The relationship between time perception and awe-inspiring landscapes by day- and night-time

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Abstract

OBJECTIVE: Various researchers have started to study the effects of the emotion 'awe' on people over the last few years. The focus of the current study is on the effects awe-inspiring, natural landscapes on time perception. This research will show what kind of landscape would be most suitable for, for instance, a waiting room. On top of that, time of day is used as a moderating variable to see if this influences time perception as well. The concepts of connectedness, alertness, nervousness and stress are taken into account as extra test variables in this research to see if landscapes can improve an environment through those feelings as well.

METHOD: Using VR (Virtual Reality), digital landscapes were created varying in 'level of awe' and 'time of day'. This resulted in a 2 (high-awe versus low-awe) by 2 (daytime versus night-time) between subject design. Participants (n=127) were shown a 45-second-long VR animation of a natural landscape, after which they filled in a questionnaire with validated scales related to all the aforementioned variables.

RESULTS: The analysis of the data shows that while night-time, low-awe landscapes made time go by faster, they also made participants feel more alert. Participants influenced by a daytime, high-awe environment, however, were more likely to spend more of their time on helping another person and felt significantly less nervous. Time of day or level of awe had no effect on connectedness or stress in this study.

CONCLUSION: The results contribute to the current knowledge of the emotion awe. The findings demonstrate that awe-inspiring landscapes have the potential to make people more willing to volunteer their (future) time to help. Additionally, awe can help people feel more at ease in their environment. The time of day inside a landscape can amplify this feeling of calmness when using a daytime landscape. These findings can be used to make spending time in waiting rooms less stressful, for example.

Keywords:

Awe – Time perception – Alertness – Connectedness – Stress – Nervousness – Daytime – Night-time

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1. Introduction

Waiting in waiting rooms of doctors, dentists, etc. is generally the most stressful thing about visiting a physician, a survey by Mangan (2016) found. This stress is at least partly caused by the time spent waiting there, as the average waiting time for a doctor was 18 minutes and 13 seconds in 2017 (Business Wire, 2018). Research argues that longer waiting times result in lower perceived quality of and satisfaction with the doctor and the care provided. It can also negatively influence a patients' likelihood to visit a doctor again, which can potentially be harmful for their health (Hill & Joonas, 2006).

The strategy that is mainly used to influence time passage in waiting rooms, for example, is distraction (e.g.: Spectrio, 2017; Screenfluence, 2019). Things such as TV's, radio and digital signage are used to take the attention of the people waiting away from the waiting itself, and in that way it is attempted to make the perceived time shorter and less boring (e.g. Pruyn & Smidts, 1998). Therefore, distraction has been the main moderator on waiting room time perception that has been studied. There are, however, other strategies possible, as Pruyn and Smidts (1998) note. Aside from distraction, these researchers also researched the effects of, for example, the attractiveness of the environment and other ways to improve the satisfaction of the person waiting. This could possibly tie in with the effect of the emotion 'awe' on time perception.

A study by Rudd, Vohs and Aaker (2012), for instance, shows that participants had different perceptions of time when they were thinking of awe-inspiring experiences. According to this study, the emotion awe led people to believe time was passing faster than in other conditions. This effect, as well as other effects that awe and natural landscapes can have, such as on feelings of stress, connectedness, nervousness (anxiety), alertness, and even briefly prosocial behaviour, will be studied throughout this paper. The way awe is most often elicited in people is through the use of natural landscapes (e.g. Bai et al., 2017). There is a very wide variety of effects that these awe-inspiring natural landscapes can elicit in people, but only the effects relevant to this study will be elaborated on.

Arguing that nature-based settings can have positive effects on a person is not new. Various studies have shown various positive effects that nature can elicit on e.g. prosocial behaviour (e.g. Parsons, 1991). Kuo and Sullivan (2001) found, for example, that people that have nature near the place they live were less likely to use aggression to solve problems and frustrations. They also stated that views of nature resulted in people having greater memory capacity and focussing their attention more easily, which Ottosson and Grahn (2005) confirmed in their study. Exposure to nature through a window in a hospital also resulted in (as compared to a view of a brick wall) fewer negative comments and complaints, lower scores of complications after surgeries, and shorter hospital stays and recovery times (Ulrich, 1984).

There is just one major difficulty that provides a certain struggle with getting all the positive effects from nature: nature is just not always readily available. In certain urban settings it is just not possible to look out of a window and clearly see trees, for instance. This complicates the use of nature but does not make it impossible. In various studies pictures, videos or even VR (Virtual Reality) animations of natural scenes were used that showed positive effects in the participants just like with real natural scenes (e.g. Berto, 2005; van Rompay & Jol, 2016). Through pictures of nature, for instance, the positive effects of nature can still be used to make people feel less stressed, nervous or impatient.

The kind of feelings and actions that result from a natural landscape or view could also depend on whether the scene is set in day- or night-time (Morris, 2011). Night-time landscapes may influence certain emotions, such as alertness, nervousness or even stress, that daytime

scenes influence differently. The cause of this may very well be the mystery that comes with night-time landscapes. Morris (2011) argues: “the darkness beyond the trees … became a mysterious void” (p. 322). Not seeing anything beyond a treeline in a daytime landscape does not elicit this feeling in a person, for example. This possible moderating effect of time of day in the landscape viewed will therefore also be discussed in this paper.

1.1 Aim of this study

Not a lot is known yet about time perception, as Matthews and Meck (2016) confirm. They argue that time perception, amongst others, has been studied mostly on itself for now, but not a lot is known concerning, for instance, psychological processes and the effects of various nontemporal stimuli, such as the (type of) art or landscape present in the room. It is therefore still very interesting for this study to see what awe-inspiring landscapes could do to influence time perception, as well as nervousness, stress, alertness and connectedness. The limited research concerning the difference between night- and daytime landscapes makes that an additional topic of interest.

According to the research by Rudd et al. (2012) as well as Piff et al. (2015), experiencing awe can make people feel like they have more time available, compared to feeling other emotions. Rudd and colleagues (2012) have also shown that people exposed to awe-inducing influences, rather than joy or neutral influences, were less impatient and less concerned about time scarcity. It is, therefore, not the very first time awe has been used in relation to time, but there is a clear research gap. The insights in what environmental characteristics make an environment awe-inspiring are very limited, for example. Interest in the emotion awe has only arisen about twenty years ago, so a lot can still be uncovered, which is where this research can help. Especially because this research uses VR to meticulously manipulate variables, making sure that the correct details and aspects are tested to get to the right conclusions and fill in new parts of the research gap.

The eventual aim of the study is to see if time perception can be altered in an environment to make time seem to pass more quickly. The insights on awe and time perception mentioned in these paragraphs as well as other studies resulted in the following main research question of this thesis:

[RQ] “To what extent can seeing an awe-inspiring, natural landscape influence and improve a person’s time perception?”.

To answer this question this research will elaborate on previous literature and raise hypotheses related to it in the next section. Then the experiment will be discussed that is used to test these hypotheses, after which the results of the experiment are shown in detail. The related conclusions, limitations and recommendations will be discussed last.

2. Awe and time of day in literature

2.1. Defining awe

Awe, the emotion that is central in this thesis, is summarised by Barbara Fredrickson (2013) as follows:

"Awe emerges when people encounter goodness on a grand scale. People feel awe, for instance, when overwhelmed by something (or someone) beautiful or powerful that seems larger than life. The experience of awe compels people to absorb and accommodate this new vastness they have encountered"(p. 6).

This summary is based on the definition of awe by Keltner and Haidt (2003), which is used most often to describe it. Fredrickson (2013) argues that the emotion awe is made up of two components that Keltner and Haidt (2003) also describe in their article: *vastness* and *a need for accommodation*. Awe, they explain, is the emotion that is elicited in a person when that person experiences something so extremely vast (in size, power, knowledge, etc.) that they need to accommodate their mental perception of the world to it. The way a person views life or the world is challenged and changed by this new, vast, awe-inspiring experience (e.g. Shiota, Keltner & Mossman, 2007; Fredrickson, 2013). The emotion awe "represents the pinnacle of human experience" (p. 336), according to Hendricks (2018), who argues that feeling awe makes people feel like they are contributing to and improving a cause bigger than oneself. This is valued very highly for people. This theory is based on Maslow's elaborated hierarchy of needs, amongst others. In the well-known pyramid 'self-transcendence' is actually the top part, even on top of self-actualisation, showing why awe can be such an important emotion (Hendricks, 2018; Chirico & Yaden, 2018; Maslow, 1969).

2.1.1. Components of awe

Awe is usually made up of two separate components (vastness and a need for accommodation), as argued in the previous section. The first component is vastness. In this context vastness means that the object, person or experience is something immensely large in any way. This could be large in size or number (like a forest or the Taj Mahal), but also something very prestigious or famous, or very complex or detailed (like an impressive piece of music or a ground-breaking idea). Chirico and Yaden (2018) explain this by arguing that things can be perceptually as well as conceptually large. Allen (2018) confirms this, arguing that anything that is either bigger than a person's regular experience or that can create a feeling in the person that they are part of something bigger than themselves can create the vastness component of awe. Spaciousness can be used to manipulate vastness, as it is closely linked to vastness. Spaciousness relates more to the actual size of a room and similar things, but already has positive effects on behaviour in itself. When people perceive a room or environment as spacious, their general self-disclosing behaviour is positively affected, for example (Okken, van Rompay, Pruyn, 2012). This makes it useful to use spaciousness to manipulate vastness in the context of awe.

The second component of awe, a need for accommodation, is defined by Chirico and Yaden (2018) as "altering mental frames or schemas according to new incoming information. […] elements of novelty and surprise are also involved with this dimension" (p. 223). Therefore, experiencing awe generally leads to people altering their views on things. On top of that there are also some cases where just the novelty or surprise of an experience are enough to create a feeling of awe in a person (Shiota et al., 2007; Chirico & Yaden, 2018).

Apart from these two standard components of awe, Keltner and Haidt (2003) also distinguish five themes that can each give awe a slightly different context. The themes they

propose are threat, beauty, ability, virtue, and supernatural. Threat, for instance, can create awe in the way of facing a threat from a safe distance, such as a high cliff that a person is standing on behind a safe railing (Chirico & Yaden, 2018). The theme 'beauty' is the closest to what is studied in this research, with awe being created through an aesthetically pleasing experience (Allen, 2018). This could, for instance, be a piece of art or a natural landscape.

2.1.2. Awe in landscapes

As has been mentioned throughout this research, natural landscapes are one of the most obvious sources of awe-inspiring experiences. However, not every landscape necessarily induces awe in the person looking at it. A skyscraper seen from below can seem very vast, for instance, but research by Piff and colleagues (2015) found that it is not nearly as effective in inducing awe as gazing up at immense eucalyptus trees. The article by Shiota and colleagues (2007) confirms this, arguing that nature is a particularly clear elicitor of awe. It is good to emphasize again that awe can be felt through seeing nature directly as well as indirectly (for instance, through pictures, animations or VR)(e.g. van Rompay & Jol, 2016; Chirico et al., 2018).

Figure 1: Pictures with the highest score on 'sublime nature'[1]

Various studies suggested various ideas on what needs to be present in a landscape to make it awe-inspiring. According to a study by Fairweather and Swaffield (2002), which focused on 'sublime nature', the pictures depicted in Figure 1 elicited the clearest and most positive feelings of awe and peace. The authors added that the trees and green bush that can be found in these pictures especially generated these feelings in the participants, as they accentuate things like distance, perspective and vastness in landscapes. These pictures as well as pictures from other studies confirm the previously mentioned finding that awe is found in wide, spacious landscapes (Chirico & Yaden, 2018). It is, however not said that a luscious, green forest necessarily needs to be present to elicit awe. In another study by Chirico and colleagues (2018) these findings are researched further. The researchers compare an awe-inspiring Virtual Reality (VR) landscape with a forest to one of snowy mountains. In this study the snowy mountains show a much wider landscape, rather than the closed off, 'non-vast' one with the forest. The results of this study show that the wider, more clearly vast landscape with the mountains was perceived as more awe-inspiring than the forest.

The study by Shiota et al. (2007) gives a few very clear components that can make a landscape elicit awe in participants, apart from wide and green settings. According to them, people respond well to the presence of trees and water as a natural element in the landscape. Clusters of trees or shrubberies also work well as a repeated element, which is another component that adds to a feeling of awe. The last element Shiota and colleagues introduce is also very interesting; "an element of 'mystery', such as a winding path or an obscured area, that encourages exploration" (p. 951). This mystery component could be elicited through other

[1] Fairweather, J.R. & Swaffield, S.R. (2002). *Photographs used for Q sorting [photograph detail].* Lincoln, New Zealand.

means than just a path, of course. A clear way to create mystery in an environment could be setting it in night-time, for example (Morris, 2011). Lastly, Allen (2018) and Yaden and colleagues (2016) add the 'overview effect' to these elements. This effect may increase the awe in a landscape when a person sees a wide landscape from a high viewpoint, such as the mountain scenery found in the experiment by Chirico et al. (2018).

All the aforementioned articles show various elements that can induce awe in participants that have been used in other studies to test awe. It seems that not all separate elements mentioned are needed at the same time, but using multiple could definitely increase the awe people would feel when looking at the landscape. These studies, however, are not enough to state clearly with undoubted confidence what components really make a landscape 'awe-inspiring'. In the end the component that most easily makes a landscape awe-inspiring, according to research mentioned before, is usually spaciousness or vastness. This can, in turn, be induced through the various ways explained previously. On the other hand, however, some research suggests spaciousness may also turn out to be boring or desolate instead of awe-inspiring (e.g. Carpman & Grant, 1993), showing another limitation. The added limitation of awe and time perception not having been researched extensively together create an interesting research gap for this study to tackle.

2.1.3. Influences of awe

Studies on the effects of awe have only really started to come up over the past twenty years or so. It is therefore very likely that additional (positive) effects will still be found. Even so, a lot of varied actions and feelings were already found that can be influenced by the emotion awe. These influences are usually positive, but negative effects were also occasionally found. Only the effects of awe that are related to this study will be elaborated on here, as there would be too many otherwise.

2.1.3.1. Time perception

Perceived time is a concept that is closely related to the duration of activities, which is, as Owen (1991) argues, defined as "how long it takes to do something" (p.351). The difference with perceived time is that a person's perception of time is what they believe the duration of something was, rather than the actual duration. This has worked well in modern societies, as most people nowadays live in what Owen (1991) calls a 'linear-separable time perception model'. This means that rather than measuring time in vague quantities, such as using outside forces like the weather, time is measured in a clear, distinct order. Time can be divided into distinct parts that are always the same, such as seconds, minutes or days. These concepts can then be used to estimate time passage individually as well, which means a person can estimate time as either too long or too short compared to the actual time, depending on how the time passage felt to that person.

Almost anything in an environment can influence a person's time perception. For instance, human senses like hearing (Sebel & Wilsoncroft, 1983; Droit-Volet et al., 2010; Droit-Volet et al., 2013) can alter time perception, but also seeing different colours (Singh, 2006; Hosseini, 2015), happy faces (Colonnello et al., 2016) or even things that scare you (Lake et al., 2016) A good example is, for instance, how smell influences time perception (Brand et al., 2016). A room with a clear smell, either good or bad, results in people being able to more accurately estimate the time it took them to perform certain tasks with 'low cognitive involvement' compared to rooms with no smell. This finding shows that even small things can already influence time perception in a significant way.

Time perception can also be influenced by awe, studies argue. It has been proven in studies by Rudd et al. (2012), for example, that experiencing awe can make people feel like they

have more time available. Various theories try to explain this connection between time perception and awe, such as the Extended-Now theory and the Socioemotional Selectivity theory (Rudd et al., 2012). These theories suggest that "focusing on the present elongates time perception. Awe focuses people's attention on what is currently unfolding before them" (p. 2) and this focus in turn could elongate a person's sense of time.

The experiments showed that experiencing awe in this way led people to feel less stressed and impatient, among other negative effects of perceived time scarcity (Rudd et al., 2012). According to this research, participants primed with awe-inducing stimuli feel like they have more time available and seem to be more willing to offer up their time for others because of that as well. The study by Berry and colleagues (2015) builds on this research. Their research found that exposing participants to awe-inspiring natural landscapes (rather than regular buildings) resulted in people behaving less impulsively, which the researchers found was due to the participants feeling like they had more time available to make choices and think things through. The findings of these studies seemingly show that awe alters people's time perception positively. Therefore, the first hypothesis of this study is:

[H1] Awe-inspiring landscapes, compared to non-awe-inspiring landscapes, lead to time seeming to pass more quickly.

There is, however, a literature gap that follows from the aforementioned and related articles in that most of these experiments are very specific. For example, some study a very specific target group, such as the article by Rodríguez-Morera et al. (2008), which only focuses on patients specifically in palliative care in a hospital and their primary caregivers. Being this specific is not necessarily wrong, but it makes it hard to use the information gathered in the research in a different or more regular setting. On top of that, very few studies show exactly what 'actual times' were tested. There may be a difference in perceived time when different smells are used, for example, but it is not defined if a participant had been waiting ten or thirty minutes. Waiting five minutes but seeing it as four seems different than waiting for fifty minutes and perceiving it as forty. This is why specific times, for example, are especially important in this particular research.

2.1.4. Connectedness

A different variable that previous studies have linked to awe is connectedness. Seeing awe-inspiring views can potentially make people feel more connected to their community or society, rather than detached from it in a more individualistic way (Krause & Hayward, 2015; Mashek, Cannaday & Tangney, 2007). Allen (2018) connects this to a feeling of small-self, which leads people to feel like their individual 'self' is less important, as well as a feeling of collective-self, which in turn leads people to feel like they are part of a group. These feelings can lead people to feel more like they are part of something bigger, rather than just a single person. Feeling connected to others may increase a person's wellbeing and make it easier to let go of some worries, for instance. This study will try to see if this effect is present when people are presented with the VR animations of awe-inspiring landscapes. The related hypothesis that will be tested is as follows:

[H2] Showing people a high-awe landscape will lead to them feeling more connected to the community.

The thought behind this hypothesis will be elaborated on in the following paragraphs. Various studies show positive effects that inducing awe on participants can elicit. A few examples of this were already mentioned in previous paragraphs, such as the effect of awe, spaciousness in particular, on self-disclosure (Okken et al., 2012). Multiple other studies have

shown that people show more prosocial behaviour when exposed to awe. They are, for instance, more generous and helpful after being influenced with an awe-inducing setting, as compared to emotions as amusement or a neutral influence (e.g. Prade & Saroglou, 2015; Valdesolo & Graham, 2013). Other examples include the study by Stellar and colleagues (2017), which shows that people that are more prone to experience awe are humbler and more social, according to themselves as well as their close friends. This also led them to have a better idea of their strengths and weaknesses, and to better acknowledge contributions of others on what they had accomplished personally, leading to people feeling more connected to others again. A study by Krause and Hayward (2015) showed that awe leads people to feel a stronger connection to others as well as humanity as a whole, especially if they were more prone to feel awe in general.

The study by Bai et al. (2017) built on this and suggested that participants that were influenced with awe said there was more overlap between themselves and the 'community at large' than people influenced with other emotions. Studies like the ones mentioned in these paragraphs show many positive effects of awe on behaviour and people in general with several causes. Due to the previously mentioned concept of collective self, for instance, people quickly feel that 'there is more' than just themselves. This could mean that they are more connected to their community, as was mentioned before, but also just other people in general or their environment (Allen, 2018; Pearce et al., 2016).

2.2. Daytime versus night-time

There are factors that could potentially influence the time perception and other feelings of participants in addition to awe. The moderating variable that is considered for this study is the time of day inside the landscapes. The sinister feelings and mystery in particular that quickly go hand in hand with dark landscapes, may create feelings of alertness in people, for instance, that do not necessarily appear in daytime settings (Morris, 2011).

2.2.1. The difference between night- and daytime

A relatively old article by Thor (1962) already studied this subject and seemed to show that daytime led people to estimate higher times than night-time. However, a study by Hancock and colleagues (1992) opposed this in their experiment. They found that the differences in time estimations seemed to come from differences in gender related to workload rather than the time of day. Still, a later study by Kuriyama et al. (2003) found, again, that people overestimated the time some actions took during daytime significantly more than during night-time. Seeing all this back-and-forth over the years, it is safe to say that there have been some disagreements around the topic. There have especially been differences about the mechanisms and causes of time perception differences, and differences between short-term and long-term time perceptions (e.g. Kuriyama et al., 2003).

The potential difference daytime and night-time could create will be considered in this research as well, but in a different way. Rather than asking participants the same questions during either the day or the night, the landscape present in the environment will be the influence. Each participant will either see a landscape at daytime or night-time to see the effects of this difference. Because of the very limited research in this particular direction it is difficult to make a prediction of the outcome. Small possibly related influences have been found, such as how bright light, associated with daytime more often than night-time, can make people more alert, which can in turn make them less likely to overestimate time (Rüger et al., 2006). Findings like this one combined with the research mentioned in the previous paragraph leads to the third hypothesis of this research, which is that:

[H3] People will underestimate time if they are influenced by a daytime landscape, as compared to a night-time landscape.

2.2.2. Feeling stressed, alert or nervous (in the dark)

While not all effects of stress are necessarily negative, a lot of them are. For instance, stress can lead (or trigger a downward spiral) to headaches (Passchier & Orlebeke, 1985), sleeping problems (Linton, 2010) and various mental health complications (e.g. Lupien et al., 2009). To reduce the chances of any of these happening, reducing or preventing stress can be important, especially in potentially stressful locations, such as waiting or meeting rooms. Studies have shown that reducing stress could be done through using (awe-inspiring) landscapes and nature in general (e.g. Stellar et al., 2017). This effect will be studied in this experiment.

As was mentioned before, there are other effects that (awe-inspiring) landscapes can have on people depending on various factors. Landscapes can also lead people to feel more alert or nervous, for example, depending on the setting (Morris, 2011). Creating a nervous atmosphere would be counterproductive for most environments, therefore it would be beneficial if that could be prevented. Some research hints that one of the main factors that creates a feeling of nervousness or alertness in a person looking at a landscape is the time of day in the landscape (night-time or daytime) (e.g. Cook & Edensor, 2014). These variables will therefore be considered.

It is interesting to see if just seeing a different time will have the same effect as if it actually were a different time of day, as was done in the studies by, for instance, Morris (2011) and Cook and Edensor (2014). According to these authors, landscapes at night may affect other variables, such as stress experienced by a participant. Morris (2011) argues that people tend to see dark, night-time surroundings as a metaphor for nature not just being beautiful and nice, but also sinister and mysterious. In the dark, many things can very suddenly come up in your limited field of vision, the author continues. Some people perceive this as thrilling and exciting, while others feel stressed and nervous. On the other hand, feeling awed generally reduces stress and nervousness in people (Stellar et al., 2017).

Cook and Edensor (2014) add that a person's imagination can be enhanced by dark landscapes. On top of that, they argue, people can feel more aware of the details and repetitive rhythms of the landscape. These various feelings can potentially influence the way a participant feels, acts or perceives their surroundings. A repetitive landscape can, for example, lead a person to feel more alert while seeking anomalies. A dark landscape could also make a person more nervous, due to either associations with the dark or the decreased visual capabilities it brings. All of these feelings are more pronounced when a person is in that environment themselves, of course, but according to Morris (2011) they can be simulated by art, for example. These effects could potentially be used in varying settings. Making people stressed should usually be avoided, for example, but making people feel more alert could be a positive effect to use during important meetings.

Seeing if all the findings explained in this section still hold when the environment that is seen is a night-time landscape can be interesting, as there are both positive and negative possible effects. While awe, excitement and mystery could be clearer at night (positive), feelings of anxiety and stress (negative) could also be more present in a night-time landscape. These considerations lead to an open sub question about daytime and night-time, rather than a hypothesis:

[SQ] To what extent is a daytime or night-time landscape better suited for the context of, amongst others, waiting rooms, relating to feelings of awe, stress, alertness and nervousness?

2.3. Conclusion

The influencing factor central in this research is feeling the emotion awe. Very little is known of using the emotion awe in, amongst others, a waiting room setting, so this study can help fill up this research gap. The possible moderating factor in this study is the time of day in the natural landscape shown. Therefore the experiment will use a 2 (high-awe or low-awe) x 2 (daytime or night-time) between subject design to test all of the hypotheses mentioned in the previous paragraphs.

The main research question that resulted from the literature review is as follows: To what extent can seeing an awe-inspiring, natural landscape influence and improve a person's time perception?

3. Method

3.1. Pre-tests

To test if the landscapes used in the study were seen as awe-inspiring or not, three separate pre-tests were done before the actual experiment began. The participants for each pre-test received a list of various landscapes that would potentially be included as stimuli in the experiment. Each pre-test was distributed as an online survey including images of landscapes made in a VR application for systematically developing and testing landscapes such as the ones used in this experiment. A convenience sample was used in this case. The results of the pre-tests were used to pick the landscapes for the experiment accordingly. In each pre-test the participant was asked, amongst others, about how awe-inspiring and spacious they perceived each image to be. Spaciousness was used here because, as was explained before, spaciousness and vastness are usually very closely related to awe and potentially make up an important part of the emotion. To make a comprehensive view of the awe in an image, spaciousness is also an important factor to measure in these pre-tests.

The first pre-test (n=21) determined the best high-awe landscape out of the six landscapes that were created. There were three night-time landscapes and three daytime landscapes. Two landscapes were intentionally made to be lower in awe and spaciousness to make a clearer difference between high awe and low awe. The landscape with the highest score in both awe and spaciousness was chosen as the high awe stimulus for the experiment. See Appendix 1 at the end of the report for the landscape selected at the end of this pre-test.

The second pre-test (n=13) was used to determine the best low-awe landscape out of the five options given. The options in this pre-test were based on the landscape with the highest awe in the first pre-test. This was done to make sure that the differences in the final results using the high-awe and low-awe landscape would really be rooted in the difference in awe and spaciousness, rather than, for instance, a difference in setting, colour of the sky, etc. The low-awe landscape that was selected based on the results can be found in the appendix again. Both this landscape and the high awe landscape selected before were then made into night-time versions as well, with the only difference with their daytime counterparts being the 'time of day' inside the image.

The third stimulus pre-test (n=11) used the four final images from the previous pre-tests and measured the differences in feelings of spaciousness and awe they elicited in the participants to make sure those differences between them were significant. This was important in order to confirm that the actual experiment would test the right factors, and that the stimuli would elicit these. The results of this pre-test were positive.

The full results of the pre-tests, including means and standard deviations, can be found in Appendix 2. The last stimulus, the control stimulus, can be found in Appendix 1. This stimulus was selected as a neutral stimulus to compare with the other four. The short video depicts someone walking through an average shopping mall and shows things like shops, other mall visitors and escalators.

3.1.1. Length of the stimuli

In an informal extra pre-test seven participants were shown either a high-awe or a low-awe animation. They were instructed to say when they lost interest in the animation shown. The participants watching the high-awe animation could watch the animation for about 50 seconds, while the low-awe stimulus could only be watched for about 30 seconds without participants losing interest. This is, of course, not a surprise for the low-awe condition. To make sure that the high-awe animation was interesting the entire time, the animations used in the final experiment

are 45 seconds long. This number would make some variation in the results of time estimation possible, or at least more variation than may be expected from a 20-second animation, for example.

3.2. Experiment design

This experiment had a 2 (high-awe vs low-awe) x 2 (daytime vs night-time landscape) between-subject design with an additional control group. The main dependent variable that was tested in the experiment was time perception. The other dependent variables that were tested are connectedness, stress, alertness and nervousness. The research design is modelled in Figure 2. In this model the independent variables (awe and time of day) are on the left, the dependent variables on the right, and in between these variables are the various connections through hypotheses.

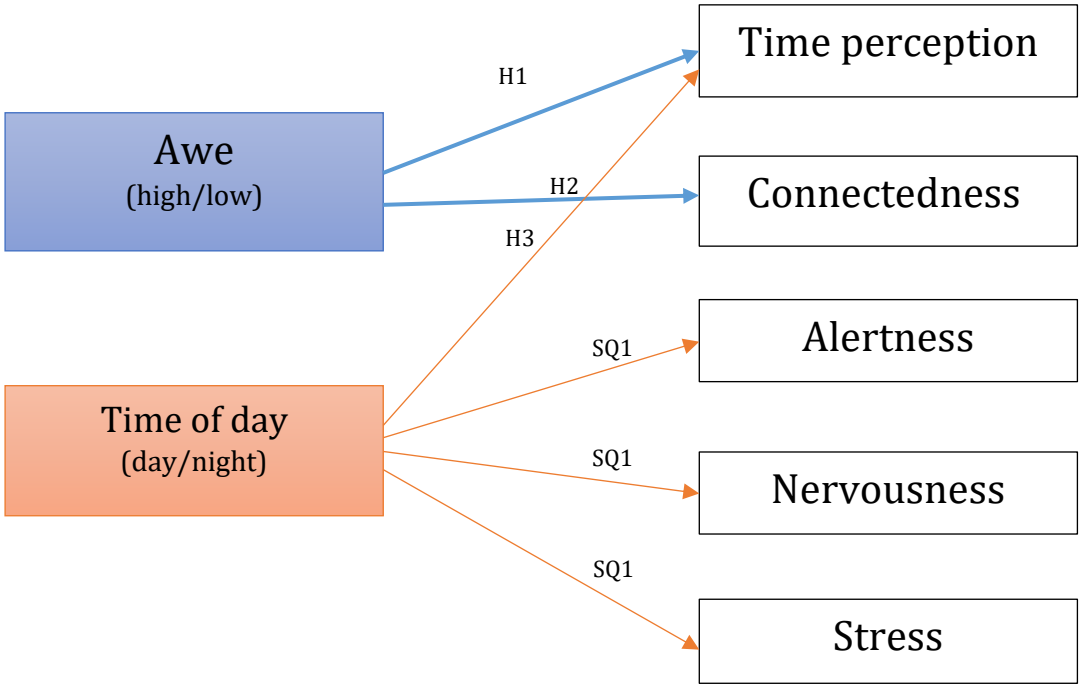

Figure 2: Model of the variables in this study

3.3. Participants

There were 127 participants that took part in the final experiment of this study, of which 60 were female and 66 male (and one participant that did not want to specify their gender). The average age of the participants was 21,9 years, with a standard deviation of 5,43. The sessions took place within a span of fourteen days. Each respondent was tech savvy enough to work well with the VR glasses as well as their smartphone or a tablet to answer the questions after.

3.4. Experiment procedure

First of all, the participant verbally agreed to participate in the experiment. The experimenter explained what would happen during the experiment and what was expected of the participant. The participant then put the VR glasses on while the experimenter set up one of the five animations with a countdown starting. This made sure that the participant did not miss a part of the animation. The animation started after the short countdown (about two seconds from when the VR glasses and the animation were fully, rightly and comfortably fastened). The participant then watched the whole animation, 45 seconds in total, through the glasses, after which he or she was instructed to take the glasses off.

During the following part the participant answered related questions in the questionnaire provided by the experimenter. They could access the questionnaire either through the tablet provided there or their own smartphone by typing in a link or scanning a QR-code leading to the questionnaire. They would also, after providing their verbal consent, provide digital, written consent at the start of the survey. After filling out the entire survey, the participant was thanked for their participation and offered a cookie before they left.

3.5. Measurements

The full list of questions that the participants needed to answer can be found in Appendix 3. The survey was made with Qualtrics. The questions were divided in several blocks, each measuring one or multiple dependent variables, as shown in the model in Figure 2. The various dependent variables were tested using validated scales of other studies as well as through self-reporting measures, such as how a participant would rate their own nervousness at that moment. Apart from the short explanation in the following paragraphs, an extensive summery explaining the survey questions and how the variables were measured can be found in Appendix 4.

3.5.1. Time perception

Time perception/time availability was measured using Rudd and others' (2012) much used statements (Cronbach's Alpha: ,43), such as "Time is plentiful" and "I have lots of time in which I can get things done". The participants were also asked to estimate the time they thought the animation had taken in total in seconds, which measured perceived time passage. Due to the poor value for Cronbach's Alpha for time perception, these questions were only used separately instead of as a combined total.

3.5.2. Connectedness

Connectedness was measured using Mashek and colleagues' (2007) connectedness scale, which can be seen in Figure 3, and questions by Yaden et al. (2018) (Cronbach's Alpha: ,70). These statements measuring connectedness were slightly adapted to fit in the context of this study, resulting in statements such as "I feel closely connected to the rest of humanity" and "I feel part of some greater entity".

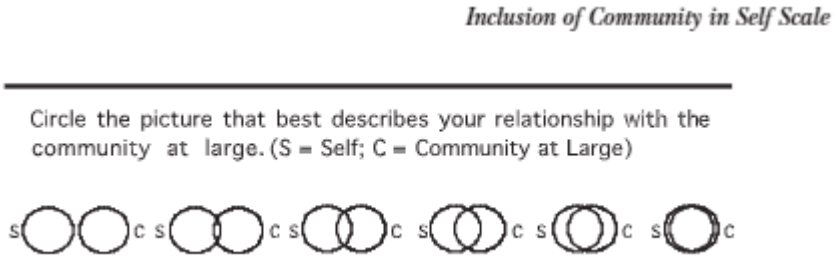

Figure 3: Inclusion of Community in the Self scale by Mashek et al. (2007)[2]

3.5.3. Alertness

The variable alertness was measured through the questions of the Cleveland Adolescent Sleepiness Questionnaire used by Spilsbury et al. (2007) and other studies, as well as self-reported alertness (Cronbach's Alpha: ,74). The statements used in the questionnaire include "I will feel wide-awake the rest of the day" and "I feel alert during my classes/work". All questions were asked related to feelings the participant had at that present moment.

[2] Mashek, D., Cannaday, L.W. & Tangney, G.M. (2007). Inclusion of Community in the Self (ICS) scale [illustration]. Claremont, CA.

3.5.4. Stress

The variable stress was measured in this study by using the questions by Levenstein's (1993) that were validated by Fliege (2005) (Cronbach's Alpha: ,83). They were sometimes adapted in minor ways to make sure that they fit the context of this research well, which resulted in statements such as "I feel tense" and "I feel like I have a lot of worries".

3.5.5. Nervousness

Lastly, nervousness was measured using the statements introduced by Weems et al. (2003) in their anxiety control questionnaire as well as self-reported nervousness again (Cronbach's Alpha: ,57). This resulted in statements such as "I feel nervous" and "I can't stop thinking about things that make me nervous or afraid".

For completeness' sake, the full list of questions and the explanations can be found in Appendices 3 and 4 along with a table showing all statements and questions used to measure each variable. All questions were asked in relation to the thoughts and feelings of the participant at the present moment of questioning ('right now').

4. Results

The results of the experiment will be explored in the following paragraphs. Firstly the main variable, time perception, will be elaborated on. Secondly connectedness will be treated. Alertness, stress and nervousness will be treated last. Level of awe, time of day and the related interaction effect will be discussed for each variable using univariate analyses.

4.1. Time perception

First the differences in time perception were checked between the five different stimuli. The univariate analysis done shows that there is a difference between these stimuli in the willingness to help at a later time that participants reported at the end of the survey ($F(1, 97) = 3,41$; $p = ,01$), showing that there is a marginally significant difference between the high awe-night condition ($M = 3,96$; $SD = ,89$) and the low awe-night condition ($M = 3,12$; $SD = 1,34$; $p = ,10$) as well as with the control group ($M = 3,08$; $SD = 1,16$; $p = ,07$). This particular view on time perception is closely linked to prosocial behaviour, as explained in previous paragraphs, but because of the context of the question it will be treated with time perception.

There is also a significant effect between the stimuli on the number of seconds the participants thought the animation lasted ($F(1, 91) = 4,42$; $p < ,01$), showing that there is a highly significant difference between the low awe-night condition ($M = 27,38$; $SD = 15,14$) and the control condition ($M = 45,20$; $SD = 19,71$; $p < ,01$). On top of that, there are marginally significant effects between the high awe-night ($M = 32,21$; $SD = 16,21$; $p = ,08$) and control group, and the low awe-night and low awe-day stimulus ($M = 41,07$; $SD = 18,79$; $p = 0,06$).

4.1.1. Perceived length of the animation

To further elaborate on these differences, the means for the difference in time perception were tested with 2 (awe: high vs low) x 2 (daytime vs night-time) analyses. A univariate test and one-way ANOVA showed that there was a significant difference for the time of day ($F(1,91) = 5,32$; $p = ,02$) and a marginally significant interaction effect of level of awe and time of day ($F(1, 91) = 3,44$; $p = ,07$) on the amount of seconds the animation was perceived to take. This shows that the value for low-awe at night ($M = 27,38$; $SD = 15,14$) is marginally significantly lower than low-awe at daytime ($M = 41,07$; $SD = 18,79$; $p = ,06$), while the difference is negligible for the high awe condition (Day: $M = 33,70$; $SD = 13,59$; Night: $M = 32,21$; $SD = 16,21$; $p = 1,00$). No significant difference was found in level of awe in itself ($F(1, 97) < 1$; $p = ,70$). These differences, especially the interaction component, can be seen depicted clearly in Figure 4. All the means given here are in seconds.

4.1.2. Willingness to help

The willingness people showed to help out and volunteer their future time also showed a marginally significant interaction effect ($F(1, 97) = 3,42$; $p = ,07$) between the two variables (level of awe and time of day) as well as for level of awe itself ($F(1, 97) = 3,42$; $p = ,07$), which can be found in Figure 5. No significant difference was found for time of day on willingness to help ($F(1, 97) = 1,32$; $p = ,25$).

While the willingness to help was virtually the same for high ($M = 3,80$; $SD = 1,12$), and low awe ($M = 3,80$; $SD = 1,19$; $p = 1,00$) in the daytime stimuli, a clear difference can be seen in the night conditions. An ANOVA test showed that the mean for high awe ($M = 3,96$; $SD = ,89$) was marginally significantly higher than the mean for low awe ($M = 3,12$; $SD = 1,34$; $p = ,10$) in night-time landscapes.

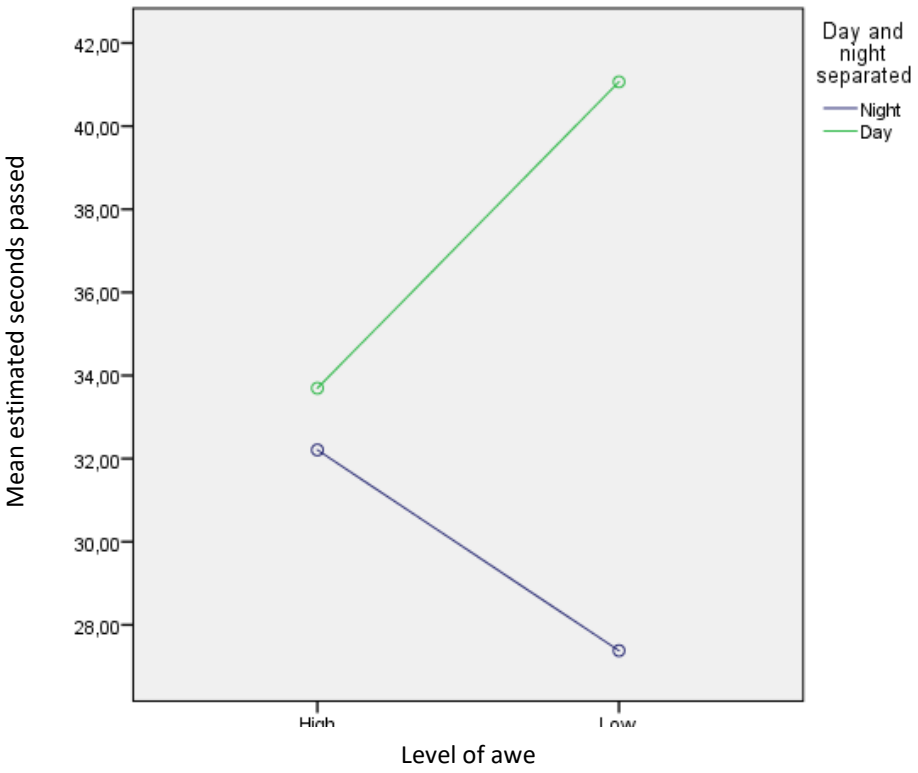

Figure 4: Differences of number of seconds the animation seemingly took in a plot

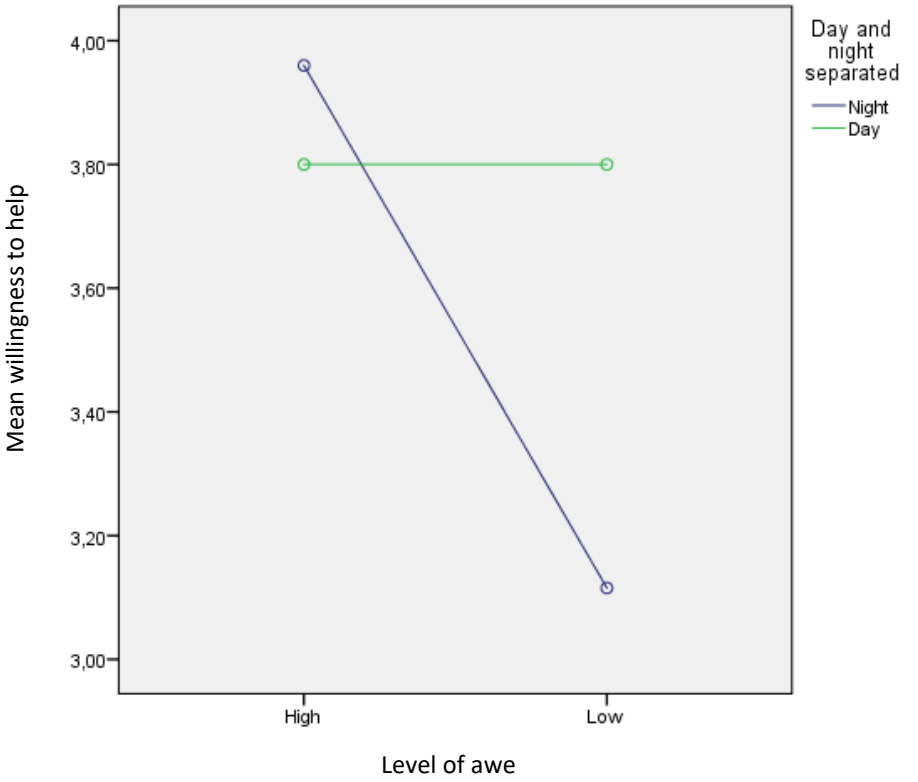

Figure 5: Plot of the differences in willingness to help

4.2. Connectedness

A univariate test shows that there are no significant differences between time of day ($F(1, 97) < 1$, $p = ,41$) on feelings of connectedness. There was also no significant effect of level of awe on connectedness ($F(1, 97) = 1,47$; $p = ,23$). The test shows that there is no significant interaction effect ($F(1, 97) = 1,72$; $p = ,19$) related to level of awe and time of day either. These results show that people do not feel more or less connected to others when presented with different landscapes.

4.3. Alertness, stress and nervousness

4.3.1. Alertness

A univariate analysis showed that there was no significant difference of time of day on the variable alertness ($F(1, 97) < 1$; $p = ,79$). So, there is no difference in alertness felt by participants between night- and daytime landscapes. There was, however, a significant difference in level of awe on alertness ($F(1, 97) = 5,01$; $p = ,03$). People feel significantly more alert when they are presented with a low-awe landscape ($M = 2,88$; $SD = ,72$) compared to a high-awe landscape ($M = 2,53$; $SD = ,86$; $p = ,03$). The univariate test showed that the interaction effect between time of day and level of awe on alertness was not significant ($F(1, 97) < 1$; $p = ,71$).

4.3.2. Stress and nervousness

A univariate test showed that there is no significant effect on the variable stress in this research related to time of day ($F(1, 97) = 1,07$; $p = ,30$) or level of awe ($F(1, 97) = 1,87$; $p = ,18$). There is also no significant interaction effect found for the variable stress ($F(1, 97) < 1$; $p = ,60$). Therefore, no difference in stress was found in participants no matter what kind of landscape they were influenced with.

There is, however, a marginally significant effect for time of day in landscapes on nervousness ($F(1, 97) = 2,89$; $p = ,09$). From the values found in a one-way ANOVA it can be argued that night-time landscapes ($M = 2,46$; $SD = ,90$) seemingly result in people feeling more nervous than daytime landscapes ($M = 2,17$; $SD = ,87$; $p = ,09$). A univariate test showed that no significant difference was found on nervousness related to the level of awe ($F(1, 97) = 1,74$; $p = ,19$) or because of an interaction effect ($F(1, 97) < 1$; $p = ,94$).

5. Discussion

In this final section conclusions will be discussed, after which limitations of this specific study as well as ideas and directions for future studies will be elaborated on.

5.1. Implications of the results

5.1.1. Time perception

The results of the experiment showed that there was an interaction effect between level of awe and the time of day of stimuli on perceived time. There was also a difference between night- and daytime stimuli itself. While for high-awe stimuli the perceived time passed during the experiment was similar, this was very different for the low-awe conditions. The time that a participant thought had passed was significantly less for the night-time landscape than for the daytime landscape, as has been depicted previously in Figure 4.

The hypotheses around these findings were that high-awe landscapes would make time seem to pass more quickly, and that daytime landscapes would also make time pass more quickly. These (combined) hypotheses hold through the interaction effect: the difference in time perception is only observed between day- and night-time for low-awe landscapes. However, instead of daytime leading to people underestimating the time spent, night-time landscapes were underestimated instead.

These findings may possibly be explained by the mystery effect of dark landscapes that Morris (2011) elaborated on in her article. Participants could find the dark, low-awe, non-spacious environment mysterious or sinister, which makes them more alert about the environment, or look for anomalies or things that unexpectedly move, for example. Because the participants are 'busy' with this environment for a longer time, time could seem to be passing more quickly.

Another finding of the experiment around the topic of time was that people influenced by the high-awe conditions were more willing to give up their future time to help someone else out, but the finding only held for night-time landscapes. This finding fits in very well with other research, such as the study by Rudd et al. (2012), which also found that awe-inspiring landscapes make people more likely to volunteer their future time.

Rudd et al. (2012), as well as other previously mentioned authors, found that feeling the emotion awe makes people more social. It makes people more likely to give the socially desired answer to questions, for example, or makes them more likely to help out strangers (e.g. Prade & Saroglou, 2015; Valdesolo & Graham, 2013). Taking away the 'awe component' in a landscape has a stronger effect on prosociality in night-time landscapes, this research shows. This could tie in with what was previously argued about non-spacious, mysterious environments making people more alert or stressed. Perceived threat, for example, may make people more focused on their own concerns. While they are feeling these emotions instead of awe and are busier with themselves individually and 'staying safe', they could feel less caring about others.

5.1.2. Alertness, connectedness, nervousness, and stress

The results of the experiment quickly showed that there were no major differences for the variables connectedness and stress. This shows that the level of awe in environments does not significantly affect these feelings, and neither does the difference in time of day inside a landscape. The hypothesis for connectedness was that showing a high-awe landscape would make people experience more connectedness with their community, but this is not proven in this study.

Nevertheless, the sub question related to the effect of night- and daytime environments on feelings of stress, nervousness and alertness can be answered more fully. While there was no effect of time of day (or level of awe) inside landscapes on stress, there were effects found for nervousness and alertness. Participants reported higher levels of nervousness when they were influenced by night-time landscapes compared to daytime landscapes. This finding held regardless of whether it was a high-awe or low-awe environment. This shows that people generally feel more nervous when they see a night-time landscape. This finding could be rooted, again, in the mystery that night-time landscapes bring (Morris, 2011). Cook and Edensor (2014) argued that people could feel more nervous in dark environments because of negative associations people have with the dark and the fact that darkness decreases their visual capabilities.

Alertness, the last variable tested in the experiment, did not show any differences between night- and daytime landscapes, but did show a difference between high-awe and low-awe landscapes. The results show that people feel significantly more alert in low-awe landscapes than in high-awe landscapes. This difference could relate to the spaciousness component being taken away. When people have a much 'smaller' environment in front of them, covered in bushes and trees, they are more concerned about what is behind those trees, for example, which makes them more alert in their surroundings than the spacious, wide landscapes in the high-awe conditions do. This could still tie in with the mystery component of landscapes that Morris (2011) introduced, although this time, the mystery is rooted in a lack of vision that does not come from darkness.

5.1.3. Overall conclusion

The research question of this study was: "To what extent can seeing an awe-inspiring, natural landscape influence and improve a person's time perception??" and because of the results of the experiment it can be answered.

A person's time perception can be influenced through the use of awe-inspiring, natural landscapes. The influence and improvement are especially clear when day- and night-time landscapes are compared. The time a person spends looking at a night-time, low-awe landscape, is easily underestimated. This time spent is also slightly underestimated in the daytime, high-awe landscape, but not significantly so. Using a daytime, high awe landscape, on the other hand, makes people more likely to help at a later time and therefore volunteer their future time. So even though people do not necessarily think that less time has passed in a daytime, high-awe landscape, they are significantly more willing to help out again if that benefits another person. That makes this kind of environment very useful for places like waiting rooms, as people will mind waiting (again) less to help a busy doctor or dentist, for example.

The sub question that was posed can also be answered related to those findings. The sub question was: To what extent is a daytime or night-time landscape better suited for the context of, amongst others, waiting rooms, relating to feelings of awe, stress, alertness and nervousness?

The results of the experiment show that a daytime landscape would be more suitable for a waiting room setting, as the willingness to volunteer time is higher. Alertness and nervousness are higher for night-time landscapes, which also make these kinds of environments less suitable for waiting room settings. It is undesirable to make people more nervous about or wary of their already potentially stressful surroundings than necessary.

5.2. Limitations and recommendations

5.2.1. Limitations of the study

The main variable tested during this research was time perception. The most difficult part about measuring time perception is that it can be influenced by a plethora of things, such as distinct things like smell (Thiabaud & Dray, 2016) and sounds or music in the environment (Sebel & Wilsoncroft, 1983; Droit-Volet et al., 2013). However, other variables that are more difficult to prevent can also influence time perception, such as social influences or hormones (Colonnello et al., 2016), or anxiety felt by a participant (Lake et al., 2016). People experiencing fear or anxiety, for example, tend to overestimate the time that has passed. While it was of course tried to make the conditions for each participant the same, filling in a questionnaire or wearing VR glasses may make one participant more anxious than another, having more talking people pass by the experiment can create added distractions, etc. Great care was put in making sure to limit these variations, but they might have influenced the results in minor ways.

Another factor that may have limited the results of this study is the days of the week. Each stimulus was tested for a large part on one particular day of the workweek (Monday through Friday) to simplify the data collection. The control stimulus, for example, was mainly shown on Wednesdays. While this generally did not prove to be a problem, it should still be mentioned. The variable stress, for example, did not show any significant results. There was, however, an interesting 'spike' in the Monday group stress level as compared to the stimulus shown on Friday. Research has shown that people feel less stressed during the weekend than throughout the week (e.g. Stone, Schneider & Harter, 2012), which has very likely influenced these results rather than just high-awe and low-awe stimuli, especially because the data was collected around local exam periods.

The exam periods tie in with another possible limitation of the results: the population used. The population was fairly homogeneous, consisting mainly of students (116 students versus 11 non-students) and collected around an exam period. The results obtained for this research could be different for other groups, such as working people and the (retired) elderly. As all these people mentioned could and do visit a doctor's waiting room, a dentist's waiting room, etc. it may be important to know if the most important results found still hold for these other groups if they are applied in these contexts.

5.2.2. Future research

To further support and substantiate the research done in this study, future research could incorporate different ways to measure the variables tested here. The variable stress, for example, was tested here using statements from the Perceived Stress Questionnaire as used by Fliege (2005). While this is a validated measure for stress, there are of course other scales that could prove to be useful and give different results. On top of that, research can still be conducted for other sorts of useful variables and feelings. Right now time perception, connectedness, alertness, stress, and nervousness were measured, but there are of course other variables that awe may have a useful, interesting effect on, such as contentment/happiness, boredom, helpfulness, or creativity. Of course the possible positive effects of awe can also be applied in various places outside of waiting rooms. Making people more alert, for example, may work very well in meeting rooms.

Another aspect of the research that could be studied more extensively is the difference between awe-inspiring landscapes set in different times of the day. In this study a late afternoon was used for the daytime landscape and the middle of the night (including an obscured moon) was used for the night-time landscape, as can be seen in Appendix 1. While this showed interesting results on, for instance, time perception and nervousness, there could be other

options. Additionally to the night and afternoon environment, a morning could be used, as well as sunset or sunrise skies. Sunset and sunrise environments, for example, are generally found to be relaxing (e.g. Oliveira et al., 2017) and may possibly amplify the effects of awe in a landscape.

Regardless of the time inside the environment, it was clear that during the experiment participants wanted to explore the landscapes they were shown. Some of the participants, while wearing the VR glasses, almost immediately started moving around, trying to go to different places inside the environment. Some of them were even a little disappointed when they realised they could not move around inside the landscape. For future research, therefore, it may be interesting to expand the VR experience into a 360 view of each landscape instead of the fixed animation used now. Using this technique might immerse the participants even further in the environment shown (e.g. Kasahara et al., 2014) and might allow for more prominent results, for instance. This may also be achieved through the use of other additions, such as audio (e.g. a rippling creek or chirping birds when the animation shows this) or even smells.

5.3. Takeaway message

The most important outcome that can be taken from this study is that landscapes can have positive effects on the comfort of people in a room. The best landscape to have in a (waiting) room, according to this study, would be a spacious, awe-inspiring natural landscape set in the daytime, as this reduces alertness and nervousness and makes people more willing to spend (more) time helping others.

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7. Appendices

Appendix 1: Final stimuli

Figure A1: Screenshot of the high-awe daytime stimulus

Figure A2: Screenshot of the low-awe daytime stimulus

Figure A3: Screenshot of the high-awe night-time stimulus

Figure A4: Screenshot of the low-awe night-time stimulus

Figure A5: Screenshot of the control stimulus

Appendix 2: Pre-test tables

Pre-test 1 (n=21):

Figure:	Mean (spaciousness)	Standard deviation (spaciousness)	Mean (awe)	Standard deviation (awe)
1	3.238	1.179	2.286	0.845
2	4.762	0.436	3.571	1.165
3	4.286	0.717	3.667	1.065
4	4.048	0.973	2.905	0.944
5	4.381	0.740	3.857	1.062
6	4.524	0.750	3.857	1.352

Pre-test 2 (n=13):

Figure:	Mean (spaciousness)	Standard deviation (spaciousness)	Mean (awe)	Standard deviation (awe)
1	3.308	1.032	2.923	1.038
2	3.077	0.641	2.538	0.967
3	1.692	0.630	2.154	1.214
4	3.077	1.441	2.615	1.325
5	3.385	0.768	2.769	1.235

Pre-test 3:

Figure:	Mean (spaciousness)	Standard deviation (spaciousness)	Mean (awe)	Standard deviation (awe)
1 – day high awe	**4.64** (1&2; 1&4)*	0.50	**4.00** (1&2; 1&4)*	0.63
2 – day low awe	*2.18* (2&1; 2&3)*	0.98	*2.45* (2&1; 2&3)*	1.21
3 – night high awe	**4.18** (3&2; 3&4)*	0.87	**3.64** (3&2; 3&4)*	1.12
4 – night low awe	*1.91* (4&1; 4&3)*	0.83	*2.45* (4&1; 4&3)*	1.51

* = differences in mean are statistically significant for $p < 0.05$

Difference between high awe and low awe by daytime: t-test for two independent means (awe: $t = 3.75$; $p = 0.001275$) (spaciousness: $t = 7.38$; $p < 0.00001$).

Difference between high awe and low awe by night-time: : t-test for two independent means (awe: $t = 2.09$; $p = 0.049894$)(spaciousness: $t = 6.25$; $p < 0.00001$).

Differences between high awe day- and night-time (not significant): : t-test for two independent means (awe: $t = 0.93761$; $p = 0.359628$) (spaciousness: $t = 1.49404$; $p = 0.150777$).

Difference between low awe day- and night-time (not significant) : t-test for two independent means (awe: $t = 0$; $p = 1$) (spaciousness: $t = 0.70321$; $p = 0.49003$).

Appendix 3: Full experiment questionnaire (Qualtrics)

Thesis Allyne Groen 19/20

Start of Block: Default Question Block

Dear participant, Thank you for participating in this survey. This survey is part of my thesis for my master Communication Science at the University of Twente. The experiment you are about to participate in has two parts: one is about the quality of seeing various environments in VR, the other is about feelings of stress on a normal day. As a participant you will first see one of the environments through the use of VR glasses, after which you can fill in this questionnaire to show what you thought of it.
The research has been approved by the BMS Ethics Committee. Doing the experiment and filling in the questionnaire will only take about 6-9 minutes of your time in total and all the answers you give, including simple demographic questions, will be kept strictly confidential and anonymous.
In case you do not want to start or finish this questionnaire, you can always close this survey without any negative repercussions.

I consent voluntarily to be a participant in this study and understand that I can refuse to answer questions or withdraw my participation at any time without providing a reason:

○ Yes, I consent.

End of Block: Default Question Block

Start of Block: Block 6

Watch the video through the VR glasses before continuing the survey.

○ I saw it!

End of Block: Block 6

Start of Block: Block 3

PART ONE:
First some questions about the quality of the animation and VR.

The VR glasses (mainly the strap around the head) fit me:

- ○ Horribly
- ○ Poorly
- ○ Adequately
- ○ Well
- ○ Perfectly

The animation itself was:

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
Of high quality	○	○	○	○	○
Interesting	○	○	○	○	○
Beautiful	○	○	○	○	○
Realistic	○	○	○	○	○

I think the animation I saw took (in seconds):

_____

The animation felt:

- ○ Very short
- ○ Short
- ○ Neither long nor short
- ○ Long
- ○ Very long

Using the VR glasses made me feel like I was 'inside' the animation **more** than watching a video on a phone or laptop.

- ○ Much less
- ○ Somewhat less
- ○ About the same
- ○ Somewhat more
- ○ Much more

End of Block: Block 3

Start of Block: STRESS + NERVOUS

PART TWO:
This next part is about feelings of stress and related emotions you have **right at this moment**. Do not take too long to think about your answers here, just take the first thing that pops in your mind. There are of course no right or wrong answers.

Right now, I feel:

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
Under pressure from deadlines	○	○	○	○	○
Tense	○	○	○	○	○
Like I have many worries	○	○	○	○	○
Frustrated	○	○	○	○	○
Full of energy	○	○	○	○	○
Nervous	○	○	○	○	○
Alert	○	○	○	○	○

Please indicate if you agree with the following statements:

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
I can't stop thinking about things that make me nervous or afraid	○	○	○	○	○
Hearing that someone is sick, I worry that I will get sick too	○	○	○	○	○
I feel that I can deal with difficult things that happen without other people helping me	○	○	○	○	○
I go through the whole school/workday without feeling tired	○	○	○	○	○
I have lots of time in which I can get things done	○	○	○	○	○
I will feel wide-awake the rest of the day	○	○	○	○	○
I feel alert during my classes/work	○	○	○	○	○
Time is plentiful	○	○	○	○	○
Time is boundless/limitless	○	○	○	○	○

I feel wide-awake the last class/work hour of the day	○	○	○	○	○

End of Block: STRESS + NERVOUS

Start of Block: Block 6

Nearly there! Please indicate if you agree with the following statements right now:

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
I feel part of some greater entity	○	○	○	○	○
I feel closely connected to the rest of humanity	○	○	○	○	○
I feel a sense of oneness with all things in this world	○	○	○	○	○

If one of these circles shows yourself (S) and the other is the community (C) at large, which combination would best describe the relationship between you and the community?

I relate the most to combination:

- ○ 1 (far left)
- ○ 2
- ○ 3
- ○ 4
- ○ 5 (far right)

End of Block: Block 6

Start of Block: Block 7

A few questions to check the animation you saw in the first part of this study.

Please indicate if you agree with the following statements concerning the animation you saw a few minutes ago.

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
While watching the animation I felt in awe.	○	○	○	○	○
The animation was spacious.	○	○	○	○	○
The animation was natural.	○	○	○	○	○

The animation I saw was:

- ○ A daytime nature landscape
- ○ A night-time nature landscape
- ○ A daytime urban landscape
- ○ A night-time urban landscape

End of Block: Block 7

Start of Block: Last block

You're basically done! Lastly, some standard demographic questions to complete the questionnaire:

What is your age in years?

_____

What is your gender?

- ○ Male
- ○ Female
- ○ Prefer not to say

What is your nationality?

▼ Afghanistan ... Zimbabwe

What day of the week is it today? (What day did you see the video?)

- ○ Monday
- ○ Tuesday
- ○ Wednesday
- ○ Thursday
- ○ Friday
- ○ Saturday
- ○ Sunday

What is the highest level of education that you have completed (so far)?

- ○ High school or similar
- ○ MBO or similar
- ○ HBO/University of Applied Sciences bachelor or similar
- ○ WO/University bachelor or similar
- ○ HBO or WO master
- ○ PhD
- ○ Not applicable/Don't want to answer

Are you a student right now?

- ○ Yes
- ○ No

Have you studied/worked at the University of Twente before or are you currently studying/working there?

- ○ Yes
- ○ No

Are you colour blind?

- ○ Yes
- ○ No

Finally, I have a small request. If we would be looking for participants for follow-up research, would you be willing to help at a later time (e.g. by participating yourself or by recruiting participants in your social network)?

- ○ Definitely not
- ○ Probably not
- ○ Might or might not
- ○ Probably yes
- ○ Definitely yes

End of Block: Last block

Appendix 4: Survey questions explained

The way the variables used in this research were measured are all explained in this appendix in the same way they were treated in the questionnaire in Appendix 3. A full list with each variable and its questions can be found in Table A1.

Time perception

The first questions are filler questions to 'distract' the participant. The latter two questions in block 3 (Appendix 3) measure the participants perceived time passage. These are connected to the questions later on in the study that also measure time perception. People fill in how long they think the animation took, which is always the same amount of time. The difference between the actual time and the perceived time will show if there is a difference between the varying landscapes.

Furthermore, three statements in Block Stress + Nervous are also about time perception, which ties in with the questions mentioned in block 3. These three statements are derived from the Article by Rudd et al. (2012) and have been used before to measure time perception in relation to (nature inspired) awe. This means that six items in total measure time. The items are Time is plentiful, I have lots of time to get things done, and Time is boundless/limitless.

Stress, Nervousness and Alertness

The questions in this block (Block Stress + Nervous) measure the variables alertness, stress and nervousness. This block is measured first to make a believable start of the 'second part' of the experiment and keep the participant unaware of the exact relation between the video and the survey questions.

The questions about stress are derived from the Perceived Stress Questionnaire, which was first made by Levenstein et al in 1993 and is validated in the article by Fliege et al (2005). In the latter article they found four sub-parts of stress and related the statements of the PSQ to them. On top of that they also found the statements that measured stress well. Of these remaining statements, two were taken from the 'worries' category, ("Like I have many worries" and "Frustrated") as this category was most important according to the article. The other three statements were each taken from one of the remaining categories (tension, joy and demands), which should make all components of stress accounted for.

The statement about self-felt nervousness measures the participants own perceived nervousness, which helps make up the measurements of nervousness in the next matrix. These three statements are taken from the anxiety control questionnaire by Weems (2003). While the questionnaire is usually used for children/teens, it also works for measuring nervousness in older people. Some statements are about more serious anxiety rather than nervousness and others have a lot of overlap with each other, so only a few questions were selected. This means that in total four items measure nervousness.

The item "alert" does the same thing for alertness as "nervous" does for nervousness. The last remaining questions in this block measure alertness. These statements are based on the Cleveland Adolescent Sleepiness Questionnaire, which has been used before by, for instance, Spilsbury et al. (2007). The questionnaire is made up of questions about sleepiness and questions about alertness. For this experiment the questions about alertness were used. Out of the five statements present in the questionnaire, four were selected and slightly adapted to fit the context of the experiment, as the last one did not work with the context of answering how you feel 'right now'. This means that in total five items measure alertness.

Connectedness

The questions in Block 6 measure the variable connectedness. The picture and question about it are developed by Mashek, Cannaday and Tangney (2007) and were proven to work well to measure the connectedness a person feels with their community at a certain point in time. It was used in various other articles about connectedness to a community.

The other questions in the matrix are taken from the article by Yaden et al. (2018). In this article they measure 6 factors of awe, of which one is connectedness. Out of the five statements they provided, these were selected (and slightly adapted in minor ways to fit the context of the study) based on how well they related to the experiment and a one-person pilot study. The statement "I feel part of some greater entity" was introduced by Piff et al (2015) to measure connectedness and is used in the Yaden (2018) article. This means that there are four items in total measuring connectedness.

Manipulation check questions

The two questions in Block 7 are questions that make sure that the participant perceived the animation they saw as awe-inspiring as well as whether they correctly perceived the animation as set in daytime or night-time.

Demographics and similar

The questions in the final block are mainly standard demographic questions. The question about what day of the week it is, helps determine which video the participants saw. Participants on Monday will see animation A, Tuesday participants will see animation B, etc. Saturday and Sunday are mainly used as fillers.

The last question of the block (would you be willing to help with…) does not necessarily add to measuring time perception, but does measure another part of time related to awe, which was also used in the study done by Rudd et al. (2012). According to this experiment as well as a few others, people that have seen awe are more inclined to feel that they have more time available, and therefore volunteer their time more easily to help others. This is measured using this additional question.

Table A1: full list of questions

Time perception	**Stress**	**Nervousness**	**Alertness**	**Connectedness**
I think the animation I saw took (in seconds):	I feel: Under pressure from deadlines	(I feel) Nervous	(I feel) Alert *(Taken out to improve Cronbach's Alpha)*	I feel part of some greater entity
I have lots of time in which I can get things done	Tense	I can't stop thinking about things that make me nervous or afraid	I go through the whole school/workday without feeling tired	I feel closely connected to the rest of humanity
Time is plentiful	Like I have many worries	Hearing that someone is sick, I worry that I will get sick too	I will feel wide-awake the rest of the day	I feel a sense of oneness with all things in this world
Time is boundless/ limitless	Frustrated	I feel that I can deal with difficult things that happen without other people helping me *(Taken out to improve Cronbach's Alpha)*	I feel alert during my classes/work	If one of these circles shows yourself (S) and the other is the community (C) at large, which combination would best describe the relationship between you and the community?
Finally, I have a small request. If we would be looking for participants for follow-up research, would you be willing to help at a later time (e.g. by participating yourself or by recruiting participants in your social network)?	Full of energy *(Taken out to improve Cronbach's Alpha)*		I feel wide-awake the last class/work hour of the day	