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Original Articles

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

Kathryn E. Schertz[a,*], Sonya Sachdeva[b], Omid Kardan[a], Hiroki P. Kotabe[a,1], Kathleen L. Wolf[c], Marc G. Berman[a,*]

[a] Department of Psychology, University of Chicago, 5848 S University Ave, Chicago, IL 60637, USA
[b] Northern Research Station, U.S. Forest Service, 1033 University Place, Suite 360, Evanston, IL 60201, USA
[c] College of the Environment, University of Washington, 1492 NE Boat St, Suite 200, Seattle, WA 98105, USA

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ABSTRACT

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.

1. Introduction

The physical properties of the environment that people spend their time in have wide ranging effects on cognitive functioning (Berman, Jonides, & Kaplan, 2008; Berman et al., 2012), health (Kardan, Gozdyra, et al., 2015), mental health (Mantler & Logan, 2015), and self-control behaviors (Kotabe, Kardan, & Berman, 2016a). Greener surroundings in public housing developments have been associated with less crime (Kuo & Sullivan, 2001), and nearby green spaces positively predict self-discipline scores in inner-city girls (Taylor, Kuo, & Sullivan, 2002). Additionally, brief exposures to nature decrease depressive rumination, a maladaptive pattern of self-referential thought (Bratman, Hamilton, Hahn, Daily, & Gross, 2015), suggesting that the physical features of the environment may influence an individual's specific thought content.

The valence and content of people's thoughts have also been associated with various effects on mood and cognitive functioning. For example, research on mind wandering has shown that people whose thoughts are off-topic are less happy than those whose thoughts are more on-topic (Killingsworth & Gilbert, 2010). In contrast, expressive writing evaluations have shown that thinking and writing about specific events, and one's emotional response to them, is associated with improvements in physical and mental health outcomes (Pennebaker & Beall, 1986). Similarly, writing about good things that happen each day has been associated with increased happiness and decreased depressive symptoms (Seligman, Steen, Park, & Peterson, 2005). Thus, thoughts can have both negative and positive effects. Our studies explored how such thought patterns might change in natural environments as these understandings could shed light on why exposure to natural environments (e.g., neighborhood parks) has mental health benefits.

* Corresponding authors.
E-mail addresses: kschertz@uchicago.edu (K.E. Schertz), sonyasachdeva@fs.fed.us (S. Sachdeva), okardan@uchicago.edu (O. Kardan), hkotabe@uchicago.edu (H.P. Kotabe), kwolf@u.washington.edu (K.L. Wolf), bermanm@uchicago.edu (M.G. Berman).
[1] Present/permanent address: Graduate School of Business, Sungkyunkwan University, 25-2 Sungkyunkwan-ro, Myeognyun 3(sam)ga, Jongno-gu, Seoul, South Korea.

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Urban parks are vital spaces for sustainable cities as they provide social and psychological benefits to residents (Chiesura, 2004) and are often used for restoration, exercise, or social gatherings (Nordh & Østby, 2013). Many studies have shown that park features and aesthetics can change how people feel in those parks. Park size, as well as the amount of grass, bushes, and trees, has been shown to affect the perceived restorative quality of the space (Nordh, Hartig, Hagerhall, & Fry, 2009). Additionally, parks with more grass and water were found to positively correlate with the perceived safety of the park, while graffiti and litter were negatively correlated with perceived safety (Schroeder & Anderson, 1984). These features likely impact when, how often, and for what reason people choose to go to a park.

In addition to these semantic cues/features, recent research suggests that low-level visual features, that is basic color and spatial features, can carry semantic information (Kotabe, Kardan, & Berman, 2016b; Oliva & Torralba, 2006; Walther, Caddigan, Fei-Fei, & Beck, 2009), as well as interact with top-down interpretations of the visual information (Ibarra et al., 2017; Kardan, Henderson, Yourganov, & Berman, 2016; Kardan et al., 2017). For instance, the amount of non-straight edges in a scene is positively correlated with the perceived naturalness (Berman et al., 2014) and preference (Kardan, Demiralp, et al., 2015) for those scenes across a wide range of urban and natural settings. Bar and Neta (2006) found that people prefer objects with curved edges over those with straight edges, which is consistent with results from more recent studies (Kardan, Demiralp, et al., 2015; Kotabe, Kardan, & Berman, 2017). Research using computer graphics has found that both curved and jagged paths create patterns that were judged to be more organic and engaging as compared to straight paths (Lockyer & Bartram, 2012). Relatedly, recent neuroaesthetic research has provided support to the idea that contour is an important factor in aesthetic judgments (Vartanian et al., 2013) and that the curvature of paths influence how goal-oriented travel on those paths will be (Loidl & Bernard, 2014). The number of edges in a scene is also highly correlated with visual complexity (Forsythe, Nadal, Sheehy, Cela-Conde, & Sawey, 2011), which in turn can lead to cognitive disfluency. While this is usually interpreted negatively, it has been shown that cognitive disfluency can increase deep, abstract thinking (Alter, 2013). In all, this research demonstrates that low-level visual features can influence higher level judgments and in particular that curves and edges have a direct influence on preferences and thought content.

In the first study, we analyzed thousands of informal, anonymous, written entries from park journals as a way to ascertain general mindsets and spontaneous thought patterns of park users during their visits, and investigated whether written entries were systematically connected to specific visual features of the environment. Across our research program, 'semantics,' refers collectively to *meaningful judgments* about a scene (naturalness, preference) and 'low-level visual features,' refers collectively to the basic spatial and color features of a scene (e.g. edges, hue). This method takes advantage of real-time impressions park goers are forming instead of relying on recall or mental reconstruction. Specifically, in Study 1, we conducted an ecological experiment, correlating visual features of parks with the semantic content of journal entries written by park visitors. This allowed us to understand the degree and type of correspondence between the low-level visual features of a park and the general topics of thought while visitors are in the park. Furthermore, it allowed us to assess whether these parks, founded by the TKF Foundation, were achieving their goal of being a place for respite and renewal (Wolf & Housley, 2016). Particular thought patterns may be noteworthy, in that shifts in thought patterns could coincide with cognitive changes, reflecting some of the restorative effects observed when spending time in nature (for reviews see Bratman, Hamilton, & Daily, 2012, and Kaplan & Berman, 2010). Results from Study 1 showed a high prevalence of topics related to religion, attention to place, and time. In particular the prevalence of the topic of "Spiritual & Life Journey" was correlated with increased numbers of non-straight edges, while the topic of "Nature" was correlated with high naturalness.

Due to the ecological nature of Study 1, we wanted to ensure that our topic modeling results which emphasized positive reflection were not due to selection bias, in that people who chose to write in park journals are generally more reflective. To address this concern, we conducted an online study where participants from across the United States were shown images of the TKF parks, asked to imagine they were visiting the parks, and then write about how visiting that park would make them think or feel. While the topics modeled from this study were unique, we again saw evidence that people were positive and reflective about life, nature and other people. We found two topics that positively correlated with both the "Spiritual & Life Journey" topic from Study 1 and non-straight edges. We also found two topics that correlated with both the "Nature" topic from Study 1 and high naturalness. These results support the validity of our ecological results from Study 1.

In Study 3, we extended our findings by experimentally manipulating exposure to different visual features using the SUN database (Xiao, Hays, Ehinger, Oliva, & Torralba, 2010), a large independent set of images from different physical environments, to assess the causal relationship between low-level and semantic visual features and thought patterns. That is, could the low-level features of an environment cause participants to think about similar topics such as those contained within the journals from TKF parks? In Study 3, we manipulated the amount of non-straight edges and naturalness of the images and found that those features induced thinking about nature, life, and spirituality under more generalized conditions. These results have implications for the design of built spaces to manipulate the reflections and thoughts for people using those spaces.

2. TKF images and journals (Study 1)

2.1. Method and materials

2.1.1. TKF parks

The TKF Foundation, based in Annapolis, MD, USA, has supported the creation of more than 120 small parks, mainly located in cities in the mid-Atlantic coastal region of the United States. These parks are designed and constructed using collaborative approaches, and are typically located in association with hospitals, museums, churches, or city neighborhoods, but installations are also in prisons, schools, college campuses and rehab centers. The parks differ from other urban parks in several ways. First, the TKF Foundation is dedicated to a mission of creating spaces that encourage spiritual connections with nature (http://naturesacred.org/our-approach/elements-of-an-open-space/). Each of the parks has four physical design elements—'portal', 'path', 'destination', and 'surround'—which were chosen to "support moments of contemplation and respite" (Wolf & Housley, 2016). The portal is a clearly marked entryway into the park, to delineate movement into the space. The path is a device to focus one's attention. Destination features, such as art pieces or water fountains, draw a person into a space, while the surround creates a "sense of boundary, safety" (http://naturesacred.org/our-approach/elements-of-an-open-space/).

The resulting park designs generally align with the spatial characteristics proposed by attention restoration theory (ART, Kaplan, 1995; Kaplan & Kaplan, 1989). ART proposes that certain types of environments can be "restorative", in that they can help recover top-down directed attention resources that have been fatigued. Kaplan (1995) proposes that these environments are high in compatibility, extent, being away and soft fascination. Soft fascination is provided by natural environments in that they capture bottom-up involuntary attention without being overwhelming (Kaplan & Berman, 2010). Think of a waterfall that is interesting to look at, which captures involuntary attention, but does not do so in an all-consuming way, i.e., one still has attentional resources to think about other things. This differs from stimuli that harshly capture attention, such as loud noises, bright lights, etc., which capture attention, but do so in an all-consuming way. Most natural parks in urban areas do not place demands on directed