Why viewing nature is more fascinating and restorative than viewing buildings: A closer look at perceived complexity

Agnes E. van den Berg
Department of Cultural Geography
University of Groningen, The Netherlands

Yannick Joye
Department of Marketing
University of Groningen, The Netherlands

Sander L. Koole
Department of Clinical Psychology
VU University, Amsterdam, The Netherlands

Direct correspondence to A.E. van den Berg, University of Groningen, Faculty of Spatial Sciences, Department of Cultural Geography, P.O. Box 800, 9700 AV, Groningen, The Netherlands, e-mail: a.e.van.den.berg@rug.nl, phone +31 50 363 3897, fax + 31 50 363 3901

Abstract

The present paper addresses the question which visual features trigger people's often more positive affective responses to natural compared to built scenes. Building on notions about visual complexity and fractal geometry, we propose that perceived complexity of magnified scene parts can predict the greater fascinating and restorative qualities of natural versus built scenes. This prediction was tested in an experiment in which 40 participants viewed and rated 40 images of unspectacular natural and built scenes in their original size, and at 400% and 1600% magnification levels. Results showed that the original, unmagnified natural scenes were viewed longer and rated more restorative than built scenes, and that these differences were statistically mediated by the greater perceived complexity of magnified parts of natural scenes. These findings fit with the idea that fractal-like, recursive complexity is an important visual cue underlying the restorative potential of natural and built environments.

Keywords: fractal geometry, green space, landscape preferences, viewing time

Introduction

Research has consistently shown that interacting with natural environments can improve mood and attention, reduce stress levels, and lead to many other healthy and restorative outcomes (Hartig, Mitchell, de Vries, & Frumkin, 2014). Merely viewing trees or plants from a window, or even images of nature can already have measurable positive effects (Grinde & Patil, 2009; Honold, Lakes, Beyer, & van der Meer, 2016; Van den Berg, Koole, & Van der Wulp, 2003). This suggests that, besides physical factors like the stimulation of exercise and improvement of air quality, psychological mechanisms play an important role in the beneficial effects of nature.

Attention Restoration Theory (ART; Kaplan & Kaplan, 1989; Kaplan, 1995) has described one of the basic psychological mechanisms by which viewing nature my lead to beneficial effects. According to ART, most natural scenes capture attention in a pleasant and effortless manner, allowing the mind to rest and wander freely while the capacity for directing attention is replenished. This gentle capturing of attention has been described as ‘soft’ fascination, to distinguish it from more hard forms of fascination that capture attention dramatically and cause depletion of executive attentional resources.

The mechanism of soft fascination is widely acknowledged and supported by analyses of people’s eye movements when viewing high and low fascination images (Berto, Massaccesi, & Pasini, 2008). It leaves, however, unanswered the fundamental question which distinctive visual characteristics make viewing natural scenes more fascinating than viewing built scenes (Valtchanov & Ellard, 2015). Finding this missing piece of the puzzle is not only of theoretical importance, but may also contribute to a more effective design of urban green space that makes optimal use of its health-supporting ingredients.

A potential candidate for being that special cue that triggers soft fascination with nature is visual complexity (Berlyne, 1971; Nadal, Munar, Marty, & Cela-Conde, 2010). Natural environments tend to be characterized by intermediate levels of visual complexity, which appear to be just right for attracting attention in a moderate, pleasant way. By contrast, most human-made environments are either highly complex (evoking hard fascination) or virtually lacking in visual complexity and unable to capture attention at all (e.g., Wohlwill, 1983). However, environmental perception studies have revealed that subjective measures of perceived complexity, such as the question “how many different elements are there in this scene”, only predict fascination and other positive responses within natural and built domains. These measures cannot account for differences between these domains (Kaplan, Kaplan, & Wendt, 1972; Sparks & Wang, 2014).

A scene's overall level of visual complexity is not only determined by the number and amount of elements, but also by the degree to which visual information is structured and ordered across scale levels (Nadal, et al., 2010). This latter, more hidden dimension of visual complexity is not readily perceivable and cannot be assessed with standard subjective measures. To capture the interplay between variety and order, researchers have increasingly used objective measures of visual complexity based on notions of information theory (e.g. Kolmogorov complexity and Shannon entropy) and fractal geometry (Machado et al., 2015; Marin & Leder, 2013). Especially fractal geometry has been found useful in describing the visual complexity of natural environments (Taylor, Spehar, Hägerhäll, & Van Donkelaar, 2011). Fractals capture the order and structure in natural environments by the recurrence of similar visual information across multiple scale levels. This is illustrated by the fact that natural scenes retain roughly the same amount of elements and form as one zooms in and out of the scene.

The fractal dimension is an index of the extent to which a space is filled by details, and as such can be considered a measure of visual complexity (Machado, et al., 2015). Research has shown that people respond most positively to fractal images and patterns with an intermediate fractal dimension that is commonly found in nature, which suggests that the visual system might be tuned to the processing of natural information (Aks & Sprott, 1996; Taylor, et al., 2011). Furthermore, EEG recorded alpha waves, an indicator of a wakefully relaxed state, tend to be larger for natural (statistical) fractals than for artificial (exact) fractals (Hagerhall et al., 2015). Thus far, however, research on human responses to fractals has exclusively relied on objective methods such as the box-counting technique to measure fractal characteristics. Although such measures are highly informative, they do not capture the more subjective components of environmental perception.

In the present research, we take a more subjective, psychological approach toward assessing recursive, fractal-like complexity. Specifically, we adapted a method described by Mandelbrot (1981), in which an image of an environment is cut into parts, after which the parts are magnified to the same size as the original image. The more elements remain visible in the magnified parts, the higher the environment's fractal complexity. Following this example, we asked participants to rate the perceived complexity of photographs of natural and urban settings, and cropped segments of these photographs at two magnification levels. We also assessed participants' free viewing times of the images as a well-established behavioral measure of fascination (Lang, Greenwald, Bradley, & Hamm, 1993), which has been previously applied in restorative environments research to assess differences in fascination between natural and built settings (Berto, 2005). Furthermore, we obtained self-reports of fascination and other restorative outcomes for the original, unmagnified images.

We had three hypotheses. First, in line with previous restorative environments research, we predicted that unmagnified natural scenes would be viewed longer, and rated as more restorative, than unmagnified built scenes. Second, reflecting the recursive, fractal complexity of nature, we predicted that magnified parts of natural scenes would maintain higher levels of perceived complexity and fascination than magnified parts of built scenes. Third, based on the idea that positive responses to nature are partly triggered by recurring visual information on lower scales that only becomes visible with magnification of scene parts, we predicted that perceived complexity of magnified scene parts would statistically mediate differences in viewing times and restorative quality between the unmagnified natural and built scenes.

Method

Stimuli

The stimulus set consisted of 40 photos of everyday, unspectacular scenes in Belgium and the Netherlands. Half of the scenes depicted common natural objects and places such as trees, bushes and grassy spots, the other half depicted residential and office buildings. We selected small-scale setting types instead of more panoramic views to minimize the influence of compositional variables such as mystery or openness, which may influence people's responses to a scene independent of its naturalness. To ensure sufficient variability in fractal complexity within the built sample, half of the built scenes depicted modern and traditional buildings with a high degree of ornamentation and detail (e.g. photos B1-B10 in the online supplementary material), while the other half depicted modern and traditional buildings with little ornamentation and detail (B11-B20). We also varied the fractal complexity of natural scenes by including both information-rich natural scenes like tree-tops and forest scenery (N1- N10) as well as more plain shrubs and grassy fields (N11-N20). None of the scenes contained water features, humans, animals or other potentially confounding features like unusual architecture or dramatic sunsets.

All photos were taken in autumn with a Canon EOS 1200D digital camera with an EF 70-200mm f/4.0L IS USM lens, at full resolution of 18 megapixels. Adobe Photoshop was used to create magnified versions of each original image. 'Medium magnification' images showed a 1/16 part of the original photo magnified to 400%. 'High magnification' images showed a 1/256 part of the original photo magnified to 1600% (See Fig. 1). All images were sized to 712 x 475 pixels (475 x 712 for vertical pictures).

Fig. 1.

Examples of photos of natural and built scenes shown at increasing magnification levels. The two top rows depict scenes with high perceived complexity of magnified scene parts, the two bottom rows depict scenes with low perceived complexity of magnified scene parts.

Participants

Forty students and employees (17 males) of a Dutch university with a mean age of 21.8 years (range 18-45) participated in the study for a compensation of 7 euro. Participants represented various departments and disciplines, about half of which were nature-oriented (e.g. landscape planning, forest management). Fifty-two percent of the participants considered themselves a "nature person", 15% considered themselves a "city person", and 33% considered themselves a bit of both.

Procedure and measures

The photos were presented on a laptop in three blocks, with order randomized within blocks. The first block showed the environments in their original size, the second block showed the four times magnified parts of the environments and the third showed the sixteen times magnified parts.

To obtain a behavioral measure of fascination, participants first watched the three blocks while their free viewing times for each photo were recorded using Macromedia Authorware. Participants were instructed to "*watch the photos in the same manner as you would watch someone's holiday pictures. If one picture is more interesting than the other, you watch it for a longer time. So please look at each setting until you no longer find it interesting*". At the beginning of the second and third block, participants were informed that they were going to view magnified parts of the previously presented environments.

After free viewing, participants rated the unmagnified photos on statements measuring perceived complexity ('*there are many different elements to see in this environment*') and four dimensions of restorative quality, including fascination ('*this environment is fascinating*'), beauty ('*I find this environment beautiful'*), relaxation ('*I experience a feeling of relaxation when I look at this environment'*) and positive affect ('*I get a warm feeling inside when I look at this environment').* They also rated the magnified parts on perceived complexity and fascination. All statements were measured on a 7-point scale (1 = 'strongly disagree', 7 = 'strongly agree'). Finally, participants completed questions about background characteristics and manipulation checks, and were paid and debriefed. The total duration of the experiment was about 45 minutes.

Viewing times (M = 5.27 seconds, SD = 4.83 seconds) were cut off at +2.5 SD to reduce the impact of outliers. Ratings of fascination, beauty, relaxation and positive affect of the unmagnified scenes were highly correlated, and were combined into one index of restorative quality by averaging the scores (Cronbach's alpha = .92).

Statistical analysis

Data were analyzed using MLwiN software for multilevel analysis to control for the clustering of settings within individuals. We estimated the effects of scene type (natural, built) and magnification level (original, 400%, 1600%) using 2-level random intercept models with random coefficients for scene type and magnification level. Mediation analyses were carried out following procedures for multilevel mediation described by Kenny, Korchmaros and Bolger (2003). In these analyses, the average scores of perceived complexity of the four and sixteen times magnified parts (centered around participants' means) were used as the mediating variable. The Monte Carlo Method was used to calculate the 95% confidence interval (CI) for the indirect effects (Selig & Preacher, 2008).

Results

Consistent with our first hypothesis, participants spent more than a second longer viewing the unmagnified natural scenes than the unmagnified built scenes, $b = 1.16$, 95% CI = 0.45 to 1.87, and they also rated the unmagnified natural scenes as significantly more restorative, $b = 1.37$, 95% CI = 1.12 to 1.62, *p*s < .001. At the same time, participants rated the unmagnified natural scenes about equally complex as their built counterparts, $b = 0.07$, 95% CI = -0.16 to 0.30, $p > .27$. This latter finding implies that the directly perceivable complexity of the unmagnified scenes does not qualify as a mediator of the longer viewing times and higher restorative quality of natural versus built scenes.

There was substantial variability in viewing times and perceived restorative quality within the sets of natural and built scenes, which was related to fractal properties of the scenes. The ten unmagnified built scenes depicting buildings with much ornamentation and detail were viewed longer, $b = 1.63$, 95% CI = 1.24 to 2.02, and rated more restorative, $b = 1.15$, 95% CI = 0.99 to 1.31, *p*s < .001, than the ten scenes depicting buildings with little ornamentation and detail. Furthermore, the ten unmagnified natural scenes depicting information-rich tree-tops and forest were viewed longer, $b = 2.3$, 95% CI = 1.91 to 2.69, and rated more restorative, $b = 1.5$, 95% CI = 1.34 to 1.66, *p*s < .00, than the ten scenes depicting shrubs and fields.

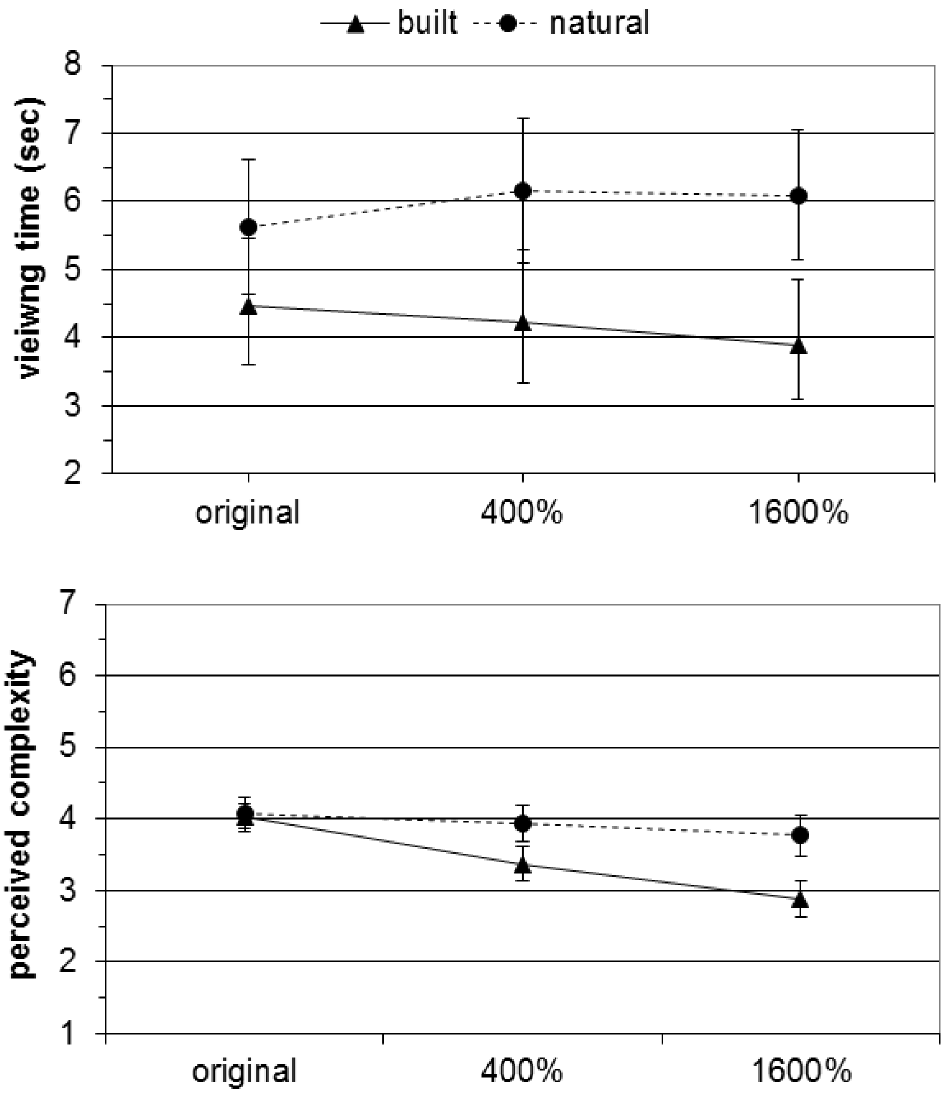

Fig. 2.

Average viewing times (top) and perceived complexity (bottom) with error bars (95% CI) of natural and built scenes across magnification levels.

Influences of magnification level

Consistent with our second hypothesis, the interaction between scene type and magnification level was significant for both complexity, $\chi^2(2) = 74.15$, $p < .001$ and viewing times, $\chi^2(2) = 40.41$, $p < .001$ As illustrated in Fig. 2, participants viewed built scenes for a shorter time, and rated them as less complex with increasing magnification. By contrast, viewing times of natural scenes slightly increased, and perceived complexity only slightly decreased, with increasing magnification.

In line with their more fractal appearance, the four and sixteen times magnified parts of buildings with much ornamentation were on average rated more complex than magnified parts of buildings with little ornamentation and detail, $b = 1.04$, 95% CI = 0.89 to 1.19, $p < .001$. Magnified parts of trees and forest scenes were also rated as more complex than magnified parts of scenes depicting shrubs and fields, $b = 0.49$, 95% CI = 0.34 to 0.64, $p < .001$.

Mediation analysis

Consistent with our third hypothesis, basic conditions for mediation were met for both outcome variables. As shown in Fig. 3, scene type was significantly associated with viewing times, $b = 1.16$, and restorative quality, $b = 1.37$, of the unmagnified scenes, *p*s < .001 (path c). Second, scene type was significantly associated with the average perceived complexity of the magnified scene parts, $b = 0.73$, $p < .001$ (path a). Third, perceived complexity of the magnified parts was significantly associated with both viewing times, $b = 0.75$, $p < .001$ and restorative quality, $b = 0.39$, $p < .001$ of the unmagnified scenes independent of scene type (path b). Fourth, the impacts of scene type on viewing times and restorative quality of the unmagnified scenes were reduced by 47% and 20%, respectively, when these were estimated while controlling for perceived complexity of the magnified parts (path c'). The statistical significance of the mediation effects was confirmed by the confidence intervals for the indirect (mediated) effects, which did not include zero for viewing times, 95% CI = 0.32 to 0.78, and restorative quality, 95% CI = 0.17 to 0.4.

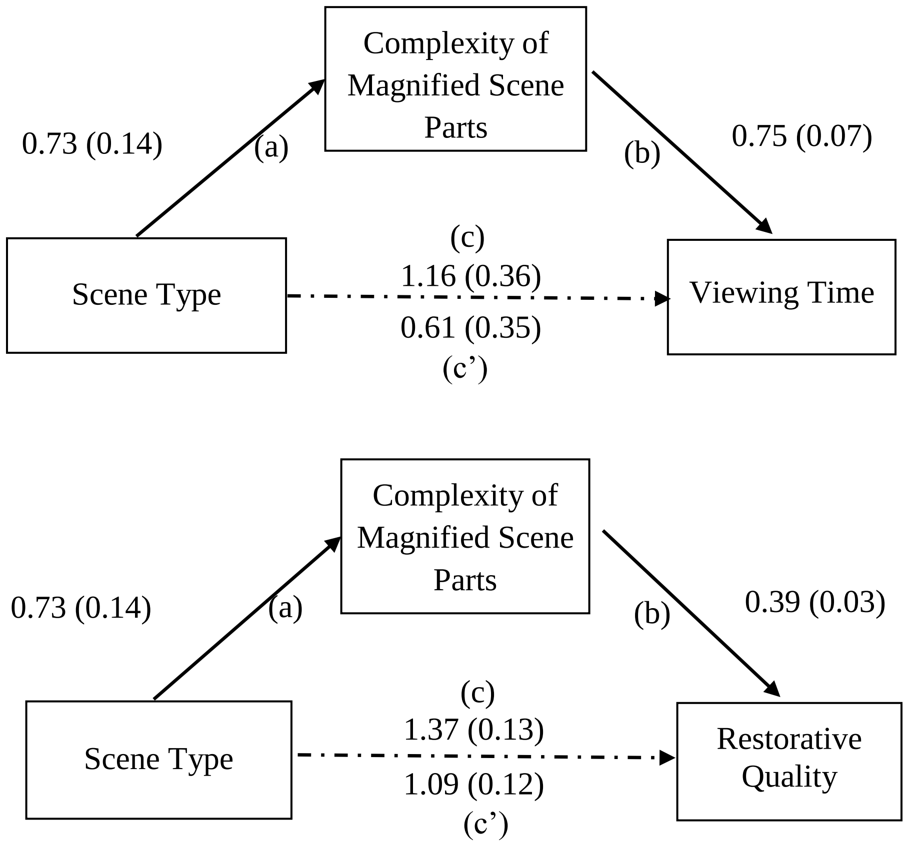

Fig. 3.

Mediation models showing the effects of scene type (natural vs. built) on viewing time and restorative quality, as mediated by the average perceived complexity of four and sixteen times magnified scene parts. Unstandardized regression weights are shown, with standard errors between parentheses.

Discussion

The present study showed that magnified parts of natural scenes were perceived as more complex than magnified parts of built scenes. Furthermore, differences in perceived complexity of magnified scene parts statistically mediated the greater fascinating and restorative qualities of unmagnified natural versus built scenes, as measured by free viewing times and self-reports. These findings suggest that positive responses to natural scenes at least partly result from bottom-up processing of recursive, fractal information patterns that are more commonly found in nature than in other types of environments.

Prior research has shown that people's psychological responses to natural environments are predicted by mathematically derived fractal characteristics, such as the fractal dimension (Joye, Steg, Ünal, & Pals, 2016; Taylor, et al., 2011). The present research complements this prior work by demonstrating similar associations using perceived complexity of magnified scene parts as a subjective, psychological measure of fractal complexity. The present research also goes beyond prior work by demonstrating that perceived complexity of magnified parts could explain substantial parts of the variability in affective responses between unmagnified natural and built scenes. This suggests that fractal complexity may be a key ingredient that makes natural scenes more fascinating and restorative than built scenes.

An important implication of our findings it that some of the fascinating and restorative potential of nature can be achieved with buildings provided they are sufficiently rich in ornamentation and detail. This finding strengthens the case for biophilic architecture (Joye, 2007). The present study also suggests that trees and forest settings may be relatively fascinating and restorative types of nature. However, more research is needed to further identify the physical correlates of fractal complexity in natural and built scenes.

We recorded participants' free viewing times as an objective measure of fascination. This measure correlated positively with perceived restorative quality and discriminated between natural and built scenes. However, a limitation of viewing times is that it cannot differentiate between restorative, "soft" types of fascination and nonrestorative, "hard" types of fascination (Kaplan, 1995). Because our stimulus set consisted of unspectacular, everyday scenes, the free viewing time in the present study is likely to reflect mostly the soft, restorative type of fascination. Nevertheless, some caution is warranted in interpreting the free viewing time data, and further research with more specific measures of soft fascination like tracking of eye movements is recommended (Berto, et al., 2008).

Several other limitations should be noted. First, the participants in the present study were relatively young and highly educated, and the majority of them had a professional or personal interest in nature. Consequently, the results from the current research may not be representative of the general population. Second, the experiment was rather lengthy with participants viewing 120 photos and subsequently rating these photos on several dimensions. It is possible that especially the ratings of the last block of highly magnified scene parts may have been less reliable due to fatigue and diminished concentration. Third, despite our efforts to standardize the stimulus set on potentially confounding variables, the natural and built scenes represented somewhat different perspectives. Most of the built scenes showed the whole building or a complete built setting, while many of the natural scenes showed just a part of a tree or setting (to avoid the wider landscape showing through). This may have influenced results, because the unmagnified natural scenes were already somewhat more magnified than the built scenes. A further limitation is that we did not determine the objective fractal dimension of our stimuli, so it was not possible to examine how the psychological approach to assessing fractal complexity is related to more direct mathematical indices of fractality.

Future research may yield more insight in the robustness of our findings by using different samples, different sets of natural and built scenes (including, for example, water bodies and other blue spaces), different magnification levels, and different outcome variables. Experimental research is needed in which participants are randomly assigned to conditions of viewing natural and built scenes that vary in pre-rated complexity of magnified scene parts to address the causal role of fractal complexity more confidently.

Taken together, the present study suggests that taking a closer look at the complexity of magnified scene parts may provide important clues to a scene's restorative potential. As such, the findings of the present study provide an important step towards a more optimal, health-supporting design of natural and built environments.

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