

**Exploring the Effects of Mysterious Nature and Storytelling on Social Connectedness in  
Young Adults: An Experimental Study**

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### **Abstract**

During the COVID-19 pandemic, young adults suffered from restrictions on social contact, leading to social isolation. Because feelings of social isolation can impact mental and physical health, it is essential to improve social wellbeing. Storytelling and nature exposure have been shown to increase connectedness, but in research, little attention has been paid to the effects of specific characteristics of nature. This study explores the effects of mysterious nature and storytelling on social connectedness. Participants watched a virtual nature video containing high or low mystery and did a neutral or storytelling writing task. 107 participants between 18-30 years old took part in the experiment. A 2 x 2 between-subjects design with a repeated measure of social connectedness was chosen. Immersion, awe, openness and social aspirations were controlled for as covariates. Watching a virtual nature video and engaging in a writing task significantly increased social connectedness, but no significant effect of mystery and storytelling was found. None of the covariates has been shown to change the significance of mystery or storytelling. The findings demonstrate that virtual nature and writing can increase social connectedness, but future research should explore whether and how mystery and storytelling can be utilised to increase social connectedness.

**Keywords:** Social Connectedness, Nature, Virtual Nature, Mystery, Storytelling, Young Adults, Awe, Social Aspirations, Openness, Immersion

## **Exploring the Effects of Mysterious Nature and Storytelling on Social Connectedness in Young Adults: An Experimental Study**

The COVID pandemic has eliminated many possibilities of social interaction, leaving many young people increasingly feeling isolated from their friends, families and peers (Birditt et al., 2020). Furthermore, recent research illustrates that young adults especially seem to be affected and suffer more from the consequences of social isolation than older people (Beam & Kim, 2020; Birditt et al., 2020). Such feelings of isolation should not be dismissed too quickly because they severely impair both mental and physical health and can thus increase the risk of depressive symptoms, anxiety, drug abuse and the chance of getting asthma and heart disease (Christiansen et al., 2021). Hence, the situation outlines the need to improve social connectedness among young adults.

Previous research states that storytelling is a factor that has been shown to decrease loneliness and enhance social relations among peers (Hossein Khanzadeh et al., 2018). Pennebaker and Seagal (1999) recognised that writing down personal stories can benefit mental and physical wellbeing. Hence, this study tries to utilise writing to improve social connectedness. Additionally, exposure to nature is related to increased social connectedness (van Houwelingen-Snippe et al., 2020a) and creative performance (van Rompay & Jol, 2016). However, research on specific nature characteristics that might trigger feelings of social connectedness is scarce (Marselle et al., 2021). To create effective nature interventions, it is necessary to attend to all possible features that impact the effects of a particular nature scene. Thus, this study aims to test whether nature and storytelling can increase feelings of social connectedness in young adults.

### **Social Connectedness**

The feeling of social connectedness reflects the inner sense of belonging to the social environment, which is developed through interaction with the social world by perceiving oneself in relation to others (Lee & Robins, 1998; van Bel et al., 2009). Here, the emphasis is not necessarily on the number of social relationships but the view of an individual on the world and their relation to it (Lee & Robins, 1998). To put this into perspective, this means that feelings of social connectedness are not always a representation of the actual situation of an individual but a reflection of the cognitive representation we have of ourselves in relation to our surroundings.

Social connectedness has proven to benefit young adults' health and wellbeing. Lee and Robins (1998) found it to be negatively related to anxiety, meaning that social connectedness

can help decrease anxiety in young adults and increase self-esteem. This is also associated with lower levels of depression, as people who experience more feelings of social connectedness have more capacity to regulate their emotions (Lee & Robins, 1998). In this way, they can profit from situations that include social interaction because they have higher interpersonal trust than people who experience fewer feelings of social connectedness and can use their social surroundings as a resource (Lee & Robins, 1998). Contrastingly, lower social connectedness and social isolation are frequently associated with higher rates of depression and anxiety and can ultimately lead to drug abuse and even heart disease (Christiansen et al., 2021; Lee & Robins, 1998). Current research on social connectedness mainly focuses on older adults. Notwithstanding, the younger population was more affected by the consequences of the pandemic (Birditt et al., 2021). Therefore, it is essential to investigate the effectiveness of interventions aiming at increasing social connectedness in young adults to prevent negative consequences of feelings of isolation and low social connectedness.

Interestingly, people who perceive more social connectedness are more likely to seek out interactions and relationships that will confirm their feeling. In contrast, people who perceive less social connectedness are more likely to refrain from participating in social interactions which could eventually confirm their negative view of themselves (Lee & Robins, 1998). This is also supported by the findings of Holt-Lunstad (2017), who discovered that subjective feelings of social connectedness in an individual are a better indicator of (mental) health than an individual's objective quantity of social contacts. To put it simply, this means that instead of bringing people into a social setting to increase their social connectedness, social connectedness should be developed first to make people competent and comfortable enough to assert themselves in social situations. Hence, interventions targeting social connectedness without social interaction are essential because they allow individuals to take the first step in increasing social connectedness without the risk of confirming possible negative beliefs about themselves.

## **Storytelling**

Storytelling is one of the most common ways of connecting with others and relating our experiences to them (East et al., 2010). In its simplest and most generic form, storytelling can be described as “(...) *the act of communicating an event (or sequence of events) to an audience (...)*” (Anderson, 2010, p. 278). Scientific discourse about the exact definition of storytelling does not seem to come to an agreement; Purists claim that storytelling only includes oral communication, whereas more inclusive voices also stress that written stories are to be

considered, too (Anderson, 2010). Along with that, Gillian (2018) recognises that writing, in contrast to oral storytelling, is a form of communication that lets the storyteller tell the story without being interrupted. This allows people who might be socially inhibited to tell their story anyways, without possibly confirming their negative views about themselves. Alexandrakis et al. (2020) investigated different types of media that can be used for storytelling, like pen & paper and voice recording. One of the findings of this study was that writing down a story can decrease feelings of loneliness and activate a sense of community in the storyteller. Consequently, for this study, storytelling will be defined as the act of communicating past events in written form.

Storytelling can be used to build a cohesive narrative about events, other people and ourselves, helping us to acquire a better understanding of our experiences and ourselves (Pennebaker & Seagal, 1999). In relation to that, Lewis (2011) argues that we are drawn to all kinds of stories because they help us give meaning to our experiences. We may not be aware of it, but our cognition uses stories as our narratives in everyday life to relate to our experiences by building a narrative that determines how we see ourselves in relation to the world (Lewis, 2011). Lewis (2011) states that the relationship between narratives and humans is as symbiotic as the symbiosis between thoughts and words, which means that one cannot exist without the other.

According to Pennebaker and Seagal (1999), storytelling can have therapeutic effects and increase both physical and mental health. They state that by creating a story about life events, people can talk about both causes and implications of an event and related feelings, which enables them to organise the event and their feelings in a logical and meaningful way (Pennebaker & Seagal, 1999). From that follows that social connectedness is not only expressed in a feeling but also in our cognition because it is encoded in the narrative we create. As our emotions and cognitions continuously interact and influence each other (Dolcos et al., 2011), feelings of social connectedness could be increased by paying attention to cognitions that resemble this feeling and then giving meaning to it, just as it happens in storytelling. Based on these arguments, storytelling could play an essential role in promoting social connectedness. To assess this, the following research question has been identified:

*RQ: can writing down a personally meaningful story change social connectedness in young adults?*

## **Nature**

In general, nature can be understood as environments in which natural features such as plants and soil are occurring and have not been adjusted by humans. These environments stand in contrast to urban environments, which are characterised by the absence of such natural features and the presence of artificial materials such as concrete. Moreover, spending time in nature frequently is related to decreased mental health issues and increased social connectedness (Maas et al., 2009). To put this into perspective, living somewhere with one or more nature areas nearby is related to more feelings of social connectedness than living somewhere without access to nature. According to Weinstein et al. (2009), nature can help to make people feel connected, as it promotes community-centred goals instead of self-centred goals. Self-centred goals tend to be stimulated by urban environments more frequently. These findings are important because they indicate that social connectedness may not only be increased by social activity but also by time spent in nature. Thus, a need arises for alternative approaches to increase social connectedness. Nature exposure seems to be especially suitable because it does not require social contact and has not yet been a target for regulations, making it a viable option for future situations in which social contact might be regulated again.

The most frequently used framework to describe the psychological effects of nature is the Attention Restoration Theory (ART; Kaplan & Kaplan, 1989). The central claim of ART is that nature, especially nature we find fascinating, restores our cognitive capacities and increases wellbeing. Commonly, we spend a lot of directed attention in our everyday lives. Generally, directed attention is related to goal-directed tasks that require a lot of effort to focus on, and to the inhibition of emotions and impulses that interfere with this focus (Kaplan & Kaplan, 1989). One possible consequence of that is directed attention fatigue (DAF), which is the result of maintained directed attention over a longer period and results in distress, poor decision-making and decreased self-regulation (Varkovetski, 2015; Kaplan & Kaplan, 1989). On the contrary, effortless attention does not result in DAF since it is related to objects or tasks that we intrinsically perceive as interesting or fascinating. Fascinating surroundings which catch our interest can, therefore, restore our attention resulting in less distress and better self-regulation (Tennessen & Cimprich, 1995). These are good presuppositions for increasing social connectedness since distress is negatively correlated with social connectedness (Nitschke et al., 2020), and self-regulation has shown to be one of the factors able to increase social connectedness (Elbers & McCraty, 2020).

Considering the previously discussed ART, a need arises to explore distinct nature characteristics that could be responsible for the beneficial effects of nature on mental wellbeing. One of these characteristics that could influence our cognition is *mystery* because it keeps us

interested in and fascinated by the scene (Kaplan & Kaplan, 1989). Mystery is not a specific nature characteristic, but it can be understood as a characteristic of natural landscapes which are not fully visible but are partly concealed by objects such as trees and mountains, phenomena such as shadow or fog, or winded pathways whose determination is not visible (Kaplan & Kaplan, 1989). The general implication of such mysterious scenes is that there is more to discover as one enters further into it, leading to more involvement with our environment (Szolosi et al., 2014). A study by van Rompay and Jol (2016) on high school students demonstrated that mystery in nature is related to higher creative performance. This is in line with the framework proposed by Kaplan and Kaplan (1989), stating that the experience of mystery stimulates curiosity and fosters exploration, thus creating effortless attention.

Along with that, a study by Otten et al. (2022) compared the effects of different nature characteristics (mystery, compatibility, soft-fascination and spaciousness) on associations that might promote conversation, finding that mystery had more effects on personally engaging associations and positively valenced associations, while the other characteristics did not display any significant effects. In the study, hills were used as mysterious stimuli, leaving the question of whether other mysterious stimuli have similar effects (Otten et al., 2022). Followingly this study is interested in whether mysterious nature characteristics have comparable effects on social connectedness as they have on engaging and positively valenced associations (Otten et al., 2022). Thus, the following research question has been identified:

RQ: *Can mysterious nature change social connectedness in young adults?*

### **Virtual Representations of Nature**

Exposure to real nature, but also virtual nature, has been shown to increase social connectedness (van Houwelingen-Snippe et al., 2020a). Virtual nature can be understood as a digital representation of nature that does not exist in the real world. Nonetheless, a distinction must be made here between digital and virtual representations. An excellent example of interventions with digital, but not virtual nature can be seen in the study by van Rompay and Jol (2016), in which nature photographs were used as stimuli. Since photographs are real nature, they are not considered virtual because they do not represent something imaginary. Virtual nature is nature that has been created by humans on digital devices and which only exists in the digital world. Virtual nature has been shown to be one of the factors that are able to increase an individual's perceived feeling of social connectedness (van Houwelingen-Snippe et al., 2020a). A study by Browning et al. (2020) on the effects of virtual nature videos found

that it has positive effects on the mood of participants, supporting the claim that virtual nature can have the same beneficial effects as real nature.

The fact that virtual nature has comparable effects to real nature is of high importance as it creates the possibility to create an environment with the most beneficial natural characteristics for increasing wellbeing. In research, the role of environmental characteristics has been underacknowledged, which is reflected by the scarceness of scientific knowledge about specific nature characteristics that could trigger certain emotions and cognitions (Marselle et al., 2021). Consequently, research with virtual nature is a good way to get a deeper understanding of specific nature characteristics' effects because it allows researchers to manipulate and control the environment. Based on these assumptions, this study will use a virtual nature scene.

### **Immersion**

Immersing in the displayed nature scene is important for virtual nature. Immersion can be understood as the feeling of being in the place of a virtual presentation instead of just feeling like sitting in front of a monitor. In an immersive experience, one can really imagine himself in the displayed scene or event, like in video games. People who feel immersed in nature scenes often report a feeling that their real location has shifted to somewhere else (Vorderer et al., 2004). Thus, this study investigates the participants' level of immersion and controls for possible effects on mystery and storytelling.

### **Openness**

Openness to experience refers to an individual's motivation to try out new things, to be interested in abstract ideas and reflection, and to enjoyment of music, art, literature and nature (McRae & de Costa Jr., 1985). 5). Additionally, Yu et al. (2021) show that openness is related to more social integration and social acceptance among new residents in China, indicating that open people might adapt faster to their social environment. Interestingly, openness to experience is also expressed in the ability for self-alteration, as it happens for example in mystical nature experiences or artistic expression (McRae & Costa Jr., 1985). Openness further has been shown to be related to increased feelings of connectedness (Yaden et al. 2018). Based on that, this study controls for possible indirect effects of openness to experience on the effects of both virtual nature and storytelling on social connectedness.

### **Awe**



Awe can be understood as an experience in which people feel connected to their surroundings, in which the experience of time is altered, and in which one perceives something bigger than the self. This is interesting for this study because awe has been shown to be a factor that stimulates pro-social behaviour (Piff et al., 2015). A study by van Houwelingen-Snippe et al. (2020b) found that virtual nature can evoke feelings of awe in the observer. However, this was only confirmed for vast nature scenes, like the experience of Antarctica described by Powell et al. (2011). According to Powell et al. (2011), the experience of awe can lead to a reevaluation of one's feelings, making people more aware of their connection with nature and even help develop meaning in life. Hence, it will be investigated in this study whether the experience of awe affects the effect of mystery and storytelling on social connectedness.

### **Social Aspirations**

Social aspirations can be described as the intrinsic motivation of an individual to connect with their surroundings. In their study, van Houwelingen-Snippe et al. (2020b) found virtual nature to be a trigger for social aspirations. Young adults have been shown to be the age group which has more social aspirations than other age groups (Nicolaisen & Thorsen, 2017). They state that social aspirations have more impact on wellbeing than the number of social contacts in an individual, which aligns with the statement that perceived feelings of social connectedness are a better indicator of mental wellbeing in an individual than the amount of actual social contact (Holt-Lunstad, 2017). Social aspirations are therefore also assessed as covariates in the relationship between mysterious nature, storytelling and social connectedness.

### **Aim of this study**

This study aims to fill the gap in research on the effects of different nature characteristics and storytelling as a writing activity on social connectedness. As only minimal research is available on the effects of mystery in nature on social connectedness and wellbeing, this study can help broaden current research's attention on mystery and other nature characteristics. Furthermore, this research also sets a first step in drawing connections between nature and storytelling effects and personality characteristics like openness, and for the future, help to create interventions that are tailored to specific individual needs. This study aims to specifically target young adults because interventions that target the social connectedness of young adults are relatively scarce compared to older age groups. Therefore, to answer the RQs, the following hypotheses have been created to support the stated research questions:

H1 After watching a video containing virtual nature and engaging in a writing task, participants' social connectedness increases among all conditions.

H2 Participants who did a storytelling task show a higher increase in social connectedness than participants who did a neutral writing task.

H3 Participants who have been shown a mysterious virtual nature setting show a higher increase in social connectedness than participants who have been shown virtual nature with low mystery.

## **Methods**

### **Research-Design**

The design of this study was a 2 (mystery: low vs high) x 2 (writing task: storytelling vs neutral) between-subjects design with four conditions, two independent variables (nature type, writing task), and one dependent variable (social connectedness). There was one control condition, which included neither mysterious nature nor the storytelling task, but low mysterious nature and a neutral writing task (group 1). For the experimental conditions, the participants saw a virtual nature scene with low mystery and did the storytelling task (group 2) or saw the virtual nature scene with high mystery and did the neutral writing task (group 3) or saw the mysterious virtual nature scene and did the storytelling task (group 4). In all conditions, a 60-second video of virtual nature was presented; two of the groups saw the non-mysterious virtual nature, and two groups saw the mysterious virtual nature scene.

### **Participants & Ethical considerations**

The research was ethically assessed and approved under request number 220256 by the BMS (Behavioural, Management & Social Sciences) Ethical Review of the University of Twente. To assure statistical power, a sample size of 100 was desired. The participants (N = 107) were recruited via convenience sampling. They participated either in return for SONA-credit points or participation in a raffle for a 20 Euro voucher of a food delivery service. Inclusion criteria concerned age and proficiency in English, as the study was only available in English. People over 30 and under 18 could not participate because they do not represent the population of young adults. Since there was only an English version of the study, proficiency in English was necessary to give informed consent and do the questionnaire. After the screening in which no participant was excluded, the total sample size was N = 107. 66 participants were German, 15 were Dutch, 8 Romanian, 3 Polish and 15 were from other countries. (Australia,

Austria, China, Colombia, Cyprus, Egypt, Finland, France, Hong Kong, Ireland, Italy, Panama, Portugal, Russia, and South Africa, 1 each). 57 of all participants were male, 49 female and 1 indicated 'other' as gender, with ages ranging from 18-30 years old ( $M = 22.13$ ,  $SD = 2.245$ ). There was no significant difference in age found between the groups in a one-way ANOVA ( $F(3,103) = 2.164$ ,  $p = .097$ ), indicating that age was randomly distributed across the groups. A chi-square test indicated no significant differences of gender distribution across the groups ( $X^2(6, N = 107) = 4.01$ ,  $p = .793$ ). Table 1 represents the demographic information for each of the four groups.

**Table 1.**

*Demographics*

Variable	Group 1		Group2		Group 3		Group 4		Total	
	n	%	n	%	n	%	n	%	n	%
Gender										
male	12	38.71	14	50.00	10	50.00	13	46.43	49	45.79
female	19	61.29	13	46.43	10	50.00	15	53.57	57	53.27
other	0	0	1	3.57	0	0	0	0	1	0.93
Nationality										
German	22	70.97	17	60.71	11	55.00	16	57.14	66	61.68
Dutch	4	12.90	8	28.57	2	10.00	1	3.57	15	14.02
Other	5	16.13	3	10.71	7	35.00	11	39.29	26	24.30
	M	SD	M	SD	M	SD	M	SD	M	SD
Age in Years	22. 06	1.57	21. 64	2.28	21. 70	1.92	23	2.84	22. 13	2.25

**Stimuli**

To compare mysterious to non-mysterious nature, seven videos containing animated virtual nature were developed for each condition using Virtual Nature Healing Environment, a software developed at the University of Twente. The software allows users to create custom virtual nature environments in a 3D space. Different features such as plants, trees, benches and hills can be added, creating a possibility for a controlled environment. Before selecting two videos as the stimuli, pilot testing was done in which participants had to rank the 14 videos

relating to how mysterious they appeared to them. In total, ten people ranked all the videos, and the video with the highest mean rank was chosen for the high-mystery condition, whereas the video with the lowest mean rank was selected for the low-mystery condition. The video high in mystery contained mysterious features, namely hills, a winding pathway and groups of trees which concealed a part of the background, whereas the video low in mystery did not contain such features and displayed a flat, open setting with just a few trees and no winding pathway. To increase immersion in the scene, the same bird sounds were added to both videos. The duration of each video was 1 minute. Figures 1 and 2 show screenshots of both videos representing either mysterious or non-mysterious scenes.

**Figure 1.**

*Mysterious Virtual Nature Scene*



**Figure 2.**

*Non-mysterious Virtual Nature Scene*



To compare storytelling to neutral writing, two writing assignments were created which both required the participants to think about and report past events. In the experiment condition, participants had to write down a subjectively meaningful/important event in as much detail as possible. In the control condition, participants had to report exactly what and how much they had eaten the day before in as much detail as possible. Below are shown the exact wording of these writing assignments.

Storytelling:

*“Now, please try to remember an event that has been meaningful or important to you, it can be anything. Describe it in the text box below in as much detail as possible. For example, try to remember what happened, where it happened, who was with you, what you felt in that moment and why it is important to you. After 5 minutes you can go on to the next question but feel free to take your time.”*

Neutral:

*“Now, please try to remember what you ate during the whole day yesterday. Tell us about it in the text box below, be as detailed as possible about the ingredients. After 5 minutes you can go on to the next question but feel free to take your time.”*

Both conditions required the participants to actively think about past events in order to make both tasks as similarly cognitively engaging as possible, but the neutral writing task does not require the reader to integrate an experience into a coherent story/narrative. The storytelling

writing task requires the participant to actively reengage in creating a narrative about a situation that they considered meaningful. By this, the participants were reconstructing the event while simultaneously being made aware of why the specific situation/event was meaningful to them. The neutral writing task did not include such an evaluation of personal values but only reporting past behaviour, in this case, related to eating.

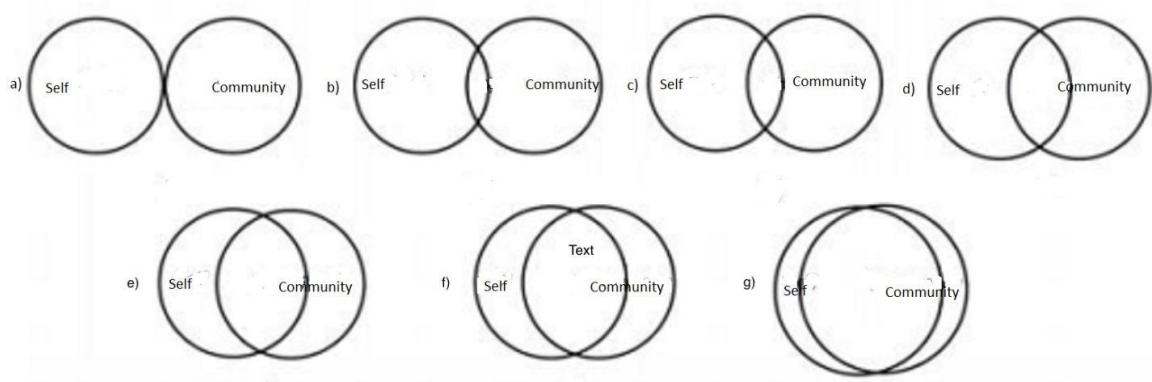
## Measures

### *Social Connectedness*

To assess the participants' social connectedness, they had to answer the Inclusion of Community in the Self Scale (ICS) (Mashek et al., 2007), a single-item measure with seven answer possibilities that uses a visual representation of the relationship between an individual and the community, as can be seen in figure 1. The item was used in the pre-and post-test, and a new variable indicating the amount of increase or decrease in the ICS score for each participant was created called *Md* (Mean difference) by subtracting the pre-test scores from the post-test scores to compare the possible increase of social connectedness in participants between the groups. Because the scale only consists of one item, it was not included in the factor analysis and no Cronbach's alpha was computed.

### Figure 3.

#### *Inclusion of Community in the Self Scale*



### *Immersion*

Immersion in the virtual nature scenes was measured using the four-item variant of the Spatial Presence: Self Location (SPSL) scale, which consists of four Likert statements with five answer possibilities, from 1 (strongly disagree) to 5 (strongly agree) (Vorderer et al., 2004). One example of such a statement would be ‘I feel like I was actually there in the environment of the presentation’. This scale was used in the post-test only. Factor analysis showed that the construct is valid, and no items had to be removed from the scale. Cronbach’s alpha of the items was .91, which is quite like the value of .92 found by Vorderer et al. (2004) and adequately consistent (Vorderer et al., 2004). For the analysis, the mean scores on this scale were computed into a new variable.

### *Openness*

Openness to Experience was measured using the Openness Scale from the Big-Five Inventory (John et al., 1991). The scale consists of 10 five-point Likert statements starting with ‘I consider myself as someone who ...’, with answers ranging from 1 (strongly disagree) to 5 (strongly agree). One example of these statements is ‘... has an active imagination’. This scale was used in the pre-test only since it measures individual predispositions. Two of the items were coded negative (‘prefers work that is routine’ and ‘has few artistic interests’). Factor analysis showed the items loading on three factors suggested deleting one of the reversed items; therefore, the item ‘... prefers work that is routine’ was not included in further analysis. After deleting the item, Cronbach's alpha of the items was .79 in our study, which is close to the .81 indicated by John et al. (1991) and therefore reliable enough (John et al., 1991). For the analysis, the mean scores on this scale were computed into a new variable.

### *Awe*

For measuring awe, 15 items of 3 subscales from the awe experience scale (AWE-S; Yaden et al., 2018) were used. The included subscales were connectedness, self-loss and vastness (Yaden et al., 2018). In total, the used scale consisted of 15 five-point Likert statements with answers ranging from 1 (strongly disagree) to 5 (strongly agree). One example of the connectedness items is ‘I felt a sense of communion with all living things’, from the self-loss subscale, one example is ‘I felt small compared to everything else’ and for the vastness scale one example is ‘I felt in the presence of greatness’. This scale was used in the post-test only. After the factor analysis that indicated adequate validity among all three subscales, no item was excluded. Cronbach's alpha for this scale was .9, which is close to the Cronbach’s alpha of .93 found by Yaden et al. (2018). According to them, a Cronbach’s alpha on this scale smaller than

.7 would show inadequate reliability, following from this, the scale showed adequate reliability in this study. For the analysis, the mean scores on the scale were computed into a new variable.

### ***Social aspirations***

For social aspirations, the social aspirations scale (van Houwelingen-Snippe et al., 2020) was used, consisting of 5 five-point Likert statements ranging from 1 (strongly disagree) to 5 (strongly agree). An example of these items is 'I would like to show this landscape to someone'. After factor analysis, no item was excluded. This scale was used in the post-test only. Cronbach's alpha for this scale was .631, which is lower than the alpha of .74 found by Houwelingen-Snippe et al. (2020). The reliability can be considered moderately adequate because it only consists of 5 items, and scales with a lower number of items tend to show a lower Cronbach's alpha than scales with more items. For the analysis, the mean scores on this scale were computed into a new variable.

### **Procedure**

Participants were collected through the SONA course-credit system and through convenience sampling by asking people on campus to participate in the study with a chance to win one of two vouchers for a food delivery service. There was no online option for this study, so participants had to attend the study on campus in one of the controlled experiment rooms. It was set up in the 'Flexperiment' rooms of the University of Twente, which are approximately six m<sup>2</sup> and have dimmable windows. The rooms only contained a chair, a desk and a computer with a mouse, keyboard and a 24" 1920x1080p monitor screen. The whole experiment was presented to the participants on the website qualtrics.com, an online survey tool that allows researchers to implement videos and randomise questionnaires.

Participants were randomly assigned to one nature scene and one writing task by qualtrics. After a brief introduction from the researchers, participants sat down in the experiment room with dimmed light and started filling out the Qualtrics survey using the computer. Firstly, participants were asked for informed consent before proceeding to the pre-test questionnaire, consisting of demographic questions regarding age, nationality and gender, the openness scale and the ICS. The next step of the experiment started with the nature scene and a short instruction on how to watch the following video, including both technical instructions on how to turn the video to full-screen and instructions on how to attend to the video:



*“In the following, we will present you a virtual nature video. Please, watch it completely and in full-screen mode. While watching, try to immerse yourself in the scene that you are seeing. Notice the different shades of green of the trees or the grass on the ground. Take in the different sensations you might perceive there, the smell of the air or the sound of the wind in the trees. Imagine that you are walking through the nature in front of you.”*

After clicking next, one of the two nature videos was randomly played. After finishing the video, participants indicated they watched the video to the end and in the following, were randomly introduced to either the neutral writing task or the storytelling writing task. The desired duration of the writing task was 5 minutes, but participants could take more time if they needed it or finish earlier if they were done. After they finished the writing task, the post-test was administered, which started with the Inclusion of Community in the Self Scale, like the pre-test. In the following questionnaire, participants filled out the Spatial Presence: Self Location Scale, the AWE-S (Awe Experience Scale), and the social aspirations scale. At the end, participants were thanked for participation and given the possibility to sign-up for the voucher raffle by giving their email address on a separate sheet of paper.

### **Data Analysis**

The data was analyzed using SPSS (Statistical Package for the Social Sciences), Version 28. First an initial screening of the data was done to exclude participants who either did not finish the study or were not in the age range from 18-30. To check for significant differences in age and gender distribution between the four experimental groups, a one-way ANOVA was run to check for differences in age and a chi-square test was used to determine possible differences in gender. Nature type and writing task were computed into two dummy variables, 0 indicating the control conditions for each (low mystery/neutral writing task), 1 indicating the experimental conditions (high mystery/ storytelling task). The reversed items of the openness scale (‘prefers work that is routine,’ ‘has few artistic interests’) and the social aspirations scale (‘if I would encounter someone here, I would feel uncomfortable’) were recorded before computing the means by subtracting their original score from 6. The mean scores of openness, awe, immersion and social aspirations were recoded into new variables, each variable indicating the mean scores of all participants for one of the prementioned scales.

To check for significant differences in the level of social connectedness (H1) before and after the intervention a paired samples t-test was executed. Followingly, an analysis of variance (ANOVA) with the *Md*-score of the ICS scale(s) as dependent variable, nature type and writing task as independent variables was run to test whether significant effects of writing

task and nature type occurred (H2, H3). To control for social aspirations, awe, immersion and openness as covariates, a similar ANOVA was run, this time with the mean scores of social aspirations, awe, immersion and openness included as covariates. For all analyses, the 95% confidence interval was used to differentiate between significant and insignificant differences ( $p < 0.05$ ), with a p-value below .05 indicating significant differences.

## Results

### Descriptive statistics

Table 2 displays the *Md*-scores of the ICS representing the change in social connectedness, and the means of the covariates.

**Table 2.**

*Means and standard deviations across the experimental conditions*

Variable	Low Mystery		High Mystery		Neutral Writing		Storytelling		Total	
	M	SD	M	SD	M	SD	M	SD	M	SD
Openness	4.13	0.54	4.11	0.63	4.22	0.56	4.04	0.59	4.12	0.58
Immersion	3.21	1.05	3.32	0.91	3.44	0.95	3.09	1.00	3.26	0.98
Social Aspiration	3.50	0.50	3.63	0.63	3.53	0.50	3.59	0.61	3.56	0.56
Awe	4.29	0.97	4.16	1.03	4.29	1.04	4.18	0.96	4.23	0.99
ICS- <i>Md</i> score	0.22	0.62	0.19	0.64	0.2	0.57	0.21	0.68	0.21	0.63

### Hypotheses Testing

#### *Social Connectedness Pre- vs Post-Test*

To check for significant differences in social connectedness in the whole sample, the results of the paired t-test which included the pre- and post-test scores on the ICS were used. Table 2 represents the mean scores and standard deviations of the pre- and post-test scores. Pretest scores ( $M = 4.13$ ,  $SD = 1.1$ ) were lower than the Posttest scores ( $M = 4.34$ ,  $SD = 1.132$ ).

A significant increase in social connectedness was found in the whole sample ( $t(106) = -3.4, p = <.001$ ), therefore hypothesis 1 can be confirmed.

### *Effects of Experimental Conditions on Social Connectedness*

To test hypotheses 2 and 3, the results of the ANOVA were used. Table 3 represents the sample size, *Md*-scores of the ICS and standard deviation for each of the four groups and the whole sample. There was no effect of writing task on the ICS *Md*-scores ( $F(1, 103) = 0.005, p = .944$ ). Therefore, hypothesis 2 must be rejected. There was no significant effect of nature type on the ICS *Md* scores ( $F(1, 103) = 0.048, p = .827$ ). Therefore, hypothesis 3 must be rejected. Furthermore, there was no interaction effect found between nature type and writing task ( $F(1, 103) = 0.875, p = .352$ ).

### **Covariates**

To check for covariates, the results of the second ANOVA which included openness, awe, immersion and social aspirations as covariates were used. When including the covariates in the ANOVA, effects of nature type ( $F(1, 103) = 0.605, p = .439$ ) were still insignificant. The effects of writing task ( $F(1,103) = .000, p = .999$ ) also remained insignificant. No significant interaction effect between nature type and writing task was observed when taking the covariates into account ( $F(1,103) = 0.66, p = .420$ ).

## **Discussion**

### **Main findings**

The purpose of this study was to explore whether exposure to mysterious nature and engaging in storytelling can increase feelings of social connectedness in young adults. The results show that social connectedness scores were significantly higher in the post-test than in the pre-test, which was hypothesized in H1. This means that participants, after watching one of the nature videos and engaging in either a storytelling- or neutral writing task, felt more socially connected. This adds to the findings of van Houwelingen-Snippe et al. (2020), who found similar effects of virtual nature alone on social connectedness without a writing task and demonstrated that even short exposures to virtual nature can significantly increase social connectedness. Contrasting the study of van Houwelingen-Snippe et al. (2020), the intervention of this study also included a writing task besides the virtual nature video, therefore it cannot be assured that the increase in social connectedness is an effect of the virtual nature video alone.

Nevertheless, this study assumes that the increase in social connectedness is mainly a result of the nature video because the effects of such videos on social connectedness have already been demonstrated and fit in with current research (van Houwelingen-Snippe et al., 2020a).

The research question: *Can writing down a personally meaningful story change social connectedness in young adults?* was answered in this study by comparing the ICS Md-scores of people in the storytelling condition with the scores of people in the neutral writing condition. Since no significant difference was found between the two conditions, hypothesis 2: *Participants who did the storytelling task show a higher increase in social connectedness than participants who did the neutral writing task* must also be rejected. This does not mean that storytelling is not a possible approach to increase social connectedness, but the storytelling-approach that was chosen in this study turned out to be inadequate. A possible reason for that might be explained by the findings of Pennebaker and Seagal (1999), which demonstrate that for storytelling to unfold its therapeutic effects, it must be done on a regular basis. In their study, participants engaged in storytelling regularly over the course of several days. This study used a one-time approach to storytelling, which might be inadequate to increase social connectedness in participants. A notable finding by Pennebaker and Seagal (1999) was that participants used more positive terms and were more engaged with the task showed higher increase in mental wellbeing than others. This means that storytelling may be effective when positive aspects of the story are considered more meaningful than the negative aspects. As this study did not emphasize engagement or positive associations with the story that was told, a storytelling approach which includes repeated engagement and emphasizes positive associations could be a better solution when trying to increase social connectedness.

The findings of this study also contradict the findings by Alexandrakis et al. (2020), who found that writing down personal stories can increase the sense of community in the writer. The study by Alexandrakis et al. (2020) used pen and paper as medium to write down the story, whereas our study used keyboard-writing on a computer. It might be that writing things down on paper instead of writing on a computer is a different experience for the storyteller. Additionally, Alexandrakis et al. (2020) investigated the effects of storytelling not on young adults but on older adults. Followingly, it may be possible that storytelling, especially in written form, has more effects on older adults than on young adults.

This paper also tried to answer the research question: *Can mysterious nature characteristics change social connectedness in young adults?* This study did not find the expected effect of mysterious nature characteristics on social connectedness (H3). Since no significant differences in the ICS Md-scores between both conditions have been found, the

hypothesis must be rejected. Despite mysterious nature characteristics being able to promote associations that might trigger conversation and increase creativity (Otten et al., 2022; van Rompay & Jol, 2016), the effect on the feeling of social connectedness could not be found in the current study. Research on the effects of mystery is still scarce (Marselle et al., 2021), and since mystery entails a wide variety of aspects in nature, there is still a lot of room for different manipulations which also can be considered mysterious. Despite the pilot test indicating that there was a huge difference in mystery between the two videos, it cannot be excluded that other manipulations of mystery might trigger more effects in the observer.

It seems that despite mysterious nature being beneficial for our creativity and for triggering associations that promote conversation (Otten et al., 2022; van Rompay & Jol, 2016), a direct effect of mysterious nature on social connectedness could not be observed. One explanation might be the notably different design that van Rompay and Jol (2016) used in their study. To start with, they used digital representations of nature, not virtual. Since digital nature is a more accurate representation of nature than virtual nature, real or digital nature might be a better stimulus to increase social connectedness. Additionally, participants were not alone while looking at the nature photographs and doing the creativity task, whereas in our study, participants were alone during the experiment. Nevertheless, van Rompay and Jol (2016) assessed creativity, not social connectedness; therefore, the beneficial effects of such mysterious nature settings do not apply to social connectedness in this study.

Controlling for openness, immersion, awe and social aspirations as covariates did not show any effects on the effects of mystery and storytelling on social connectedness. Despite openness being related to the enjoyment of nature and artistic expression (McRae & De Costa Jr., 1985), it does not seem to alter the effects of mysterious nature and storytelling on social connectedness in an individual. Immersion also could not be confirmed as a covariate. This means that even if immersion would have been the same among all conditions, the effects of mystery and storytelling would still be insignificant. Therefore, this study could not find the effects of mystery and storytelling on social connectedness, even if immersion was considered. Awe, which is related to increased capacity for reevaluation of one's feelings and relation to nature (Powell et al., 2011), could also not be confirmed as a covariate, as effects of mystery and storytelling still stayed insignificant while controlling for awe. Lastly, social aspirations also did not alter the effects of mystery and storytelling to the extent that their significance would change. Therefore, experiencing social aspirations did not influence the effect of mystery and storytelling on social aspirations, as their effect would still be insignificant if social aspirations were equal among all conditions.

## **Limitations & Strengths**

One limitation of this study was that the software with which the virtual nature scenes were created is still a work in progress software. This regards especially the possibilities of manipulating virtual nature, as there are limited possibilities to change the environment. First, there are two different main scenes in the software, one with hills and one without hills, which are not similar in appearance. So, it is impossible to create the same scene with and without hills; every scene with hills also has a different map than every scene without hills, making it hard to keep manipulations controlled. Therefore, the possibility that the manipulation of mystery was not as efficient as necessary cannot be excluded. Since no measure for perceived mystery was included in the experimental phase, it cannot be said whether participants in the high mystery condition experienced more mystery than participants in the low mystery condition, despite the pilot test indicating that the high mystery condition was more mysterious than the low mystery condition.

This study was also limited for storytelling because only a one-time approach was used instead of a longitudinal study that could explore the effects of maintaining a storytelling routine over a more extended period. Furthermore, questions regarding the experience of social aspirations and awe were tailored to the virtual nature setting alone. Therefore, this study could not assess whether storytelling can also trigger social aspirations and awe and therefore was limited to using them as covariates instead of independent variables. Regarding the wording of the storytelling task, it might also be possible that asking participants to write down a meaningful event without further specifications is not ideal for increasing social connectedness since negative events can also be considered meaningful. As Pennebaker and Seagal (1999) mentioned, for expressive writing, building a narrative about a negative experience often leads to negative feelings immediately after writing. For an experimental study with just one writing session, it might be beneficial to ask participants to report an event they perceived not only meaningful but also positive, or an event in which they felt connected to others.

One of the strengths of this study is that it took place under controlled conditions. Therefore, all participants experienced the virtual nature and the writing task under the same conditions. Compared to the study by Otten et al. (2022), which could only make use of an online survey due to Covid-restrictions, this study could assure that participants are provided with necessary hardware and will not be interrupted while filling out the questionnaire. Additionally, the sample of this study represented the target population adequately, and the groups did not differ statistically in age or gender. Nevertheless, most of the participants were

university students, therefore, the sample only represents the population of young adults with a high level of education. For future research, this might be beneficial, as it would be interesting to study the effects of storytelling and virtual nature not only among young adults in general but also on more specified sub-groups of this population, for example, people suffering from mental health issues, as their social connectedness is usually lower than in healthy people (Christiansen et al., 2021).

### **Recommendations for future research**

Even though a small amount of research is already available on virtual nature and different characteristics of nature, only little is known about the effects of specific manipulations in the virtual environment. Features like mystery might rely on the observers' personal preferences and perceptions. Future research should therefore try to keep manipulations as small as possible by taking two similar nature scenes and just changing one stimulus at a time, for example, by adding only a winding pathway to a nature scene without changing something else. If two nature scenes look too different, it might be possible that the intended manipulation of a particular characteristic like mystery is disturbed because of other characteristics, like the colour scheme of the scene. Therefore, it might also be beneficial to include a qualitative approach so that participants can share their experience of virtual nature with the researcher. Furthermore, little attention has been paid to auditory stimuli. In this study, the same bird sounds were used in both conditions. Future research could also use different sounds of nature as experimental conditions without changing the visual appearance of nature.

Furthermore, a longitudinal research design is recommended for future research, especially for testing the effects of storytelling on social connectedness and related measures. As Pennebaker and Seagal (1999) described, the effects of storytelling do not always occur instantly but require a storytelling routine. A longitudinal study also enables research to check whether the strength of effects of virtual nature and different nature characteristics changes if applied more frequently. When applied outside of research, knowing what amount of virtual nature exposure is most beneficial is essential. Furthermore, future research should also explore the isolated effects of storytelling on social connectedness. Setting up a study that does not include virtual nature but only storytelling makes it easier to manipulate the storytelling conditions and search for specific triggers that could make storytelling a viable approach to increase social connectedness.

### **Conclusion**

Watching a video containing a virtual nature scene and engaging in a writing task increases feelings of social connectedness in young adults. Therefore, it can be argued that virtual nature is a good alternative to real nature, making the application of virtual nature valuable, especially when real nature is not accessible. Mystery, however, did not influence the increase in social connectedness. Future research has yet to determine which nature characteristics are most suited to increase social connectedness among young adults. Writing down a personally meaningful story also showed no effect on the increase in social connectedness; therefore, future research is advised to explore how storytelling can be better utilised to increase social connectedness.



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## Appendix

### Appendix 1 - Pilot Test

Please rank the following videos from most mysterious to least mysterious, with 1 being the most and 14 the least mysterious.

*Results of the pilot test for the virtual nature video*

Nature Scene	Participant										Total
	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	
1	4	5	1	7	5	4	5	5	7	1	44
2	2	7	6	4	8	7	4	2	2	3	45
3*	1	1	3	5	1	2	1	1	4	2	21
4	3	6	5	13	6	6	2	4	3	7	55
5	5	4	2	2	7	3	3	3	1	8	38
6	7	8	8	1	3	5	9	8	9	6	64
7	6	2	4	9	4	1	7	7	6	4	50
8	11	3	7	3	2	10	6	6	8	5	61
9**	14	14	10	12	9	14	12	14	7	1	120
10	8	9	13	10	11	9	10	11	11	1	102
11	13	12	12	6	12	8	8	13	13	9	106
12	10	13	9	8	14	12	11	10	14	1	114
13	12	10	14	11	10	13	13	12	12	1	118
14	9	11	12	14	13	11	14	9	11	1	116

\* chosen high-mystery video

\*\* chosen low-mystery video

### Appendix 2 – Informed consent

**Welcome to our study about social connectedness, virtual nature and storytelling!**

We thank you for taking the time to participate in our study. Please note, during the study you will not be able to go back to questions, as the order in which you answer them is important.

Underneath you find the informed consent from.

Please do not hesitate to ask questions, should something be unclear.

### **Informed Consent:**

Please take your time to read the following information carefully before proceeding to the experiment. Note that you can at any time, and without any penalty, withdraw from the experiment.

#### Who can participate?

Everyone between 18-30 years is invited to take part in this experiment. Your English reading and writing skills should be sufficient in order to understand questions and answer them.

#### What will happen during the experiment?

The experiment consists of four parts, which will approximately take 30 minutes, depending on your pace.

1. You fill in a short questionnaire
2. You will watch an animated video of virtual nature
3. You will be asked to perform a writing task (ca. 5 minutes). We may ask you for personal experiences here. Please be aware that all data will be handled anonymously in the system, so we will only see what you wrote, not that it was you. All information like names or places that are mentioned in your writing task will be censored once the data collection is finished, so that an identification of the author from the given information will not be possible.
4. You will fill out a short questionnaire again.

We will not give you more detailed information now, because we do not want to bias your answers. If you are interested in our research, we will gladly debrief and explain it to you in detail after your participation.

#### What are the risks?

We do not expect any potential harming side-effects, but should something make you very uncomfortable, please do not hesitate to reach out to us.

#### What happens with the collected data?

As mentioned, all data will be kept anonymously and confidentially. No information that could lead to identification of someone will be shared. We will ask you for your email to participate in the voucher-affle, but this will be independent from the experiment and there is no possibility of relating your answers in the experiment to your email.

#### What do I get in return?

If you participated via the SONA-credit system, you will be granted 1 SONA-point.

Additionally, all participants will be given the chance to win a 20€ voucher of thuisbezord.nl, a food-delivery service founded and based in Enschede. The winners will be contacted personally via email after our data collection is finished.

By clicking to the next page you agree to the following:

I understand the terms and conditions of this study. I am aware that participation is voluntary and that I can withdraw from it anytime. Hereby, I agree to participate in the study:

### **Appendix 3 – Pre-Test (without ICS)**

#### Demographics

Item 1: How old are you?

Item 2: What is your gender?

Item 3: What is your nationality?

#### Openness

In the following, you will see some statements about yourself. Please indicate for each statement how much you agree with.

I consider myself as someone who...

Item 1: ... is original, comes up with new ideas

Item 2: ... is curious about many different things

Item 3: ... has few or no artistic interests

Item 4: ... is ingenious, a deep thinker

Item 5: ... has an active imagination

Item 6: ... is inventive

Item 7: ... values artistic, aesthetic experiences

Item 8: ... prefers work that is routine

Item 9: ... likes to reflect, play with ideas

Item 10: ... is sophisticated in art, music or literature

### **Appendix 4 – Post-Test (without ICS)**

#### Social Aspirations

Please, think back to the nature video you just saw. In the following, you will see some statements regarding how you feel in this moment. Please answer them by choosing the option that intuitively fits most for you.

Item 1: I would like to show this landscape to someone.

Item 2: I would like to meet here with a friend.



Item 3: I would like to have a spontaneous chat.

Item 4: This landscape is suitable to experience together.

Item 5: If I would encounter someone here, I would feel uncomfortable.

### Awe

Again, please answer with regards to how you feel right now after having watched the nature video. Please answer them by choosing the option that intuitively fits most for you.

Item 1: I felt that my sense of self was diminished.

Item 2: I felt my sense of self shrink.

Item 3: I experienced a reduced sense of self.

Item 4: I felt my sense of self become somehow smaller.

Item 5: I felt small compared to everything else.

Item 6: I had the sense of being connected to everything.

Item 7: I felt a sense of communion with all living things.

Item 8: I experienced a sense of oneness with all things.

Item 9: I felt closely connected to humanity.

Item 10: I had a sense of complete connectedness.

Item 11: I felt that I was in the presence of something grand.

Item 12: I experienced something greater than myself.

Item 13: I felt in the presence of greatness.

Item 14: I perceived something that was much larger than me.

Item 15: I perceived vastness.

### Immersion

For each item, please indicate how much agree or disagree with these statements regarding your experience watching the nature video.

Item 1: I felt like I was actually there in the environment of the presentation.

Item 2: It was as though my true location had shifted into the environment of the presentation.

Item 3: I felt as though I was physically present in the environment of the presentation.

Item 4: It seemed as though I actually took part in the environment of the presentation.