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Growing Natural Connections: The Effects of Modality and Type of Nature on Connectedness to Nature

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ABSTRACT

An important predictor of pro-environmental attitudes and behavior is connectedness to nature. However, current research lacks consensus on how to effectively cultivate it in individuals, particularly with media messages. To address this gap, this study investigated how the modality of nature experiences and type of nature influence connectedness to nature in young adults. Data collection involved 164 undergraduate students at a Singapore university who participated in a 2 (modality: physical tour vs video tour) × 2 (nature type: forested area vs botanic garden) factorial experiment. Results showed that nature type did not affect connectedness to nature, nor did fear or disgust mediate that linkage. However, connectedness to nature was higher among participants who took the physical tour than among those who watched the video tour. This effect is consistent with past research and suggests that mediated experiences of nature diminish the richness of sensory experience. It reaffirms the importance of directly experiencing nature as a part of environmental communication and education to promote environmental stewardship.

KEYWORDS

Connectedness to nature; nature tours; mediated experience; negative emotion; environmental education

Human activity often harms the environment (Wuebbles et al., 2017) and it is important for individuals to form attitudes and engage in behaviors that safeguard the environment and ensure the sustainable management of ecosystems and natural resources (Lange & Dewitte, 2019; Steg & Vlek, 2009). Environmental communication and education are valuable in this context because they enable individuals to work toward and achieve a more ecological way of life (Roczen et al., 2013). Although many factors can influence pro-environmental attitudes and behaviors, several studies have focused on knowledge acquisition (e.g. Farmer et al., 2007; Jensen, 2002; Schneiderhan-Opel & Bogner, 2020; Zsóka et al., 2013). Some of those studies also focused on connectedness to nature, which broadly reflects an emotional feeling of bond with nature. There are different factors that may promote connectedness to nature, such as participating in nature activities (Barton et al., 2016; Ward-Smith et al., 2020), the frequency and duration of visits to nature (Braun & Dierkes, 2017; Schultz & Tabanico, 2007), the experience of nature through the media (Smith et al., 2018; Sneed et al., 2021), and the type of nature individuals experience (Wyles et al., 2017). Despite the breadth of work in this area, there is a lack of consensus on how to effectively cultivate connectedness to nature (Lengieza & Swim, 2021).

The present study contributes new research on the effects of the *modality* and *type* of nature experiences as factors that may support connectedness to nature. Modality of nature refers to whether an experience of nature is direct (i.e. firsthand) or mediated (i.e. via communication media). There have been a few

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studies looking at the effects of modality, but with mixed conclusions (Mayer et al., 2009; Smith et al., 2018; Sneed et al., 2021), presenting a research opportunity. Type of nature, as it concerns this study, refers to the extent to which a natural space is manicured. In this regard, a wild forest and a botanic garden are different types of nature because the former is not manicured, and the latter is. There is sparse research on the relationship between type of nature and connectedness to nature and, where it exists, the findings are inconclusive (Wyles et al., 2017). Although the experience of wild nature may result in more connectedness to nature because of "higher quality" green and blue spaces (Wyles et al., 2017), it can also lead to negative emotions like fear and disgust (Bixler & Floyd, 1997; Lin et al., 2018). Other research suggests manicured natural spaces evoke positive emotions like tranquility (Martens et al., 2011). There is a need for additional research to clarify the role of type of nature. Finally, we extend prior research by considering how fear and disgust may mediate the effects of nature modality and type on connectedness to nature, which some work has hinted (Anderson et al., 2017; Schutte et al., 2017).

Connectedness to nature

Individuals who have more environmental knowledge (e.g. about the concepts of ecosystems and sustainable development) have more environmental concern and more positive attitudes toward pro-environmental behaviors (Janmaimool & Khajohnmanee, 2019). So, it is unsurprising that environmental communication and education often seek to impart different kinds of knowledge (Gurevitz, 2010; Kao et al., 2017). However, there is evidence that environmental knowledge explains minimal variance in pro-environmental behavior (Geiger et al., 2019). Environmental communication and education should therefore go beyond the transmission of knowledge.

Connectedness to nature, or the "perceived closeness in the relationship between an individual and nature" (Otto & Pensini, 2017, p. 89) can supplement knowledge-based interventions and motivate individuals to engage in pro-environmental behaviors (Mackay & Schmitt, 2019; Whitburn et al., 2019). Not only is connectedness to nature a better predictor than knowledge acquisition of pro-environmental behavior, but it can motivate individuals to acquire environmental knowledge (Otto & Pensini, 2017; Roczen et al., 2013). There is also evidence that environmental management efforts, such as nature conservation, can benefit from understanding with what aspects of nature or locales members of the public feel a connection (Restall et al., 2021).

Connectedness to nature is multidimensional and may reflect affect, cognitions, and behaviors, among others (Mayer & Frantz, 2004; Schultz, 2002). The affective dimension is related to an emotional feeling of a bond with nature, the cognitive aspect is related to a sense of identity, and the behavioral dimension is related to actions individuals take to protect nature. Within the affective and cognitive dimensions, scholars have conceptualized connectedness to nature as a trait (Mayer et al., 2009; Mayer & Frantz, 2004), attitude (Roczen et al., 2013), and disposition (Brügger et al., 2011). On the behavioral dimension, individuals can engage in nature conservation directly or be involved in policy decisions concerning environmental planning and management (Restall & Conrad, 2015).

There is consensus that connectedness to nature derives from experience (Mayer & Frantz, 2004; Nisbet et al., 2008), particularly, an accumulation of positive experiences of nature (Hinds & Sparks, 2008; Kals et al., 1999). For example, Ballew and Omoto (2018) found that individuals who spent time in a natural environment versus a built environment felt more absorbed in nature and experienced more positive emotions, including awe. Such experiences can lead to trait-like connectedness to nature, which is an individual characteristic that remains stable over time (Schmitt & Blum, 2020). But connectedness to nature can also be state-like, where individual experiences may produce a more transient feeling (Mayer et al., 2009). For instance, Nisbet and Zelenski (2011) found that individuals who completed an arboretum tour reported feeling a stronger "current relationship" with nature than those who took a tour of indoor spaces. Although trait-like connectedness to nature is desirable for its persistence, it is the result of repeated nature experiences, each of which generates a state-like response. Therefore, it is useful to understand how different kinds of experiences can produce stronger state-like connectedness to nature.

Modality of nature experiences

Individuals can have direct and indirect experiences of nature, which pertains to the *modality* of nature. Direct experiences involve being physically present in natural spaces, such as parks and forests. Indirect experiences often involve communication, which can include descriptions, photographs, videos, and digital games about nature, among other media. These mediated experiences provide individuals with opportunities to encounter and interact with nature without being physically present (Dobrin & Morey, 2019; Freeman & van Heezik, 2018).

Media use can be both negatively and positively associated with connectedness to nature. Some studies reported that spending more time looking at digital screens has led to a decline in connectedness to nature (Larson et al., 2018; Pergams & Zaradic, 2006). This may be a byproduct of videophilia, where individuals are drawn to more sedentary activities revolving around digital screens, displacing biophilia, or a preference for activities in natural spaces (Lowell, 2008). A related concept is nature deficit disorder, according to which physical and emotional health worsens when screen time displaces green time during childhood and adolescence (Louv, 2005). Both videophilia and nature deficit disorder are negatively related to environmental concern (Kareiva, 2008; Pergams & Zaradic, 2008), and some research shows a link between screen time and lower levels of connectedness to nature (Bashan et al., 2021; Richardson et al., 2018).

In contrast to those studies, which focused on general use of digital media, people can also use the media to have convenient experiences of nature without being physically present. Although mediated experiences of nature might not have the same sensory richness as direct experiences when it comes to seeing, hearing, smelling, and touching nature, there is evidence that using images (Coughlan et al., 2022), videos (Yang et al., 2018), and immersive media (Breves & Heber, 2019) to experience nature can instill more connectedness to nature. There is also some evidence that using digital games to create virtual engagement may result in more affective commitment to environmental causes than direct experiences of nature (Fletcher, 2017).

Yet only a handful of studies have compared direct versus mediated experiences of nature and their influence on connectedness to nature. For example, Smith et al. (2018) found that direct experiences of nature and immersive videos of nature did not result in different levels of connectedness to nature among study participants. In contrast, Sneed et al. (2021) found that direct experiences of nature resulted in higher levels of connectedness to nature than did immersive videos of nature. That latter finding is consistent with Kjellgren and Buhrkall (2010), who observed that direct experiences are related to feelings of "harmony and union with nature," while mediated experiences are related to feelings of being "cut off from nature's sensory input" and a "longing to be in 'real' nature" (p. 464). Other scholars have drawn similar conclusions (Richardson et al., 2015; Russell et al., 2013) and there is growing consensus that direct experiences of nature are superior to mediated experiences in the formation of connectedness to nature. We aim to add to that consensus with our first hypothesis concerning the modality of nature (see Figure 1):

> Hypothesis 1: Connectedness to nature will be higher among individuals who participate in a guided tour of a natural setting than among those who watch a video tour of the same natural setting.

The influence of type of nature

Experiences of nature can also vary by how much the setting is manicured or wild, which is a difference of *type* of nature. Manicured spaces refer to "neatly trimmed natural environments that are easy to understand," while wild spaces are "unstructured natural environments that can be difficult to understand and navigate" (Davis & Gatersleben, 2013, p. 93). For example, botanic gardens are typically more manicured and naturally forested areas are typically wilder.

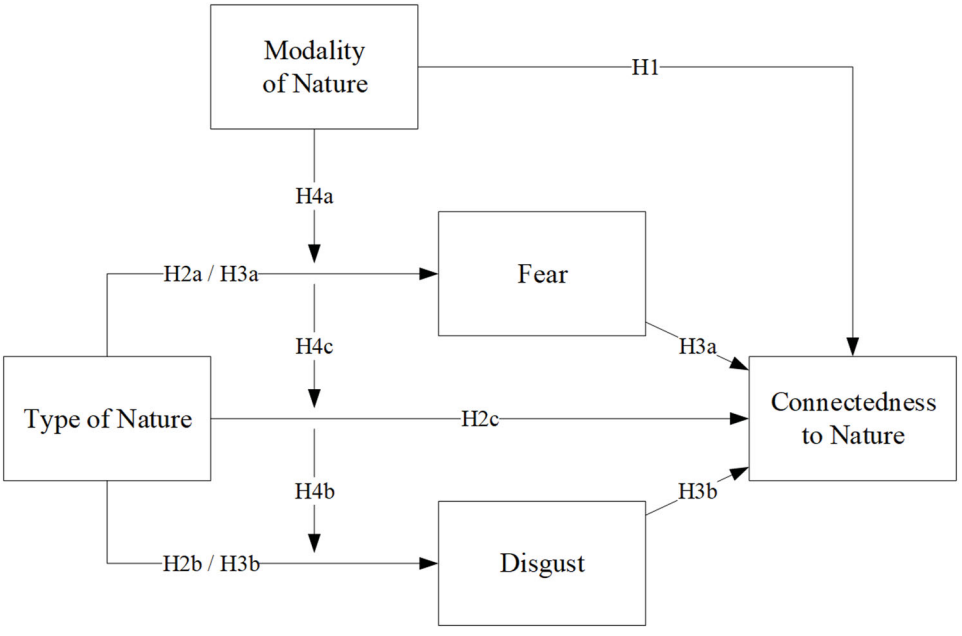

Figure 1. Hypothetical model.

Research has shown that individuals are often fearful of or disgusted by natural elements more prevalent in wild nature, such as dirt and "creepy" animals like snakes and spiders (Bixler & Floyd, 1997; Lin et al., 2018). Such responses align with the concept of biphobia, or the fear of natural spaces (White, 2004). Natural environments often have complex and dense structures (e.g. the foliage and undergrowth in a thick forest), which can enhance perceived danger (Andrews & Gatersleben, 2010; Milligan & Bingley, 2007). In contrast, manicured spaces contain fewer disgusting, scary, or dangerous elements. Individuals are less likely to have fearful responses to manicured spaces, facilitating their interaction with natural elements (Lin et al., 2018).

The experience of fear or disgust of nature may lead to lower connectedness to nature. This is because connectedness to nature is partly rooted in the affective domain of the psyche (McAllister et al., 2017), and unpleasant affective states like fear and disgust can inhibit its formation and growth (Knight, 2008). These states may be more likely to arise in a forested area than in a botanic garden because of the relative preponderance of dirt, critters, and other unkempt aspects of the forest. As Lengieza and Swim (2021) explained, "contact with the 'bugs and mud' of nature might create an aversive experience that counteracts the usually positive effect of nature, perhaps because such exposure feels threatening" (p. 14). As a general disposition, being afraid of nature is negatively related to trait-like connectedness to nature (Lumber et al., 2017). Germane to the current study, there is some evidence that induced feelings such as disgust and fear of nature are negatively related to state-like connectedness to nature (see Study 2 in Mayer et al., 2009). This suggests that exposure to "bugs and mud" may trigger negative emotions that reduce state-like connectedness to nature. Taking the reasonable assumption that such experiences are more likely to arise in wilder spaces than in more manicured ones, we propose two more hypotheses (see Figure 1):

Hypothesis 2: Individuals who tour a forested area will report experiencing (a) more fear, (b) more disgust, and (c) lower connectedness to nature than individuals who tour a botanic garden.

Hypothesis 3: The relationship between type of nature and connectedness to nature will be mediated by (a) fear and (b) disgust.

The conditional influence of type of nature

The preceding examples involved direct experiences of wild nature. Do those effects remain when people have mediated experiences of nature? We suggest those effects depend somewhat on the richness of direct experience, and the negative affective states that may arise in certain nature experiences would attenuate when the experiences are mediated. This argument is consistent with research showing that people experience lower levels of negative affect when they have mediated experiences of nature than when they have direct experiences (e.g. Anderson et al., 2017; Schutte et al., 2017). Other research has shown that augmented and virtual reality can help reduce fear of animals like spiders and cockroaches (Botella et al., 2016; Suso-Ribera et al., 2019). Thus, we expect that the effect of type of nature on connectedness to nature and its mediation through fear and disgust are conditional on the modality of nature. Specifically, we propose:

> Hypothesis 4: The effects of type of nature on (a) fear, (b) disgust, and (c) connectedness to nature will be weaker among individuals who watch a video tour than among individuals who participate in a physical tour.

Methods

Participants

After obtaining approval from the school-level Ethics Review Committee at Nanyang Technological University, Singapore (FYP202021S1-046), we collected data from a convenience sample of Singapore university undergraduates through school-wide email blasts, social messaging channels, and physical posters. The recruitment materials advertised that we were looking for undergraduate students to participate in a "nature experience" and stated that participants would either take a guided nature walk or view a video recording of one. During sign-ups, we excluded individuals who reported previously taking a tour of the botanic garden at the university where this research took place. Out of 214 individuals who signed up, 164 participated in the study. Participants had an average age of 22.1 years ($SD = 1.59$). Most reported they were female (68.3%), followed by male (31.1%) and other (0.6%). Their nationalities included Singaporean (74.4%), Singapore permanent resident (4.9%), and foreigner (20.7%). Upon completion of the study, we selected 30 participants at random to receive $10 food delivery vouchers.

Design and procedure

We employed a pretest-posttest 2 (direct vs. mediated experience) × 2 (forested area vs. botanic garden) factorial experimental design. Participants used the sign-up form to choose a tour session according to their availability. Then we randomly assigned each session to one of the four conditions. There were 41 participants who took a tour of the forested area, 44 participants who watched a video tour of the forested area, 40 participants who took a tour of the botanic garden, and 39 participants who watched a video tour of the botanic garden.

Experimental sessions took place in Singapore from 10 January to 18 February 2022. Each session lasted roughly 30 min. After arriving for a session, participants gave their informed consent and received a unique participant ID and a link to the pretest survey, which they completed on their personal smartphones. The pretest survey included a measure of trait-like connectedness to nature and demographics items. Upon completing the pretest surveys, the participants took a scripted physical or video tour. Four of the researchers were undergraduate students, who rotated tour guide assignment. The sessions had between one and four participants. When a session had only one participant, one of the student researchers – excluding the guide – pretended to be a participant to give the impression of group sessions. The tours took roughly 10 min, at the end of which participants completed the posttest questionnaire measuring their state-like connectedness to nature and feelings of fear and disgust.

We note that Singapore is a low-lying Equatorial country with summer-like weather throughout the year. In the event of rain during a scheduled physical tour, we canceled it and asked the participants to sign up for a different session. That happened only one time during the duration of data collection. Since the occurrence of rain is highly unpredictable and participants remained blind to the experimental treatment of the new session, such swapping was unlikely to have induced a systematic bias in the data.

Manipulation

The manipulation of modality of nature involved participants either going on a guided tour of a physical nature space (direct experience) or watching a prerecorded video that followed the tour guide (mediated experience). Figures 2 and 3 show photographs of the nature spaces participants visited in the direct experience condition. Figure 4 shows the classroom where participants in the mediated experience condition watched the video tours. Both the direct and mediated versions of the tours followed a designated path and at a set pace and involved scripted descriptions of five species of flora that the tour passed (see Appendices A and B for the scripts).

The manipulation of type of nature involved a tour of either a forested area adjacent to the university where this research took place (Figure 2) or a botanic garden located on campus (Figure 3). We note that the forested area was secondary growth. Singapore's primary forests have been reduced by more than 99% and none of the primary forest areas is near the university where this study took place (see Noreen & Webb, 2013). We selected an area adjacent to the university because reaching it required about the same amount of travel as reaching the botanic garden or classroom. This reduced the confound of convenience, which we prioritized.

Measures

Pretest

We used the Connectedness to Nature Scale (Mayer & Frantz, 2004) to measure trait-like connectedness to nature. An example measurement item is "I often feel a sense of oneness with the natural world around me." Response options ranged from 1 (*strongly disagree*) to 5 (*strongly agree*). After

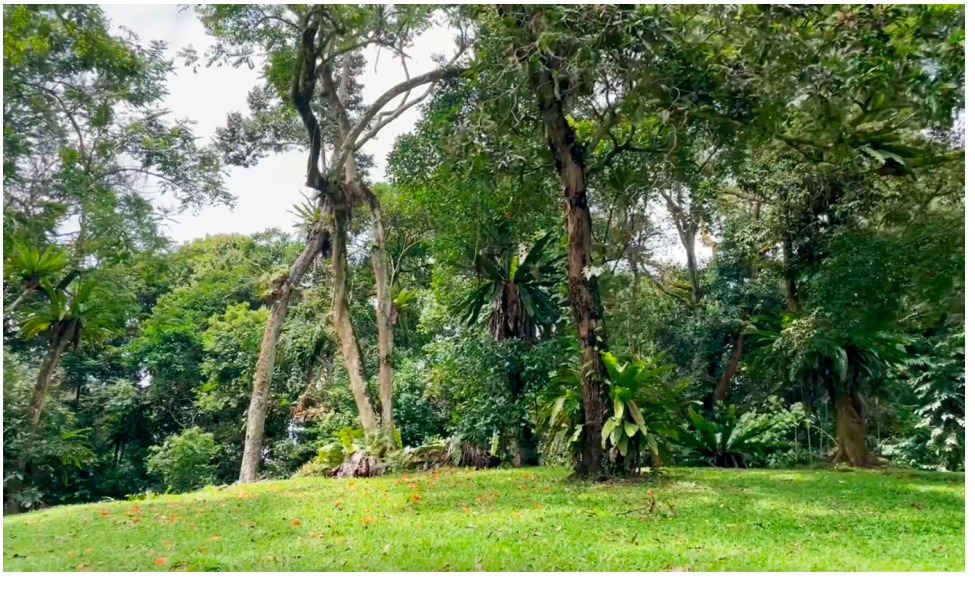

Figure 2. Forested area setting.

Figure 3. Botanic garden setting.

removing two items due to poor reliability, the remaining 13 items had acceptable reliability (M = 3.43, SD = 0.53, Cronbach's α = .80). We used this measure to assess random treatment assignment and as a covariate in our hypothesis testing.

Posttest

Following Mayer et al. (2009), we modified the Connectedness to Nature Scale to measure state-like connectedness to nature to indicate a current state (e.g. "currently") rather than a general one (e.g. "often"). Response options ranged from 1 (*strongly disagree*) to 5 (*strongly agree*). We removed two

Figure 4. Video tour setting.

items parallel to those we removed from the pretest and the remaining 13 items had good reliability ($M = 3.75$, $SD = 0.61$, Cronbach's $\alpha = .89$).

The posttest also included three items measuring fear ($M = 1.51$, $SD = 0.69$, Cronbach's $\alpha = .78$) and two items measuring disgust ($M = 1.34$, $SD = 0.58$, Spearman-Brown $r = .81$) that participants felt during the nature experience. Examples of these items are "During the experience, I felt fearful" and "During the experience, I felt grossed out." Response options ranged from 1 (*strongly disagree*) to 5 (*strongly agree*). None of the items were reverse-coded and we averaged them so that a higher score indicated higher levels of fear and disgust.

Two of the items measuring trait- and state-like connectedness to nature were reverse-coded. None of the measures of fear or disgust were reverse-coded. The higher the score of the composite measure, the stronger the trait- and state-like connectedness to nature and the higher the levels of fear and disgust. Appendices C and D contains the wordings, means, and standard deviations of the measurement items. Table 1 contains the correlations and descriptive statistics of the composite variables.

Analytical approach

We assessed random assignment using one-way ANOVA on trait-like connectedness to nature. We used a two-way univariate MANCOVA with main effects to test hypotheses 1 and 2, and with the 2×2 treatment interaction to test hypothesis 4. The dependent variables were state-like connectedness to nature, fear, and disgust. Trait-like connectedness to nature was a covariate and modality of nature (0 = *physical tour*, 1 = *virtual tour*) and type of nature (0 = *botanic garden*, 1 = *forested area*) were fixed factors. We probed significant main effects using an independent samples *t*-test and reported unadjusted means for simpler presentation and interpretation. We used Model 4 of the PROCESS macro in SPSS to test hypothesis 3. We estimated standardized parameters using 5,000 bootstrap samples and requested 95% confidence intervals. State-like connectedness to nature was the dependent variable, trait-like connectedness to nature was a covariate, fear and disgust were mediators, and type of nature was an independent variable.

Results

The one-way ANOVA showed that trait-like connectedness to nature was not different among the four experimental groups, $F(3,160) = 1.36$, $p = .257$, suggesting random group assignment was successful. The MANCOVA multivariate tests showed significant main effects on state-like connectedness to nature of trait-like connectedness to nature, $F(3,158) = 25.07$, $p < .001$, $= .323$, and modality of nature, $F(3,158) = 9.54$, $p < .001$, $\eta_p^2 = .153$. The main effect of type of nature was non-significant, $F(3,158) = 1.17$, $p = .325$. The additional interaction of modality and type of nature was also non-significant, $F(3,157) = 0.57$, $p = .638$. Table 2 shows the means and standard deviations of the composite variables by experimental condition.

Hypothesis 1 predicted that connectedness to nature would be higher among participants who took a physical tour than among those who watched a video tour. The univariate test supported that prediction, $F(1,160) = 23.80$, $p < .001$, $\eta_p^2 = .129$. We probed this effect with an independent-samples *t*-test. That test failed Levene's test for equality of variances ($p < .001$), so we report the adjusted

Table 1. Intercorrelations ($N = 164$) and descriptive statistics of the composite variables.

	Trait-like CTN	State-like CTN	Fear	Disgust
State-like CTN	.531***			
Fear	−.153	−.300***		
Disgust	−.125	−.340***	.498***	
M	4.77	3.75	1.51	1.34
SD	0.53	0.61	0.69	0.58

Note. CTN = connectedness to nature. *M* = mean. *SD* = standard deviation. ***$p < .001$.

Table 2. Descriptive statistics of the composite variables by experimental condition.

Experimental Condition		*n*	State-like CTN		Trait-like CTN		Fear		Disgust	
			M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Physical tour	Botanic garden	41	3.45	0.47	4.00	0.43	1.31	0.51	1.26	0.57
	Forested area	40	3.33	0.51	3.83	0.46	1.61	0.79	1.45	0.55
Video tour	Botanic garden	44	3.54	0.54	3.68	0.66	1.52	0.68	1.33	0.66
	Forested area	39	3.36	0.60	3.48	0.73	1.62	0.75	1.32	0.51
F(3,160)			1.36	5.70***	1.79		0.79			

Note. CTN = connectedness to nature. *n* = experimental cell size. *M* = mean. *SD* = standard deviation. The *F*-test with 3 (between groups) and 160 (within groups) degrees of freedom shows if there were any significant differences among the four experimental groups. ***$p < .001$.

degrees of freedom. State-like connectedness to nature was higher among participants who took a physical tour ($M = 3.91$, $SD = 0.45$) than among those who watched a video tour ($M = 3.59$, $SD = 0.70$), $t(140.06) = 3.56$, $p < .001$, Cohen's $d = 0.59$. This was a medium effect. Figure 5 shows the unadjusted cell means and their 95% confidence intervals based on 5,000 bootstrap samples.

Hypothesis 2 predicted that (a) fear and (b) disgust would be higher and (c) connectedness to nature would be lower among those who toured a forested area than among those who toured a botanic garden. Failing to support our predictions, univariate tests showed that type of nature did not affect fear, $F(1,160) = 2.64$, $p = .106$, disgust, $F(1,159) = 0.63$, $p = .427$, or state-like connectedness to nature, $F(1,160) = 1.61$, $p = .206$.

Hypothesis 3 predicted that (a) fear and (b) disgust would mediate the effect of type of nature on connectedness to nature. Results of the process analysis showed there was no indirect effect of type of nature on state-like connectedness to nature via fear, $\beta = -0.03$, 95% CI [−0.10, 0.02], nor via disgust, $\beta = -0.03$, 95% CI [−0.09, 0.05]. This model also showed that state-like connectedness to nature was unrelated to fear ($\beta = -0.11$, $p = .142$) and negatively related to disgust ($\beta = -0.22$, $p = .003$), which are post hoc findings.

Hypothesis 4 predicted that the modality of nature would moderate the effect of type of nature on (a) fear, (b) disgust, and (c) connectedness to nature. Failing to support these predictions, modality of nature did not moderate the effect of type of nature on fear, $F(1,159) = 0.89$, $p = .347$, disgust, $F(1,159) = 1.36$, $p = .245$, or state-like connectedness to nature, $F(1,159) = 0.003$, $p = .956$. For interested readers, analysis of the main effects model showed that modality of nature did not affect fear, $F(1,160) = 1.39$, $p = .241$, or disgust, $F(1,160) = 0.03$, $p = .856$.

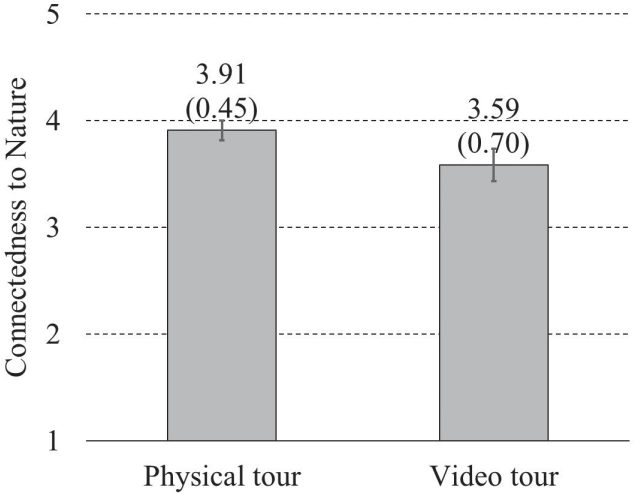

Figure 5. The effect of modality of nature on state-like connectedness to nature. The numbers above indicate the estimated marginal means with standard deviations in parentheses. The error bars show 95% confidence intervals.

Discussion

This study investigated the effect of modality of nature on connectedness to nature, the effects of fear and disgust as mediators, and the effect of type of nature as a moderator. We tested hypotheses by conducting 10-minute guided tours of a forested area and a botanic garden, which constituted our manipulation of type of nature. Participants either joined a physical group tour or watched a video tour in a classroom, which constituted our manipulation of modality of nature. Consistent with one of our predictions, we found that the physical tours resulted in higher levels of connectedness to nature than did the video tours. Although prior research has noted the effectiveness of direct contact with nature in fostering connectedness to nature (e.g. Beery, 2013; Lumber et al., 2017; Schultz & Tabanico, 2007), our work adds to the relatively small body of literature that compares direct and mediated experiences of nature. Our findings replicated prior work showing direct experiences of nature elicit higher levels of connectedness to nature than do videos (Mayer et al., 2009; Sneed et al., 2021). Both those prior studies took place in the United States, and the current study showed a similar pattern of results in the national context of Singapore, a highly urbanized country where public opinion favors the development of manicured natural spaces over wild ones (Khew et al., 2014).

There was one other significant effect worth discussing, which came from a post hoc analysis. Although state-like connectedness to nature was negatively correlated with both fear and disgust (see Table 1), in the ANOVA it was related only to disgust. This suggests that connectedness to nature is lower among individuals with aversive experiences they may associate with both fear and disgust. However, if individuals experience both fear and disgust in relation to nature, their disgust more than their fear will tend to inhibit their connectedness to nature. Also, of the "bugs and mud" that Lengieza and Swim (2021) noted, mud is probably more disgusting than scary, and there is evidence of the same regarding insects (Olivos-Jara et al., 2020). Of course, there is more to a forest than bugs and mud, but it may be that the disgusting features are more salient than the scary ones.

Our other predictions were unsupported. There was no effect of the type of nature on state-like connectedness to nature, fear and disgust did not mediate that effect, and modality of nature did not moderate the effects as predicted. We offer two explanations of these null findings. First, they suggest that whatever difference there is between forested areas and botanic gardens in cultivating connectedness to nature, the difference is small. They also suggest that forested areas are neither fearful nor disgusting, at least relative to a botanic garden. It may be more informative to examine positive emotions, such as awe, which research has linked with connectedness to nature (Ballew & Omoto, 2018; Yang et al., 2018). The second explanation concerns potential artefacts of our experimental design. We had sought to balance the convenience of the different study locations (i.e. the botanic garden, forested area, and classroom). However, wild nature is often inconvenient to access, being further away from public thoroughfares than are botanic gardens and academic buildings. The accessibility of the forested area and the occasional noise from a passing vehicle may have diminished its aura of "wildness" and failed to produce the predicted moderation effects. In hindsight, this study may have benefitted from forgoing convenience for a "wilder" setting, perhaps a primary growth forest in a more remote area of Singapore. Another potential artefact was the use of group tours. Research has identified solitude as an important factor in the cultivation of connectedness to nature (Mateer, 2022), and the absence of solitude during the tours may have muted the treatment effects. Related, the simple presence of the tour guide could have had such a muting effect, as being on an organized tour may have created a sense of safety.

On the topic of limitations, there are five additional ones we should note. First, the small convenience sample of university undergraduate students is not representative of the population of young adults in Singapore. Second, the participants knew in advance that the study involved a "nature experience," which may have induced a self-selection bias where only those with an

interest in nature volunteered to participate. Third, there were markedly different dropout rates among the four conditions. However, the highest dropouts were in the physical tour of the forested area and the video tour of the botanic garden, which suggests the dropouts were not related to either main effect. Fourth, our modification of the Connectedness to Nature Scale potentially threatened the internal validity of state-like connectedness to nature. However, prior research had similarly modified the scale and found it reliable (Mayer et al., 2009). Fifth, this study used only a single flat-screen television to display the video tour. Other video technologies, such as virtual reality, may have greater potential to create immersive experiences of nature. Therefore, our findings do not generalize to all kinds of mediated experiences, but to a narrow category of them.

Application of findings

This study showed what can happen when young adults have green time by visiting nature spaces or screen time that simulates visits to nature spaces. While it may be valuable to cultivate connectedness to nature in all individuals, it is particularly important to cultivate in younger individuals, as their frequent contact with nature can foster a lifelong connection to nature (Chawla, 1999; Kals et al., 1999). Further, most young adults are active users of digital devices (Kemp, 2021). Recent studies of young individuals have examined physiological and psychological effects of screen time versus green time, suggesting time spent using digital devices may displace time spent outdoors (e.g. Christian et al., 2017; Oswald et al., 2021). But those studies also highlight the potential of screen time to create mediated green time, which in theory can help overcome things like nature deficit disorder related to videophilia. Generally, young adults who spend much of their time looking at screens can still form connections to nature. But we found, as had some prior research, that direct experiences are superior to mediated ones, perhaps through eliciting positive feelings such as awe (Ballew & Omoto, 2018). Thus, we recommend that communicators, educators, and others interested in fostering connectedness to nature among young adults should prioritize direct experiences over mediated ones. This recommendation is consistent with research showing outdoor learning enhances connectedness to nature (Braun & Dierkes, 2017; Burgess & Mayer-Smith, 2011; Pirchio et al., 2021). It is also consistent with arguments that institutions of higher learning should do more to integrate topics of sustainability and environmental management into curricula to ensure future leaders can contribute to sustainable development (Obrecht et al., 2022).

This is not to say screens have no role to play in fostering connectedness to nature, as they can serve as steppingstones toward more active and direct engagement with nature. For instance, Hynes et al. (2021) found that individuals who watched the documentary series, *Blue Planet II*, had stronger preferences for marine conservation. Other research has highlighted the ability of online videos to build excitement about hands-on activities and online platforms to enable young individuals to document their nature experiences (Paulsen & Andrews, 2019). Related, augmented reality games like Pokémon Go can encourage individuals to spend time outdoors (LeBlanc & Chaput, 2017; Ruiz-Ariza et al., 2018). Also, recent research suggests that people may form beliefs about their lived experiences of natural phenomenon based on ideas they encounter in the media (Rosenthal, 2022). There is a need for further research examining how digital communication technology, such as augmented reality, can encourage young people to spend more time in nature and develop their connectedness to nature.

In conclusion, this study sought to find out more about the factors influencing connectedness to nature in young adults. This is important if connectedness to nature leads to pro-environmental attitudes and behaviors. Our findings affirmed that young adults have more connectedness to nature after experiencing nature directly rather than on a screen. We reassert the value of being physically present in natural spaces as a part of environmental communication, environmental education, and everyday experience.

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Appendix A. Script for tour of botanic garden.

Segment	Script
Introduction	Hi there! I'm < guide's name > and we'll be taking a short walk through Yunnan Garden, where you'll be seeing different kinds of plants and flowers. We will be taking short stops to look at some of them more closely. You might also spot some animals, such as birds, spiders, lizards, and snakes. If you spot any animals along the way, follow us and observe quietly from a distance. Please be careful while walking and look out for fallen branches or uneven ground. If we're all ready, let's go!
Boston fern	Plant parents will probably find this fern here familiar. This is the Boston fern or sword fern, which are considered classic house plants because they are one of the easiest ferns to care for and are cat and dog friendly. The fern also actually has cleaning qualities, meaning it can help remove toxic substances like cigarette smoke from the air. It can also restore moisture to the air naturally, which is beneficial for people who suffer from dry skin or throats. Although it's called the Boston fern, it's native to tropical regions all around the world and there are about 30 varieties of it.
Mangrove holly	Over here we have the mangrove holly. When you think of hollies, you might immediately think about Christmas wreaths with their bright red berries. But that's actually the common holly, which is the mangrove holly's European counterpart. The mangrove holly is native to Australasia and is usually found

(*Continued*)

Continued.

Segment	Script
	in mangrove habitats. It also has green fruits instead of red fruits. Look at the mangrove holly's leaves; they are spiny and shiny. They almost resemble barbed wire right? So, if you're living somewhere with a garden and you want to deter people from trespassing, you could plant this as a natural barrier. Other than its use in landscape design, it's also commonly used in Indian and Chinese traditional medicine. It's used to treat asthma, rheumatism, snake bites, and other wounds.
African oil palm	This large tree here is the African oil palm. It is originally native to Africa's tropical forests, but it was brought over to Southeast Asia over 100 years ago as ornamental trees. Now, the tree is most well-known for its economic value. Our neighbors, Indonesia and Malaysia, make up more than 85% of the global supply of palm oil. Palm oil is versatile and used in almost everything. Your favorite foods like pizza and chocolate, and products you use every day, like shampoo and toothpaste, all use palm oil. In fact, it's used in more than 50% of the packaged products in supermarkets! Unfortunately, palm oil plantations are major drivers of deforestation of some of the world's most biodiverse forests. Already-endangered species like the Orangutan are left without homes or are killed by forest fires. But you can do your part to help the situation by only buying products which use palm oil that are certified as sustainable.
Purple cat whiskers	These flowers here are part of the cat whiskers plant, and it's pretty easy to see why. These flowers are violet, but the plant can also come with white flowers. The cat whiskers plant is also known as java tea or kidney tea plant. That's because the cat whiskers' leaves can be infused in tea to make a concoction with various health benefits. In fact, it's a very popular natural remedy in South Asia and some parts of Europe because it's believed to help you urinate better and prevent kidney stones. It also has anti-microbial and anti-inflammatory properties. Interestingly, while the parts of the plant that are above soil have medicinal properties, any part of the plant below the soil is considered toxic.
Eggplant	Here we have the eggplant, but you might know it by its other names like brinjal and aubergine. If you've ever wondered why it's called an "eggplant", it's because early European variations of the plant in the 1700s were smaller and yellow or white, which looked like goose or chicken eggs. Here we are looking at the dark purple variation, which contains more of a rare antioxidant called Nasunin. The antioxidant fights inflammation and helps absorb iron into the body. It's found on the skin of the eggplant, so when you eat eggplant, don't peel them so you can get all those antioxidants into your body! One last fun fact: although most people consider eggplant a vegetable in cooking, it's actually a berry.
Outro	We've come to the end of our walk. I hope you enjoyed yourself and have learnt more about the plants and flowers in Yunnan Garden. Bye!

Appendix B. Script for tour of forested area.

Segment	Script
Introduction	Hi there! I'm < guide's name > and we will be taking a short walk through this forested area, where you will be seeing different kinds of plants and flowers. We'll be taking short stops to look at some of them more closely. You might also spot some animals, such as birds, spiders, lizards, and snakes. If you spot any animals along the way, follow us and observe quietly from a distance. Please be careful while walking and look out for fallen branches or uneven ground. If we're all ready, let's go!
Jelutong tree	For our first stop, we have the jelutong tree, a large native forest tree which can grow to over 60 m tall, which is roughly the length of 5 buses. When younger, the crown of the tree forms a pagoda shape with layered leaf branches, (point) like the one we see here. In forests, the crown of the tree opens up once it has matured, so it's raised above the rest of the canopy to get greater exposure to sunlight. In Indonesia and Malaysia, the latex tapped from the Jelutong is called gutta jelutong and was once commonly used as the base for producing chewing gum. The wood of the Jelutong is also popular with model makers, because it behaves like soft wood.
African tulip tree	These trumpet-shaped flowers are from a tree called the African Tulip Tree. The flowers are pollinated by birds and bats and the seeds are scattered by water and wind. This flower is now mature. But as a flower bud, it's filled with watery nectar. If you squeeze the bud just right, it can become a water gun! Let's take a closer look at the tree these flowers come from. The African Tulip Tree was first introduced to Singapore in 1910 to be planted as roadside trees. The tree has brittle branches and shallow roots, which makes it a victim of strong winds. Now, it's often found growing wild all over Singapore. This tree has many medicinal uses. The bark and leaves are used to treat wounds and burns in Africa, while the leaves have been used to treat malaria.
Strangler fig	Now we are looking at the strangler fig. It's huge, but it really starts as a tiny seed dropped by a bird or bat. It lives on the tree's surface and gets its nutrients from air and water. The roots then grow down to the forest floor and begin to take nutrients from the soil. Look at the way the roots wrap around the tree. Eventually the roots will widen and slowly form a lattice network that surrounds the tree trunk. In due course, the fig causes the host tree to die, leaving the fig with a hollow trunk. Ironically, strangler figs actually protect their hosts from being uprooted in tropical storms. Their roots help stabilize the host, while the leaves increase shielding from the wind. The fig's scaffold-like root networks may also help strengthen the tree trunks. Now, we'll be moving on to the next stop.

(*Continued*)

Continued.

Segment	Script
Bird's nest fern	Right now we're looking at the Bird's Nest Fern. While it might be a familiar sight in Singapore, it's also found in other parts of the world like Australia and Africa. Let's take a look at the nest. It traps fallen leaves and other debris. They then decompose and become a dark-colored, spongy substance which provides the fern with nutrients. And when it rains, water is absorbed by the sponge of roots. This allows the fern to be self-sufficient because it can grow without soil. It can even provide a habitat for other ferns and mosses to grow or become a home for small animals. The spores are found on the underside of the leaves in parallel rows. Notice that some leaves appear to not have any spores? That's because spores are light brown and transparent when fresh, but opaque when old. The leaves are non-poisonous and edible. In fact, they are occasionally eaten by aboriginal tribes in Malaysia. Now let's move on to our last stop of the day.
Common yellow stem-fig	Look over here and you'll find the yellow stem-fig. It's probably the most common forest fig in Singapore. As you can see, these fig fruits are somewhat round and green in color, with white dots. When these figs ripen, they turn greenish yellow in color, hence giving the tree its name "yellow stem-fig". The fruits are usually found in clusters at the leaf-axils or on trunks and branches. These figs are actually an important food source for wild animals such as squirrels and fruit-eating bats. Interestingly, all fig trees are dependent on tiny wasps to help them pollinate their flowers. These fig wasps do not feed as adults, lack stings and are totally harmless to humans.
Outro	We've come to the end of our walk. I hope you enjoyed yourself and have learnt more about the plants and flowers in this forested area. Bye!

Appendix C. Connectedness to nature scale.

Wording	Trait-like CTN *M* (*SD*)	State-like CTN *M* (*SD*)
I often [currently] feel a sense of oneness with the natural world around me.	3.33 (0.91)	3.66 (0.93)
I think of the natural world as a community I belong to.	3.60 (0.97)	4.01 (0.74)
I recognize and appreciate the intelligence of other living organisms.	4.16 (0.78)	4.30 (0.67)
I often [currently] feel disconnected from nature.†	3.27 (1.05)	3.66 (1.06)
When I think of my life, I imagine myself to be part of a larger cyclical process of living.	3.57 (0.99)	3.87 (0.88)
I often [currently] feel a kinship with animals and plants.	3.39 (1.05)	3.66 (.92)
[At this moment,] I feel like I belong to the Earth as equally as it belongs to me.	3.48 (1.00)	3.66 (0.95)
I have a deep understanding of how my actions affect the natural world.	3.68 (0.89)	3.76 (0.90)
I often [currently] feel part of the web of life.	3.35 (0.96)	3.84 (0.91)
I feel that all inhabitants of Earth, human, and nonhuman, share a common "life force".	3.41 (1.02)	3.75 (0.92)
Like a tree can be part of a forest, I feel embedded within the broader natural world.	3.44 (0.94)	3.87 (0.78)
I consider myself as more important than other living things, e.g. plants and animals.†	2.90 (1.16)	3.33 (1.15)
[At this moment,] I am no more important than the grass on the ground or the birds in the trees.	2.95 (1.02)	3.37 (1.14)

Note. CTN = connectedness to nature. M = mean. SD = standard deviation. †reverse-coded. Words in brackets replaced the underlined words or were added to the question (where there are no underlined words) in the posttest questionnaire. The two removed items were "I often [currently] feel like I am only a small part of the natural world around me" and "[At this moment,] I feel that my personal welfare is independent of the welfare of the natural world."

Appendix D. Measurement of fear and disgust.

Construct/Wording	*M (SD)*
Fear	
During the experience, I felt tense.	1.61 (0.92)
During the experience, I felt fearful.	1.38 (0.68)
During the experience, I felt uneasy.	1.55 (0.87)
Disgust	
During the experience, I felt grossed out.	1.32 (0.64)
The nature experience felt yucky to me.	1.35 (0.62)

Note. *M* = mean. *SD* = standard deviation.