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Research Paper

Evaluations of landscape preference, complexity, and coherence for designed digital landscape models

Rob Kuper

Temple University, Dixon Hall 205, 580 Meetinghouse Road, Ambler, PA 19002, USA

HIGHLIGHTS

- Related designed and estimated complexity and coherence, setting, and preference.
- Preference increased with estimations of complexity, but not with coherence.
- Designed complexity and coherence correlated with respective estimations of each.
- As entropy rose, preference increased more in urban settings than in residential.
- Clustered plants preferred over formal, but varied with entropy and setting.

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ABSTRACT

Few studies have investigated whether intentionally manipulating objective measures related to the informational concepts of complexity and coherence, within the context of natural and built settings, affects respondents' preference ratings and estimations of complexity and coherence. Our study addresses this research need. Color digital landscape model views depicted three variations in the number of unique plant species (complexity), translated into Shannon's information entropy bit values, and three methods of plant organization (coherence)—formal, clustered, and scattershot—within field, residential, and urban settings. Participants viewed and evaluated the digital landscape model views for preference ($n = 77$) or estimated the presence of complexity ($n = 34$) or coherence ($n = 38$). Strong, direct correlations resulted between respondents' estimations of complexity and designed entropy bit values. Respondents' estimations of coherence inversely correlated with the number of regions depicted in model views that represent the methods of plant organization. Preference did not correlate with estimations of coherence or designed entropy values, but did correlate with estimations of complexity. Repeated measures ANOVA test results suggest that respondents' preference for scenes increased as entropy values increased between two and four bits, and that plants arranged in clusters were liked more than scattershot or formal compositions. Moreover, respondents liked residential settings significantly more than urban settings, and preference increased significantly more with increasing entropy values in urban settings than in residential. The interaction between setting and entropy values for depictions of clustered and formal plant arrangements affected preference differently in each setting.

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1. Introduction

In the last 40 years, environmental psychologists have sought to understand human landscape preference by associating respondents' evaluations of photographs that depict actual landscapes with the presence of objects, spaces, or concepts represented within the photographs. Coherence and complexity are two informational concepts that have emerged from such research and been examined as potential predictors of landscape preference. Kaplan and Kaplan (1989) defined complexity as the richness of a setting, or "how much there is to look at...[and] think about" (Kaplan & Kaplan, 1989: 53–54). Identifying attributes of complexity may include numerous, distinct colors, textures, shapes, and physical dimensions of foliage, flowers, path materials, topography, and structures. An orderly setting that is organized into a "few distinct regions or areas" that have "some repeating themes and unifying textures... and a limited number of contrasting textures" defines coherence (Kaplan, Kaplan, & Ryan, 1998: 14). Coherence also directs attention and allows a scene to "hang together" (Kaplan & Kaplan, 1989: 54).

E-mail address: rkuper@temple.edu

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Stamps (2004b) indicated that relationships between preference and coherence, and preference and complexity may exist, but the magnitude and direction of correlations between respondents' preference ratings and respondents' estimations of each criterion varied widely and were not replicable. He suggested that future research should relate respondents' preference ratings to the "obvious mathematical expression" of complexity—Shannon's information entropy (Stamps, 2002, 2003; Shannon & Weaver, 1949)—but did not offer an objective measure of coherence. Kaplan et al. (1998: 14) illustrated that placing plants of the same species close to one another relates directly to landscape coherence. To date, no studies we found on record have used the illustration in Kaplan et al. (1998), or any other, to create or test an objective measure of coherence.

Principles and objectives that landscape designers and planners have been applying for the last several hundred years support the implication that coherence and complexity are integral to creating landscapes that people like. In planting design, unity and variety may underlie all major design principles, and act together to form a two-pronged fundamental goal (Robinson, 1992). Unity, like the informational concept of coherence, creates aesthetic harmony, balances and "binds the various parts [of a composition] into a whole;" links or emphasizes elements; and forms "an ordered sequence of spaces and planting" (Robinson, 1992: 116). Variety, like the informational concept of complexity, can be achieved with a "range of species and cultivars," which "includes all the diversity" a designer may need (Robinson, 1992: 116).

Given the potential relationship between research in environmental psychology and the practices of landscape design and planning, this study asks: Can preferred landscapes be designed with replicable values related to the informational concepts of coherence and complexity? Four purposes address this question: first, we examine whether student laypersons' estimations of complexity for digital model views relate to designed complexity, which is represented by Shannon's information entropy values; second, we examine whether participants' estimations of coherence for digital model views relate to designed coherence, which is represented by the number of plant groups depicted in digital model views; third, we examine the potential relationship between student laypersons' preference ratings, estimations of complexity, and estimations of coherence; and finally, we examine the potential effect of designed complexity values and designed coherence values on laypersons' preference ratings within the contexts of field, residential, and urban settings.

1.1. Literature review & study hypotheses

1.1.1. Designed complexity, estimated complexity, and preference

This study begins by investigating the potential relationship between *designed* information entropy values and respondents' *estimations* of complexity. Claude Shannon distinguished information entropy from physical or thermodynamic entropy and defined it as a measure of information disorder (Shannon & Weaver, 1949; Spellerberg & Fedor, 2003). Entropy values are presented in bits. Generally, as the number of bits increase, the number of alternatives one may decide between, or levels of an informational factor, double. Following is the formula for calculating information entropy, which is otherwise known as the Shannon Index or Shannon-Wiener Index:

$$H_{factor} = -\sum_{i=1}^{nlevels} p_i \log_2 p_i \quad (1)$$

where H is entropy in bits and p is the proportion of informational items found in the ith level.

Recently, the Shannon-Wiener Index has been called the Shannon diversity index, related to complexity, as defined by Kaplan and Kaplan (1989), and used as an indicator of the variety of elements in a landscape (Dramstad, Tveit, Fjellstad, & Fry, 2006; Frank, Fürst, Koschke, Witt, & Makeschin, 2013; Ode, Hagerhall, & Sang, 2010; Ode & Miller, 2011; Schirpke, Tasser, & Tappeiner, 2013), or as a measure of species diversity in ecology (Magurran, 1988). Shannon's evenness index is also used to measure how equally information (or species) is distributed (Magurran, 1988). Higher Shannon evenness values mean information is equally distributed, whereas lower values indicate unequal distribution.

Arthur Stamps, III, has investigated "diversity" as a prevalent criterion in architectural aesthetic regulations and directly linked it to literature upon which the concept of complexity is based (see Stamps, 2002, 2003), and the definition that Kaplan and Kaplan (1989) have presented. Consequently, correlations between designed information entropy values and respondents' estimations of diversity suggest a possible relationship between designed entropy values and respondents' estimations of complexity. In one experiment, Stamps (2002) found strong, direct correlations between respondents' estimations of diversity and designed entropy values for depictions of row house color, scale, and shape ($0.94 \leq r \leq 0.97$). A second experiment resulted in a direct correlation between estimations of diversity and designed entropy values for row house shape ($r = 0.86$) and articulation ($r = 0.36$), or variation in the façade surface (Stamps, 2002). In a third experiment, Stamps (2003) found direct correlations between estimations of diversity and designed barn shape, material, articulation, openings, and opening color ($0.56 \leq r \leq 0.81$). In a meta-analysis of study results investigating the potential relationship between designed entropy values and respondents' estimations of diversity or complexity, Stamps (2004a) presented direct correlations for commercial block face shape and openings ($r = 0.81$), though inverse correlations were presented for signscape shape, orientation, and height ($r = -0.60$), and row house character (stucco or Victorian) and number of stories ($r = -0.21$). After combining the results for these and other experiments, a direct correlation of $r = 0.73$ resulted between designed entropy values and respondents' estimations of diversity (Stamps, 2004a). Given these study results, we hypothesized the following:

H1. Designed information entropy values will correlate directly with respondents' estimations of complexity, as defined by Kaplan and Kaplan (1989).

Study results presented in two publications imply that designed information entropy values and respondents' preference ratings are associated. In one, respondents' ratings of pleasure for scenes that included barns correlated directly with designed entropy values ($r = 0.84$) (Stamps, 2003). In a second, a meta-analysis of findings from multiple studies indicated direct correlations for stimuli depicting commercial block faces, high-rise building skylines, and row houses, but inverse correlations for stimuli depicting façades of old buildings, signs, and residential contextual fit (Stamps, 2004a).

Two study results indicate that respondents' preference ratings directly correlate with Shannon diversity index values (SDI). Student respondents' preference ratings of photographs that contained views of cereal fields, meadows, "built-up land," and deciduous and coniferous woodlands correlated directly and significantly with SDI values for the mapped area and view angle of the photograph ($r = 0.58$); local residents' preference ratings did not correlate significantly (Dramstad et al., 2006). Frank et al. (2013) found that respondents' ratings of beauty for photographs of regions in Saxony, Germany, directly correlated ($r = 0.73$) to SDI values that were aggregated with two other objective measures representing land cover diversity and human impact.

Two study results indicate that respondents' preference ratings inversely correlate with SDI and Shannon evenness index (SEI)

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