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Life on the Non-straight Edge

A Review of the Cognitive Effects of Nature on the Individual

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Humans have a complex relationship with nature. In many ways, humans are in opposition to nature, constructing cities and roads, fighting diseases, herding animals, etc. Given the prevalence of this opposition throughout history, it would be reasonable to deem the opposition itself natural. However, when presented with a society that increases its opposition to nature, individuals commonly fight these changes, which are perceived as a threat to their humanity. For example, romanticism in response to the Industrial Revolution.

The argument for opposing nature is understandable: nature is chaotic, humans have an incentive to mitigate against the chaos or else, face an existential threat. Building a dam greatly disrupts nature but provides a community with protection from drought and floods, as well as a place for recreation. At the same time, nature is purported to have an intricate balance, symmetry, the opposite of chaos. How is it then that humans can hold these two conflicting views of nature, and furthermore, what motivates these views? Recently, psychologists have begun to study the influence of nature on our minds. Their research provides a valuable scientific perspective on this age-long dispute.

1. Cognitive Benefits of Nature

Why is it that humans, despite acting in opposition to nature, continue to defend it? There must be some sort of self-interest involved. Nature unarguably provides humans with materials needed for survival. For example, nature provides a source of nutrition, necessary for an individual to live. However, there is clearly a distinction between meals which solely provide nutrients, and ones that also look appealing. Moreover, a meal that looks and tastes good will qualitatively be superior to a meal that simply tastes good (e.g., the same meal pureed).

Therefore, it makes sense that researchers have focused on effects of visual depictions of nature, in particular, as opposed to other senses.

Berman, Jonides, & Kaplan (2008) consider attention, which they divide into two types: voluntary and involuntary. Voluntary attention is attention directed towards something, whereas involuntary attention is attention that results from novel stimuli, such as flashing lights or a loud noise. Berman, et al. (2008) investigate attention restoration theory (ART) which claims that interacting with nature improves voluntary attention. The theory proposes that nature is less taxing on involuntary attention than an urban environment, and thus, provides voluntary attention “a chance to replenish” (Berman et al., 2008, p. 1207). Additionally, the theory suggests an improvement in short-term memory. The first experiment, in which participants took a roughly hour-long walk in either nature or downtown Ann Arbor, provided support for this theory.

Though, before continuing, it should be noted that the authors assume that natural environments do not invoke involuntary attention as much as an urban environment would, and thus, voluntary attention is not required to address the stimuli. This assumption is not necessarily true. There are many places in nature in which this would clearly not be the case, such as an unfamiliar jungle or near alligators. In these environments, even the slightest surprising stimulus would immediately invoke most individuals’ voluntary attention in the same way that a car horn would in an urban environment. Thus, unless otherwise stated, the term ‘nature’ refers to natural environments in which there is no immediate or perceived threat to an individual.

Indeed, Berman et al. (2008) note that the peaceful aspect of nature is an important contributor to its restorative effects on voluntary attention but cannot be assumed to be the only contributor. In their second experiment, the authors found that among visual stimuli in a quiet room, pictures of nature improved voluntary attention whereas pictures of urban environments

did not. However, there was no control group lacking stimuli to compare against, so the effect of peacefulness alone cannot be obtained from these results.

2. What Aspects of Nature Provide These Benefits?

In Schertz et al. (2018), this question is examined from the perspective of thought content. That is, given that thought content has been shown to affect cognitive functioning, studying the impact that nature has on thought content should reveal some insight into what particular aspects of nature provide these cognitive benefits. The authors did this by completing three studies: the first in which journals written by visitors to a range of parks constructed by the TKF foundation were analyzed by content for topics, the second in which participants were shown pictures of the parks and asked to write freely, and the third in which participants were shown images varying in naturalness and non-straight edge density (NSED) and asked to select a set of words that best fit the picture.

The authors found that NSED was positively correlated with thoughts related to the topic of “Spiritual & Life Journey.” In addition, naturalness and NSED had a strong positive correlation with thinking about “Nature.” From these results, the authors suggest that fewer built structures, which usually have low NSED, should be constructed in parks, so as to “increase spiritual reflections” (Schertz et al., 2018, p. 92), with the hope of improving mental health in the community. While this might seem like a clear-cut solution, some of the authors’ previous research complicates this issue.

3. From NSED to “Spiritual & Life Journey” and “Nature”

Kotabe, Kardan, & Berman (2016) show that non-straight edge density has a strong positive correlation with visual disorder. Furthermore, the authors show that visual disorder has a positive correlation with rule-breaking. Thus, a question arises: would the suggestion by Schertz

et al. (2018) to decrease built structures, thereby increasing NSED, actually result in increased “spiritual reflections” (Schertz et al., 2018, p. 92), increased rule-breaking instead, or, perhaps, both? This is the Nature–Disorder paradox: “nature is disorderly yet aesthetically preferred” (Kotabe, Kardan, & Berman, 2017).

Kotabe, et al. (2017) ran a series of experiments to test three competing theories: nature is preferred more than disorder is opposed; in natural contexts, disorder’s appeal is insignificant relative to that of nature’s; and, in natural contexts, disorder is preferred over nature. The first theory, referred to as nature-trumps-disorder, is the only one supported by the experimental results. In particular, scene semantics were shown to drive this effect; removing or obscuring the semantics from the scene, such as in experiments 3a–c, 3d–f, and 4a–c, resulted in the paradox disappearing. Additionally, the authors found that low-level features, such as NSED, serve to amplify the nature-trumps-disorder effect, but alone, do not cause it.

Since Kotabe, Kardan, and Berman are authors on Schertz et al. (2018) and Kotabe et al. (2016, 2017) and because Schertz et al. cite the other two papers, surely when making their suggestion, Schertz et al. considered these previous results. Thus, from the results in Schertz et al. (2018), it is reasonable to presume that reducing built structures may indeed increase “spiritual reflections.” However, depending on the net effect on NSED relative to the naturalness of the park, rule-breaking could be increased (Kotabe et al., 2016). It’s also not clear as to why the authors suggest a method to increase thoughts related to the topic of “Spiritual & Life Journey” rather than “Nature.” One could suppose that the benefits obtained through ART are less effective in a more-disorderly environment, which would be the result of the proposed change, as NSED would be increased (Kotabe et al., 2016). Instead, the authors’ proposal should

be coupled with a directed increase in naturalness within the park, focusing on the topic of “Nature” instead of “Spiritual & Life Journey.”

4. The Mechanism Behind these Effects

In regards to “Spirituality & Life Journeys,” two possible explanations for this effect are proposed: first, visual disorder (due to higher NSED) is more cognitively taxing, leading to cognitive disfluency, and thus increasing abstract thought; second, higher levels of NSED may allow individuals to relax and reflect (Schertz et al., 2018). The latter proposal suffers from the same faults as discussed in the previous section: more visual disorder is not necessarily relaxing without sufficient balance in naturalness.

Similarly, in regards to visual disorder’s effect on rule breaking, two explanations are proposed: the first is the same as in regards to spirituality & life journeys, except that a detrimental impact on self-regulation is suggested as a further result; the second explanation is that visual disorder may appear random and therefore self-regulation is negatively impacted by a lack of motivation to comprehend the apparent randomness (Kotabe et al., 2016). The authors note that the latter explanation is far from the prevalent theories and suggest further research.

The theory that visual disorder, by effecting cognitive disfluency, induces abstract thought is shared between the two studies, and thus, deserves more consideration. On the basis that humans use two systems, heuristics and analytics, for judgement, Alter, Oppenheimer, Epley, and Eyre (2007) demonstrated that one cause for switching between the two systems is fluency. They found a fluent stimulus invokes heuristic judgment, whereas a disfluent stimulus invokes analytic judgment. So then, the disfluency resulting from visual disorder would shift the individual away from heuristics and towards more analytic judgement. This proposed explanation works generally for both studies and has the most experimental evidence to support

it. Thus, while other possibilities cannot be ruled out, the provided evidence suggests this to be the most likely explanation.

5. Applications of the Research

What value does this research provide beyond a deeper understanding of the mind? Coburn, Vartanian, & Chatterjee (2017) propose a neuroscientific framework for studying architecture: a triad divided into knowledge–meaning, sensory–motor, and emotion–valuation. Their proposal, unsurprisingly, goes far beyond interaction with nature, with a large majority of the paper discussing neurological mechanisms in support of their framework. However, focusing on the psychological basis for their argument, there are similarities with the studies previously mentioned. In their discussion on visual complexity, the authors explain how curvilinear architecture is preferred over rectilinear architecture, similar to the results regarding NSED. Additionally, the authors argue that poorly designed architecture induces an increased stress response, ultimately resulting in negative effects on long-term health. This point, in particular, has largely been overlooked until now, though it is perhaps the most important insight shared across many of the papers discussed here.

6. The Results in the Present Social Context

Thus far, an outline of the benefits of nature and theories about their cause have been the topic of discussion. However, there exists a world outside of the research. Understanding the relationship between the research and the outside world is necessary in order to understand the research topic as a whole. Observing this relationship over time is perhaps the most valuable method to gain a more complete understanding of the topic, not just in regards to the research itself, but also in regards to the interaction between the researchers and the external world. Luckily, three of the papers discussed herein share three of the same authors and are distributed

across three years (Kotabe et al., 2016, 2017; Schertz et al., 2018). Comparing the conclusion paragraph in each paper reveals a pattern.

Kotabe et al. (2016), conclude “this approach *may* inform the design of both real and virtual environments” (emphasis added; Kotabe et al., 2016, p. 13); Kotabe et al. (2017), “there is a *pressing demand* to incorporate nature into built environments” (emphasis added; Kotabe et al., 2017, p. 1140); and finally, Schertz et al. (2018), “influences of low-level visual features *must* be taken into account” (Schertz et al., 2018, p. 92). In three years, the authors’ suggestion became an assertion that implementing changes in response to their findings is of absolute necessity.

In a study that predates all of the aforementioned, Berman et al. (2008) suggest alternative methods of improving voluntary attention, including meditation, sleep, and glucose consumption. Ultimately, though, the authors conclude that, “To consider the availability of nature as merely an amenity fails to recognize the vital importance of nature in effective cognitive functioning” (Berman et al., 2008, p. 1211). If the alternative methods mentioned are seen as offsetting the strong phrasing in the conclusion, then the authors of these four studies demonstrate a clear progression in their confidence in the conclusiveness of their results.

In the context of modern cities, new-urbanism is leading the way to urban environments that integrate natural elements such as those presented in this research. Yet, it remains to be seen what impact the research has had or will have. The revival of a desire for natural environments in urban spaces was not the result of these studies, but perhaps the studies could be used to convince policy-makers that integrating natural environments within cities is more than just a fad. Regardless, based on the current trends, nature is coming to a city near you. Even if this research has no effect on that outcome, it does provide valuable insight into human cognition.

Virtual reality is a target that this research will likely influence, as the context is inherently unable to support nature natively. That is, cities can address a lack of nature by planting trees, whereas VR companies must construct nature artificially.

An enticing approach to increasing exposure to ‘nature’ is to improve VR to the point that it can trick our brains to think that we are actually in nature. However, this may not be possible as presenting nature through technology such as a monitor decreases the positive benefits (Kotabe et al., 2017). Whether or not VR is capable of achieving parity with nature remains an open question.

7. Conclusion

The present research challenges previously held assumptions, demonstrating that low-level visual features such as NSED are significant predictors of thought content and rule-breaking. The positive benefits of nature are widespread, with no discernable negative effects, thus motivating an increase in nature in urban environments presently lacking availability. Many questions remain open in the present research, such as validation of theories explaining our affinity to nature as well as our ability to reproduce the beneficial aspects of nature in an artificial environment. Nevertheless, research into this topic is active and quickly moving forward, so some of these questions may soon be answered.

Works Cited with Abstracts

Alter, A. L., Oppenheimer, D. M., Epley, N., & Eyre, R. N. (2007). Overcoming intuition:

metacognitive difficulty activates analytic reasoning. *Journal of Experimental Psychology: General*, 136(4), 569.

Humans appear to reason using two processing styles: System 1 processes that are quick, intuitive, and effortless and System 2 processes that are slow, analytical, and deliberate that occasionally correct the output of System 1. Four experiments suggest that System 2 processes are activated by metacognitive experiences of difficulty or disfluency during the process of reasoning. Incidental experiences of difficulty or disfluency—receiving information in a degraded font (Experiments 1 and 4), in difficult-to-read lettering (Experiment 2), or while furrowing one's brow (Experiment 3)—reduced the impact of heuristics and defaults in judgment (Experiments 1 and 3), reduced reliance on peripheral cues in persuasion (Experiment 2), and improved syllogistic reasoning (Experiment 4). Metacognitive experiences of difficulty or disfluency appear to serve as an alarm that activates analytic forms of reasoning that assess and sometimes correct the output of more intuitive forms of reasoning.

Berman, M. G., Jonides, J., & Kaplan, S. (2008). The cognitive benefits of interacting with nature. *Psychological Science*, 19(12), 1207–1212.

We compare the restorative effects on cognitive functioning of interactions with natural versus urban environments. Attention restoration theory (ART) provides an analysis of the kinds of environments that lead to improvements in directed-attention abilities. Nature, which is filled with intriguing stimuli, modestly grabs attention in a bottom-up fashion, allowing top-down directed-attention abilities a chance to replenish. Unlike natural environments, urban environments are filled with stimulation that captures attention dramatically and additionally requires directed attention (e.g., to avoid being hit by a car), making them less restorative. We present two experiments that show that walking in nature or viewing pictures of nature can improve directed-attention abilities as measured with a backwards digit-span task and the Attention Network Task, thus validating attention restoration theory.

Coburn, A., Vartanian, O., & Chatterjee, A. (2017). Buildings, Beauty, and the Brain: A

Neuroscience of Architectural Experience. *Journal of Cognitive Neuroscience*, 29(9), 1521–1531. https://doi.org/10.1162/jocn_a_01146

A burgeoning interest in the intersection of neuroscience and architecture promises to offer biologically inspired insights into the design of spaces. The goal of such interdisciplinary approaches to architecture is to motivate construction of environments that would contribute to peoples' flourishing in behavior, health, and well-being. We suggest that this nascent field of neuroarchitecture is at a pivotal point in which neuroscience and architecture are poised to extend to a neuroscience of architecture. In such a research program, architectural experiences themselves are the target of neuroscientific inquiry. Here, we draw lessons from recent developments in neuroaesthetics to suggest how neuroarchitecture might mature into an experimental science. We review the extant literature and offer an initial framework from which to contextualize such research. Finally, we outline theoretical and technical challenges that lie ahead.

Kotabe, H. P., Kardan, O., & Berman, M. G. (2016). The order of disorder: Deconstructing visual disorder and its effect on rule-breaking. *Journal of Experimental Psychology: General*, 145(12), 1713.

General, 145(12), 1713.

Disorderly environments are linked to disorderly behaviors. Broken windows theory (Wilson & Kelling, 1982), an influential theory of crime and rule-breaking, assumes that scene-level social disorder cues (e.g., litter, graffiti) cause people to reason that they can get away with breaking rules. But what if part of the story is not about such complex social reasoning? Recent research suggests that basic visual disorder cues may be sufficient to encourage complex rule-breaking behavior. To test this hypothesis, we first conducted a set of experiments (Experiments 1–3) in which we identified basic visual disorder cues that generalize across visual stimuli with a variety of semantic content. Our results revealed that spatial features (e.g., nonstraight edges, asymmetry) are more important than color features (e.g., hue, saturation, value) for visual disorder. Exploiting this knowledge, we then reconstructed stimuli contrasted in terms of visual disorder, but absent of scene-level social disorder cues, to test whether visual disorder alone encourages cheating in a second set of experiments (Experiments 4 and 5). In these experiments, manipulating visual disorder increased the likelihood of cheating by up to 35% and the average magnitude of cheating by up to 87%. This work suggests that theories of rule-breaking that assume that complex social reasoning (e.g., about norms, policing, poverty) is necessary, should be reconsidered (e.g., Kelling & Coles, 1997; Sampson & Raudenbush, 2004). Furthermore, these experiments show that simple perceptual properties of the environment can affect complex behavior and sheds light on the extent to which our actions are within our control.

Kotabe, H. P., Kardan, O., & Berman, M. G. (2017). The Nature-Disorder Paradox: A Perceptual

Study on How Nature Is Disorderly Yet Aesthetically Preferred. *Journal of Experimental Psychology-General*, 146(8), 1126–1142. <https://doi.org/10.1037/xge0000321>

Natural environments have powerful aesthetic appeal linked to their capacity for psychological restoration. In contrast, disorderly environments are aesthetically aversive, and have various detrimental psychological effects. But in our research, we have repeatedly found that natural environments are perceptually disorderly. What could explain this paradox? We present 3 competing hypotheses: the aesthetic preference for naturalness is more powerful than the aesthetic aversion to disorder (the nature-trumps-disorder hypothesis); disorder is trivial to aesthetic preference in natural contexts (the harmless-disorder hypothesis); and disorder is aesthetically preferred in natural contexts (the beneficial-disorder hypothesis). Utilizing novel methods of perceptual study and diverse stimuli, we rule in the nature-trumps-disorder hypothesis and rule out the harmless-disorder and beneficial-disorder hypotheses. In examining perceptual mechanisms, we find evidence that high-level scene semantics are both necessary and sufficient for the nature-trumps-disorder effect. Necessity is evidenced by the effect disappearing in experiments utilizing only low-level visual stimuli (i.e., where scene semantics have been removed) and experiments utilizing a rapid-scene-presentation procedure that obscures scene semantics. Sufficiency is evidenced by the effect reappearing in experiments utilizing noun stimuli which remove low-level visual features. Furthermore, we present evidence that the interaction of scene semantics with low-level visual features amplifies the nature-trumps-disorder effect—the effect is weaker both when statistically adjusting for quantified low-level visual features and when using noun stimuli which remove low-level visual features. These results have implications for psychological theories bearing on the joint influence of low- and high-level perceptual inputs on affect and cognition, as well as for aesthetic design.

Schertz, K. E., Sachdeva, S., Kardan, O., Kotabe, H. P., Wolf, K. L., & Berman, M. G. (2018). A

thought in the park: The influence of naturalness and low-level visual features on

expressed thoughts. *Cognition*, 174, 82–93.

<https://doi.org/10.1016/j.cognition.2018.01.011>

Prior research has shown that the physical characteristics of one's environment have wide ranging effects on affect and cognition. Other research has demonstrated that one's thoughts have impacts on mood and behavior, and in this three-part research program we investigated how physical features of the environment can alter thought content. In one study, we analyzed thousands of journal entries written by park visitors to examine how low-level and semantic visual features of the parks correlate with different thought topics. In a second study, we validated our ecological results by conducting an online study where participants were asked to write journal entries while imagining they were visiting a park, to ensure that results from Study 1 were not due to selection bias of park visitors. In the third study, we experimentally manipulated exposure to specific visual features to determine if they induced thinking about the same thought topics under more generalized conditions. Results from Study 3 demonstrated a potential causal role for perceived naturalness and high non-straight edges on thinking about "Nature", with a significant positive interaction. Results also showed a potential causal effect of naturalness and non-straight edges on thinking about topics related to "Spiritual & Life Journey", with perceived naturalness having a negative relationship and non-straight edges having a positive relationship. We also observed a significant positive interaction between non-straight edge density and naturalness in relation to "Spiritual & Life Journey". These results have implications for the design of the built environment to influence human reflection and well-being.