorative effects of nature by delivering nature via another channel (Largo-Wight, O'Hara, & Chen, 2016). Nature sounds may even enhance the soft-fascinating aspect of a nature scene. When comparing three conditions (nature sound, classical music, no sound) they found that only the nature sound group showed a decrease in self-reported stress, pulse rate and muscle tension. Important about this study is that it involved nature sounds only, suggesting that merely listening to nature sounds has a stress-reducing effect. Diette et al. (2003) combined a nature video with sounds of streaming water and fauna (e.g. bird chirping) during bronchoscopies and discovered that it resulted in a higher increase in pain control compared to the group that only watched the video, which suggests that a combination of video and sounds will lead to better effects.

Video glasses

A way to present the nature videos to people in a way that is both comfortable and mesmerizing is by means of head mounted display (HMD) video glasses. Probably the most well-known example of an HMD are virtual reality (VR) glasses. VR glasses can help a patient cope with uncomfortable medical procedures, reduce anxiety and reduce pain (Hudson, Ogden, & Whiteley, 2015; Guo, Deng, & Yang, 2015; Nuvvula, Alahari, Kamatham, & Challa, 2015). VR is successful within health care because it is immersive and it distracts (Rose, Nam & Chang, 2018). Immersion is described as the degree to which VR delivers experiences that involve multimodality sensory stimuli, omnidirectional (surrounding) stimuli and is inclusive in that it shuts down attention from the physical environment, according to Rose, Nam and Chang (2018). Because of this immersive aspect, VR gives a feeling that one is present in the virtual environment, it creates a "feeling of being there", they argue. However, standard VR glasses are not well-suited for bronchoscopy patients, because they cannot move their head during the procedure. Moving the head may lead to unpredicted shifts in the bronchoscope that can lead to piercing lung tissue which can result in bleeding or pneumothorax (Schiffman & Balentine, 2017). Therefore the RelaxMaker video glasses (Beter door Beeld, 2018) are used in this study. Those video glasses still are HMDs and have the immersive, distractive features VR glasses have, but allow contact with the surrounding environment as well. This is quite important within the bronchoscopy setting.

The present study

The present study is a follow up study of the pilot-study of Jansen (2017). It combines the restorative effects of nature landscapes and sounds with the engaging effects of HMD video glasses during bronchoscopy. The study is unique in that it measures the effects of the intervention in both physiological values and self-report. Furthermore, the use of an HMD increases the feeling of presence in the environment, which is a unique additional feature of the present study compared to the study of Diette et al. (2003). The benefits of the intervention used in the present study should be visible in both self-reported mood, arousal, pain, discomfort and in physiological indicators of stress.

The use of electro dermal activity (EDA) as physiological parameter is common in the field of psychophysiology. EDA is very sensitive to psychological states (Dawson, Schell, & Filion, 2009) and is defined in terms of sweat secretion from sweat glands in the skin. Sweat is primarily produced in response on activity of the sympathetic nervous system according to Dawson, Schell and Filion (2009). There are several sub-parameters of EDA, such as for example phasic skin conductance responses (SCRs) and tonic skin conductance level (SCL). There appears to be a high correlation between SCRs and sympathetic nervous activity (Dawson, Schell, & Filion, 2009), which makes that SCRs measures were used as primary parameters of physiology. SCRs are defined as phasic increases in skin conductance according to Dawson, Schell, & Filion, 2009). SCRs can vary from very weak/eligible to extremely strong. Special attention is given to the mean amplitude of the SCRs, which is the mean strength of the peaks in conductance deviating from the mean skin conductance over time.

In the present study, two nature videos will be used that differ from each other in the degree of SF. The first nature video involves zoomed-in views of water streams, a lot of movements on the foreground and were qualified as relatively spacious. The second video involves scenes from a helicopter-view with little movement on the foreground and some spaciousness. According to the pre-test that has been conducted by Jansen (2017), the difference between the two nature landscapes in terms of fascination is significant. Participants indicated they found the landscape high on soft-fascination more fascinating and that they could watch that view for a longer period of time without getting bored. Last, nature sounds of streaming water will be used, that are roughly the same for both groups.

Because standard virtual reality (VR) is not compatible with the standard bronchoscopy procedures, special HMD video glasses will be used in combination with headphones. The videos participants will be viewing are static images, with moving elements. The virtual immersive HMD aspect is in the breeze that moves the leaves and the grass, and the streaming water. Because of the video glasses, the participant will be distracted from everything in the bronchoscopy room, but still be able to communicate with the staff. Also, a benefit of these HMD glasses is that the patients do not need to move their head in order to see the full video, as is the case in standard VR. The nature scenes are not 360° which further discourages the participants to look around. Furthermore, the HMD enables the viewing of nature scenes with Hi-Fi sound quality, because of inbuilt headphones.

Three Dutch self-report questionnaires are given to the participants in this study to assess phenomenologically experienced stress/arousal, mood, discomfort, pain, anxiety/nervousness etc. A follow-up questionnaire was added with the goals to see whether there were any delayed effects of exposure to nature scenes during bronchoscopy and to assess overall intervention satisfaction (e.g. would you chose to use the glasses again with another bronchoscopy?).

To summarize, firstly viewing nature landscapes appear to have restorative benefits and tends to result in stress-reductions. Secondly nature sounds tend to have an amplifying positive effects. Thirdly the HMD has immersive effects. Based on these three things, two hypothesis were proposed: (1) patients in this study will experience a reduction in both self-reported stress and SCRs over time during the bronchoscopy; (2) these positive effects are stronger for the group viewing the video high on soft-fascination compared to the group viewing the video low on soft-fascination (Kaplan, 1995).

Methods

Design

A quasi-experimental 2 (between-subjects) x 2 (within-subjects) design was used. Primary outcome measures were perceived stress and anxiety, both self-reported and physiological recorded. The between-subject design was used to compare the effect of soft-fascination (SF) elements of nature between the two conditions (high on SF, low on SF). The within-subject design was used to compare the differences in stress and anxiety before and after the bronchoscopy.

Participants

Participants were patients (N = 19) who had an appointment for a bronchoscopy in the hospital MST (Medisch Spectrum Twente) in Enschede. The 19 participants had ages ranging from 43 to 87 (n = 19, M_{age} = 68.16, *SD* = 13.45), see table 1. Participants were assigned to either the condition high on SF (n = 9, M_{age} = 68.00, *SD* = 14.78), or the condition low on SF (n = 10, M_{age} = 68.30, *SD* = 12.94). Exclusion criteria were reduced vision of more than -5 myopic, the administration of a dormicum during bronchoscopy, insufficient mastery of the Dutch language and/or a visual handicap that could strongly hinder reading or watching videos. Researchers selected the participants based on their willingness to participate in the study. The participants were alternately allocated to one of the two conditions: first one to condition high on SF, then the next participant to the condition low on SF, then another one to the condition to high SF again, and so on. The study was approved by the medical ethical committee, code K17-34.

Materials and Apparatus

First of all, video glasses (RelaxMaker) were used. The RelaxMaker has two LCD displays, with both 1280 x 720 (HD) pixels, an aspect ratio of 16:9, 24-bit RGB colors, 26° sight and 98 inch screen (Beter door Beeld, 2018). Second, headphones were used that belonged to the RelaxMaker. Third, the Empatica E4 wristband was used to record physiological data (Empatica Inc., 2018). Fourth, three short Dutch questionnaires were used (Appendix A, B, and C). The first was conducted before the bronchoscopy, the second directly after the procedure, and the third questionnaire during the follow-up appointment with the doctor. Last, a laptop was used to upload the Empatica E4 data to a server.

Within the three Dutch questionnaires several scales have been included. In the first questionnaire, two scales were used to measure the mood of the participant before the bronchoscopy. The first scale was Mood Feelings, which consisted of one item (“what is your mood at this moment?”) on a 7-point scale ranging from very bad (1) to very good (7). This scale originally is answered on an eleven-point scale (-5 to 5) (Hardy & Rejeski, 1989). The second scale was Mood Arousal, which also consisted of 1 item (“how relaxed/calm or aroused/restless are you at this moment?”) on a seven-point scale ranging from aroused/restless (1) to relaxed/calm (7). Originally, this scale was filled in on a 7-point scale ranging from 0 to 6 (Svebak & Murgatroyd, 1985). Unfortunately, no data has been collected about the validity of these two scales.

In the second questionnaire, which was filled directly after the bronchoscopy, these two scales were used again. Also two scales about procedural discomfort were included. The first one was Discomfort Insertion Scope and consisted of one item (“how comfortable or uncomfortable did you think the insertion of the scope was?”). The second scale was

Discomfort After Insertion and also had one item ("how comfortable or uncomfortable did you think the bronchoscopy was after the insertion of the scope?"). Both items were answered on a scale ranging from very uncomfortable (1) to very comfortable (10). Thereafter the scale Experienced Pain Relief was used, which consisted of one item as well ("how good or bad did the sedation worked that you received against pain during the bronchoscopy?") (Diette et al., 2003). This 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). In addition, the tension dimension of the Profile of Mood States short form (POMS-SF) was used (Baker, Denniston, Zabora, Polland, & Dudley, 2002), measuring perceived stress (α = .856). The tension dimension had six items consisting of single adjectives: Anxious, Nervous, Restless, Uncertain, Tensed, and Panic. The participants had to indicate how well an adjective described their feelings during the bronchoscopy ranging from absolutely not (0) to very strong (4). Moreover, three items about fascination of the nature videos were included as a manipulation check of the different nature views. These three items had a five point scale, ranging from completely disagree (1) to completely agree (5). An example item is: "I think this is a fascinating video". Finally, perceived distraction was measured with one item ("I had the idea that I was distracted from the bronchoscopy because of the video"). This item also had a five point scale, ranging from completely disagree (1) to completely agree (5).

The third questionnaire consisted of seven items in total and were all formed with the idea that participants had to recall their experiences with the bronchoscopy or had to indicate what they would choose next time. The first two items are identical to the first items of the first and second questionnaire and involved questions about mood and arousal. The third item involves the question: "how much would you dread if you had to undergo another bronchoscopy?". This question was answered on a seven-point scale ranging from 1 (I dread very much), to 7 (I do not dread at all). The fourth, fifth items correspond to the procedural discomfort items of the second questionnaire and the sixth item is the same as the experienced pain relief item of the second questionnaire. The last item is about whether one would again choose to put on the video glasses at another bronchoscopy and is answered on a 5 point scale ranging from "absolutely yes" to "absolutely not". This item considers a behavioral intention and can therefore be considered as a proxy of the overall experience with the video glasses.

Last, two different nature videos were used (high on SF and low on SF). The difference between the two videos was significant in terms of fascination, but not in terms of long exposure, boring and appealing according to the pre-test conducted by Jansen (2017). Figures 1 and 2 show a scene of both nature videos. During the present study 4 items were added as a means of manipulation check. Table 1 shows the descriptive statistics of this manipulation check.

Table 1.

Descriptive statistics of items about manipulation check.

Manipulation check						
Fascination	3.02	.71	3.30	.95	3.17	.83
Interesting	2.63	.86	2.77	1.23	2.71	1.04
Presence	2.17	1.06	2.85	1.29	2.53	1.21
Distraction*	2.15	.30	3.00	1.22	2.62	.99

Note. **n total* = 9 (4 high SF, 5 low SF).

Figure 1. A screenshot from the nature video of the high on SF condition. Copyright 2018 by Beter door Beeld.

Figure 2. A screenshot from the nature video of the low on SF condition. Copyright 2018 by Beter door Beeld.

Procedure

The researcher approached the participants with some information about the study in the waiting room of the lung department at the MST. Participants received an information letter. After reading the information letter, participants had the opportunity to ask questions to the researcher. Those who wanted to take part signed the informed consent. After some time, the participants were called in by the nurse and went to the treatment room. In the treatment room, some information was given about the bronchoscopy procedure. The researcher put on the Empatica E4 on the wrist of the participant to measure physiological data. After the E4 Empatica was turned on, a flashing green light was shown for forty seconds. The moment the light turned red the E4 started to record physiological values. At the same time, participants answered the two questions of the first questionnaire. Then the usual bronchoscopy procedure started. First, the nurse sprayed the anesthesia Xylocaine in the throat of the patient. This procedure was repeated several times, depending on the state of participant. Second, the doctor sprayed local sedation into the trachea. Then the RelaxMaker was installed. After the nature video started, participants were asked to lie down and the doctor inserted the bronchoscope. At the end of the bronchoscopy the RelaxMaker was taken off. Then the participant was given five minutes to relax and filled in the second questionnaire. After that, the E4 wristband was taken off and the researcher asked when the participant had the next appointment, or at what department of the hospital they were staying. At the end, the participant had the opportunity to give feedback about their personal experiences with the RelaxMaker video glasses.

During the bronchoscopy, several things were written down: the exact UTC times of all the anesthesia insertions, when the E4 Empatica started recording (when the light turned red) and when it stopped recording, when the video glasses were put on and off, when the bronchoscope was inserted and in position, when the removal of the bronchoscope was started and completed. Also some other important observations during the procedure were noted. Examples are whether the participant had looked through the glasses or not, and whether the participant had to change position. The physiological data recorded by the E4 wristband was uploaded to a computer at a later moment.

At the follow-up appointment of the participant, roughly a week after the bronchoscopy, the third questionnaire was filled in five minutes before the appointment. When a participant stayed in the hospital, they were visited approximately one week after their bronchoscopy and filled in the same questionnaire.

Data analysis

In the high on SF condition four missing values were found, one for all of the four items of the manipulation check. In the low on SF condition two missing values were found, one for the item about “Presence” and one for the item about “Interesting”. The missing values were imputed with the mean score of the group on that item.

The Skin Conductance Level (SCL) together with amplitudes of the Skin conductance responses (SCRs) were calculated via through-to-peak analysis as implemented in Ledalab (Benedek & Kaernback, 2010). Afterwards, the mean amplitude of the SCRs per minute was calculated for each participant. The SCRs were counted from 5 minutes before the bronchoscope was inserted up till the moment the bronchoscope was removed again and were divided over three time periods: before insertion, insertion of the bronchoscope and the actual bronchoscopy from the moment the bronchoscope was in position. The mean amplitude of the SCRs per minute was calculated by adding the amplitude of all raw SCR signals of that minute together and then dividing it by the number of signals. To test the hypothesis that participants will experience a reduction in SCRs when wearing the video glasses, a GLM repeated measures analysis was conducted with the variable 'amplitude SCRs', on the three levels 'before insertion', 'insertion', and 'during bronchoscopy'. Condition (high versus low soft fascination) was added as between-subjects factor and variables 'mood' and 'arousal' from the pre-test questionnaire were used as covariates. Also the Bonferroni post hoc test was conducted to see where any differences in means occurred. The same analysis was used for the self-report measures, using the variables 'self-reported mood' and 'self-reported arousal' for the two levels 'before' and 'after' the bronchoscopy. Because 'condition' was added as between-subjects factor, also the second hypothesis that the reduction in stress is better for participants in the high on SF-condition was tested.

Third, one-way ANOVA analyses were conducted for the items of the POMS, the two procedural discomfort items and the item about experienced pain relief to see whether there are any group differences on these items, due to the absence of any pre-test data. Again covariates 'mood' and 'arousal' items of pre-test were added.

Lastly, several N = 1 analyses were conducted in the following way. First graphs were plotted for the skin conductance responses (SCRs) per minute and the skin conductance level (SCL) during the whole procedure (before, insertion and during) of all participants. Second, three individuals were selected for further analysis and those were described in more detail. They were selected based on the course of their SCL (one showed a reduction in SCL, one a decrease, and one remained relatively stable over time). Third, the individual graphs were compared to observations made by the researcher, to see whether some peaks or dips could be further explained.

Results

Descriptive statistics. Not much is known about the norm scores of the mood and arousal items. However, in the study of Sveback and Murgatroyd (1985), arousal elicited by a car simulation task was measured. The mean score on the arousal items in that study ranged from 3.8 (*SD* = 1.03) to 4.4 (*SD* = .97), on a scale of 0 to 6. The scores of participants of the current study score approximately equally, taking into account that our scale ranged from 1 to 7. According to the study of Baker et al. (2002), the mean total score of the tension dimension of the POMS-SF ranges from 10.32 to 8.64, derived from different studies with patients and non-patients. In the current sample, the mean total score is 7.95 (*SD* = 5.54), which is relatively low compared to the studies cited in Baker et al. (2002). Also the mean SCL of the participants of this sample was relatively low during the complete bronchoscopy procedures compared to studies of resting SCL. The mean SCL at rest was on average 4.26 (*SD* = 2.59) in the study of Mori and Iwanega (2014), but they did not use wearables to measure SCL. However, according to Dawson, Schell, and Filion (2009), SCL typically ranges between 2 and 20 µs for healthy adults. The average amplitude of an elicited SCR varies between 0.2 and 1.0 µs (Dawson, Schell, & Filion, 2009), which indicates that patients in the condition high on SF have strong SCRs on the insertion and those in the condition low on SF have average SCRs, but still on the strong side. See table 2 for average answers on the items of the questionnaires, and table 3 for the average physiological values.

Table 2.

Descriptive statistics of self-report questionnaires.

	High on SF		Low on SF		Total	
Measure	*M*	*SD*	*M*	*SD*	*M*	*SD*
Age	68.00	14.78	68.30	12.94	68.16	13.45
Pre-test						
Mood	4.67	.79	5.50	1.31	5.11	1.15
Arousal	4.22	.91	5.20	1.18	4.74	1.15
Post-test						
Mood	4.61	1.45	5.45	1.44	5.05	1.47
Arousal	4.39	1.58	5.25	.98	4.84	1.33
POMS						
Nervous	1.89	.78	1.00	1.15	1.42	1.07
Panic	1.78	1.30	.90	1.29	1.32	1.34
Aroused	1.89	1.17	1.60	1.26	1.74	1.19
Restless	1.33	1.12	1.40	1.58	1.37	1.34
Anxious	1.33	1.22	.80	.92	1.05	1.08
Insecure	1.22	1.39	.90	1.10	1.05	1.22

Mean	1.57	.94	1.10	.90	1.32	.92
Discomfort						
Insertion scope	3.44	2.13	3.80	2.15	3.63	2.09
After insertion	3.00	1.66	4.80	1.69	3.95	1.87
Experienced pain relief	7.11	2.71	7.10	2.33	7.11	2.45
Follow-up*						
Mood	3.50	1.00	5.20	1.64	4.44	1.59
Arousal	3.75	.96	4.80	1.30	4.33	1.22
Dread	2.50	1.29	4.00	1.58	3.33	1.58
Discomfort insertion	1.75	1.50	3.80	2.49	2.89	2.26
Discomfort after insertion	2.00	.82	5.20	2.05	3.78	2.28
Experienced pain relief	4.00	1.41	7.10	1.75	5.72	2.22
Glasses	3.25	1.50	4.00	1.00	3.67	1.22

Note. **n total* = 9 (4 high SF, 5 low SF).

Table 3.

Mean amplitude of SCRs and SCL before bronchoscopy, during insertion of bronchoscope, and during the bronchoscopy.

	High on SF				Low on SF				Total			
Measure	*M*		*SD*		*M*		*SD*		*M*		*SD*	
	SCR	*SCL*	*SCR*	*SCL*	*SCR*	*SCL*	*SCR*	*SCL*	*SCR*	*SCL*	*SCR*	*SCL*
Before	.44	1.99	.58	2.22	.22	1.31	.36	1.55	.33	1.63	.47	1.88
Insertion	1.02	2.42	1.34	2.68	.89	2.13	1.33	2.31	.96	2.27	1.30	2.42
During	.70	2.99	.85	3.16	.85	4.89	1.16	7.77	.78	3.99	1.00	5.96

Quantitative analyses. For all quantitative analyses, intention-to-treat was applied. First a GLM repeated measures analysis was conducted to test whether there was a significant difference in mean SCRs over time. Mauchly’s test of sphericity indicated that the assumption of sphericity had not been violated ($\chi^2(2) = .922$, $p = .565$). In figure 3 the differences in mean amplitude of the SCRs can be seen. The figure shows a stronger physiological reaction on the insertion for the condition low on SF. After insertion, both groups showed an approximately equally strong reduction of mean amplitude SCRs. This is not in line with the expectations with regard to differences between conditions, but is in line with the general expectation that there is a reduction in SCRs after insertion. There was no significant effect of time on the mean amplitude of the SCRs ($F(2, 30) = .617$, $p = .546$). Also no interaction effect of time with condition was observed ($F(2, 30) = .133$, $p = .876$). This implies that there is no statistical significant difference over time in the mean SCRs in participants for both conditions (high vs. low SF). Post hoc tests using the Bonferroni correction showed that the mean amplitude of the SCRs increased between the 'before' and 'insertion' measure from $M = .332$ to $M = .953$, but this was not statistically significant ($p = .123$). Also between the 'before' and 'during' measure an increase in mean amplitude of SCRs was observed ($M_{before} = .332$ vs. $M_{\text{during}} = .779$), which was also not significant ($p = .189$). Between the 'insertion' and 'during' measures, no significant difference was observed ($p = 1.00$).

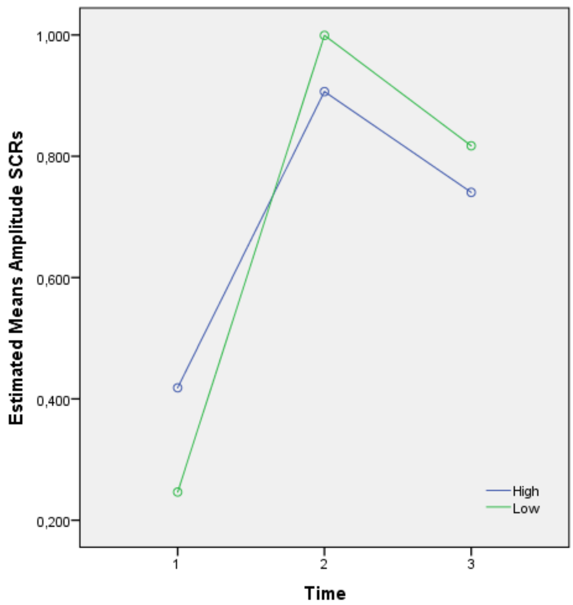

Figure 3. The effect of the two nature conditions over time on the mean amplitude of SCRs.

Second, for both the self-report items "mood" and "arousal" another GLM repeated measures analysis was conducted. No significant main effect of time was found for the item about mood ($F(1, 17) = .046$, $p = .832$) in both conditions. Also no significant interaction effect of time and condition was found ($F(1, 17) = .000$, $p = .991$). This was not as expected. For the item about arousal, no significant main effect of time was found ($F(1, 17) = .127$, $p = .726$). The interaction effect of time and condition ($F(1, 17) = .037$, $p = .850$) was also not significant.

Third, for all items of the post-test self-report questionnaire filled in directly after the bronchoscopy, one-way ANOVA analyses were conducted to see whether there are any other differences between the two conditions. In table 1 can be seen that in general the group low on SF scores lower on the POMS items, which indicates that they were less anxious, nervous, restless and so on. The same group rated their procedural discomfort in general higher, which means they found it less uncomfortable than the group high on SF. However, no statistical significant differences between the two groups on any of those measures was found by means of the one-way ANOVA analyses, which is against expectations.

Qualitative analyses. Because the follow-up questionnaire was filled in by 9 participants only, the data do not lend themselves for reliable quantitative statistical testing and therefore they are discussed qualitatively. Because only 9 participants filled in all three questionnaires (pre-, post-, and follow-up), only these were included in analysis. Interestingly, all items were on average rated more positive by the group low on SF than the group high on SF, which is against expectations. Another interesting fact is that the 'Mood' and 'Arousal' items were rated more negative on average on the follow-up measurement compared to both the pre- and post-measure for both conditions. This suggests that participants on average judged their mood and arousal worse when thinking back about the procedure on a later moment. The participants in the low on SF condition rated their experienced pain relief due to sedation better afterwards ($M_{follow\text{-}up}$ = 7.1 vs. $M_{post\text{-}test}$ = 6.2), while the participants in the high on SF condition rated their experienced pain relief worse when looking back to the bronchoscopy ($M_{follow\text{-}up}$ = 4 vs. $M_{post\text{-}test}$ = 4.75). This difference between the two conditions was not significant ($F(1, 8) = 2.708$, $p = .155$). For the item about discomfort after insertion, a significant group difference was found ($F(1, 8) = 5.730$, $p = .045$). This was against expectations because the group high on SF rated their discomfort worse a week after the bronchoscopy than the group low on SF. For the item about discomfort during insertion, there was a negligible difference in scores over time for both conditions.

Single-case analyses. To better understand the physiological processes in patients undergoing bronchoscopy and potential effects of the nature videos, three cases independent of condition were selected for a more elaborative qualitative analysis. See figures 4, 5 and 6 for changes in SCL over time for the corresponding participants X, Y and Z.

Participant X had a tough insertion, which is in line with the high peaks in SC in the red area of 'insertion'. Interestingly, after the insertion there is a gradual restoration to a lower SC, almost similar to that of the yellow 'before' area. This reduction is interesting because the participant had barely been exposed to the nature videos. The participant's eyes were closed almost all the time. However, the participant has heard the nature sounds, which leads to the question whether the nature sounds have been partly responsible for the reduction in SC. During the reduction in SC, one more peak occurred around three minutes after insertion. Unfortunately, observation notes were too limited to explain this relatively high peak. Near the end, the SC increases again. The increase near the end could be ascribed to two things: the first one is that the bronchoscope is removed again and the second one is that the participant had to sit up again, which implies increased physical activity.

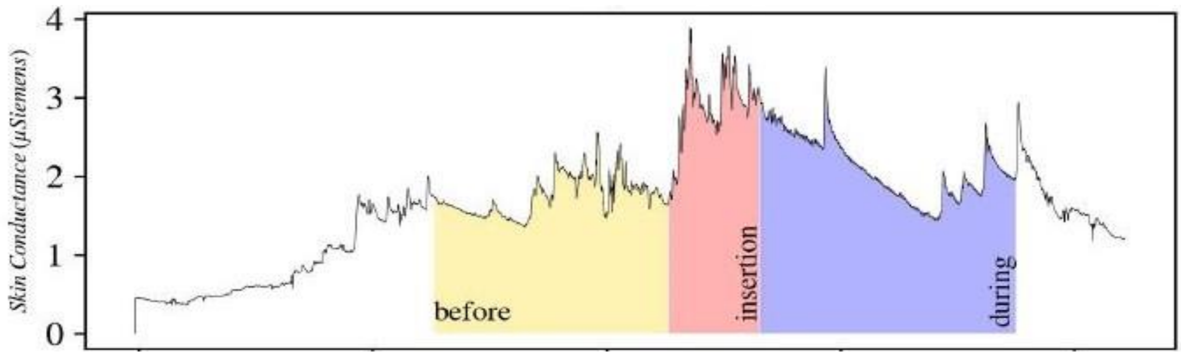

Figure 4. Changes in skin conductance over time for participant X.

Participant Y was quite calm in the beginning, according to the self-reports and non-verbal observations, which is in line with what is visible in figure 3. After insertion, the participant started to cough increasingly, and was coughing a lot near the end of the bronchoscopy, which is again in line with the increases in SC. When taking the nature video into account, the increase in SC is puzzling, because the participant was fully exposed to the video during the whole procedure. The participant did not close the eyes and did not look around. Because of this, two opposing questions arose. The first one is whether the low SC during insertion and shortly thereafter together with the relatively gradual increase indicate that the nature video had been effective. The second one is whether the increase in SC during the bronchoscopy indicates that the nature video was possibly not effective.

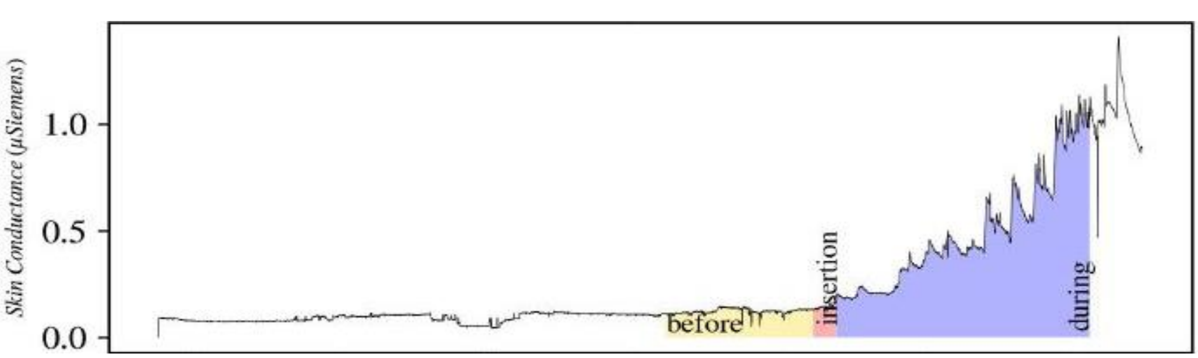

Figure 5. Changes in skin conductance over time for participant Y.

Participant Z was a special case because the insertion had to be done twice due to procedural difficulties. As can be seen in figure 4, the SC level of participant Z was during the procedure on average quite the same (the white areas not included), but did show some enormous peaks. Most of the peaks can be explained by the fact that the participant coughed a lot, from the moment the bronchoscope was inserted up till the moment it was removed again. The participant closed the eyes from the moment the bronchoscope went in the second time, but opened them again three minutes later. From that moment on (the first two high peaks after insertion) the SC shows more subtle peaks, if any. However, directly after the second insertion, a short-during restoration in SC is already visible. It may therefore also be possible that the two peaks are simply due to severe coughs and thus that restoration in SC did not start after the two peaks, but already after the second insertion. The peak at the end of the 'during' period can again be explained by either the fact that the participant had to sit up again, or the fact that the procedure was finished and bronchoscope was removed.

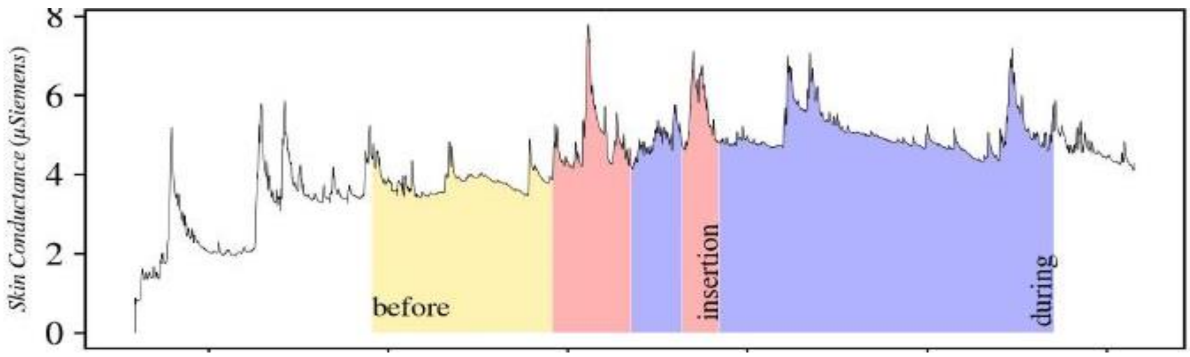

Figure 6. Changes in skin conductance over time for participant Z.

Discussion

The present study was designed to study how nature could contribute to restoration of stress and anxiety during bronchoscopy. The attention restoration theory of Kaplan (1995) proposes that nature can allow directed attention to rest, which consequently leads to restoration from attention-fatigue and enhances recovery from stress. Participants viewed nature scenes with accompanying sounds through an HMD. The nature scenes differed in the degree of Soft-Fascination (SF), with one scene high on SF and the other low on SF. Perceived stress and anxiety were measured along with physiological responses of the autonomous nervous system. Unique aspects of the present study are the ecological validity and the multi-modal delivery of nature scenes (e.g. sounds and views). The study was conducted in a hospital within the natural setting of a bronchoscopy. A disadvantage of such a naturalistic environment is that there are several unexpected variables that could be difficult to control. The fact that the present study used both physiology and self-report data to test its hypothesis, is an additional unique aspect compared to other studies in this field (Tanja-Dijkstra et al., 2017; Diette et al., 2003). It was expected that the nature videos would show a reduction in both phenomenologically experienced stress and anxiety and in SCRs over time after the bronchoscope was inserted. This reduction was expected to be stronger for the participants in the condition high on SF than participants in the condition low on SF.

Findings

It remains largely unclear whether any effects of exposure to nature were present in this study, whether they be phenomenological or physiological. Although some promising trends were visible, quantitative analyses showed only non-significant results which suggests the effects were not strong enough to be confident. The main findings show that there is a reduction in mean amplitude of SCRs in both conditions after an initial strong physiological reaction on the insertion of the bronchoscope. However, this reduction was not significant and did not differ between conditions. The single-case analyses of the physiology of several participants did not show a certain typical pattern in all cases that could be indicative of a restorative effect. The results of the self-report questionnaire appear to suggest that no significant effects of exposure to nature scenes during the bronchoscopy on mood and arousal in both conditions were present in this study. Also no significant differences between the two conditions were found on POMS-SF items, experienced pain relief, and discomfort items.

First, the trend visible in physiological data was in line with expectation that the amplitude of SCRs decreases after insertion of the bronchoscope and raises the question whether the reduction could possibly be attributed to the nature videos. The reduction in SCRs after insertion appeared to be non-significant for both conditions, suggesting that the nature scenes were not as effective as was expected. The trend in mean amplitude of SCRs over time is roughly the same for both conditions, although the participants in the low SF condition had a stronger initial physiological response and those in the high SF condition had a higher amplitude of SCRs before the bronchoscopy itself started. Despite those differences, the analyses suggest that there is no difference between high and low SF in terms of amplitude of SCRs. Because no control group was involved, it is unclear what physiological reactions people would have had while not watching nature scenes. Therefore it is also unclear whether the small, non-significant reduction in mean amplitude of SCRs can be ascribed to effects of the nature scenes. A control group may possibly show an increase in mean amplitude of SCRs over time.

In analysing the single-cases it became clear that there are strong individual differences; some cases showed an increase in amplitude of SCRs and/or SCL over time, some showed a relatively stable pattern over time, and yet others showed a decreasing amplitude of SCRs and/or SCL over time. This makes it difficult to identify the effectiveness of nature scenes based on individual figures. Also, not every participant was equally exposed to the nature videos. Some had their eyes closed during the whole procedure, while others viewed the nature scenes the whole time. This was not controlled for in the analyses, because participants also listened to sounds and the study of Largo-Wight, O'Hara and Chen (2016) showed that sounds were effective as well. Nevertheless, most individuals did show some reduction in SCRs/SCL, or a maintained a relatively low and stable SCL, which could possibly be indicative of effects of exposure to nature. An interesting phenomena is that SCRs can also be elicited by an orienting response according to Dawson, Schell, and Filion (2009). This would mean that orienting to the nature videos again every time after looking away from it shows SCRs. It may therefore be recommended to use an HMD that shuts one off more than the HMD in the present study, but still is suitable for usage during a bronchoscopy. Because no controls were involved and there were large individual differences, it is impossible to infer hard conclusions from the single case analysis. Next to the control group, eye-tracking would be necessary to find out which participants are fully exposed to the nature videos and which are not. It is unclear whether any specific physiological effects of the nature scenes are present, and if they are present, in what form they should arise.

. Concerning the ANOVA analyses of the self-report items the results are quite confusing. In general no significant differences were found except for the follow-up item about discomfort after insertion. Nevertheless, this difference was in the other direction than expected (e.g. the condition low on SF scored better than the condition high on SF). The results of the self-report items therefore deviate from expectations and qualitative analyses as conducted in the study of Jansen (2017). Because Kaplan and Berman (2010) indicated that SF is a very important restorative feature of nature scenes, it was expected that the condition high on SF would show stronger effects, if there were any. According to the results of the ANOVA analyses it can be concluded that the differences in SF were too small to be detected. However, because it is assumed that there appear to be no effects of exposure to the nature scenes at all, this might be an indication for the fact that there are no differences between conditions.

The main results of the present study are not in line with the positive results found in other studies (Diette et al., 2003; Tanja-Dijkstra et al., 2017) with regard to the effectiveness of nature exposure during invasive treatments. Also the restorative benefits of nature, suggested by Ulrich (1989) were not found in this study. Interesting is that the physiological analyses showed a clear trend of reduction in the mean amplitude of the SCRs for both conditions, which is in favor of expectations, but the mood and arousal items do not show such a trend in any of the conditions. A possible explanation is that the self-report data are not completely reliable due to two potential reasons. The first could be the small sample, which automatically leads to a low statistical power. The second may be that some participants appeared to show an inconsistent response style (all items of the POMS-SF were 0 by one participant, but mood was not rated as extremely well and arousal not as completely calm). However, because of the small sample it is not certain whether these responses should be regarded as outliers. Even if it were certain, the outliers still could not be removed due to the small sample. For the physiological analyses the data is much richer although reductions to means have been made. A richer dataset with many measure points for each participant reduces the limitations of a small sample.

Limitations

First, the small sample of the present study was a limitation, in particular for testing the second hypothesis whether the group high on SF would show stronger effects of exposure to nature videos via an HMD. Although there appears to be a reduction in the mean amplitude of SCRs in both groups and a somewhat stronger reduction in the condition high on SF, no similar effects were found for the self-report items. This clearly shows the limitations of a small sample, especially with regard to self-reports.

Secondly, no control group was involved in the study, which limits the ability to conclude whether there are any effects of the nature scenes. Some results indicated a possible hidden effect of exposure to nature scenes, such as the increase in SCRs between 'before' and 'insertion', which may have been stronger without the nature videos. Especially those relative improvements are difficult to determine without a control group. The lack of a control group implies an inability to know and understand the typical physiological responses of people undergoing a bronchoscopy. Because there are neither baseline measures of SCRs and self-report items, nor a control group, conclusions about the (in)effectiveness of exposure to nature videos must be interpreted with sufficient care.

Thirdly, the practicing doctor and nurses can have profound effects on the experience of an invasive medical treatment and the health of a patient (van Dulmen, 2001). The characteristics of the practitioner and/or nurses were not included in the analyses as covariates. Those characteristics may have operated as confounding variables and therefore explain why no effects of exposure to nature scenes on stress and anxiety, or an effect of SF condition, have been found in the present study. Also several other covariates have not been used that may help explain the non-significant results. For example, no baseline measurements of SCRs during rest (e.g. without increased arousal as is usually the case in patients anticipating an invasive treatment) were available of these participants. Since there are big individual differences in SCRs, it is a relatively serious shortcoming that baselines were not involved in the analyses as covariate. Furthermore, for the POMS-SF also no baseline measures were obtained.

A fourth limitation of the present study was the way physiological data was handled. The relatively rich set of data was reduced to three means (SCL, amp. SCRs and heart rate) for each phase of the bronchoscopy procedure (before, insertion, during). Because of this reduction, small effects (occurring within a minute) possibly indicative of benefits of exposure to nature scenes, may remain unnoticed. Also, some participants had values of zero for skin conductance responses (SCRs) and mean amplitude of the SCRs, but it is uncertain whether or not these are missing values due to malfunctioning of the E4 or these are true values. This contributes to the uncertainty regarding the physiological data. Furthermore, the amplitude of SCRs as physiological parameter may not have been the best choice, since this parameter is mostly used as measurement of reaction to (novel) stimuli and is thus stimulus-specific (Dawson, Schell, Filion, 2009). In this case, no presentation of stimuli was involved, thus the mean amplitude of SCRs may not have been the right choice. Furthermore, the amplitude of SCRs does not allow one to distinguish between people with few high SCRs and people with many low SCRs, the mean amplitude is the same (Dawson, Schell, & Filion, 2009). Therefore, these authors just cited recommend to use magnitude, frequency and amplitude of SCRs and to compare these three.

Reflection

Because there was no evidence for accepting either of the hypotheses, several possible explanations are proposed. The first is that the nature videos did not differ enough from one another in the aspect of SF. The differences in SF were pre-tested with a student sample, which may differ from a patient sample. Furthermore, the pre-test was done with the aid of self-report, while fascination itself is an implicit process (Kaplan, 1995). Fascination simply happens and often people cannot explain why exactly they are fascinated. The question raised whether the fascination people experienced while watching the nature scenes can be reliably captured by a self-report questionnaire. Furthermore, only two criteria were chosen for selection of the nature videos as has been described in the introduction. However, also other criteria appear to be important for SF which may make the difference between the two videos stronger.

Vegetation. Medium to high levels of vegetation have been associated with the best results in terms of stress reduction (Chiang, Li & Jane, 2017). However, when density of vegetation increases, the effect of stress recovery tends to stop increasing. De La Fuente De Val and Mühlhauser (2014) found that people in general rate landscape scenes higher when the vegetation density is rather high, compared to when vegetation density is low. Vegetation should not be too dense, because people prefer an intermediate-range density of vegetation.

Water. Tang et al. (2017) studied brain activity and physiology in patients who viewed landscapes and discovered that participants who viewed the water environment after experiencing stress showed the best restorative benefits (slowed respiratory rate and decreased muscle tension), compared to participants who watched the plant environment, congested traffic, normal traffic, crowded pedestrian environment or common pedestrian environment. Furthermore, sounds of a flowing water stream during a bronchoscopy led to a higher increase in self-reported pain control (Diette et al., 2003), although they did not investigate whether water sounds were the best option compared to other sounds. It can be expected that the combination of both seeing water and hearing water streaming may have additional benefits.

However, before implementing the new videos in research, they should be pre-tested again because doubts may arise whether these added differences in water and vegetation are sufficient enough to make a difference. It may be necessary to strengthen the difference between the videos, for example by increasing other aspects indicative of benefits of nature. Examples could be boredom and attraction, constructs found to be non-significant in terms of differences between the two nature videos in the study of Jansen (2017).

A second consideration involves the applicability of the ART in the context of bronchoscopy. ART is mainly concerned with chronical stress and pain (Kaplan & Berman, 2010), while patients undergoing a bronchoscopy are more likely to experience unexpected acute periods of pain. The study of Sinatra (2010) supported this view by showing that there are mainly long-term benefits of exposure to nature in terms of stress reduction. On the long term nature tends to result in reduction of chronical pain, faster recovery, improved sleep and an overall better functioning. Those effects are not likely in the sample of the present study. Nature may therefore be less beneficial for reducing acute pain, but could be effective in reducing negative psychosomatic factors such as shown in the study of Piccininni, Michaelson, Janssen and Pickett (2018). Furthermore, ART argues that those who need to restore their directed attention are cognitively depleted. One could ask whether this cognitive depletion referred to in ART is the same cognitive depletion of patients worrying about the bronchoscopy. Could it be possible that the anticipated anxiety/stress/pain before and during the bronchoscopy are a form of involuntary attention? Those anxious and stressful thoughts also arise automatically, just as one is thought to be captured by fascinating nature scenes. The only difference is that those thoughts are a form of negative involuntary attention. This may be an indication that the phenomena of cognitive depletion in this case deviates from the cognitive depletion Kaplan (1995) referred to. Lastly, another idea of ART raised the question whether reflection on and dealing with stressful thoughts automatically results in putting the thoughts to rest. Kaplan (1995) described that reflection on feelings of stress would allow one to put those feelings and thoughts to rest. The reflection may prevent one from suppressing the thoughts and feelings that lead to stress. However, one may ask whether this reflection on the stressful thoughts can also result in rumination which could make the stress even worse. Especially in the case of an invasive treatment such as bronchoscopy, it is imaginable that patients are not able to reflect on such stressful ideas and put them to rest in an effective way.

Future research

Because the physiological patterns of participants in this study raised many questions and offer interesting possibilities, it is recommended that further research is conducted in this field that emphasizes physiology. The single-case analyses raised among others the question to what form of restoration one should look for, if there is any. It may be valuable to compare several physiological parameters to see whether there appear to be differences in effects of exposure to nature scenes during bronchoscopy when different parameters are used. Therefore it is recommended to more extensively and broadly study physiological patterns of several parameters. Presumably exposure to nature scenes appear to be effective in some individuals but not in others. Therefore it may be particularly interesting to look at the physiology of participants for which the nature scenes are thought to be effective in terms of positive self-report data, such as participants in the study of Tanja-Dijkstra et al. (2017).

Second, the follow-up measurements indicated a decrease in self-reported mood and arousal when participants had to think back about the bronchoscopy. It may therefore be interesting to find out why they do so; is it because the nature scenes had been effective during the bronchoscopy itself but do not have any effects on the long term, or is it because they only remember the negative aspects of the procedure? It is therefore interesting to dig deeper into the thoughts and ideas of the participants one week (or longer) after the bronchoscopy with emphasis on the experiences with the nature scenes. However, the lack of a control group makes it even more difficult to conclude whether the slight decrease in mood and arousal is beneficial and would have been worse when not wearing the HMD with the nature scenes.

A third recommendation, following logically from the limitations is that further research involves a control group to compare the two groups with one another. Also further research has to take into account baseline measures of physiology during rest of the same participants. Participants could wear the e4 empatica wristband on another day for the time period their bronchoscopy lasted, for example. When these two things are added, more confidentiality and information can be given about the effectiveness of exposure to nature videos during bronchoscopy via an HMD.

To summarize, it can be concluded that the present study did not allow us to make hard inferences about the effectiveness of exposure to nature scenes delivered through an HMD, whether those effects are physiological or phenomenologically experienced. Some trends were visible that indicated a possible effect of nature, but the analyses did not lead to any significant results supporting either hypotheses. The effects in the present study did not appear to be strong enough to be certain. Unique aspects of this study are the fact that it combines physiological and psychological indicators of stress and anxiety, and that it is ecological valid. The strongest limitations of this study are the small sample and the lack of a control group. The present study did show a clear need for (nonpharmacological) intervention. It is recommended to continue this study with the involvement of a control group and a clear emphasis on physiology to identify typical patterns indicative of effects of exposure to nature scenes.

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Appendices

Appendix A. Pre-test questionnaire

Vragenlijst

Deelnemer code: ☐

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**

Appendix B. Post-test questionnaire

<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 <u>tijdens de bronchoscopie</u>.

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. ZENUWACHTIG

   ☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4

2. PANIEKERIG

   ☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4

3. GESPANNEN

   ☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4

4. RUSTELOOS

   ☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4

5. ANGSTIG

   ☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4

6. ONZEKER

   ☐ 0 ☐ 1 ☐ 2 ☐ 3 ☐ 4

Hieronder staat een aantal stellingen. Omcirkel bij elke stelling het cijfer dat voor u het meest van toepassing is.

Ik vind dit een fascinerend filmpje.

Helemaal mee oneens	1	2	3	4	5	Helemaal mee eens

Dit filmpje bleef me boeien tijdens de bronchoscopie.

Helemaal mee oneens	1	2	3	4	5	Helemaal mee eens

Ik had het gevoel echt in de omgeving aanwezig te zijn.

Helemaal mee oneens	1	2	3	4	5	Helemaal mee eens

Ik had het idee door het filmpje afgeleid te zijn van de bronchoscopie.

Helemaal mee oneens	1	2	3	4	5	Helemaal mee eens

Appendix C. Follow-up questionnaire

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.

Als u weer een bronchoscopie zou moeten ondergaan, zou u dan kiezen om de bril op te zetten?

- ☐ Zeker wel
- ☐ Waarschijnlijk wel
- ☐ Misschien wel, misschien niet
- ☐ Waarschijnlijk niet
- ☐ Zeker niet