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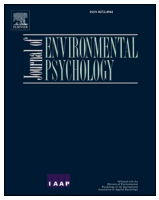

Fascination moderates the effects of nature video exposure on creative thinking☆,☆☆

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ABSTRACT

Exposure to nature has been thought to facilitate creativity, but there exists only limited causal evidence to support such relationship. The present online experiment (n = 297) examined whether exposure to nature videos, as opposed to urban videos, enhances creative divergent thinking in verbal or visual modalities and whether the restorative components assumed by Attention Restoration Theory (being away, fascination, scope, coherence) or by Stress Reduction Theory (positive emotions, relaxation) mediate or moderate the effects of the exposure on verbal or visual divergent thinking. The responses' creative quality, originality, flexibility, and fluency were measured. Nature video enhanced the creativity and originality of verbal divergent thinking and the creativity of visual divergent thinking. No mediation effects were detected. However, of the restorative components, fascination was most clearly found to moderate the effects of video exposure on the originality of verbal and visual divergent thinking, suggesting that participants who were fascinated or inspired by nature benefited the most from nature exposure. The results support the positive impact of nature exposure on creative divergent thinking. Additionally, individual differences in the subjective experiences of nature appear to play a significant role in the beneficial effects of nature on creative thinking. The results encourage incorporating natural elements into built environments, such as workplaces and schools, where creativity is important.

1. Introduction

Exposure to natural environments or images, videos, or virtual reality depicting nature or natural elements has demonstrated positive outcomes in stress reduction, emotions, and other psychological and physiological functions (Berto, 2005; Bratman et al., 2021; Grassini et al., 2019, 2022; Ohly et al., 2016; Spano et al., 2023; Stevenson et al., 2018). In artistic domains, nature has been a source of inspiration for different creative activities such as paintings, poetry, plays, etc. (Katayama & Baba, 2020). Recently, nature's effects on creativity have also gained increased scientific interest (Palanica et al., 2019; Ratcliffe et al., 2022; Williams et al., 2018; Yeh et al., 2022). Qualitative studies (Plambech & Konijnendijk Van Den Bosch, 2015; Ratcliffe et al., 2022) and self-reports of creativity (Jones, 2013; Tyrväinen et al., 2014; Van Rompay & Jol, 2016) have typically revealed that people perceive nature as promoting creativity. However, there are only a few well-controlled studies examining experimentally the causal effects of nature exposure on creativity. The present study focuses on the possible effects of nature video exposure on creative divergent thinking and the possible mediators or moderators related to nature's effects on creativity.

Creativity can be defined as the ability to produce ideas that are, to some extent, both original and useful or effective (Runco & Jaeger, 2012). In psychological studies, creativity or creative potential is typically associated with two different types of cognitive processes: convergent and divergent thinking (Guilford, 1967). The tasks measuring convergent thinking are linked to the ability to determine the single best or correct answer to a problem. For example, in the Remote Associates Test (Mednick, 1962), three words are presented, and the participants are asked to provide a fourth word that links the words together. On the other hand, divergent thinking involves generating multiple ideas or solutions in open-ended tasks with no predetermined correct answer. Divergent thinking is more central to the creative process than convergent thinking because it allows for the emergence of

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new and innovative ideas without restrictions or preconceptions, while convergent thinking focuses more on finding one correct answer and uses logical reasoning and analytical thinking, which generally does not produce as many new and creative ideas as divergent thinking. Therefore, the present study focuses on divergent thinking.

The most commonly used task measuring divergent thinking is the Alternate Uses Task (AUT) (Guilford, 1967). In this task, the participants are asked to produce new, original uses for everyday objects (e.g., brick). Divergent thinking can be further divided into specific components: originality (uniqueness or novelty of ideas), flexibility (thinking about from different perspectives), fluency (number of ideas), and elaboration (details in ideas). Visual divergent thinking tasks typically require drawing connections between shapes (Studente et al., 2016) or giving interpretations for nonsense figures (Erwin et al., 2022).

Few studies have tested the causal effects of exposure to nature stimuli on creativity of divergent thinking experimentally, and these studies have revealed inconsistent results. Palanica et al. (2019) found that exposure to a nature video, as compared to an urban video, enhanced fluency, originality, and flexibility in responses to AUT (Experiment 1). Their second experiment manipulated the environment (nature vs. urban) and the form of exposure (video vs. real environment). The results revealed that the natural environment elicited higher creativity (fluency, originality, flexibility) than the urban environment, but only in the video condition. Yeh et al. (2022) exposed students to high-, medium-, or low-perceived naturalness photosets and found that the manipulation did not influence creative performance in the verbal divergent thinking task (consequences task) or the first figural divergent thinking tasks of the Abbreviated Torrance Test for Adults (ATTA) (Goff & Torrance, 2012). However, originality, elaboration, and flexibility were enhanced in the second figural task of ATTA due to viewing highly natural photos. Van Rompay and Jol (2016) showed participants a slide show of pictures depicting different natural environments and urban environments and asked the participants to imagine walking around there. The results showed that especially spacious and unpredictable nature scenes stimulated self-reported creativity and creativity in a drawing production task. Surprisingly, even merely presenting virtual nature background during videoconferencing improved AUT performance (fluency, flexibility, originality) compared to urban or control backgrounds (Palanica & Fossat, 2022). In addition, a room enriched with a large poster depicting a natural woodland scene enhanced the rated quality of verbal divergent thinking (AUT, consequences task), not the quantity of participants' ideas (Batey et al., 2021). In a classroom setting, access to natural views through windows and plants in the room increased figural divergent thinking in a drawing task. Still, it did not affect verbal creativity in AUT, compared to a setting without access to nature views or plants (Studente et al., 2016). A within-participant study (Kimura et al., 2023) on the effects of indoor vs outdoor exercise on creative thinking did not detect any influence of the exercise mode on creative thinking in AUT. However, EEG's alpha power, which has been linked to enhanced creativity (Fink & Benedek, 2014), was higher after the outdoor exercise. In summary, exposure to nature stimuli has produced inconsistent results on verbal and figural divergent thinking tasks. In addition, the mechanisms mediating or moderating the possible causal relationship between nature exposure and divergent thinking have not been explicitly studied.

Why may exposure to real or virtual nature increase divergent thinking? The answer can be sought from the theories that aim to explain the psychological effects of nature more generally. Attention Restoration Theory (ART) (Kaplan, 1995; Kaplan & Kaplan, 1989) suggests that natural environments promote cognitive restoration by reducing mental fatigue and facilitating the recovery of directed attention. This effect is mediated through environmental characteristics such as "fascination" (effortless attention that arises when we encounter inherently interesting and stimulating elements in our environment), "being away" (sense of escape from the pressures and stressors of daily life), "coherence" (clear structure and organization), and "scope" (sense of immersion and connectedness in an environment that feels rich) (Pasini et al., 2014). These characteristics allegedly promote effortless engagement and provide mental restoration. Natural environments are thought to shift cognitive resources away from stress-inducing or attention-demanding tasks, allowing for an increased capacity for cognitive processing in a process often referred as "soft fascination" (Kaplan & Kaplan, 1989). On the other hand, Stress Reduction Theory (SRT) (Ulrich et al., 1991) emphasizes nature's role in triggering positive emotional states and physiological relaxation from stress. Research has shown that positive emotions and moods broaden thought-action repertoire and foster flexible, creative thinking (Baas et al., 2008; Fredrickson, 2001). In addition, nature's influence on relaxation is linked to increased alpha band activity in the brain (Grassini et al., 2019; 2022, Koivisto et al., 2024), and heightened alpha activity has been consistently shown to be related to increased creative ideation (Fink & Benedek, 2014). Thus, exposure to nature may enhance creativity via the restorative elements assumed in ART or emotional states, such as positive mood or relaxation, assumed in SRT.

In the present pre-registered study, the first aim was to clarify the response to the question: Does exposure to nature videos, compared to urban videos, increase verbal or visual creative divergent thinking as measured using verbal (AUT) and/or visual (Figural Interpretation Quest, FIQ, Erwin et al., 2022) tasks? Second, if nature video exposure proves beneficial for creative thinking, which dimensions assumed in ART (perceived fascination, being away, coherence, or scope) or in SRT (positive emotional activation, relaxation) mediate or moderate nature's influence on creative thinking? Creativity of the responses was rated subjectively by blinded scorers so that the ratings considered both the usefulness and originality of the responses, which are important aspects in the standard definition of creativity (Runco & Jaeger, 2012). Originality and flexibility of the responses were scored objectively based on recent computational methods (Beaty & Johnson, 2021; Grajzel et al., 2023).

2. Method

2.1. Participants

The participants were recruited via Prolific (www.prolific.com). They were paid £ 1.80 for the approximately 12-min performance. We aimed for 300 participants (150/group) and initially recruited 320 participants. The sample size was based on the notion that mediation analyses typically require at least 100 subjects per group and on a priori power calculations with G*Power (Faul et al., 2007), which suggested that the sample size of 300 participants would be sufficient for detecting with higher than 90 % power at alpha level of 0.05 a small-medium size ($f^2 = 0.06$) difference between two groups (n = 150 + 150) and interactions between the grouping variable and continuous variables in our moderation analyses. Using the filters of Prolific, the invitation was sent to native English speakers between 18 and 65 years of age and who lived in countries where English was the dominant language (UK, USA, Australia, Ireland, Canada, New Zealand). Participation was possible only using either PC or laptop computer. After having screened out 23 inattentive participants (see Procedure), we had valid data from 297 participants (152 female, 145 male), 148 of whom were randomized to the nature video condition and 149 to the urban video condition. The mean age of the participants was 37.6 years (SD = 12.4, range: 20–65) in the nature condition and 37.8 (SD = 12.0, range: 19–64) in the urban condition. As the highest education level, 35.4 % in the nature condition and 37.1 % in the urban condition had either an associate degree, vocational school, high-school or elementary school, whereas the rest of participants in both conditions had an academic degree such as bachelor or higher.

The study was conducted in accordance with the Declaration of Helsinki and with each participant's understanding and informed consent. The study was accepted by Ethics Committee for Human Sciences

at the University of Turku (September 26, 2023, decision TY/695/06.01.01/2023) and pre-registered at OSF.io: https://osf.io/9gkep/.

2.2. Materials

We created a 1-min long nature video and a 1-min long urban video to be used and presented in loops in the nature and urban exposure conditions. Both videos consisted of six 10 s freely useable video clips selected from Pexels.com. The videos did not contain any sounds. Fig. 1 presents still images as examples from the clips. We tried to select the nature and urban clips so that similar lighting, visual views (close-ups or long shots), and the same number of water settings were present in both types of clips and that both videos contained clips where the camera stayed still, or where the camera moved slowly either horizontally or forwards. Nature videos depicted, for example, a view moving forward in a forest path, a view moving closer to the trees, or a flow of water in a babbling brook or a waterfall; urban videos depicted, for example, a view from a vehicle moving forward in a tunnel, the movement of people or cars on the street, or the flow of water in the street or from a sewer pipe.

The perceived restorativeness of the environments in the videos was measured with the PRS-11 (Pasini et al., 2014). It measures the four elements of ART with 11 items: fascination (3 items), being away (3 items), coherence (3 items), and scope (2 items). The items were rated on a scale of 1 (*not at all*) to 9 (*very much*). Cronbach's α for PRS-11 in the present data was 0.86 for the whole scale,0.76 for fascination, 0.86 for being away, 0.73 for coherence, and 0.55 for scope. The low reliability of the scope sub-scale of the PRS is not surprising, as it was calculated from only two items, and Cronbach's α is known to depend on the number of items.

Nature connection was measured using the Extended Inclusion of Nature in Self scale (EINS, Martin & Czellar, 2016). EINS consists of 4 items (overlap, size, distance, centrality) with seven alternative figures. The participants selected the alternative that best describes their relationship with the natural environment for each item. The sum score can vary between 7 and 28. Cronbach's α for EINS was 0.89 in the present data.

AUT used object names "box" and "candle" as the probes. FIQ used as the probes two nonsense figures (Fig. 2) from Erwin et al. (2022; originally generated for Koutstaal et al., 2003). For creativity in AUT and FIQ, interrater reliability was measured as Intraclass Correlation Coefficient (ICC) using two-way model, consistency type, and average unit. ICC was 0.81 for the box and 0.82 for the candle in AUT; the ICCs were 0.88 and 0.87 for the two FIQ probes, respectively.

2.3. Procedure

The experiment was conducted online using Psytoolkit (Stoet, 2010, 2017), which randomized participants to either nature or urban video exposure conditions. After informed consent and before the video exposure started, the participants were asked about their current emotional state: "How aroused or excited do you feel now on a scale from 1 (*not at all*) to 9 (*very*)?", "How positive are your emotions now on a scale from 1 (*not at all*) to 9 (*very*)?", and "How relaxed do you feel now

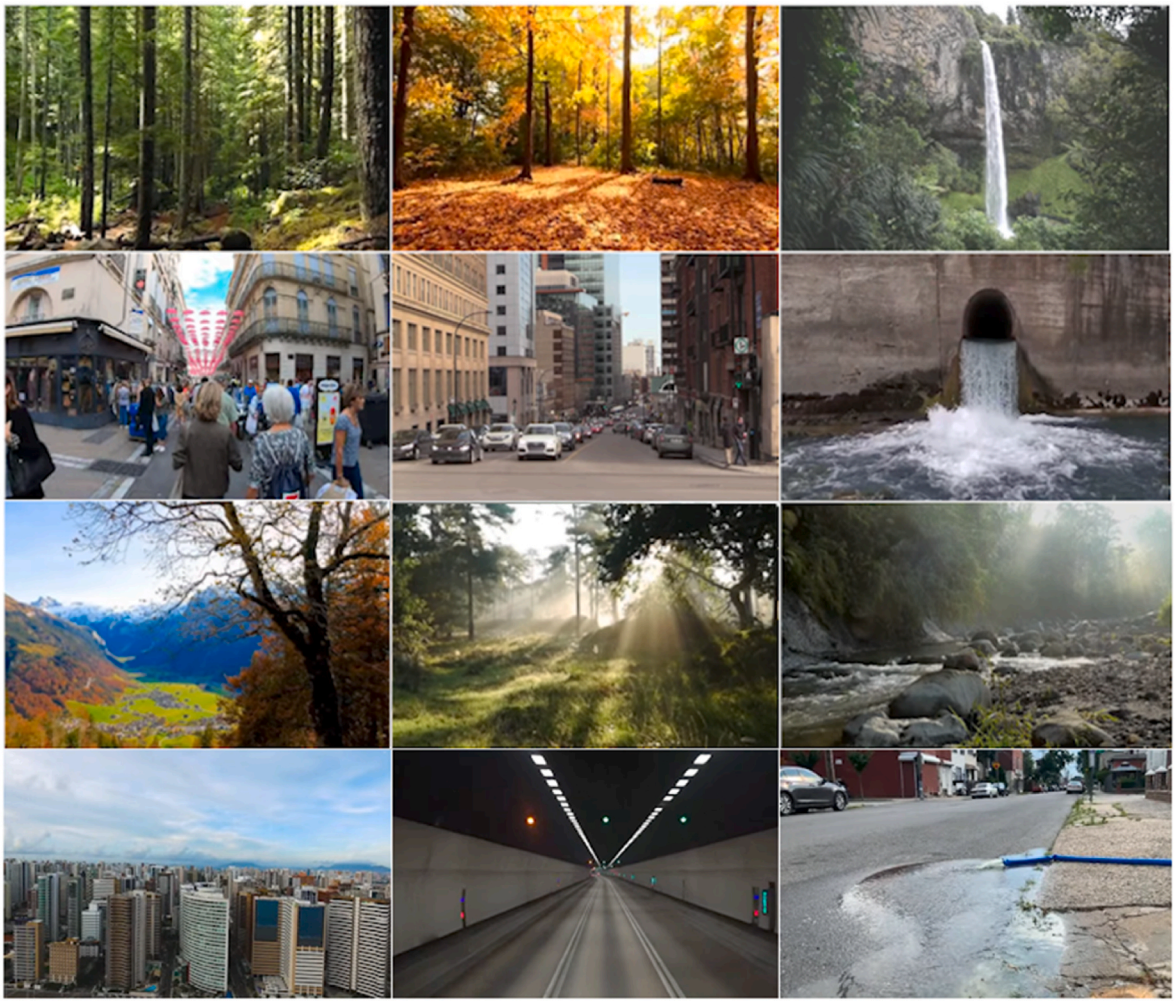

Fig. 1. Still images as examples of the clips used in the nature (up) and urban (down) videos.

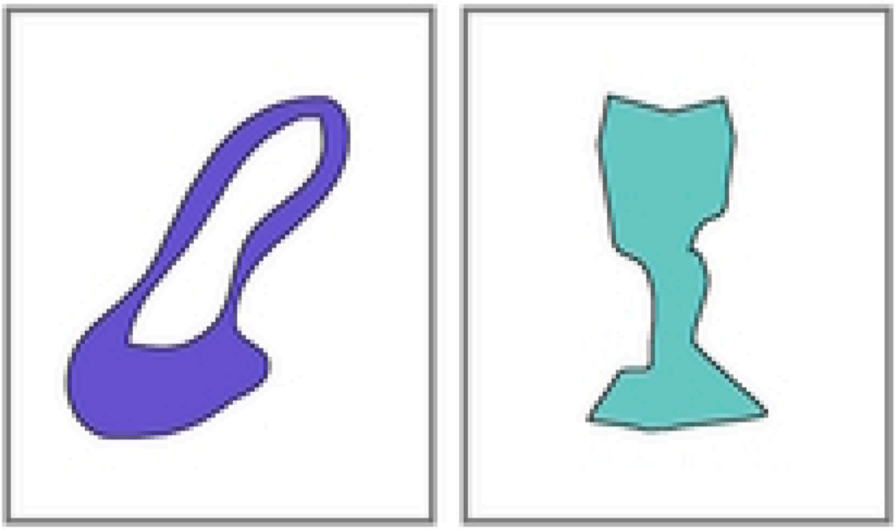

Fig. 2. The probes in Figural interpretation quest (Fiq).

on a scale from 1 (*not at all*) to 9 (*very*)?" After responding to these questions, the exposure phase began.

At the beginning of the exposure phase, the participants were told that they would be shown video clips and most of the time, they simply needed to watch them and relax. In addition, they were told that sometimes a prompt to repond with a key press within 5 s would be presented to control that they are attending to the video. In addition, they were told that sometimes statements about the video clips are presented, and they needed to respond to each statement using a scale from 1 (*not at all*) to 9 (*very*). After understanding the instructions, a spacebar press started the video presentation.

The videos were presented in loops. After 25 s of exposure, the prompt to respond with key press within 5 s occurred for the first time, and then 25 s after the response, the probe was presented for the 2nd time. These prompts were used to check that the participants were paying attention to the task. They were followed by 11 statements from PRS-11, presented individually at the bottom of the video. There was 15 s time to respond to each statement, and after the response, the following statement was presented after 10 s; if the participant did not respond within the 15 s time limit, the exposure continued for an additional 10 s until the following statement was presented (the 15 s time limit was another way to verify that the participant was attending to the screen). When all the 11 statements had been presented and 20 s had passed, the prompt to press a key within 5 s was presented for the 3rd time, and then 20 s after the response for the 4th time. This exposure phase ended after the key press or after 15 s if the participant did not follow the instructions. The exposure phase lasted at least 5 min, depending in part on how quickly the participant responded to the probes and the PRS-11 questions. Then, the three questions about the current emotional state (arousal, positivity of emotions, relaxation) were presented again, followed by a question about the beauty of the videos: "How beautiful do you think the videos were on scale from 1 (*not at all*) to 9 (*very*)?

The divergent thinking tests followed the question about the beauty in such a way that the video exposure continued all the time in a loop in the upper half of the screen. At the same time, the AUT and FIQ tasks were presented and responded to in the lower half of the screen. The order of the AUT and FIQ tasks was counterbalanced across the participants. Also, the order of the objects/figures within the tasks was counterbalanced.

For AUT, the participants were asked to propose original and creative uses for an object. Following the instructions of Beaty and Johnson (2021), the goal was to come up with creative ideas, which are ideas that strike people as clever, unusual, interesting, uncommon, humorous, innovative, or different. They were told that they can type in as many ideas as possible, but creative quality is more important than quantity, and that they had 60 s to respond to each object, after which the task ends automatically. For FIQ, the participants were told that they were to be presented with nonsense figures in the following tasks. They were asked to invite different interpretations for each figure. They had 45 s to respond to each figure, after which the task ended automatically. In the end, EINS was filled in.

A total of twenty-two participants were considered inactive or inattentive, and their data were rejected. Following the preregistration, we eliminated the results of the participants who showed larger than 5 s response times in two or more of the four trials in which they were asked to press a key within 5 s during the video exposure. In addition, the data of the participants whose all responses were lacking for one or more subscales of PRS-11 had to be rejected, since it was impossible to calculate their scores for every subscale. These participants were considered inactive and inattentive as there was 15 s time to respond to each statement.

2.3.1. *Scoring creativity*

Four variables were calculated for both AUT and FIQ: creativity, originality, flexibility, and fluency. *Creativity* was based on subjective evaluations of three independent raters who were blinded to the participants' identity and exposure condition. In scoring AUT, the raters evaluated the creativity of each response on scale from 1 (*usual or illogical*) to 5 (*very creative*). They were asked to rate the creativity against the instructions given to the participants. The individual responses (i.e., uses of the object) were presented to the raters as a list, arranged in alphabetical order so that the raters also got an idea of the frequency of each use. Expressions such as "Use it as ….", You can create a ….", "Make a …. "or other expressions which did not carry any additional information were eliminated (for example, in response to the probe "box," the expression "Use it as a cat bed" was reduced to "cat bed") so that the basic idea was retained. Such a procedure was necessary because the number of words in the responses may bias both the human-made ratings and the automatic assessment of the originality of the responses, which was based on the same list of responses given to the raters. For scoring FIQ, the responses (i.e., interpretations of the nonsense figures) were arranged in a similar alphabetically ordered list, and the blinded raters evaluated each response on a scale from 0 (*not at*

all creative) to 2 (*very creative*).

2.3.2. Originality

The *originality* of the responses in AUT was evaluated automatically using SemDis platform (Beaty & Johnson, 2021), which calculated the semantic distance between the probe and the response. Semantic distance correlates primarily with originality (Acar et al., 2023; Beaty et al., 2022; Beaty & Johnson, 2021). In SemDis, the responses were pre-processed using the "remove filler and clean" setting, which removes "stop words" (e.g., the, an, a, to) and punctuation marks that can confound semantic distance computations. The semantic distance was computed with five semantic models using the multiplicative compositional model (for a detailed description, see Beaty & Johnson, 2021), and the average score across the five models served as the semantic distance measure (i.e., originality) for each response.

In FIQ, the probes were nonsense figures, so there were no correct or unambiguous interpretations for them. Therefore, the same procedure as in AUT could not be used to calculate the originality (i.e., semantic distance) between the "probe" and each response. Also, the more conventional approach, where originality is based on the uniqueness of the responses, was not appropriate because of a large number of unique responses (28 % of the responses). Instead, we operationalized the originality as the semantic distance between the response and the three most frequent responses in the whole participant group. The most frequent responses to Fiq1 were "shoe" (f = 72), "necklace" (f = 52), and "handbag" (f = 50), and in response to Fiq2 they were "wine class" (f = 80), "trophy" (f = 80), and "vase" (f = 80). The most frequent responses were entered into SemDis as the probe item, and the resulting distance between the probe and the response describes how far away semantically the response is from the common responses. Poisson regression examining how semantic distance and the probe (Fiq1 vs. Fig. 2) predict the frequency of different responses, revealed that the higher the semantic distance, the lower the frequency, b = 6.77, SE = 0.25, 95 % CI [−7.25, −6.28], z = −27.565, p < .001; the relationship between semantic distance and frequency differed between the probes such that it was weaker for Fiq 2 than for Fiq1, b = 0.29, SE = 0.04, 95 % CI [0.21, 0.38], z = 6.98, p < .001. Thus, semantic distance was highly related to the more conventional measure of originality.

2.3.3. Flexibility and fluency

Flexibility in both AUT and FIQ was calculated on the basis of semantic distance between the responses, using the procedure suggested by Grajzel et al. (2023). Flexibility has traditionally involved measuring the number of switches between semantic categories or the number of different categories. It is evident that responses belonging to the same semantic category are semantically closer to each other than responses belonging to different semantic categories. The method based on semantic distance allows for a more nuanced measure of flexibility, capturing how far apart ideas are within a semantic network, rather than merely counting the number of categories or switches. First, each participant's successive responses were arranged into pairs (response1-response2, response2-response3, etc.), and then the semantic distance for each pair was calculated with SemDis across the five semantic spaces. The more distant the successive responses are from each other, the more flexible the thinking. Since calculating the flexibility score requires at least two responses per object, it could not be calculated for twelve participants in AUT and two participants in FIQ.

Fluency in both AUT and FIQ was operationalized as the total number of responses in each task. Fluency was primarily used as a covariate in the analyses of AUT and FIQ, because the instructions did not specifically encourage the number of responses, but the creative quality of responses was stressed.

To calculate the creativity, originality, and flexibility scores for each participant, we used the max scoring method (Beaty et al., 2022). In AUT, everyone's maximum scores for "box" and "candle" were averaged, and correspondingly, for FIQ, the average of the maximum scores for "Fig. 1" and "Fiq2" was calculated.

2.4. Statistical analyses

Descriptive statistics, correlations, Mann-Whitney U tests, and simple effects analyses were computed using Jamovi 4.4.11 (The jamovi project, 2024) and the regression models with R (R Core Team, 2021). In all the regression models involving Video (nature vs. urban) as a predictor, the video type was simple coded. First, the effect of the video type (nature vs. urban) on the DT variables was tested with linear regression models, including Video as a predictor, while Fluency and the perceived Beauty of the videos were used as covariates. Fluency was used as a covariate since it is known to be a confounding factor in analyses of divergent thinking (Forthmann et al., 2021). Beauty (or preference) is known to be a confounding factor in studies of the influence of nature exposure on psychological outcome variables, as some of the restorative effects of nature exposure can be attributed to participants' preferences or perceived beauty of nature (Koivisto & Grassini, 2024; Meidenbauer et al., 2020). The AUT and FIQ variables were typically skewed to the left. Therefore, they were normalized and standardized (M = 0, SD = 1) with Blom's procedure (Mangiafico, 2023) before entering them into the regression models. This procedure led also to normally distributed residuals in the regression models. The VIF values were below 2.5 in the first set of regression analyses, suggesting no problems with collinearity.

Next, Mann-Whitney U tests were used to test how the video exposure (urban vs. nature) predicted the PRS-11 and emotional variables. These analyses were followed by linear regression analyses testing how the PRS-11 and emotional variables predict those of the AUT or FIQ outcome measures, which showed statistically significant effects due to the video exposure. The PRS-11 and emotional scores were standardized for these regression models. The VIF values were below 4 in these models. We had pre-registered mediation analyses examining how the PRS-11 or emotional variables predict divergent thinking, provided the analyses described above meet the classical prerequisites for mediation (i.e., Video predicts divergent thinking and the mediators predict divergent thinking). Finally, the interactions between the PRS-11 variables and the video type and the interactions between the emotional variables and video type were tested in two sets of regression models (one for PRS-11 variables and one for emotional variables), to reveal which of the variables moderate the effects of the video type on divergent thinking. The VIF values in the moderation analyses were below 5.

3. Results

The data matrices and R scripts are available at OSF.io: osf.io/3js5v. Descriptive statistics for the divergent thinking variables are presented

Table 1
Descriptive statistics for the divergent thinking variables in alternate uses task (AUT) and Figural interpretation quest (FIQ).

Task	Variable	Video	Mean	SD	Min	Max	n
AUT	Creativity	Nature	3.15	0.52	1.00	4.33	148
		Urban	2.98	0.61	1.17	4.83	149
	Originality	Nature	1.01	0.05	0.74	1.09	148
		Urban	0.99	0.07	0.71	1.07	149
	Flexibility	Nature	0.98	0.13	0.50	1.20	144
		Urban	0.95	0.15	0.50	1.20	141
	Fluency	Nature	3.38	1.45	0.50	8.50	148
		Urban	3.22	1.53	0.50	7.50	149
FIQ	Creativity	Nature	0.91	0.36	0.00	1.67	147
		Urban	0.86	0.38	0.00	1.61	148
	Originality	Nature	1.00	0.05	0.82	1.11	147
		Urban	0.99	0.06	0.82	1.08	148
	Flexibility	Nature	0.96	0.12	0.39	1.10	147
		Urban	0.95	0.15	0.39	1.11	148
	Fluency	Nature	3.99	1.46	1.00	8.00	147
		Urban	4.09	1.80	0.50	10.00	148

in Table 1. Spearman's rho correlations were computed to understand the relationship between demographic variables and divergent thinking scores. Education correlated weakly with creativity in AUT ($r_s = 0.14$, $p = .011$) and flexibility in FIQ ($r_s = 0.14$, $p = .015$) but not with other variables. Age did not correlate with any of the variables ($-0.03 < r_s < 0.05$).

3.1. The effects of video exposure on divergent thinking

The linear regression analyses with Video (urban vs nature) as the predictor and fluency and beauty as covariates for each outcome variable were performed (the models on fluency had only beauty as a covariate). The modeled effects of video type are presented in Fig. 3. The complete models are presented in Supplementary Materials (Table S1). For AUT, the analyses revealed that Nature video produced higher scores than Urban video in creativity, $B = 0.42$, $SE = 0.16$, $t = 2.65$, $p = .009$, and originality, $B = 0.33$, $SE = 0.15$, $t = 2.13$, $p = .034$, but not in flexibility, $B = 0.19$, $SE = 0.14$, $t = 1.29$, $p = .199$, or fluency, $B = 0.26$, $SE = 0.16$, $t = 1.59$, $p = .112$. For FIQ, exposure to nature video elicited higher scores in creativity, $B = 0.31$, $SE = 0.15$, $t = 2.09$, $p = .040$, but not in originality, $B = 0.09$, $SE = 0.16$, $t = 0.57$, $p = .569$, flexibility, $B = -0.01$, $SE = 0.14$, $t = -0.08$, $p = .936$, or fluency, $B = -0.06$, $SE = 0.16$, $t = -0.39$, $p = .696$. Fluency had a highly significant ($p < .001$) positive effect on creativity, originality, and flexibility (Bs = 0.24–0.60) in both AUT and FIQ.

In summary, the most important findings were that exposure to the nature video, compared to the urban video, enhanced creativity in both tasks of divergent thinking, AUT and FIQ. The originality of the responses to AUT was also enhanced, and as can be seen in Fig. 3, there are non-significant trends in the same direction also for flexibility and fluency.

3.2. The effects of video exposure on subjective variables

The subjective ratings (on scale from 1 to 9) of arousal before the video exposure did not differ between urban ($M = 3.44$, $SD = 2.03$) and nature ($M = 3.17$, $SD = 2.07$) conditions, $U = 8743$, $p = .197$, $r = 0.09$. Neither did ratings of the positivity of emotions differ before the exposure between urban ($M = 5.70$, $SD = 1.89$) and nature ($M = 5.57$, $SD = 1.83$) conditions, $U = 10311$, $p = .559$, $r = 0.04$. Similarly, no difference was detected in the pre-exposure ratings of relaxation between urban ($M = 6.13$, $SD = 1.85$) and nature ($M = 5.85$, $SE = 2.08$) conditions, $U = 9822$, $p = .282$, $r = 0.07$. Thus, none of the comparisons was statistically significant, and effects sizes were negligible in all comparisons, suggesting that the participants randomized into the nature and urban video exposure conditions did not differ in the measured emotions before the exposure began.

Table 2 shows the effects of the video exposure on the PRS-11 variables (fascination, being away, coherence, scope), post-exposure emotional variables (arousal, positive emotions, relaxation), perceived

Table 2
The Effects of the Video Exposure to the PRS-11 Variables (Fascination, Being away, Coherence, Scope), Emotional Variables (Arousal, Positive Emotions, Relaxation), Perceived Beauty of the Videos, and on Nature Connectedness (EINS).

Variable	Video	Mean	SD	U	p	r
Fascination	Urban	5.47	1.59	3737	<0.001	0.66
	Nature	7.36	1.34			
Being away	Urban	3.91	1.77	1497	<0.001	0.86
	Nature	7.38	1.31			
Coherence	Urban	5.35	1.44	10407	0.402	0.06
	Nature	5.5	2.12			
Scope	Urban	5.94	1.73	4085	<0.001	0.63
	Nature	7.78	1.11			
Arousal	Urban	3.32	2.01	9488	0.035	0.14
	Nature	3.98	2.45			
Positive e.	Urban	5.72	1.86	7808	<0.001	0.29
	Nature	6.6	1.86			
Relaxation	Urban	6.09	1.96	7435	<0.001	0.33
	Nature	7.14	1.74			
Beauty	Urban	5.12	2.02	1420	<0.001	0.87
	Nature	8.37	0.87			
EINS	Urban	18.51	4.86	9753	0.085	0.12
	Nature	19.5	4.83			

Note. The subjective scale was from 1 (*not at all*) to 9 (*very much*) in all other variables except in EINS where the sum score of the four items could theoretically vary from 7 to 28. r = rank biserial correlation.

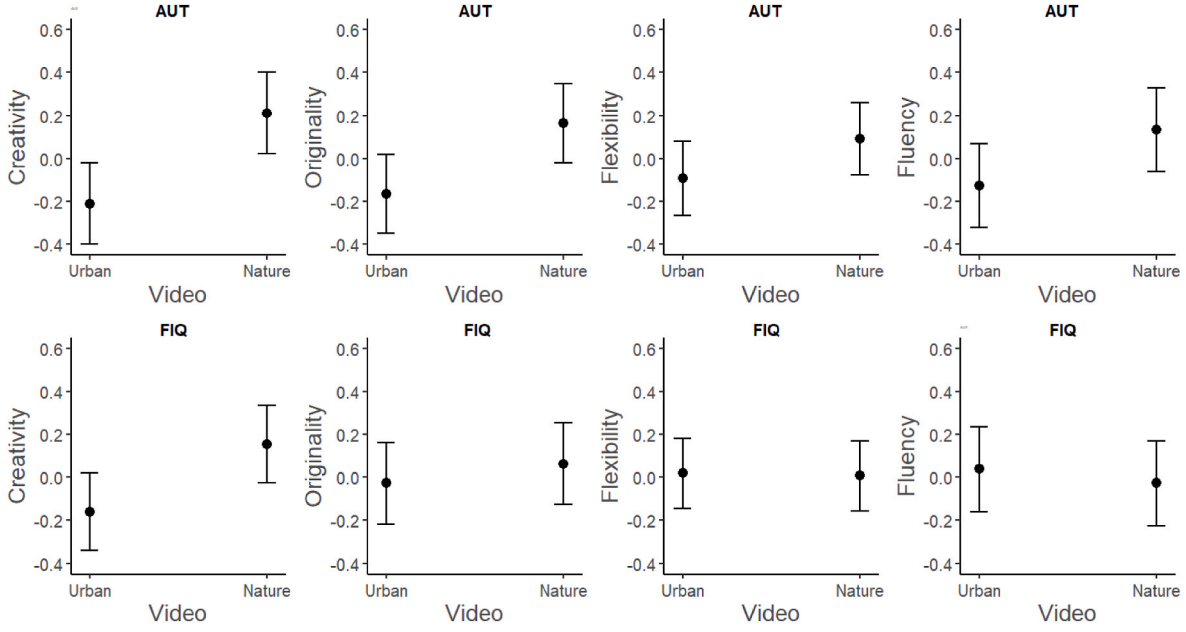

Fig. 3. Modeled Effects of the Video (Urban vs. Nature) on Creativity, Originality, Flexibility, and Fluency in Alternate Uses Task (AUT) (upper panels) and in Figural Interpretation Quest (FIQ) (lower panels).
Note. The values of the outcome variables in y-axis represent standardized values. Error bars show 95 % confidence intervals.

beauty of the videos, and nature connectedness (EINS). Mann-Whitney *U* test was used because most of the subjective variables were skewed ($p < .05$). It showed that exposure to the nature video resulted in higher scores than the urban video in all other PRS-11 variables, except in coherence. All the emotional scores (arousal, positive emotions, relaxation) and experienced beauty of the videos were higher after the nature video than after the urban video.

The video type did not have any statistically significant effect on EINS, which was included for exploratory purposes only without any preregistered hypotheses. The result suggests that this measure of nature connectedness may reflect a relatively stable trait-like nature connectedness which is not responsive to temporary changes after short virtual exposure, although it may temporarily fluctuate in real-world settings (Sheffield et al., 2022).

3.3. The PRS-11 and emotional variables as predictors of divergent thinking

The analyses above revealed that nature exposure produced higher creativity and originality in AUT and higher creativity in FIQ compared to urban exposure. Next, to justify possible mediation analyses, linear regression analyses tested which PRS-11 and emotional variables predicted creativity and originality in AUT and FIQ (with beauty and fluency as covariates). Each outcome variable was tested with separate models, including either the PRS-11 variables (fascination, being away, coherence, scope) or the emotional variables (positivity of emotions, relaxation, and arousal) as predictors. Table 3 reports the effects of the predictors. Only one of the effects was statistically significant: coherence predicted creativity in AUT, $\beta = -0.12$, 95 % CI [−0.23, 0.00]. However, because coherence did not differ between the videos (Table 2), it was not theoretically sound to test its mediation effects.

3.4. The PRS-11 and emotional variables as moderators

The moderation effects were analyzed with two sets of models on each outcome variable rather than examining each moderator separately. One set of models included the PRS-11 variables (fascination, being away, coherence, scope), and the other model set included the emotional variables (positivity of emotions, relaxation, arousal) as moderators. Table 4 lists these models' moderation effects (i.e., interactions).

Table 3
PRS-11 and emotional variables as predictors of creativity and originality in alternate uses task (AUT) and creativity in Figural interpretation quest (FIQ).

Task	Outcome	Predictor	β	*SE*	*t*	*p*
AUT	Creativity	Fascination	0.11	0.09	1.27	0.205
		Being away	−0.06	0.10	−0.63	0.527
		Coherence	−0.12	0.06	−2.02	0.045*
		Scope	0.12	0.08	1.53	0.126
		Positive	−0.03	0.07	−0.34	0.736
		Relaxation	−0.03	0.07	−0.42	0.674
		Arousal	−0.02	0.06	−0.28	0.778
	Originality	Fascination	−0.05	0.09	−0.55	0.582
		Being away	0.11	0.10	1.10	0.274
		Coherence	−0.10	0.06	−1.80	0.073
		Scope	0.10	0.07	1.32	0.187
		Positive	−0.11	0.07	−1.57	0.118
		Relaxation	0.07	0.07	0.95	0.341
		Arousal	−0.06	0.06	−0.99	0.324
FIQ	Creativity	Fascination	−0.03	0.09	−0.39	0.698
		Being away	−0.06	0.10	−0.58	0.564
		Coherence	0.02	0.06	0.42	0.677
		Scope	−0.02	0.07	−0.32	0.751
		Positive	−0.09	0.07	−1.25	0.211
		Relaxation	0.02	0.07	0.26	0.794
		Arousal	0.07	0.06	1.24	0.215

Note. *$p < .05$.

Four moderations were detected, all showing that the higher the value of the moderator, the larger the difference between the nature and urban conditions in the outcome variable. Fascination moderated the effect of exposure on originality in AUT with a relatively large effect size, B = 0.40 (Fig. 4a). Analysis of simple effects revealed that the nature video elicited higher originality than the urban one when fascination was high (M+1SD), B = 0.64, SE = 0.25, 95 % CI [0.15, 1.14], t(285) = 2.56, p = .011, whereas at mean level of fascination (B = 0.242, 95 % CI [−0.126, 0.61], or low level (M-2SD), B = -0.16, 95 % CI [−0.66, 0.34], no difference was detected. Fascination moderated the effect of video type on originality also in FIQ with a relatively large effect size, B = 0.40, 95 % CI [0.047, 0.749], t(283) = −2.23, p = .026 (Fig. 4b). Still, here, the difference between nature and urban conditions did not reach statistical significance at high, B = 0.406, 95 % CI [−0.11, 0.92], mean, B = 0.01, 95 % CI [−0.372, 0.393], or low, B = −0.385, 95 % CI [−0.904, 0.134], levels of fascination. However, the pattern of moderation is similar to that of originality in AUT. In addition, fascination moderated the effect of video type on flexibility in FIQ with an intermediate effect size, B = 0.35 (Fig. 4c). Nature video exposure produced higher flexibility in FIQ than urban exposure at a high level of fascination, B = 0.463, SE = 0.222, 95 % CI [0.03, 0.90], t(283) = 2.08, p = .038. No differences between the exposure conditions were detected at the mean level, B = 0.12, SE = 0.17, 95 % CI [−0.21, 0.44], t(283) = 0.72, p = .471, or low level, B = −0.23, SE = 0.22, 95 % CI -0.66, 0.21], t(283) = −1.01, p = .314, of fascination. Finally, relaxation moderated the effect of video exposure on flexibility in AUT with a medium effect size, B = 0.30 (Fig. 4d). Nature exposure produced higher flexibility than urban exposure at the high level of relaxation, B = 0.46, SE = 0.19, 95 % CI [0.09, 0.83, t(275) = 2.44, p = .015, but not at mean level, B = 0.16, SE = 0.15, 95 % CI [−0.14, 0.45], t(275) = 1.04, p = .300, or low level of relaxation, B = −0.15, SE = 0.20, 95 % CI [−0.54, 0.25], t(275) = −0.74, p = .461.

In summary, the higher the fascination, the higher the originality of the responses in AUT and FIQ, particularly after exposure to the nature video. In addition, high fascination was related to high flexibility in FIQ and high flexibility in AUT was related to relaxation after the nature video exposure.

4. Discussion

The current study examined whether exposure to nature videos, as opposed to urban videos, enhances creative thinking in verbal or visual modalities. Creativity (subjectively rated creative quality), originality (objectively measured semantic distance between the probe and response), flexibility (semantic distance between the responses), and fluency (the number of responses) were measured. We also aimed to investigate whether components of the ART (being away, fascination, scope, coherence) and SRT (positive emotions, relaxation) mediate or moderate the effects of the exposure on divergent thinking.

Our findings provide support for the positive impact of nature video exposure on creative divergent thinking, particularly using the verbal AUT ta sk. The influence of exposure to nature stimuli on divergent thinking in previous studies has been inconsistent, both in verbal (Batey et al., 2021; Kimura et al., 2023; Palanica et al., 2019; Palanica & Fossat, 2022; Studente et al., 2016; Yeh et al., 2022) and figural (Studente et al., 2016; Van Rompay & Jol, 2016; Yeh et al., 2022) divergent thinking. Our results suggest that both verbal and figural divergent thinking are positively influenced by nature video exposure, compared to urban video exposure. In verbal AUT, the subjectively rated creative quality and objectively assessed originality of responses were statistically significantly enhanced, whereas in figural FIQ, only creativity was influenced.

The different effects observed between the verbal AUT and the visual FIQ tasks may be attributable to the cognitive processes involved. Verbal creativity tasks, such as AUT, use common objects as probes. Therefore,

Table 4
PRS-11 Variables (Fascination, Being away, Coherence, Scope) and Emotional Variables (Positivity of emotions, Relaxation, Arousal) as Moderators of the Effects of Nature Exposure on Divergent Thinking.

Outcome	Moderation	Alternate Uses Task			Figural Interpretation Quest		
		B	95 % *CI*	*p*	*B*	95 % *CI*	*p*
Creativity	Video*Fascination	0.11	−0.23–0.46	0.517	0.30	−0.03–0.63	0.075
	Video*Being away	−0.12	−0.57–0.32	0.584	−0.20	−0.62–0.22	0.357
	Video*Coherence	−0.01	−0.27–0.25	0.936	−0.22	−0.46–0.03	0.083
	Video*Scope	0.17	−0.16–0.50	0.317	0.00	−0.32–0.33	0.983
	Video*Positive	0.25	−0.04–0.54	0.093	0.19	−0.08–0.47	0.172
	Video*Relaxation	−0.21	−0.49–0.06	0.130	−0.08	−0.34–0.19	0.573
	Video*Arousal	−0.06	−0.31–0.19	0.641	0.16	−0.08–0.39	0.185
Originality	Video*Fascination	0.40	0.07–0.74	0.019*	0.40	0.05–0.75	0.026*
	Video*Being away	−0.25	−0.68–0.18	0.260	−0.19	−0.64–0.26	0.405
	Video*Coherence	0.00	−0.25–0.24	0.970	0.07	−0.18–0.33	0.572
	Video*Scope	−0.17	−0.50–0.15	0.290	0.01	−0.33–0.36	0.938
	Video*Positive	0.03	−0.25–0.31	0.822	0.20	−0.09–0.49	0.181
	Video*Relaxation	0.00	−0.26–0.27	0.974	−0.03	−0.31–0.25	0.828
	Video*Arousal	0.03	−0.22–0.27	0.832	−0.07	−0.32–0.18	0.583
Flexibility	Video*Fascination	−0.01	−0.32–0.30	0.957	0.35	0.05–0.64	0.023*
	Video*Being away	0.20	−0.20–0.60	0.335	−0.33	−0.71–0.05	0.091
	Video*Coherence	−0.08	−0.32–0.15	0.490	−0.14	−0.36–0.08	0.201
	Video*Scope	−0.05	−0.35–0.25	0.746	−0.09	−0.39–0.20	0.530
	Video*Positive	−0.08	−0.34–0.17	0.527	0.11	−0.14–0.35	0.399
	Video*Relaxation	0.30	0.06–0.55	0.015*	0.05	−0.18–0.29	0.656
	Video*Arousal	−0.07	−0.30–0.15	0.530	0.02	−0.19–0.24	0.821

Note. The moderations by PRS-11 variables (fascination, being away, coherence, scope) are from models where they were all simultaneously included with their interactions with video type. The moderations by emotional variables (positive emotions, relaxation, arousal) are from models where they were all included with their interactions with video type. *$p < .05$.

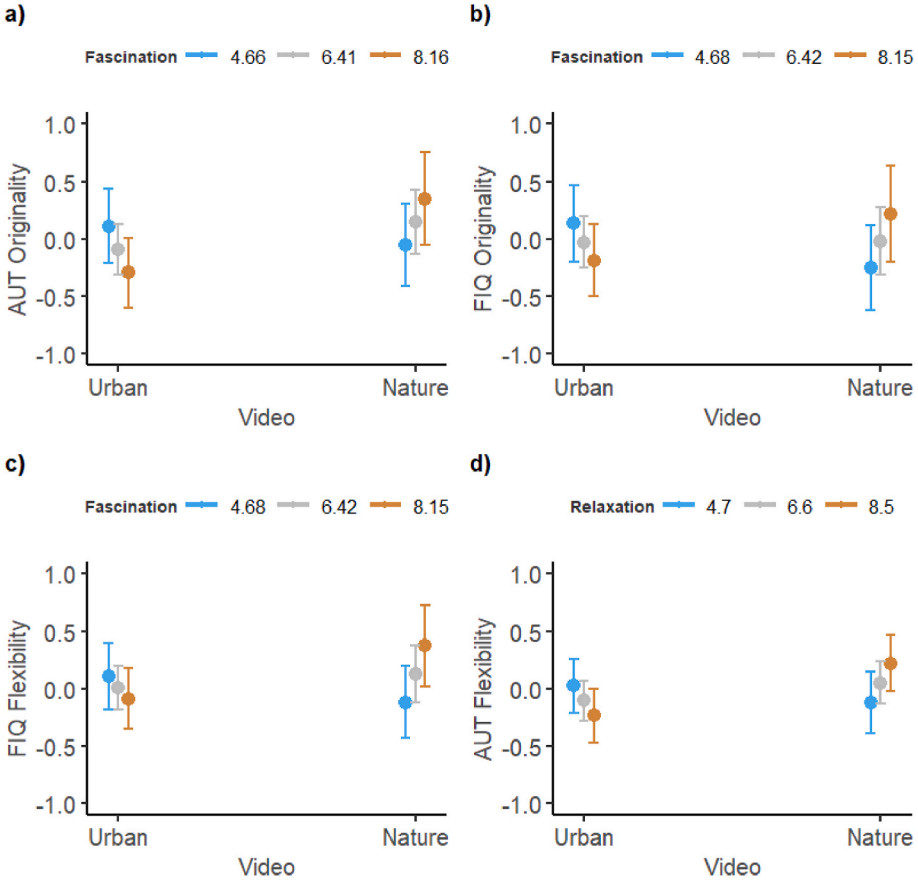

Fig. 4. The moderation effects. Fascination moderated the effects of video type on originality in (a) AUT and in (b) Fiq, and on (c) flexibility in Fiq. (d) Relaxation moderated the effect of video on flexibility in AUT
Note. The values of the outcome variables in y-axis represent standardized values. Error bars show 95 % confidence intervals. The colors blue, gray, and brown represent low (mean – 1SD), mean, and high (mean + 1SD) levels of the moderator, respectively.

they rely heavily on semantic memory and associative processes (Beaty & Kenett, 2023), which may be more sensitive to affective states induced by nature exposure. Positive emotions are known to broaden cognitive scope and facilitate flexible thinking (Fredrickson, 2001), which could enhance performance on tasks like the AUT (Isen et al., 1987). In contrast, visual creativity tasks like FIQ use abstract, unfamiliar figures as probes and require perceptual processing and spatial reasoning (Koutstaal et al., 2024). The concurrent exposure to videos during the execution of the FIQ task engages overlapping visuo-spatial cognitive processes, potentially inducing a higher cognitive load compared to performing a verbal task during video presentation. This increased demand on visuo-spatial working memory resources (Baddeley, 2012) may have constrained the potential cognitive benefits associated with nature video exposure, thereby attenuating its positive effects on visual creative performance. The dissociation between improved creative quality (rated by independent raters) and unchanged originality (measured as the semantic distance from the most common responses) in the figural task may reflect a task-specific limitation of how originality was measured. While semantic distance is a useful metric for verbal tasks grounded in language and associative meaning (such as the AUT) (Beaty & Johnson, 2021), it may underrepresent originality in visually-driven tasks like the FIQ (Erwin et al., 2022). In figural tasks, creativity often emerges through perceptual richness, metaphorical insight, or imaginative visual interpretation—dimensions more likely to influence holistic quality ratings by independent raters than to be captured by language-based semantic distance. Thus, nature exposure may have enhanced the depth and coherence of interpretations without substantially altering their measurable semantic deviation.

Following our pre-registered hypotheses, we investigated the potential mediation and moderation effects of nature video exposure on divergent thinking: specifically, whether the effects occur due to positive emotions and relaxation (as suggested by SRT, Ulrich et al., 1991)) or the components of ART (Kaplan, 1995) such as fascination, being away, coherence, and scope. Our results indicated that, despite nature videos leading to increased levels of fascination, being away, scope, positive emotions, and relaxation, these variables did not mediate the effects of nature exposure on divergent thinking tasks. This outcome contrasts with the predictions of ART and SRT, which suggest that the restorative qualities of natural environments and the positive emotional states they induce should facilitate cognitive functions such as creativity (Fredrickson, 2001; Kaplan & Kaplan, 1989; Ulrich et al., 1991).

One explanation for the lack of mediation effects might be that the different components interact in complex ways when they enhance creative thinking, and such effects were not detected by our analyses. For example, it is known that the effects of mood on creativity depend on the interplay of emotional, motivational, and cognitive components (Baas et al., 2008). It also remains possible that the ART and SRT components, as measured in this study, may not have been the primary mechanisms driving the enhancement in divergent thinking, and other unmeasured factors played a more critical role. For instance, exposure to nature videos might have triggered implicit cognitive or affective processes not captured by our measures of perceived fascination, being away, scope, positive emotions, or relaxation. Additionally, the measures used to assess the ART and SRT components might not have been sensitive enough to detect subtle variations that could mediate the relationship between nature video exposure and creative thinking.

Although the mediation hypothesis was not supported, moderation analyses revealed that individual differences in specific ART components and emotional states influenced the extent of the influence of exposure to nature videos on divergent thinking. Specifically, the fascination component was found to moderate the effect of nature video exposure on originality in both the AUT and FIQ tasks with intermediate to strong effect sizes. Participants who reported higher levels of fascination with the nature videos demonstrated greater originality than those who were less fascinated. Similarly, fascination moderated the effect of nature video exposure on flexibility in the FIQ, and relaxation moderated the effect on flexibility in the AUT.

These findings suggest that individual differences in the subjective experience of nature exposure may significantly promote divergent thinking. The moderating roles of fascination and relaxation partially support ART and SRT. ART suggests that environmental stimuli evoking soft fascination allow for the replenishment of directed attention resources, enhancing cognitive functions such as creativity. Our findings that fascination moderated the effects of nature video exposure on originality and flexibility align with this aspect of ART, suggesting that when individuals are more captivated by natural stimuli and perceive them as interesting and stimulating, they may experience more cognitive benefits and be more inspired to creative thinking. Similarly, SRT highlights the role of positive emotional states and physiological relaxation in restoring cognitive functioning. The moderation by relaxation on flexibility in the AUT suggests that individuals who felt more relaxed after viewing nature videos exhibited greater cognitive flexibility, an important component of creative thinking. Relaxation reduces stress, increases brain's alpha power, and activates the Default Mode Network, promoting divergent and flexible thinking (Baas et al., 2008; Beaty et al., 2016; Fink & Benedek, 2014; Fredrickson, 2001). In the present study, the moderation by relaxation was specifically related to flexibility of verbal divergent thinking in AUT, that is, in producing different kinds of uses for familiar objects.

The absence of mediation effects from ART and SRT components suggests that restorative mechanisms alone may not fully explain the cognitive benefits of nature exposure. This invites the consideration of alternative theoretical frameworks. One such model is the Dual Pathway to Creativity Model (DPCM) (De Dreu et al., 2008; Nijstad et al., 2010), which posits that creative thinking can be facilitated via two distinct cognitive pathways: cognitive flexibility and cognitive persistence. The flexibility pathway is related to creativity through the use of broad and inclusive cognitive categories, flexible switching among categories, approaches, and sets, and through the use of remote associations. Thus, cognitive flexibility is viewed in DPCM as a broader concept than the one typically used in scoring the divergent thinking tasks. In the persistence pathway, creative ideas and solutions are obtained through systematic and effortful exploration of possibilities, and in-depth exploration of only a few categories or perspectives.

According to DPCM, positive and activating mood states, such as happiness and inspiration, activate the flexibility pathway and thus enhance creativity, whereas negative active mood states (e.g., anger, fear), on the other hand, lead to creativity because they stimulate persistence (Baas et al., 2008; Nijstad et al., 2010). Similarly, the Broaden-and-Build Theory (Fredrickson, 2001; Fredrickson & Branigan, 2005) posits that positive emotions (like joy, interest, awe, and contentment) may enhance creative performance because they broaden an individual's scope of attention and thought–action repertoire (e.g., being more exploratory, open, and creative). In the context of the present findings, the exposure to nature videos may have facilitated creative performance primarily by activating the use of the flexibility pathway and broadening attention. Nature's ability to elicit positive emotions and states of fascination may have supported a more exploratory and associative mindset, aligning with the flexibility pathway. This is particularly relevant given that verbal divergent thinking relies heavily on associative semantic networks (Beaty & Kenett, 2023), which are more responsive to broadened attentional states. Importantly, the DPCM accommodates the role of affectively driven individual differences and situational factors (Nijstad et al., 2010), consistent with the present finding that fascination moderated the effects of nature exposure on originality and flexibility. DPCM assumes that different states or traits may be associated with creativity because they influence cognitive flexibility, cognitive persistence, or both. Thus, rather than being a passive consequence of restoration, fascination may act as a motivational-cognitive amplifier that drives engagement along the flexibility pathway. This supports a shift in emphasis from viewing nature's effects solely through the restorative mechanisms of ART and SRT

to a motivational-cognitive view that integrates affective engagement and creative cognition.

4.1. Limitations and future directions

Several limitations of the study should be acknowledged. First, the brief duration of the video exposure may not have been sufficient to produce sufficiently robust restorative effects. Previous research suggests that longer exposure durations may be necessary to observe significant cognitive benefits from nature exposure (Stevenson et al., 2018). Future studies should consider extending the duration of exposure to assess whether longer periods yield stronger effects.

Second, the continuous presentation of the videos during the divergent thinking tasks, which were presented and responded to simultaneously on the screen, may have introduced an unintended cognitive load, particularly in the visual domain. Unfortunately, the study did not include any task load index, such as NASA-TLX (Hart & Staveland, 1988). The inclusion of such an index in future research could provide valuable insights into the lack of mediation observed especially in visual creativity, as visual processes were loaded simultaneously by the video and the figural creativity task. In addition, separating the exposure phase from the task performance phase could help to isolate the effects of nature exposure on creativity without the confounding influence of simultaneous visual stimuli. This approach would align with prior studies that have found cognitive benefits when the restorative environment is experienced only prior to cognitive tasks where performance is evaluated (Berman et al., 2008). However, please note that the effect sizes of the possible cognitive benefits of nature exposure are typically small (Ohly et al., 2016), and studies that have used cognitive tasks to evaluate performance only after exposure to virtual natural stimuli in laboratory settings, have often failed to replicate these findings (Grassini et al., 2019; 2022, Johnson et al., 2021)

Third, using videos instead of authentic or immersive natural environments limits the sensory modalities engaged during exposure, potentially reducing ecological validity. Real-life nature experiences involve multisensory engagement, including auditory, olfactory, and tactile stimuli, which may contribute to the restorative effects (Ratcliffe et al., 2013, 2022). However, Palanica et al. (2019) did not detect any difference in divergent thinking between real nature and nature video conditions. In addition, several studies have shown that brief exposure to nature images and videos in laboratory settings produces detectable psychological and physiological effects in participants (Grassini et al., 2019, 2022, Koivisto et al., 2024, for a review see Stevenson et al., 2018).

Moreover, the sample consisted of participants recruited online through the Prolific platform, which, while providing a more diverse participant pool compared to traditional experiments in the field of psychology (mainly including the student population), may still not represent the general population. Factors such as screen size, viewing conditions, and participant distractions in uncontrolled environments could have influenced the results in unpredictable and difficult-to-predict ways, making mitigation challenging. Although such uncontrolled variations in conditions produce noise that may reduce the detectability of some effects, on the positive side, the variability also increases the generalizability of the results. Additionally, participants in Prolific are generally known to provide high-quality data (Peer et al., 2017). Comparisons of results from online vs. laboratory conditions have shown that participants in online platforms perform similarly to participants in traditional laboratory experiments (Dandurand et al., 2008; Prissé & Jorrat, 2022). To obtain high-quality data in online experiments, one needs to screen out the results of inattentive participants, which was done in the present study by including control tasks requiring responses within a specified time limit.[1]

4.2. Practical implications and conclusion

Despite the limitations, the present findings have practical implications for incorporating natural elements into environments where creativity is critical. Interventions designed to foster creativity should aim not only to expose individuals to natural environments, but also to evoke specific affective and attentional states, such as fascination and activating positive emotions, which might activate flexible and broad mindsets. For example, workplaces and educational settings could integrate nature-inspired designs (Batey et al., 2021), promote access to green spaces through window views (Studente et al., 2016), or include brief virtual nature experiences or breaks before tasks that require idea generation or divergent thinking (Koivisto et al., 2024). Innovation teams or sessions might begin with nature videos, rated to be highly inspiring and fascinating, as cognitive primers to creative thinking. Urban planners and architects could consider biophilic design principles (e.g., nature-based digital art) to create environments that support cognitive functioning, creativity, and well-being (Kellert, 2005; Soares et al., 2022). It would be important to recognize individual differences and plan interventions that are personalizable and adaptive, allowing the persons select the elements that they experience as stimulating and fascinating.

In conclusion, the present study contributes to the current scientific literature, suggesting that exposure to natural environments in the form of videos can enhance certain aspects of creative thinking, particularly in the verbal domain. While the perceived restorative qualities of nature videos, as proposed by ART and SRT, did not mediate the effects as hypothesized, the moderation effects of fascination and relaxation indicate that individual engagement with the natural stimuli plays a significant role in the cognitive benefits received.

CRediT authorship contribution statement

Mika Koivisto: Writing – review & editing, Writing – original draft, Visualization, Supervision, Software, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Iida Lahnalahti:** Methodology, Investigation, Formal analysis, Data curation. **Ida Malmberg:** Methodology, Investigation, Formal analysis, Data curation. **Simone Grassini:** Writing – review & editing, Writing – original draft, Supervision, Methodology, Conceptualization.

Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this work the authors used ChatGPT4 in order to improve readability and as as aid to search relevant literature. The authors reviewed and edited the content of the present article., and the authors take full responsibility for the content of the publication.

[1] We had preregistered the control tasks requiring a simple button press within 5 s to prompts presented during the video exposure. However, because it turned out that some of the participants failed consistently to respond within required time (15 s) to the PRS-11 questions during the video exposure, we had to include also the responding within the time limit of 15 s to the PRS-11 questions as an attention check.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jenvp.2025.102699.

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