“The Image Should be Based on the Story, the Story not on the Image” - Moderating the Use of Generative AI for the Promotion of Meaning-Making

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Abstract

Meaning derived from a past nature experience can benefit well-being, possibly due to feelings of connectedness to nature. Digital nature can be used to make people feel connected to nature and openness to experience might influence the meaning made using this tool. Young adults seem to be the most proliferate meaning-makers, as it would improve their mental well-being. In this research, the aim was to investigate the use of generative artificial intelligence (AI) for meaning-making. 48 young adults retrieved a meaningful nature experience in one of two storytelling conditions, either with or without personalized AI images. Interactions of state connectedness to nature and openness to experience were assessed. Against the expectations, it was found that digital nature images did not affect meaning-making or connectedness to nature. Surprisingly, results even suggest that state connectedness to nature might decrease as a consequence of AI nature images. Openness to experience had no influence on these processes. To conclude, AI might lack a part of lived human experience, making it less suitable for reviving meaningful nature experiences. Perhaps, the use of digital nature is limited to emergency situations, such as the pandemic lockdown.

Keywords: meaning-making, past nature experience, AI, storytelling, connectedness to nature, openness to experience

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Young adults need meaning-making. As Viktor Frankl wrote in his book *Search for meaning* (1984): “searching for meaning, and trying to make sense of life, is an important developmental task for young people” (p. 1). Indeed, having a sense of meaning in life is important for both mental health (Chen et al., 2022; Graci & Fivush, 2016; Halama & Dědová, 2007) and well-being (Howell et al., 2013; Tavernier & Willoughby, 2012). This might be especially important for young adults, as the recent COVID-19 pandemic greatly impacted their mental well-being (Kauhanen et al., 2022; Liang et al., 2020; Luthra et al., 2023). To engage in the narrating activity of autobiographical meaning-making, one uses cognitive capabilities, for example to create thematic coherence, that develop during adolescence (Habermas & Bluck, 2000). It has been found that people in early adulthood search for more meaning than later in life (Alea & Bluck, 2013; Işık & Üzbe, 2015), and this can have personal and social benefits for them, such as higher self-esteem or lower social anxiety (Tavernier & Willoughby, 2012).

Meaning derived from nature experiences can benefit well-being. Meaning can be derived from life events or life stories, which are inextricably linked to their respective place and setting (Pollio et al., 2003, see also Camia & Zafar, 2021). Notably, place has been proposed to play a central role in the meaning-making process (Hawkins, 2014), and one type of place or setting could be nature environments. Experiences with nature can contribute to a multitude of benefits for well-being (Keniger et al., 2013), and people who feel connected to nature are likely to be happier and more satisfied with life (Capaldi et al., 2014), as well as have higher levels of psychological well-being and meaning in life (Guo et al., 2023; Pritchard et al., 2020). Meaning has even been identified as the link explaining the positive effects of connectedness to nature on well-being (Aruta, 2021; Guo et al., 2023; Howell et al., 2013). The positive effects of nature are also important for the mental well-being of adolescents (Rowley et al., 2022; Tillmann et al., 2018).

Digital nature can be used for meaning-making from nature experiences. With lockdowns due to COVID-19 as a recent example, there are instances when nature might not be accessible. In such situations, digital nature has the potential to provide a nature experience that can make one feel connected to nature and contribute to (social) well-being (Chan et al., 2021; Yeo et al., 2020; van Houwelingen-Snippe et al., 2020). Nature images have been found to be able to counter social withdrawal behaviour in adolescents, compared to images of urban environments (Chen et al., 2023). Next to this, virtual environments can positively influence meaning in life (Rivera et al., 2020) and provide meaning-making processes (Georgieva & Georgiev, 2022; Silseth et al., 2024).

Therefore, in this research it will be tested whether digital nature images can be used to improve meaning-making from reminiscing a past nature experience for young adults. This group will be especially well-suited for this research, as they are able to create narratives or life-stories and seem to be the most proliferate meaning-makers.

What is meaning-making

Meaning makes sense of life. Meaning in life could be seen as the common thread running through one's life, stringing events, experiences, and social relations together (Baumeister, 1991). It forms a mental web that represents the connection between the self and the external throughout the past, present and coming future (Baumeister, 1991; Baumeister et al., 2013). By creating narratives, humans can make sense of themselves, their lives, and their relationship with others, thereby forming their mental web (Bernard et al., 2015; McLean et al., 2007; Shamir & Eilam, 2005). The spinning and drawing of the thread of the web, is what would be the process of meaning-making (Bernard et al., 2015; Bendassolli, 2017; van de Goor et al., 2020).

Meaning-making is essential in life. Trying to find meaning is a central element of human existence (Baumeister et al., 2013; Chen et al., 2022; Frankl, 1984). It has been posited that people "must find a meaning to their lives in order to function" (Frankl, 1990, p. 592), and that finding meaning is the hardest but most satisfying objective in life (Bettelheim, 1991). Meaning-making is a dynamic (Waters et al., 2013) and multifaceted activity (Bonanno, 2013), happening all our lives (Kegan, 1982). It has an explorative quality (Glavan et al., 2019), and becomes apparent in the way people express themselves (Baumeister et al., 2013). A sense of personal authority is present, as an individual deliberately looks back on and interprets events in life (Frankl, 1984). The mental web created, is then used to navigate one's future actions (Alea & Bluck, 2013; Bluck, 2003; Bluck & Liao, 2013), to create concepts of the self (McLean et al., 2007; Shamir & Eilam, 2005), and to make sense of the events in one's life (Bernard et al., 2015).

This notion of meaning-making could fit with the three function model of autobiographical memory described by Bluck et al. (2005), in which autobiographical memories serve a directive (making sense of the past to direct the future), a self (identity and life reflection), and a social (initiating and maintaining relationships) function. According to Olivares (2010), these three functions together create a coherent whole that provides meaning-ness.

Health effects of meaning-making

Meaning-making can be important for one's health. Meaning has been found to predict self-esteem and life satisfaction (Halama & Dědová, 2007, see also Liao et al., 2017), can be of aid in the processing of traumatic experience (Delgado et al., 2023; Fitzke et al., 2021; Li et al., 2015), and it has been associated with having less symptoms of depression (Mascaro & Rosen, 2005). On the other hand, a lack of meaning or failing to find it may lead to impaired mental health (Bendassolli, 2024; Steger et al., 2008), while having negatively tainted life stories has actually been related to depression (Thomsen et al, 2016). At the same time, stressful events can also lead to a search for meaning (Park, 2010). Autobiographical meaning-making may reduce psychological distress (Camia & Zafar, 2021), and it has been found that meaning-making might be more successful in times of stress than when stress is absent (Chu & Fung, 2020). Whether meaning-making actually has effects may depend on the fact whether meaning was made (Lachnit et al., 2020), and both the strength and quantity of meanings play a role (Park, 2010). For youngsters getting into early adulthood, meaning-making seems to be mainly beneficial for their psychological well-being (Tavernier & Willoughby, 2012).

Nature's effect on meaning

Experiences with nature can have significant effects on people's life. A study from Mathers and Brymer (2022) investigated the effects of profound experiences with nature and found that they can have deep and enduring influences on a person. A single significant experience with nature could change the way people view themselves and how they relate to others and to nature. Such experiences could instigate meaningful changes in one's life that can affect both one's life choices and behaviour (Mathers & Brymer, 2022). Indeed, experiences with nature can contribute to a multitude of benefits for well-being (Keniger et al., 2013), for example in promoting social tendencies (Zhang et al., 2014), encouraging pro-environmental behaviours (Guo et al., 2023; Rosa & Collado, 2019), and nature interactions might even have a preventive effect on psychosomatic problems among adolescents, such as depressive symptoms and difficulties with sleeping (Piccininni et al., 2018). Moreover, watching or being in nature has been found to help reflecting on obstacles in one's life (Mayer et al., 2008).

Feeling connected to nature positively affects meaning-making and subsequent well-being. The beneficial effects of a nature experience are due to increased feelings of connectedness to nature (Aruta, 2021; Guo et al., 2023; Howell et al., 2013). Connectedness to nature has been associated with happiness and life satisfaction (Capaldi et al., 2014), as well as with psychological well-being and meaning in life (Guo et al., 2023; Pritchard et al., 2020). A recent study found that poor access to nature can lead to loneliness (van Houwelingen-Snippe et al., 2020), and losing connectedness with nature has effects on meaning-making processes on an individual as well as societal level (Beery et al., 2023). Perhaps, this link between meaning-making, connectedness to nature, and well-being relates to biophilia (Wilson, 1984) and the biophilia hypothesis (Kellert & Wilson, 1993), which states that humans are naturally drawn to nature. It highlights an innate connection with nature, a meaningful human drive, which might make people feel happier and healthier (Kellert & Wilson, 1993).

Relevance of digital nature

Digital nature can have similar effects as actual nature. A recent systematic review found that the majority of studies investigating the psycho- and physiological effects of virtual nature indicated a positive effect of virtual nature on its users (Spano et al., 2023). It can improve well-being (Reese et al., 2022), foster calmness (Noronha & Campos, 2021), reduce or aid recovering from stress (Ch et al., 2023; Martínez Manchón & Šimunić, 2023; Syed Abdullah, 2021), counteract the impact from significant events (Nigg et al., 2023), and can benefit affect (Kaplan Mintz et al., 2021). Moreover, it can also enhance connectedness to nature (Brambilla et al., 2022; Chan et al., 2021).

Therefore, when access to nature is taken away, digital nature can be a valuable option. Even though real nature has stronger effects on affect and well-being than digital nature (Browning et al., 2020; Lee et al., 2022; Mayer et al., 2008), digital nature can be an effective alternative for actual nature experiences, when this is not possible anymore (Syed Abdullah, 2021). Digital nature has been useful for periods in isolation during COVID-19 (Browning et al., 2020; Kaplan Mintz et al., 2019), and for elderly people (van Houwelingen-Snippe et al., 2022, 2023). It has been found to be better than no nature exposure at all (Browning et al., 2020), and can have positive effects with only a few minutes of exposure (van Houwelingen-Snippe et al., 2020, 2023; Noronha & Campos, 2021).

Openness

Openness to experience might influence the process of meaning-making when using digital nature. The beneficial effects meaning can have is subject to personal variation (Graci & Fivush, 2016). It has been found that different people search and find meaning in different ways, depending on their personality traits. (Lavigne et al., 2013; Schnell & Becker, 2006). Openness to experience has been linked to meaning in life (Tan et al., 2021), both to presence of meaning (Chu & Fung, 2020; Işık & Üzbe, 2015) and search for meaning (Işık & Üzbe, 2015; Steger et al., 2008). Openness or Openness to Experience, also sometimes called Intellect, is a domain of personality (Costa & McCrae, 1976; Tellegen & Atkinson, 1974), represented in the Five-Factor Model (Digman, 1990), Big Five Model (McCrae, 1994), and HEXACO personality inventory (Ashton & Lee, 2007). People who score high on openness to experience are open to new and different experiences, for which they are motivated to actively search (McCrae & Costa, 1997), and they possess a more flexible consciousness that can lead them to "deeper and more intense experience" (McCrae & Costa, 1997, p. 839). Those people can have a strong imagination, are sensitive to beauty from nature or art, and their emotional palette is diverse and bears importance to them (Costa & McCrea, 1992, see also Silvia et al., 2015). Lavigne and colleagues (2013) found that the way these people make meaning happens through learning experiences and through creative and unusual ways, while Forgeard and colleagues (2022) found that openness is stable in times of stress. Moreover, openness might influence the ability to learn from visual sources (Thompson et al., 2009) and therefore, this character trait might influence meaning-making from an unusual technique such as digital nature.

The present study

In the present study, the roles of openness to experience and connectedness to nature in the process of meaning-making from a significant nature experience will be investigated, when digital nature is implemented in this process. This leads to the following research question:

- *What is the effect of personalized AI nature images on meaning-making from a past nature experience and to what extent do state connectedness to nature and openness to experience play a role in this process, in a population of young adults?*

Four hypotheses were formulated to answer this question.

- Hypothesis 1 (H1): Watching (compared to not watching) personalized AI-nature during storytelling leads to significantly higher levels of meaning-making.
- Hypothesis 2 (H2): Watching (compared to not watching) personalized AI-nature leads to significantly higher levels of meaning-making, because of an increase in state connectedness to nature.
- Hypothesis 3 (H3): Watching personalized AI-nature images leads to significantly higher levels of meaning-making, for those scoring high (compared to low) on openness to experience.
- Hypothesis 4 (H4): Higher levels of state connectedness to nature lead to significantly higher levels of meaning-making, for those scoring high (compared to low) on openness to experience.

Methods

Research design

This study consisted of two parts: an online writing part with an additional measure for openness, and an in-person interview part with a measure for state connectedness to nature. Where the writing part of the study was the same for all participants, the interview session had two scenarios, to examine the effect of the independent variable ‘storytelling condition’ with or without AI images on the dependent variable ‘meaning-making’.

In the experimental scenario, the participants were presented with their nature images before storytelling, which they did with the preferred image displayed on a screen in front of them. Next, these participants filled out a questionnaire regarding their state nature connectedness. The control scenario had a different sequence of order. In that case, the participants were first asked to talk about their nature experience, then they filled out the questionnaire about state nature connectedness, and after this they were presented with their images. They were given a moment to watch their chosen image, so both groups had similar exposure to the images.

Participants

Eligible participants were young adults in the age of 18 to 30 years, who were required to have internet access. No participants were excluded because they fell outside the age criterion. Four participants were deleted, as they did not partake in the second part of the study. Consequently, the final sample comprised of 48 participants, with 32 identifying as female (67%), 15 as male (31%), and 1 person preferred not to say (2%). The age range of the participants was between 20 and 30 years (M = 22.6, SD = 2.04). 63% of the participants were German, 19% were Dutch, and 19% came from another country, such as Austria or Spain. Participants were reached by convenience and snowball sampling. In addition, students from the BMS faculty of the University of Twente could sign up through the university’s SONA website. These participants were rewarded with SONA points, a prerequisite for their graduation. In the final sample, 26 participants (54%) were in the experimental condition, and 22 participants (46%) were in the control condition.

Materials

AI image generation

The Artificial Intelligence program Leonardo.Ai (https://leonardo.ai/) was used in this study to generate customized nature scenery. This easy-to-use AI generator from Australian descent is especially well-suited for creative content generation, like artwork or images, on the basis of text (a prompt). It gives users a high level of control with, for example, 'prompt adherence', a parameter that can be used to set the level of image matching the prompt. Other options are 'model fine-tuning' for content creation in specific styles, an 'image prompt' to let it adapt to a certain layout or composition, and the ability to provide 'negative prompts' to instruct which features should not be included in the image. After generation, the output images can be refined via an option called 'canvas', for even further controlled adjustments. Leonardo.Ai is also capable of creating realistic looking persons and nature scenes.

The creation of the images went as follows. For all images, the fine-tuned model Stable Diffusion 2.1 was used. The first image was created using a prompt consisting only of the title that participants provided and a general description of the environment. The prompt was finished using the words 'Photorealistic, high rendering, panoramic shot' to improve the quality and realisticness of the generated images. 'Prompt magic' was enabled, 'high contract' turned on, and the 'prompt strength' set at 0.4. The second image was created with the same prompt and settings, but with the addition of an image prompt ('image guidance'), in case a reference picture was provided by the participants. The 'strenght' of the image guidance was set at a value of 0.5. When no image was available, an image under the same settings as image 1 was created again. With the third variation, 'prompt strength' was increased to 0.55, giving the prompt more weight. Here also, a reference picture was used when available. The last image had a slightly different prompt. The title and description were kept the same, but striking details provided by the participant were added. ‘Prompt strength’ was at 0.55 and ‘image guidance’ was used when possible. The four generated images were saved on a computer.

Meaning-making

Meaning-making was identified using the coding system of McLean and Pratt (2004). Their system can be used to identify meaning-making in stories or narratives, by using a four-category (0-3) scale. Code 0 (no meaning) is when the narrator remains at describing an event, often in terms of actions, but does not touch upon any significance it has for them. Code 1 (lessons) pertains to situations where a specific rule is learned. One has learned that a certain action can have a certain consequence. The lesson learned should be clearly stated. No elaboration is made towards other areas of one’s life. Code 2 (vague meaning) is when the narrator acknowledges that they have undergone change or growth following an event but in telling this, does not go beyond abstract terms. It might be that the person is still in the process of growth or change. Also, one might feel an affiliation with an event without knowing what it is exactly, that gives them this connected feeling. Lastly, Code 3 (insight) is when one discovers something about oneself that reaches beyond the circumstances of a particular event. Often, one recognizes a transformation that impacts their surroundings and as well as their future. Insight can be recognized by clear cut and persuasive language. According to this framework, insight is the most complex form of meaning-making (McLean & Pratt, 2004). After discussing, interrater agreement between three independent raters was achieved ($W = .90$, $p = .02$).

Openness to Experience

The Big Five Inventory (BFI; John et al., 1991; see also John et al., 2008) was developed for assessment of the personality traits of the Big Five. In this study, the 10 items that measure the dimension openness to experience (see Appendix B) were used. Statements regarding the self “I am someone who…” should be answered on a 5-point Likert scale, ranging from disagree strongly to agree strongly. Example statements following the prompt "I am someone who…", are "is inventive", "is curious about many different things", and "has few artistic interests". This dimension of the BFI has been found to be reliable in actually measuring this broad personality trait (John et al., 1991), which it can do in different cultures (Benet-Martínez & John, 1998). Cronbach's alpha of the current sample was .569, indicating poor reliability. This is a limitation that will be discussed later.

Connectedness to nature

The state version of the Connectedness to Nature Scale (CNS; Frantz et al., 2005) was used to assess participants' feelings of connectedness to nature after they had viewed nature AI-images. Consisting of 13 items, the state-CNS (see Appendix C) is a reworded version of the original CNS (Mayer & Frantz, 2004), with one item dropped because of incompatibility with rephrasing to the present. The scale is answered on a Likert scale, ranging from 1 (strongly disagree) to 7 (strongly agree). Example statements of this version of the state-CNS are "Right now I am feeling a sense of oneness with the natural world around me" and "Presently I feel like I am part of the web of life". The two measures have been found to correspond with each other well, and both have been found to have good internal consistency, with very high and high reliability rates in student samples, respectively (Mayer & Frantz, 2004, 2008; Frantz et al., 2005). Cronbach's alpha of the current sample was .891, indicating good reliability.

Procedure

This study's procedure consisted of two parts. For the first part of the study, participants received a link that led them to an online survey in Qualtrics XM (https://www.qualtrics.com/), a free-to-use software that allows for the creation and administration of surveys and can generate reports of the gathered data. Here, the participants were welcomed and informed about the general setup of the study. They were asked to provide informed consent (see Appendix A) and answered a few demographic questions. Next, they filled out two questionnaires regarding openness to experience. Then the participants were asked to remember a meaningful nature experience they have had, that they were willing to share for the purpose of this study. They had to describe this event or experience, think of a title for it, and indicate what stood out most to them, that is, what details they remembered most vividly. This survey could be completed by the participants on their own and took approximately 15 minutes.

An appointment was made for the second part of the study, which entailed an in-person session. The elements – viewing nature images, storytelling, and questionnaire – in this session were present for all participants, although the order of the elements differed for the two conditions, as described above. The participants were presented with four AI-generated nature images on a computer. They were asked to look at the images and choose the one that best matched their experience, in terms of content of the nature scene or capturing the emotional valence of the moment. Every participant was also invited to tell their meaningful nature experience. During this storytelling, the research could ask semi-structured questions, so that for every participant a sufficient level of personal experience was obtained. Also, participants filled in a questionnaire regarding state connectedness to nature. Finally, the participants were thanked for their participation and any remaining questions they had were answered. The second part of the study lasted for approximately 20 minutes.

Data analysis

Two datasets for part one and part two of the study were loaded into RStudio. After merging the two sets, one dataset was formed which contained and connected the information from part one and part two for each participant. Four participants with missing data from the second part were deleted from the dataset.

First of all, the inclusion and exclusion criteria were checked. Next, statistics describing demographic information such as age (mean and SD), sex (*n* and percentage) and nationality (*n* and percentage) were acquired to get an overview of the sample, as well as Cronbach's alpha to assess the internal consistency of the questionnaires. After this, the analyses for the research question and hypotheses were conducted. A Chi-squared test of independence was used to test whether the independent variable of storytelling condition had a significant influence on the dependent variable of meaning-making (H1). A Wilcoxon Rank Sum test and Chi-squared test were conducted to assess the direct effects of storytelling condition on state connectedness to nature, and state connectedness to nature on meaning-making, respectively. Subsequently, a mediatory effect of state nature connectedness on meaning-making was assessed with a Cochran-Mantel-Haenszel test (H2). The same test was also used to investigate the role of openness in the effects between AI and meaning-making (H3) and between connectedness to nature and meaning-making (H4). Finally, an Ordinal Logistic Regression analysis was conducted including all variables, to get a concluding overview of the effects. The script for RStudio can be found in Appendix D.

Results

In Table 1, the results of meaning-making per storytelling condition are shown. With 18 times, vague meaning was most often reached by participants (37.5%), followed by 13 participants reaching lesson (27.1%). 9 participants got to insight (18.8%), while 8 participants achieved no meaning in their story (16.7%).

Table 1

Frequency of Meaning-making for the Two Storytelling Conditions

Storytelling condition	Meaning-Making				Total
	Low		High		
	No meaning	Lesson	Vague meaning	Insight	
With AI image	4 (15.4%)	7 (26.9%)	10 (38.5%)	5 (19.2%)	26 (100%)
Without AI image	4 (18.2%)	6 (27.3%)	8 (36.3%)	4 (18.2%)	22 (100%)
Total	8 (16.7%)	13 (27.1%)	18 (37.5%)	9 (18.8%)	48 (100%)

Note. The percentage for each level of meaning-making per condition is shown in brackets. The ordinal variable meaning-making was converted into a binary variable (high, low) using a median split.

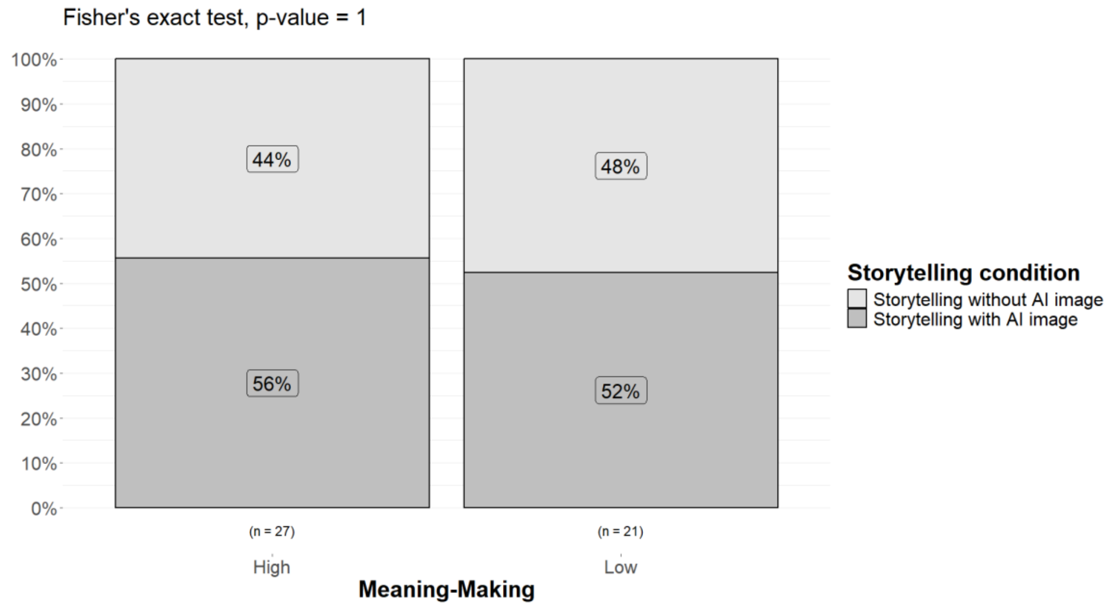
H1: *Watching (compared to not watching) personalized AI-nature during storytelling leads to significantly higher levels of meaning-making.*

To test H1, a Chi-squared test was planned. As the parametric assumption for a Chi-square test was violated by having less than 5 expected observations per cell count, a binary variable was created for meaning-making. After splitting meaning-making into high (insight, vague meaning; $n = 27$) and low (lesson, no meaning; $n = 21$), this ‘expected values’ assumption was met. A Chi-squared test of independence was conducted to assess a relationship of the created 2 (storytelling condition: with or without AI image) X 2 (meaning-making: low or high) design.

Results show that being presented with an AI-image led to more meaning-making, see Figure 1. The Chi-squared test showed that this difference was not significant ($\chi^2 = 0$, $df = 1$, $p = 1$). Therefore, the null-hypothesis that there is no association between storytelling condition and meaning-making, cannot be rejected.

Figure 1

Division of High and Low Meaning-Making per Storytelling Condition



H2: *Watching (compared to not watching) personalized AI-nature leads to significantly higher levels of meaning-making, because of an increase in state connectedness to nature.*

To test H2, a compound score for state connectedness to nature (state-CN) was created and checked for normality. It was found to be significantly different from a normal distribution (W = .95, p = .049). Therefore, a non-parametric test was used, to compare the means of state-CN for the two storytelling conditions.

Before testing H2, a preparatory comparison shows that state-CN was higher for the 'Storytelling with AI' condition than for the 'Storytelling without AI' condition, see Figure 2. However, a Wilcoxon Rank Sum test showed that this difference was not significant (p = .16).

Figure 2

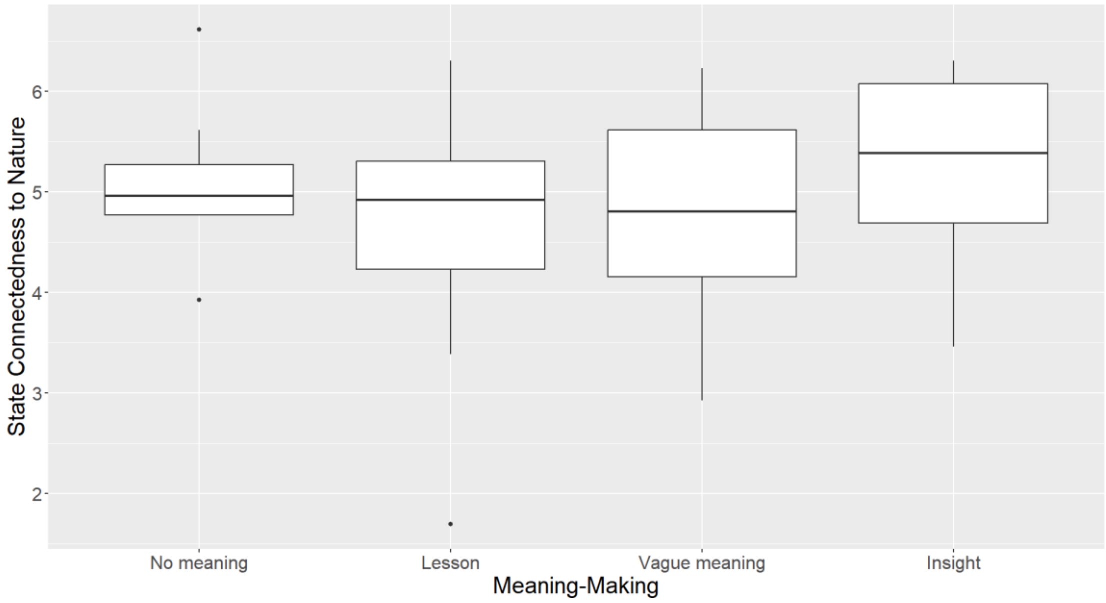
Differences in the Scores of State Connectedness to Nature for Each Storytelling Condition

Still in preparation for H2, a comparison of state-CN with the ordinal variable meaning-making shows that state-CN was slightly higher for higher levels of meaning-making, see Figure 3. However, the dependent variable meaning-making was ordinal, so a categorical variable for state-CN was required in order to conduct analyses. Therefore, a median-split was performed to divide state-CN into two groups, high (n = 23) and low (n = 25). The 'expected values' assumption of the Chi-square test was violated for state-CN in combination with the ordinal variable meaning-making but was met with the binary variable meaning-making.

Comparing then state-CN with the binary variable meaning-making, the results of a Chi-squared test ($\chi^2 = 0$, $df = 1$, $p = 1$) did not indicate a significant relationship between state-CN and meaning-making.

Figure 3

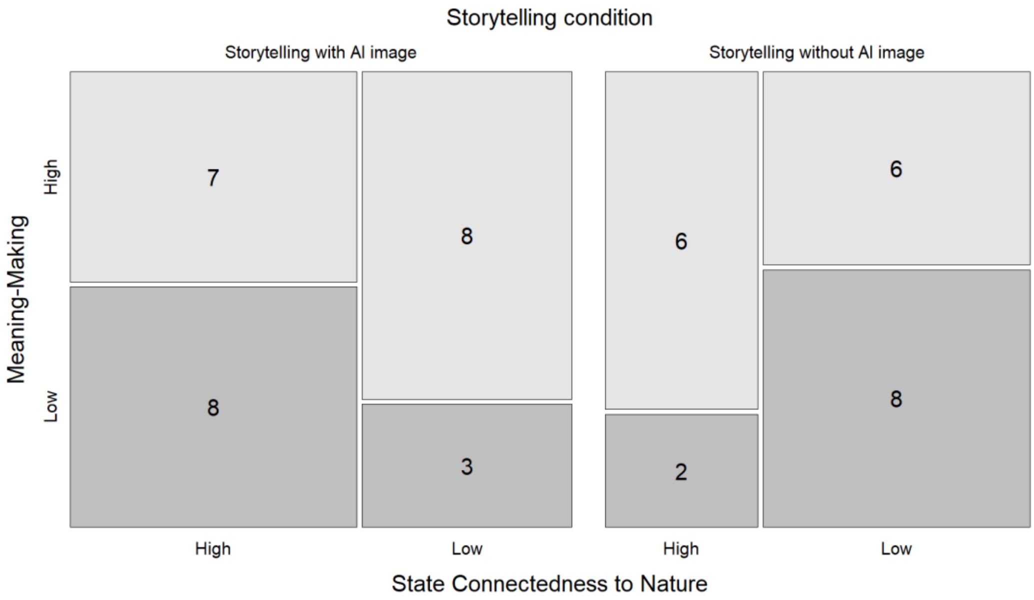
Differences in the Scores of State Connectedness to Nature for Each Level of Meaning-Making



To test H2, results show that high state-CN led to more higher-level meaning-making in the 'storytelling without AI' condition than in the 'storytelling with AI' condition, see Figure 4. A Cochran-Mantel-Haenszel Chi-squared test showed that this difference was not significant ($\chi^2 = 3.71$, $df = 1$, $p = .054$). Therefore, the null hypothesis that the association between state connectedness to nature and meaning-making is the same across the two levels of storytelling condition, cannot be rejected.

Figure 4

Meaning-Making per Level of State Connectedness to Nature for the Two Storytelling Conditions



Note. Division based on *N* for each category, as represented by the numbers. The size of the boxes is relative to *N*.

H3: *Watching personalized AI-nature images leads to significantly higher levels of meaning-making, for those scoring high (compared to low) on openness to experience.*

Results show that storytelling while watching an AI image led to more higher-level meaning-making for low openness than for high openness, see Figure 5. A Woolf test showed that this difference was not significant ($\chi^2 = 0.23$, $df = 1$, $p = .63$). Therefore, the null hypothesis that the association between storytelling condition and meaning-making is the same across the two levels of openness to experience, cannot be rejected.

Figure 5

Meaning-Making per Storytelling Condition for Scoring Low and High on Openness to Experience

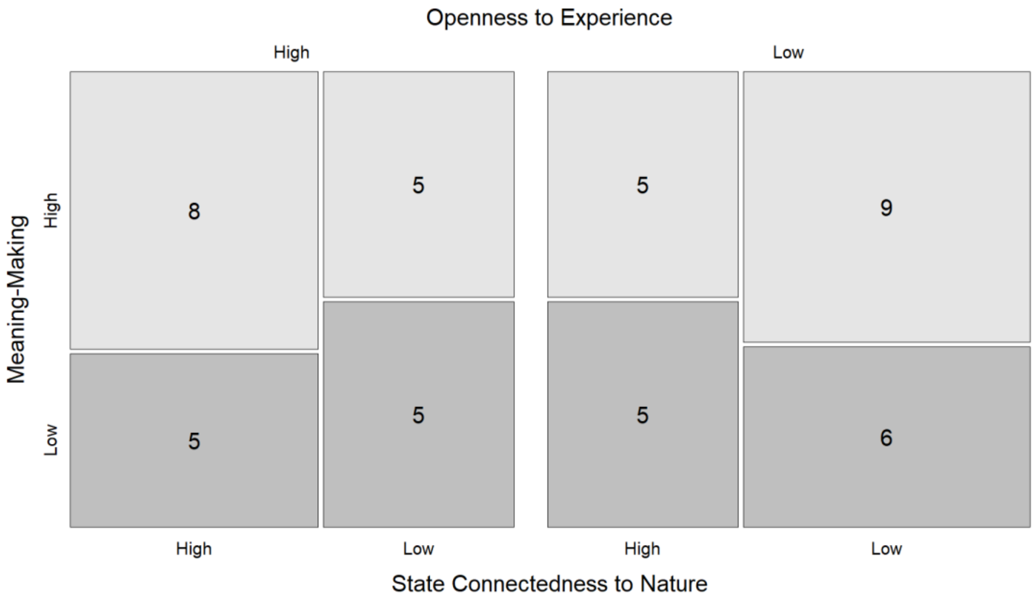
Note. Division based on *N* for each category, as represented by the numbers. The size of the boxes is relative to *N*.

H4: *Higher levels of state connectedness to nature lead to significantly higher levels of meaning-making, for those scoring high (compared to low) on openness to experience.*

Results show that high state-CN led to more higher-level meaning-making for high openness than for low openness, see Figure 6. A Woolf test showed that this difference was not significant ($\chi^2 = 0.55$, $df = 1$, $p = .46$). Therefore, the null hypothesis that the association between state connectedness to nature and meaning-making is the same across the two levels of meaning-making, cannot be rejected.

Figure 6

Meaning-Making per Level of State Connectedness to Nature for the Two Levels of Openness to Experience



Note. Division based on *N* for each category, as represented by the numbers. The size of the boxes is relative to *N*.

Additional analysis including all variables

An additional Ordinal Regression analysis was carried out, including all variables in this study and additional interaction terms, to test which variable had the most impact on the ordinal levels of meaning-making. To assess the validity of the model, the parametric assumptions for Ordinal Logistic Regression analysis were checked. No multicollinearity was found for any of the variables (correlation coefficients < .8, VIF < 10) and the proportional odds assumption was not violated since all values were above the alpha of 0.05.

Results of the Ordinal Regression analysis show that low state-CN or low openness, storytelling without an AI image, or a combination of low state-CN and low openness increased the odds for a higher level of meaning-making, when all other variables would be controlled for. Storytelling without an AI image in combination with either low state-CN or low openness, decreased the odds of scoring a higher level of meaning-making, if the other variables were kept constant. None of the odds ratios were found to be significant, see Table 2.

Table 2

Odds Ratios (OR's) of the Ordinal Logistic Regression (OLR) Analysis

	OR	95% CI	*p*
CN_{low}	1.245	[0.187, 8.215]	.82
$Openness_{low}$	1.097	[0.188, 6.325]	.92
$Condition_{Storytelling\ without\ AI\ image}$	1.724	[0.278, 10.754]	.56
CN:Openness	1.290	[0.149, 11.229]	.82
CN:Condition	0.385	[0.041, 3.397]	.40
Openness:Condition	0.758	[0.088, 6.557]	.80

Note. CN = state connectedness to nature. The odds ratio indicates how likely or less likely a change on a variable (Openness/CN: low compared to high; Condition: storytelling without compared to with an AI image) is to increase the level of meaning-making. Analysis includes interaction terms. All results are insignificant.

Discussion

The aim of this research was to investigate whether digital nature images increased meaning-making from a past nature experience, in a population of young adults. Findings indicated that personalized digital nature images did not seem to affect meaning-making or connectedness to nature. Contrary to expectation however, digital nature images did seem to decrease the effect of connectedness to nature on meaning-making, with an effect that was just not significant. Furthermore, openness to experience did not influence the effects of the digital nature images or connectedness to nature on the process of meaning-making from a past nature experience. First-hand experiences from participants (indicated with PP) were used to explore the findings.

The hypothesis that *watching (compared to not watching) personalized AI-nature during storytelling leads to significantly higher levels of meaning-making* (H1), was not supported. This is not in line with previous findings that digital nature can facilitate meaning-making processes (Georgieva & Georgiev, 2022; Rivera et al., 2020; Silseth et al., 2024). An explanation could be that the AI images might have been counterproductive, as one study found that participants remembered less memories with a cue than without one (van den Hoven & Eggen, 2009), although a considerable number of other studies have shown that cues were effective for the retrieval of autobiographical memories (e.g. El Haj et al., 2020; Mateo et al., 2018; Knowles & Cole, 2008; van den Hoven, 2014).

Another reason might be that the AI images did not accurately represent the intended nature scenes, either because of the description provided by the participants (PP 12: "the accuracy was fine, for the info provided") or the self-completing feature of generative AI. This aspect of generative AI, as participant 45 indicated, might have made the images appear more realistic but also decreased their accuracy. Some details were more prominent in the image than in the participant's memory, possibly shifting the emphasis away from their own experience and leading them to be "biased by the pictures" (PP 34) in their storytelling. The images might have led them to focus on a smaller part of the experience, as participant 27 said. Furthermore, several participants mentioned that the images offered a different (third person) or more observing perspective, making them less personal and more difficult to connect with emotionally.

Related are the comments that the images were more helpful for remembering the surrounding than in reawakening the momentary emotions (PP 10: "it helped me while telling the story to remind myself of the surrounding, … but less the feeling of emotions that went through me in this specific moment"). Similar responses regarding the capturing ability of pictures were also found in a photo-elicitation study by Loeffler (2004). An image cannot capture an experience but can serve as a cue to remember that experience (Sellen & Whittaker, 2010), and perhaps the elements not captured might have been part of what constituted the meaning of the nature experience for the participants. Concluding, it can be said, as participant 6 did, that "if the image is not 100% accurate, it can also be a bit distorting", although it must be said that all images, whether photographed or AI generated, have the ability to distort reality (Knowles & Cole, 2008).

Also the second hypothesis that *watching (compared to not watching) personalized AI-nature leads to significantly higher levels of meaning-making, because of an increase in state connectedness to nature*, was not supported. The current findings contradict previous research findings that meaning and connectedness to nature are related (e.g. Howell et al., 2013; Lengieza, 2024). The indication that connectedness to nature might negatively affect meaning-making when AI images are implemented, could be in line with the study of Beery and colleagues (2013). These authors have suggested that virtual nature experiences as well as diminishment of experience are two factors that could lead one to feel disconnected from nature (Beery et al., 2023), possibly explaining the inversed effect of connectedness to nature on meaning-making, when the digital nature images were implemented.

Perhaps these results might be related to the concept of solastalgia. This concept, coined by Albrecht (2005), has been described as "the distress caused by the unwelcome transformation of cherished landscapes" (Galway et al., 2019, p. 11). Typically, this concept is used in the context of climate change or land degradation and related to the nature environment where one feels home. But perhaps, perceiving a change in the representation of a dear environment belonging to a meaningful experience, might lead to similar feelings as solastalgia (Albrecht, 2005, see also Riechers et al., 2020). It would put the fact that one participant found it disturbing to look at the AI image while simultaneously describing how the actual scene and emotional setting had been (PP 41: "my brain had to adjust to the differences"), in a different light. Watching AI images that were similar, but necessarily different from the actual place of a meaningful nature experience, might have led to disconnection from depicted environment and resulted in lower-level meaning-making.

Both H3 *watching personalized AI-nature images leads to significantly higher levels of meaning-making, for those scoring high (compared to low) on openness to experience* and H4 *higher levels of state connectedness to nature lead to significantly higher levels of meaning-making, for those scoring high (compared to low) on openness to experience* regarding openness to experience, were not supported. This is against the idea that people high on openness can achieve meaning with uncommon methods (Lavigne et al., 2013) and that digital visual interventions are possibly dependent on the level of openness of a subject (Thompson et al., 2009). An apparent explanation might be that openness to experience did not have an impact, because an effect of AI images on meaning-making was absent. But perhaps also the use of AI images may not have been as new and alternative of a tool to the current generation of young adults, or university students in particular (Selwyn & Gallo Cordoba, 2021), possibly diminishing the potential influence openness could have had.

It is important to note that these results do not mean that openness cannot lead to increased feelings of connectedness to nature. It only indicates that openness does not seem to influence the effect of connectedness to nature on the process of meaning-making. Thus, it might still be that having higher levels of openness can lead one to have more intense experiences and stronger emotional responses (Costa & McCrae, 1992; McCrae & Costa, 1997). Similarly, it might still be that openness to experience is related to meaning in life, as was found by previous studies (Işık & Üzbe, 2015; Steger et al., 2008; Tan et al., 2021), although openness likely did not play a role in meaning achieved by using virtual nature.

Limitations

A limitation of this study might have been the use of an ordinal scoring system for meaning-making. The ordinal character of the coding system limited the options for more detailed analyses, also due to the low number of values for some categories. As a result, only possible effects regarding high and low meaning-making were able to be examined. The use or addition of a numerical scale to assess meaning-making might have given a more accurate insight about the presence and magnitude of an effect. Especially if this effect were to be small, this would have been picked up better with a numerical scale.

Also, the poor reliability of the BFI subscale Openness for this sample was a limitation of this study. Although Benet-Martínez and John (1998) previously found this subscale possessing acceptable ($\alpha = .79$) and good ($\alpha = .81$) reliabilities for Spanish and English samples, the present study showed poor reliability for this subscale ($\alpha = .569$). Especially items 7 ("I am someone who prefers work that is routine") and 9 ("I am someone who has few artistic interests") - the reversed items - had a great impact on the reliability of the scale. Perhaps because the current sample consisted of mostly non-native English speakers, this might have led to different interpretations of the questionnaire items. Adequately addressing this issue, either by adjusting the analysis or implementing another measurement instrument, could have given a more reliable insight into the role of openness to experience in the process of meaning-making from AI images.

Another limitation might have been the need to ask questions during the storytelling. Participants were invited to tell about their nature experience, while the researcher tried to restrict the posing of questions to avoid steering their stories. In this sense, the storytelling was not an interview, rather a narration. There was much personal variation in the amount of information participants shared, and for some people a question needed to be asked to obtain more personal experience, for a few participants even multiple times. Although the questions asked were somewhat standardized, the non-neutrality of them might have guided the participants in a certain direction, possibly having influenced their meaning-making process. Removing the opportunity for questions might have given more unaffected results. Or, as a previous interview study found that the use of images led to more meaningful conversations between researcher and participants (Loeffler, 2004), actually implementing a more conversational style might have led to stronger or even different results for meaning-making.

A fourth limitation of this study was the fact that participants already wrote about their experience in the first part of the study, when describing the nature scenes in context. The retelling in the second session was then a repetition of the story, possibly flattening the emotional response during this session. Some participants actually preferred the first part over the second (e.g. PP 28: “I felt more in the moment when writing about the situation beforehand, because then I could fully concentrate on my memory”, and PP 13: “I did not feel that I was able to verbalize it better than writing about it”). The effects of writing about their experience, without an AI image, might have transferred to the second session (Mace & Hidalgo, 2022). Consequently, the presentation of the image during the second session might have lost its additive value, having resulted in a decreased potential effect of storytelling condition on the outcome of meaning-making. Maybe a greater interval between the two sessions or a more focused description task would have reduced transfer effects from the writing session.

Directions for future research

Future research might further investigate the effectiveness of AI images in storytelling research. As the images were sometimes found to be inaccurate, it could be investigated whether writing a prompt oneself changes the effectiveness of using an AI image for storytelling compared to the researcher writing it, or whether the type of prompt also plays a role. Moreover, the use of photographs has been found to improve people’s ability to reflect upon a past nature experience (Loeffler, 2004). Perhaps, AI images in one condition could be compared to actual photos in another condition, with respect to autobiographical memory, meaning-making, or emotions elicited. Future research could also explore what happens when participants would create images themselves, for example through drawing. Bagnoli (2009) argues that drawing can be used as a method of creative reflection, giving rise to the reexperience of broader dimensions than can be elicited with just words. Additionally, nature scenes could be drawn fully from memory, without the interference from an image. It would also make the images more personal, thereby possibly better to connect with.

More research could be conducted about personal differences in AI and storytelling research. One possibility could be to look at the cognitive style a person has. Priming memories with images requires complex visual processes (Mace et al., 2023), and people with a more visual cognitive style have been found to remember more details and contextual information of past experiences (D'Argembeau & van der Linden, 2006; Vannuci et al., 2015). Maybe people with this cognitive style would be more responsive to the use of AI nature image to increase autobiographical meaning-making.

It would also be interesting to investigate how watching personalized digital nature would have influenced meaning-making processes in older adults. It has been found that older adults lose more details when they mentally store memories of an event and they retrieve less memories than young adults (St-Laurent & Buchsbaum, 2019). Therefore, it might be that the AI images can have a greater support function as a referential tool for older adults, although their input would be required to generate those images. Nonetheless, the self-completing character of generative AI might propose details that perhaps bring back other memories when perceived by the elderly.

Practical implications

Whether young adults are more proliferate meaning-makers than older adults, was not investigated in this research. However, after the present research it is known that personalized digital nature did not make them feel more connected to nature and it did not improve their meaning-making level. It is also a little clearer that the role of openness to experience in this process seems to be absent or weak.

Emerging from this study is the idea that the promising, sometimes rosy view towards the seemingly infinite potential of AI and the possibilities of digital nature should be nuanced. Although its value is promising in a wide range of applications, adopting it to facilitate personalized nature experiences is likely not one of them. Also, its employment for storytelling research could not offer the emulating experiences it was hoped for. At the moment, its use might be limited to accommodate enjoyable subjective experiences, as its ability to create nature landscapes gave rise to many positive comments. Therefore, it could be deduced that generative AI has entertainment value.

For storytelling research, the findings suggest that it has to be well considered for what purpose this tool would be employed. Litleskare and colleagues (2020) proposed that digital nature could function as a) an addition to actual nature, b) a reconnecting tool with nature, or c) to boost human-nature interactions. Although generative AI might not be able to recreate settings or environments for people to reexperience past events, it can be helpful to extend storytelling about those events or experiences (see also Van Houwelingen-Snippe et al., 2020, 2023). Employing it to provide visual cues could aid in bringing back more details. For clinical purposes, generative AI might not be suited to facilitate meaning-making processes, but it might be useful in trauma processing, as it can simulate scenes without reviving the original place and might even decrease emotional connectedness to the depicted scenes. Perhaps digital nature might only be helpful in case people are deprived of nature contact (Zabini et al., 2020), for example during a lockdown or for older adults in elderly homes. Generative AI might bring back memories of attended places but cannot deliver those places into their homes or lives again. Bottom line is that even when AI or digital nature does not affect the meaning or connectedness to a place, people might still benefit from the opportunities it can provide that would not be available otherwise.

But the one overarching implication of the present study might be that deriving meaning from a past event is less dependent on the tangible souvenirs one has but rather depends on the remembrance of how one experienced that event. AI lacks an element of natural or lived experience, and perhaps this might suggest that AI cannot - and would never be able to - replace the human world, in which mankind's real meaningful memories for stories are made. As one participant strikingly said, "the image should be based on the story, the story not on the image".

Conclusion

Nature and meaning are tightly related and benefit well-being but, as the recent COVID pandemic pointed out, this might not always be available. The present study investigated the use of personalized digital nature images on the process of meaning-making in young adults. It was found that the AI images did not affect the level of meaning-making and neither state connectedness to nature nor openness to experience had a significant influence in this. Connectedness to nature even seemed to decrease as a result of the AI images. Perhaps generative AI is not ready yet for clinical implementation. Future research should investigate how AI images compare to photos in storytelling research, and whether age affects meaning-making using AI.

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Appendices

Appendix A – Informed Consent Form

Please, carefully read the following information about your participation in this study.

- I have read and understood the study information, or it has been read to me. I have been able to ask questions about the study and my questions have been answered to my satisfaction.

- I consent voluntarily to be a participant in this study and understand that I can refuse to answer questions and I can withdraw from the study at any time, without having to give a reason.

- I understand that taking part in the study involves completing individual questionnaires and an audio-recorded interview that will be transcribed to text, which will be deleted by the end of this research. Any personal information will not be shared beyond the study team.

- I understand that taking part in the study involves the following risks: possible negative emotions from reexperiencing a meaningful event.

- I agree to be audio recorded, and that the information I provide can be anonymously quoted in research outputs.

After reading the above, do you agree to voluntarily take part in this study?

- Yes, I consent
- No

Contact Information for Questions about Your Rights as a Research Participant: If you have questions about your rights as a research participant, or wish to obtain information, ask questions, or discuss any concerns about this study with someone other than the researcher(s), please contact the Secretary of the Ethics Committee/domain Humanities & Social Sciences of the Faculty of Behavioural, Management and Social Sciences at the University of Twente by ethicscommittee-hss@utwente.nl

Appendix B

Openness subscale from the Big Five Inventory

Please, rate to what extent the following statements apply to you. There are no right or wrong answers. Please answer honestly.

1 = disagree strongly 2 = disagree a little 3 = neither agree nor disagree
4 = agree a little 5 = agree strongly

I am someone who...

___ is original, comes up with new ideas
___ is curious about many different thing
___ is ingenious, a deep thinker
___ has an active imagination
___ is inventive
___ values artistic, aesthetic experiences
___ prefers work that is routine
___ likes to reflect, play with ideas
___ has few artistic interests
___ is sophisticated in art, music, or literature

Appendix C

Connectedness to Nature Scale – state version

Please answer each of these questions in terms of the way you feel at the present moment. There are no right or wrong answers.

Using the following scale, in the space provided next to each question simply state as honestly and candidly as you can what you are presently experiencing.

1 (strongly disagree) – 4 (neutral) – 7 (strongly agree)

1. Right now I'm feeling a sense of oneness with the natural world around me.
2. At the moment, I'm feeling that the natural world is a community to which I belong.
3. I presently recognize and appreciate the intelligence of other living organisms.
4. At the present moment, I don't feel connected to nature.
5. At the moment, I can imagine myself as part of the larger cyclical process of living.
6. At this moment, I'm feeling a kinship with animals and plants.
7. Right now, I feel as though I belong to the earth just as much as it belongs to me.
8. Right now, I am feeling deeply aware of how my actions affect the natural world.
9. Presently, I feel like I am part of the web of life.
10. Right now, I feel that all inhabitants of earth, human and nonhuman, share a common life force.
11. At the moment, I am feeling embedded within the broader natural world, like a tree in a forest.
12. When I think of humans' place on earth right now, I consider them to be the most valuable species in nature.
13. At this moment, I am feeling like I am only a part of the natural world around me, and that I am no more important than the grass on the ground or the birds in the trees.

Appendix D

Script Rstudio

```
### Script meaning-making ### M12 ###

# Packages
library(tidyverse)
library(dplyr)
library(janitor)
library(misty)
library(car)
library(stats)
library(Hmisc)
library(MASS)
library(GGally)
library(ggplot2)
library(brant)
library(ggstatsplot)
library(irr)
library(vcd)

### Preparing and combining data sets

# Loading data set
Dataset1 <- Using_AI_Generated_Nature_to_Promote_Meaning_Making_Pt1
view(Dataset1)
# Selecting variables
Dataset1 <- Dataset1 %>% dplyr::select(Age_1, Gender, Nationality, Nationality_3_TEXT,
Identifier, Openness_1:Openness_10, `Nature Connectedness_1`:`Nature
Connectedness_14`)
# Excluding people who missed questions
Dataset1 <- Dataset1 %>%
  drop_na(Openness_1:Openness_10, `Nature Connectedness_1`:`Nature Connectedness_14`)
# Excluding question text and test runs
Dataset1 <- Dataset1[-c(1), ]

# Loading data set
Dataset2 <- Using_AI_Generated_Nature_to_Promote_Meaning_Making_Pt2
view(Dataset2)
# Selecting variables
Dataset2 <- Dataset2 %>% dplyr::select(Identifier, Condition, `Nature
Connectedness_1`:`Nature Connectedness_13`, `Meaning-Making`, Question)
# Excluding people who missed questions
Dataset2 <- Dataset2 %>%
  drop_na(`Nature Connectedness_1`:`Nature Connectedness_13`, `Meaning-Making`)

# Combining the first part of the study with the second part
Combdata <- merge(Dataset1, Dataset2, by = "Identifier", all = TRUE)
```

```
# Excluding participants that missed part 2
Combdata <- Combdata %>%
  drop_na(Openness_1:Openness_10, `Nature Connectedness_1.y`:`Nature
Connectedness_13.y`)

# Converting scores from characteristic to numerical
str(Combdata$Openness_1)
Combdata$Openness_1 <- as.numeric(Combdata$Openness_1)
Combdata$Openness_2 <- as.numeric(Combdata$Openness_2)
Combdata$Openness_3 <- as.numeric(Combdata$Openness_3)
Combdata$Openness_4 <- as.numeric(Combdata$Openness_4)
Combdata$Openness_5 <- as.numeric(Combdata$Openness_5)
Combdata$Openness_6 <- as.numeric(Combdata$Openness_6)
Combdata$Openness_7 <- as.numeric(Combdata$Openness_7)
Combdata$Openness_8 <- as.numeric(Combdata$Openness_8)
Combdata$Openness_9 <- as.numeric(Combdata$Openness_9)
Combdata$Openness_10 <- as.numeric(Combdata$Openness_10)

str(Combdata$`Nature Connectedness_1.x`)
Combdata$`CNS_trait_1`<- as.numeric(Combdata$`Nature Connectedness_1.x`)
Combdata$`CNS_trait_2`<- as.numeric(Combdata$`Nature Connectedness_2.x`)
Combdata$`CNS_trait_3`<- as.numeric(Combdata$`Nature Connectedness_3.x`)
Combdata$`CNS_trait_4`<- as.numeric(Combdata$`Nature Connectedness_4.x`)
Combdata$`CNS_trait_5`<- as.numeric(Combdata$`Nature Connectedness_5.x`)
Combdata$`CNS_trait_6`<- as.numeric(Combdata$`Nature Connectedness_6.x`)
Combdata$`CNS_trait_7`<- as.numeric(Combdata$`Nature Connectedness_7.x`)
Combdata$`CNS_trait_8`<- as.numeric(Combdata$`Nature Connectedness_8.x`)
Combdata$`CNS_trait_9`<- as.numeric(Combdata$`Nature Connectedness_9.x`)
Combdata$`CNS_trait_10`<- as.numeric(Combdata$`Nature Connectedness_10.x`)
Combdata$`CNS_trait_11`<- as.numeric(Combdata$`Nature Connectedness_11.x`)
Combdata$`CNS_trait_12`<- as.numeric(Combdata$`Nature Connectedness_12.x`)
Combdata$`CNS_trait_13`<- as.numeric(Combdata$`Nature Connectedness_13.x`)
Combdata$`CNS_trait_14`<- as.numeric(Combdata$`Nature Connectedness_14`)
str(Combdata$CNS_trait_10)

Combdata$`CNS_state_1`<- as.numeric(Combdata$`Nature Connectedness_1.y`)
Combdata$`CNS_state_2`<- as.numeric(Combdata$`Nature Connectedness_2.y`)
Combdata$`CNS_state_3`<- as.numeric(Combdata$`Nature Connectedness_3.y`)
Combdata$`CNS_state_4`<- as.numeric(Combdata$`Nature Connectedness_4.y`)
Combdata$`CNS_state_5`<- as.numeric(Combdata$`Nature Connectedness_5.y`)
Combdata$`CNS_state_6`<- as.numeric(Combdata$`Nature Connectedness_6.y`)
Combdata$`CNS_state_7`<- as.numeric(Combdata$`Nature Connectedness_7.y`)
Combdata$`CNS_state_8`<- as.numeric(Combdata$`Nature Connectedness_8.y`)
Combdata$`CNS_state_9`<- as.numeric(Combdata$`Nature Connectedness_9.y`)
Combdata$`CNS_state_10`<- as.numeric(Combdata$`Nature Connectedness_10.y`)
Combdata$`CNS_state_11`<- as.numeric(Combdata$`Nature Connectedness_11.y`)
Combdata$`CNS_state_12`<- as.numeric(Combdata$`Nature Connectedness_12.y`)
Combdata$`CNS_state_13`<- as.numeric(Combdata$`Nature Connectedness_13.y`)

# Reversing some items for Nature Connectedness and Openness to Experience
```

```
Combdata$Openness_7R <- item.reverse(Combdata$Openness_7, min = 1, max = 5)
Combdata$Openness_9R <- item.reverse(Combdata$Openness_9, min = 1, max = 5)

Combdata$`CNS_trait_4R` <- item.reverse(Combdata$`CNS_trait_4`, min = 1, max = 7)
Combdata$`CNS_trait_12R` <- item.reverse(Combdata$`CNS_trait_12`, min = 1, max = 7)
Combdata$`CNS_trait_14R` <- item.reverse(Combdata$`CNS_trait_14`, min = 1, max = 7)

Combdata$`CNS_state_4R` <- item.reverse(Combdata$`CNS_state_4`, min = 1, max = 7)
Combdata$`CNS_state_12R` <- item.reverse(Combdata$`CNS_state_12`, min = 1, max = 7)

# Creating compound scores for Nature Connectedness and Openness to Experience
Combdata <- Combdata %>%
  mutate(Openness = (Openness_1 + Openness_2 + Openness_3 + Openness_4 + Openness_5
+ Openness_6 + Openness_7R + Openness_8 + Openness_9R + Openness_10) /10)

Combdata <- Combdata %>%
  mutate(State_NC = (CNS_state_1 + CNS_state_2 + CNS_state_3 + CNS_state_4R +
CNS_state_5 + CNS_state_6 + CNS_state_7 + CNS_state_8 + CNS_state_9 + CNS_state_10
+ CNS_state_11 + CNS_state_12R + CNS_state_13) /13)
Combdata <- Combdata %>%
  mutate(Trait_NC = (CNS_trait_1 + CNS_trait_2 + CNS_trait_3 + CNS_trait_4R +
CNS_trait_5 + CNS_trait_6 + CNS_trait_7 + CNS_trait_8 + CNS_trait_9 + CNS_trait_10 +
CNS_trait_11 + CNS_trait_12R + CNS_trait_13 + CNS_trait_14R) /14)

# Recoding Meaning-Making and Condition
Combdata$`Meaning-score`<- as.numeric(Combdata$`Meaning-Making`)

Combdata$`Meaning-Making`<- factor(Combdata$`Meaning-Making`, levels = c(0,1,2,3),
                          labels = c("No meaning",  "Lesson", "Vague meaning", "Insight"))

Combdata$`Condition_score` <- as.numeric(Combdata$Condition)

Combdata$Condition <- factor(Combdata$Condition, levels = c(2,1),
                      labels = c("Storytelling with AI image", "Storytelling without AI image"))
str(Combdata$Condition_score)

### Inspecting the data set

# Descriptive statistics for age, sex, and nationality
Combdata$Age_1 <- as.numeric(Combdata$Age_1)
Combdata$Age_1 %>% summary()
mean_age <- mean(Combdata$Age_1)
print(mean_age)
sd_age <- sd(Combdata$Age_1)
print(sd_age)

Combdata$Gender %>% tabyl()

Combdata$Nationality %>% tabyl()
Combdata$Nationality_3_TEXT %>% tabyl()
```

```
# Interrater agreement meaning-making
R1 <- c("2", "1", "0", "2", "1", "3")
R2 <- c("2", "1", "0", "2", "1", "3")
R3 <- c("2", "1", "0", "2", "1", "2")
interrater <- data.frame(R1, R2, R3)
kappam.fleiss(interrater)
irr::kendall(interrater, correct = FALSE)

# Descriptive statistics for condition and meaning-making
summary(Combdata$`Meaning-Making`)
summary(Combdata$Condition)

maintable = table(Combdata$Condition, Combdata$`Meaning-Making`)
print(maintable)

Combdata %>%
  ggplot(aes(x=`Meaning-Making`))+
  geom_bar()
plo
plot(`Meaning-Making` ~ Condition, data=Combdata)

barplot(maintable, main = "Meaning-making per condition", beside = TRUE)
legend(x = 10, y = 2, legend = rownames(maintable)) #https://www.geeksforgeeks.org/chi-
square-test-in-r/ #

# Cronbach's alpha for Connectedness to Nature and Openness to Experience
CNS_alpha <- Combdata %>%
  select(CNS_state_1:CNS_state_3, CNS_state_4R, CNS_state_5:CNS_state_11,
CNS_state_12R, CNS_state_13) %>%
  as.matrix() %>%
  itemAnalysis()
CNS_alpha$alpha
CNS_alpha$itemReport

Openness_alpha <- Combdata %>%
  select(Openness_1:Openness_6, Openness_7R, Openness_8, Openness_9R, Openness_10)
%>%
  as.matrix() %>%
  itemAnalysis()
Openness_alpha$alpha
Openness_alpha$itemReport

# Inspecting state-NC
ggplot(Combdata, aes(x = State_NC))+
  geom_histogram()
shapiro.test(Combdata$State_NC)

# Inspecting Openness
ggplot(Combdata, aes (x = Openness))+
```

```
geom_histogram()
shapiro.test(Combdata$Openness)

### Main analyses of effect AI condition on meaning-making

# Checking for assumption of expected values >5 per cell for Chi-square test
chisq.test(maintable)$expected

# Splitting meaning-making in high and low
Combdata$Meaning <- ifelse(Combdata$`Meaning-score` > mean(Combdata$`Meaning-
score`), "High", "Low")
Combdata$Meaning %>% tabyl()

# Checking assumption for splitted variable meaning
Condition_table = table(Combdata$Condition, Combdata$Meaning)
chisq.test(Condition_table)$expected

# Chi-squared test
chisq.test(Condition_table)

# Barplot to visualize test result
ggbarstats(
  Combdata, Condition, Meaning,
  results.subtitle = FALSE)

ggbarstats(
  Combdata, Condition, Meaning,
  results.subtitle = FALSE,
  subtitle = paste0(
    "Fisher's exact test", ", p-value = ",
    ifelse(fisher$p.value < 0.001, "< 0.001", round(fisher$p.value, 3))
  ), xlab = "Meaning-Making", legend.title = "Storytelling condition",
  ggplot.component = list(theme(legend.title = element_text(size = 20), axis.title.x =
element_text(size = 20), text = element_text(size = 20), plot.text = element_text(size = 30)))
) + geom_label(aes(label = paste0(round(x = perc, digits = 0), "%")), show.legend = FALSE,
position = position_fill(vjust = 0.5), size = 6) +
  scale_fill_manual(values = c("gray90", "gray75"))

### Direct effect analysis of AI condition on state Connectedness to Nature

# Inspecting direct effect
ggplot(data = Combdata, aes(x = Condition, y = State_NC))+
  geom_boxplot()+
  theme_gray()+
  labs(x = "Storytelling condition", y = "State Connectedness to Nature")+
  list(theme(axis.title.y = element_text(size = 20), text = element_text(size = 20))) +

# Wilcoxon Rank Sum test
wilcox.test(Combdata$State_NC ~ Combdata$Condition, exact = FALSE, conf.level = 0.95)
```

```
### Mediation analysis for AI, NC, and meaning-making

# Inspecting effect of State-NC on meaning-making
ggduo(Combdata, "Meaning-Making", "State_NC")
ggplot(Combdata, aes(x = `Meaning-Making`, y = State_NC))+
  geom_boxplot()+
  labs(x = "Meaning-Making", y = "State Connectedness to Nature")+
  list(theme(axis.title = element_text(size = 20), text = element_text(size = 20)))

ggplot(Combdata, aes(x = Meaning, y = State_NC))+
  geom_boxplot()

# Splitting NC into high and low
Combdata$NC <- ifelse(Combdata$State_NC > median(Combdata$State_NC), "High",
"Low")
Combdata$NC %>% tabyl()

# Checking for assumption of expected values >5 per cell for Chi-square test
nature_table = table(Combdata$NC, Combdata$`Meaning-Making`)
chisq.test(nature_table)$expected

# Chi-squared test with binary variable meaning-making
NC_table = table(Combdata$NC, Combdata$Meaning)
chisq.test(NC_table)$expected
chisq.test(NC_table)

# Creating separate data sets for the two conditions
controlcondition <- Combdata %>% filter(Condition == "Storytelling without AI image")
experimentalcondition <- Combdata %>% filter(Condition == "Storytelling with AI image")

# Creating tables for the two datasets
controltable = table(controlcondition$NC, controlcondition$Meaning)
experimentaltable = table(experimentalcondition$NC, experimentalcondition$Meaning)

# Inspecting meaning-making per condition for low and high Openness
mosaic(~ Condition + Meaning + NC, data = Combdata,
       highlighting = "Meaning", highlighting_fill = c("gray90", "gray75"),
       direction = c("v", "h", "v"),
       spacing = spacing_conditional, condvars = "Condition",
       margins = unit(c(4.5,4.5,4.5,4.5), "lines"),
       labeling_args = list(
         set_varnames = c(NC = "State Connectedness to Nature", Condition = "Storytelling
condition", Meaning = "Meaning-Making"),
         gp_labels = gpar(fontsize = 15),
         gp_varnames = gpar(fontsize = 20),
         gp_text = gpar(fontsize = 20)),
       labeling = labeling_values
       )

# Creating a 2X2 stratified table
```

```
conditionalnature <- xtabs(data = Combdata, ~ NC + Meaning + Condition)

# Testing assumption of expected values >5 strata
chisq.test(controltable)$expected
chisq.test(experimentaltable)$expected

# Testing assumption for homogeneity of odds ratios for Cochran-Mantel-Haenszel Chi-
squared test
woolf_test(conditionalnature)

# Cochran-Mantel-Haenszel Chi-squared test
mantelhaen.test(conditionalnature)

### Moderation analysis for AI, Openness, and meaning-making

# Inspecting openness and meaning-making
ggduo(Combdata, "Meaning", "Openness")

# Splitting openness in high and low
Combdata$Open <- ifelse(Combdata$Openness > median(Combdata$Openness), "High",
"Low")
Combdata$Open %>% tabyl()

# Creating separate data sets for low and high Openness
lowopenness <- Combdata %>% filter(Open == "Low")
highopenness <- Combdata %>% filter(Open == "High")

# Creating tables for the two datasets
lowopennesstable = table(lowopenness$Condition, lowopenness$Meaning)
highopennesstable = table(highopenness$Condition, highopenness$Meaning)

# Inspecting meaning-making per condition for low and high Openness
mosaic(~ Open + Meaning + Condition, data = Combdata,
       highlighting = "Meaning", highlighting_fill = c("gray90", "gray75"),
       direction = c("v", "h", "v"),
       spacing = spacing_conditional, condvars = 1,
       margins = unit(c(4.5,4.5,4.5,4.5), "lines"),
       labeling_args = list(
         set_varnames = c(Open = "Openness to Experience", Condition = "Storytelling
condition", Meaning = "Meaning-Making"),
         gp_labels = gpar(fontsize = 15),
         gp_varnames = gpar(fontsize = 20),
         gp_text = gpar(fontsize = 15)),
       labeling = labeling_values
       )

# Creating a 2X2 stratified table
OpenforAIandmeaning <- xtabs(data = Combdata, ~ Condition + Meaning + Open)

# Testing assumption of expected values >5 per strata
```

```
chisq.test(lowopennesstable)$expected
chisq.test(highopennesstable)$expected

# Testing for homogeneity of odds ratios across levels of openness
woolf_test(OpenforAIandmeaning)

### Moderation analysis for NC, Openness, and meaning-making

# Creating separate for tables with state-NC for the two data sets
lowopennessnaturetable <- table(lowopenness$NC, lowopenness$Meaning)
highopennessnaturetable <- table(highopenness$NC, highopenness$Meaning)

# Inspecting meaning-making and state-NC for low and high Openness
mosaic(~ Open + Meaning + NC, data = Combdata,
       highlighting = "Meaning", highlighting_fill = c("gray90", "gray75"),
       direction = c("v", "h", "v"),
       spacing = spacing_conditional, condvars = 1,
       margins = unit(c(4.5,4.5,4.5,4.5), "lines"),
       labeling_args = list(
         set_varnames = c(Open = "Openness to Experience", NC = "State Connectedness to
Nature", Meaning = "Meaning-Making"),
         gp_labels = gpar(fontsize = 15),
         gp_varnames = gpar(fontsize = 20),
         gp_text = gpar(fontsize = 20)),
         labeling = labeling_values
       )

# Creating a 2X2 stratified table
Openfornatureandmeaning <- xtabs(data = Combdata, ~ NC + Meaning + Open)

# Testing assumption of expected values >5 per strata
chisq.test(lowopennessnaturetable)$expected
chisq.test(highopennessnaturetable)$expected

# Testing assumption for homogeneity of odds ratios
woolf_test(Openfornatureandmeaning)

# Cochran-Mantel-Haenszel Chi-squared test
mantelhaen.test(Openfornatureandmeaning)

### Final analysis including all variables

# Ordinal logistic regression analysis
totalanalysis = polr(`Meaning-Making` ~ NC + Open + Condition + NC:Open +
NC:Condition + Open:Condition, data = Combdata, Hess = TRUE)
summary(totalanalysis)

# Converting log odds to odds ratios with confidence intervals
exp(cbind(OR = coef(totalanalysis), confint(totalanalysis)))
```

```
# Calculating p-values
summary_totaltable <- coef(summary(totalanalysis))
pval_total <- pnorm(abs(summary_totaltable[, "t value"]), lower.tail = FALSE)*2
summary_totaltable <- cbind(summary_totaltable, "p value" = round(pval_total, 3))
summary_totaltable

# Checking assumptions for model
fit_total <- lm(Combdata$`Meaning-score` ~ Combdata$Condition_score +
Combdata$State_NC + Combdata$Openness)
vif(fit_total)

brant(totalanalysis)
```