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Perceived Cognitive Effort and Exposure to Natural Stimuli

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Abstract

This study investigated the effects of exposure to aversive natural stimuli, such as spiders and snakes, on perceived cognitive effort and affect. Previous research has found that interaction with nature can produce benefits, such as the restoration of attention or reduction of stress, perhaps because some features of the natural environment may indicate the absence of threats, the availability of needed natural resources, or the overall positive health of an ecosystem. However, other features of the natural world may be threatening thereby producing negative effects. While much research focuses on the positive effects of interaction with nature, there is little research on the negative. This study hypothesized that threatening natural stimuli may impair thinking and produce negative affect. A within-subjects design was used in which each participant was exposed to three experimental conditions: aversive nature, attractive nature, and human made objects. Outcome measures were an anagram task to index perceived cognitive effort, the Positive and Negative Affect Schedule, and the Connectedness to Nature Scale to measure individual differences. Ninety-two UNCA psychology students participated. Preliminary data analysis shows that the aversive condition produced significant negative affect and greater perceived cognitive effort compared to the attractive and human-made conditions. The results will be described in the context of previous research on exposure to natural stimuli, suggesting that the understanding of the value of nature exposure should be tempered to include a more comprehensive understanding that recognizes that some nature elements elicit negative feelings and can even impair thinking.

1. Perceived Cognitive Performance and Anagram Tasks and Natural Stimuli

Biophilia is a concept first hypothesized by Erich Fromm, but was later independently developed and popularized by the biologist E.O. Wilson[1]. Biophilia means a love of life and is generally thought of as an affinity or preference for natural stimuli. Wilson's view of biophilia posits that the preference for natural stimuli is a byproduct of natural selection[1]. It is reasonable from an evolutionary perspective that natural stimuli, particularly living things, would be pleasing to the human mind: the survival of humans depended on the abundance of animals and plants for all of our existence. Moreover, the overwhelming majority of human history, especially pre-history, took place within nature rather than apart from it, as when indoors.

Since Wilson's popularization of the term there has been a modest quantity of research which supports the biophilia hypothesis. Various studies have demonstrated the benefits which natural stimuli can produce. For example, exposure to natural scenes has been shown to aid in the recovery of attention[2]. Likewise, exposure to nature has been shown to reduce stress[3]. Exposure to natural stimuli has also been demonstrated to reduce experienced pain during medical procedures[4].

While the bulk of research on the positive effects of nature has focused on visual stimuli, or visual paired with auditory, naturally occuring auditory stimuli also, independent of vision, have positive effects. Exposure to natural sounds can reduce anxiety or otherwise aid in mood recovery[5,6]. Exposure to natural sounds has also been shown to improve cognitive performance[7]. Exposure to nature confers other benefits that are not as readily quantifiable, such as the finding that experiences with nature are often associated with the feelings of awe[8].

All this evidence collectively seems to make a strong case for the biophilia hypothesis. However, such a conclusion would be premature. Not all experiences with nature or all natural stimuli are necessarily pleasing nor beneficial. Biophobia, the antithesis of biophilia, can be viewed as either an indifference to nature or an outright dislike of it[9]

Using the same logic of adaptation through selection, one can easily see how some potentially harmful natural stimuli would end up being perceived, instinctually, as unpleasant. There may be greater weight, evolutionarily, placed on paying attention to negative stimuli (e.g., venomous snakes) as opposed to positive stimuli (e.g., butterflies) due to the differing severity of the consequences of physical encounters[10]. A significant portion of phobias tend to focus on natural stimuli, such as snakes or spiders, and nature centered phobias appear consistently across cultures suggesting some innate/instinctual basis[11]. Interaction with nature often treads a fine line between being pleasant and producing anxiety or fear. In a study involving five-year-old children happiness was most commonly attributed to experiences with nature, while fear was second[12]. If negative interactions with natural stimuli are not more response provoking than positive ones, as proposed by Baumeister and his colleagues, then they are at least as equally provoking as natural stimuli, as shown by a study performed with the Implicit Association Test[13]. Whether positively or negatively valenced, individuals tend to

have greater subjective connection to natural stimuli as opposed to built, humanmade, stimuli[13].

Affective responses, feelings of like-dislike, can be considered automatic, less susceptible to introspection than cognition[14]. Affective response, however powerful, is not a strong predictor of cognitive performance in the presence of certain stimuli [14]. Even when natural stimuli are rated positively, the affective rating does not correlate strongly with cognitive performance[7]. Little research has been done on natural stimuli, negatively rated in terms of affect, and their impact on cognitive performance.

The Connectedness to Nature (CNS) scale is a relatively new scale, but it has been shown to be both valid and reliable[15]. It measures one's personal sense of closeness to the natural world. It is very useful for indexing affinity for nature and pro-environmental behavior–the latter which historically lacks a strong empirical background. Scores on the CNS are moderately positively correlated with pro-nature behaviors, endowing it with greater predictive ability compared to other similar measures, such as the IAT or the New Environmental Paradigm[15]. The measure consists of fourteen items, with responses on a five-point scale (1 = strongly disagree to 5 = strongly agree). The questions focus on affective response rather than cognitive beliefs, such as, "I often feel a sense of oneness with the natural world around me," or "I often feel part of the web of life,"[15].

The CNS has been shown to correlate strongly with environmental conscious behaviors and attitudes[15]. A high score on the CNS indicates an affinity for nature. Therefore, this study expects that people who score higher on the CNS will be more biophilic and less biophobic. High scorers should experience fewer negative effects, whether affective or cognitive, as opposed to low scorers on the measure. For example, seeing an earthworm writhing on the ground may be a positive experience for biophilic-oriented individuals but evoke some disgust in biophobic-oriented individuals.

The goal of this study is to determine the effects on perceived cognitive effort and affective response after exposure to natural stimuli. Connection to nature, as determined by the CNS, may be predictive of both affective and cognitive responses to exposure to natural stimuli. As much research has been done on the positive effects of exposure to nature, this study will focus on what negative effects exposure may elicit and how they may be mediated by individual differences in CNS.

2. Method

2.1 Participants

This study made use of a convenience sample. Participants were university students of varying ages. They were recruited via an online survey made available through the Psychology Research Participation section of Moodle. The sample consisted of 92 participants.

2.2 Assessments and Measures

This study utilized the Connectedness to Nature Scale[15]. The CNS is a measure of an individual's personal feelings of closeness with nature. For the purposes of this study, it will be a mediating variable.

The Positive and Negative Affect Schedule is a measure of affect[16]. It uses scaled adjectives which are then scored. In his study it was used to track any changes in affect which the different stimuli may produce.

Anagrams were used as a measure of perceived cognitive effort in this study. Subjects were asked to attempt to solve anagrams and then rate how difficult the anagrams were to solve. Anagrams have been widely used in psychological research as far back as the 1950's[17]. In fact, Anagrams have been used in psychological studies as recently as 2019[18]. The anagrams in this study were developed by the researchers and consist of five letters. Five letters were determined to be adequate in terms of difficulty; they are short enough to be solved but long enough to cause subjects to quit.

2.3 Procedure

The survey developed using Google Forms by the researchers was uploaded to the university's psychology research participation section of Moodle. Participants read a brief description of the study, being fully informed as to what they were going to see and indicated their consent to participate. Deception was not necessary for this study.

Participants were asked to complete the CNS prior to viewing any images or attempting to solve any anagrams. Afterwards, they moved on to the first condition in which they were asked to solve the first anagram and rate how difficult it was for them. Upon completing the first anagram, participants were asked to look at each image that they were about to view for a minute and to focus on the feelings that the images produced. Once they had finished viewing all five of the images, they were then prompted to solve a second anagram and to rate how difficult it was. Afterwards, they were asked to complete the PANAS to indicate which feelings they were currently experiencing and indicate the level of intensity using the provided scale. This concludes the first condition.

In the second condition, participants were asked again to solve an anagram before viewing any images and to rate their perceived effort. In this condition they were given the same viewing instructions as before, but they were shown images of human-made objects such as a bicycle or a building. They were asked to solve another anagram and rate it as well. They were again asked, with the same instructions, to fill out the PANAS. This concludes the second condition.

In the third and final condition, the procedure was repeated. Participants attempted an anagram before viewing any images and rated its difficulty. Afterwards, they were asked to view the images, attempt to solve another anagram, and complete the PANAS. After completing this section, the participants had completed the survey and were told they could contact the researcher with any questions.

There were two versions of the survey for the purpose of counterbalancing. In the first version of the survey, the conditions were natural images first, human-made objects images second, and aversive natural images last. In the second version of the study, the conditions were aversive natural images first, human-made objects images second, and natural images last. Other than the order of the images, all other parts of the survey remained the same as did the instructions.

3. Results

Chi-square tests showed that there were no order effects on the perceived difficulty of the anagrams between the two counterbalanced versions of the survey. Chi-square tests were also used for determining the effect of the varying image conditions on the perceived cognitive effort used when solving the anagrams.

Table 1 (Anagram 1 Perceived Effort)

Count

		How difficult was that anagram?						
		A little difficult	Difficult	Not difficult at all	Somewhat difficult	Unable to solve	Very Difficult	Total
condition	1 (AN)	32	5	26	17	8	4	92
	2 (HM)	18	11	10	13	26	13	91
	3 (PN)	24	10	26	17	8	6	91
Total		74	26	62	47	42	23	274

Unexpectedly, the initial anagram in the human-made objects condition was rated as extremely more difficult for participants to solve than the initial anagrams in the other conditions. In Table 1, it is apparent how disproportionately difficult the first anagram was in condition two relative to the other conditions. As a result, this resulted in a robustly significant chi-square value, $\chi 2$ (10, N = 274) = 36.60, $p < .001$.

Table 2 (Anagram 2 Perceived Difficulty)

Count

	How difficult was that anagram?						
	A little difficult	Difficult	Not difficult at all	Somewhat difficult	Unable to solve	Very Difficult	Total

condition	1 (AN)	20	12	32	15	9	4	92
	2 (HM)	21	5	36	12	14	3	91
	3 (PN)	15	5	56	4	7	4	91
Total		56	22	124	31	30	11	274

However, as the hypothesis suggested, the participants had the most difficulty solving the second anagram after viewing the images in the aversive natural images condition compared to the other conditions, as indicated by the significant chi-square value, χ^2 (10, N = 274) = 22.60, p < .012. In Table 2, one can see the noticeable difference between the participants' responses between conditions 1 and 3.

Table 3 (Descriptives PANAS)

						95% Confidence Interval for Mean			
		N	Mean	Std. Deviation	Std. Error	Lower Bound	Upper Bound	Minimum	Maximum
negativetotal	1 (AN)	92	23.72	8.23	.86	22.01	25.42	10.00	41.00
	2 (HM)	91	16.98	6.76	.71	15.57	18.39	10.00	36.00
	3 (PN)	91	11.71	2.72	.29	11.15	12.28	10.00	25.00
	Total	274	17.49	8.02	.48	16.54	18.45	10.00	41.00
positivetotal	1 (AN)	92	20.92	7.34	.77	19.40	22.44	10.00	44.00
	2 (HM)	91	21.85	7.51	.79	20.28	23.41	10.00	43.00
	3 (PN)	91	30.89	6.76	.71	29.48	32.30	15.00	45.00
	Total	274	24.54	8.45	.51	23.53	25.55	10.00	45.00

The scores on the PANAS were divided and summed into a total negative score for the negative mood adjectives and a total positive score for the positive mood adjectives to allow for a more nuanced analysis of participant feelings across the conditions. As predicted, analyses indicate a stark mean mood score difference between the different conditions. The aversive nature images condition had the highest mean total negative mood score (M = 23.72, SD = 8.23), the human-made objects condition had a middling mean (M = 16.98, SD = 6.76), and the attractive nature images condition had the lowest mean total negative mood score (M = 11.71, SD =2.72). The mean total positive scores

showed an inverse pattern, as expected. Attractive nature image condition had the highest mean total positive mood score (M = 30.89, SD = 6.76), human-made condition had a mean somewhere in the middle (M = 21.84, SD = 7.51), and the aversive nature images condition had the lowest mean total positive mood score (M = 20.92, SD = 7.34). An ANOVA was conducted on the total positive and negative scores of the PANAS.

Table 4 (ANOVA PANAS)

		Sum of Squares	df	Mean Square	F	Sig.
negativetotal	Between Groups	6627.31	2	3313.65	82.05	<.001
	Within Groups	10945.18	271	40.39		
	Total	17572.49	273			
positivetotal	Between Groups	5532.84	2	2766.42	53.20	<.001
	Within Groups	14091.22	271	51.99		
	Total	19624.06	273			

The results of the ANOVA for the total negative emotions was $F(2,271) = 82.05$, $p < .001$. The results of the ANOVA for the total positive emotions was $F(2,271) = 52.20$, $p < .001$. These results are consistent with the hypothesis that the aversive natural stimuli would produce more negative affect and that the positive natural stimuli would produce more positive affect.

Lastly, scores on the CNS were not found to correlate with perceived difficulty on the anagram tasks, or scores on the PANAS.

4. Discussion

The data analysis yielded some interesting results in support of the hypothesis that some natural features elicit negative feelings and may even impair thinking. However, the data analysis also yielded an anomaly, elaborated upon below. There was not an order-of-condition presentation effect between the counterbalanced versions of the study, which provides a somewhat greater level of confidence in the general findings. As expected, exposure to aversive natural stimuli provoked a strong negative affective response while exposure to positive natural stimuli was significantly associated with participants' positive affect. Exposure to aversive natural stimuli also produced a significant effect on the participants' perceived cognitive effort while working to solve the second anagram task. However, participants reported that they had a remarkably difficult time solving the first anagram in the human-made objects condition even before exposure to the images within that condition. Nature connection scores were not found to correlate with either affective responses or perceived cognitive effort.

The results are partially consistent with the concept of Biophobia, as many features of the natural world are viewed negatively, both consciously, as when the participants of this study reflected on how the images made them feel, and instinctively[9,13]. Given the significant effects that the aversive natural images condition had on both affect and perceived cognitive performance, it is safe to conclude that the results of this study suggest that some interactions with nature can be emotionally and cognitively deleterious. It may be relevant to note that some of the images used in the study were of organisms not common to the Americas and may have not been culturally salient. This fact could be interpreted as lending further support to the idea that certain features typical of predators, such as large sharp teeth or claws, produce fear due to an evolutionary force of natural selection. Specifically, experiencing a strong negative emotional reaction to such natural stimuli would prime the body for flight or fight thereby enhancing an individual's probability of surviving to the age or reproduction and the propensity for having that emotional reaction was therefore naturally selected across prehistoric human generations.

The findings of this study are also in line with previous research on the effects of interaction with positive natural stimuli, such as attractive natural environment's effects on the restoration of attention or the reduction of stress[2,3]. This study found that exposure to positive natural stimuli produced a rather large increase in positive affect. Even when compared to the human-made images condition, people experienced more positive emotions in greater intensity when looking at a picture of a Fennec Fox, for example, as opposed to Les Hotel des Invalides. This could be interpreted as further support for nature's ability to produce awe and its positive effects[8].

While this study yielded significant results, and is consistent with previous research, there are some limitations which have to be identified. The first limitation was the use of anagrams as a measure of perceived cognitive effort. As previously noted, the participants reported far greater difficulty with one of the anagrams, the first of the human-made objects condition, relative to the others. Due to the within-subjects design, different words had to be used for the anagram tasks in each condition. The researchers attempted to find anagram words of equal difficulty, but clearly some were more difficult than others. This casts some doubt as to whether the anagrams are a valid or reliable measure of perceived cognitive effort between conditions. The researchers intended to make use of the Backward Digit Span (BDS) originally, but due to the limitations of the online survey making tools, it was not implemented. The BDS is a stronger, more concrete measure of cognitive performance and has been used in other studies focusing on natural stimuli's effects on cognition[7]. A second limitation was that this study used a convenience (as opposed to a true random) sample of university students in the developed world. Perhaps the effects would have been different with a different group of people from another culture who are more familiar with nature. Another possible limitation may have been the images used. While the use of images of natural objects has been shown to produce an effect, it may be possible that sounds or videos could produce a wider range of effects or effects of greater intensity.

In closing, this study investigated the effects of exposure to natural stimuli and how participants responded emotionally as well as the effect of exposure on their perceived

cognitive effort. Various measures were used such as the CNS, PANAS, and anagrams developed by the researchers. While the validity and reliability of the anagrams may not be as robust as other measures, participants reported significantly greater perceived cognitive effort when solving the anagrams after exposure to aversive natural stimuli. Additionally, participants experienced significantly more negative emotions after exposure to aversive natural stimuli relative to how they felt after viewing positive natural stimuli. The results of this study illustrate the need to recognize that interaction with nature is not automatically good; the presence of certain natural stimuli may induce more negative reactions than positive.

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