THE UNIVERSITY of EDINBURGH
Edinburgh College of Art

Fractal Nature

Understanding landscape preference using fractal geometry

ESALA
Edinburgh School of Architecture & Landscape Architecture

HarFA
Harmonic and Fractal Image Analyzer

openspace

Dr. Agnès Patuano - Digital Landscape Architecture Conference 2019

What is the fractal dimension of a landscape?

Is it correlated with preference?

Agnès Patuano

The fractal dimensions of landscape photographs as predictors of landscape preference.

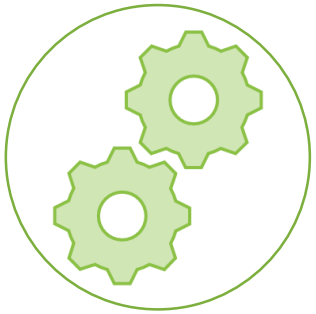
PhD thesis in Landscape Architecture.
The University of Edinburgh, 2018.

Image from the Forestry Commission Scotland Database

Outline

Summary:

- Digital photographs of forests and fields were segmented using various techniques then analyzed with the box counting method



Background:

- The aesthetic value of fractals
- The health benefits of fractals
- Fractal analysis in landscape preference studies

Methodology:

- Online preference survey in the UK and France

Results:

- Correlation between preference ratings and fractal dimensions
- Demographic differences between nationality and environment participants grew up in.

Discussion:

- One main correlation with participants' desire to explore a scene.
- Naturalness, complexity and Information Processing Theory

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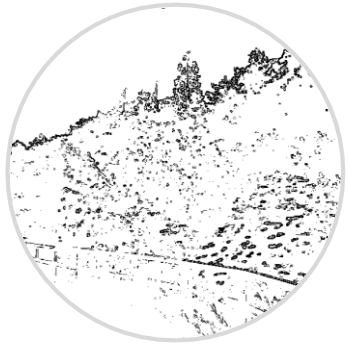
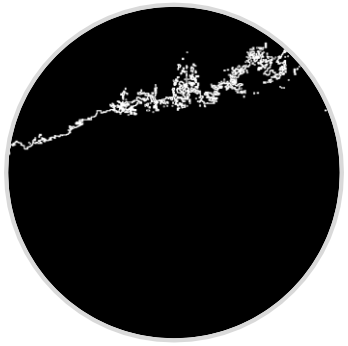
Summary of previous part

Original image

Silhouette outline



Extracted edges



Minimum D from greyscale

Maximum D from greyscale

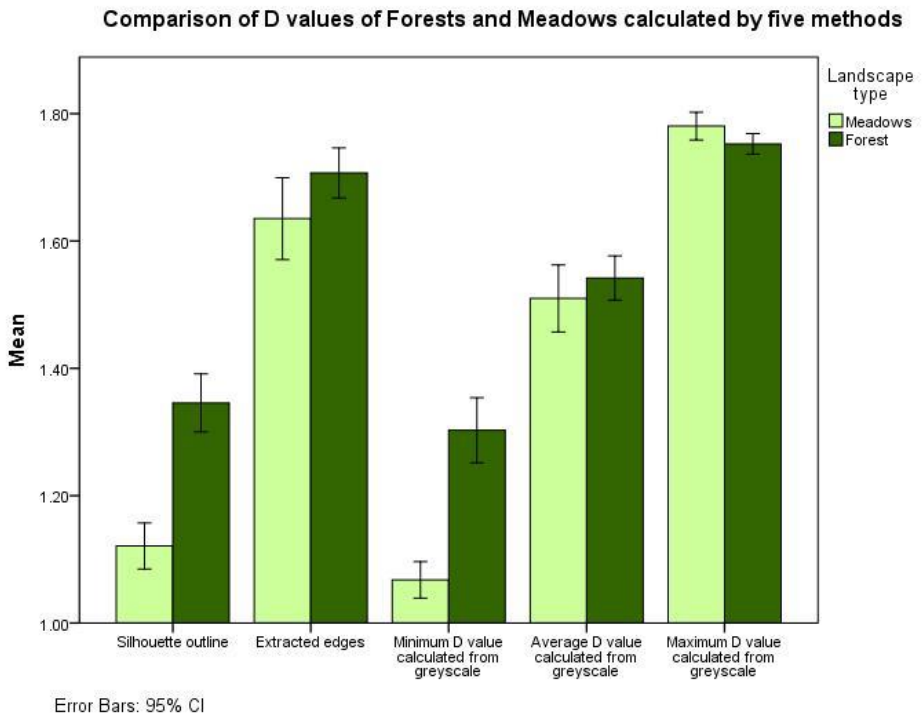
Average D from greyscale

- 58 images from the Forestry Commission Scotland Database in .bmp, 300ppi/8 bit, 900x 598 px.
- Fractal analysis with two softwares, HarFA and BENOIT^{TM}, previously tested on simple geometric shapes.
- Two types of landscapes: Forests and Fields/Meadows

For more details on the protocol, see Patuano, A., 2018. Measuring Naturalness and Complexity Using the Fractal Dimensions of Landscape Photographs. *Journal of Digital Landscape Architecture*, pp.328-335.

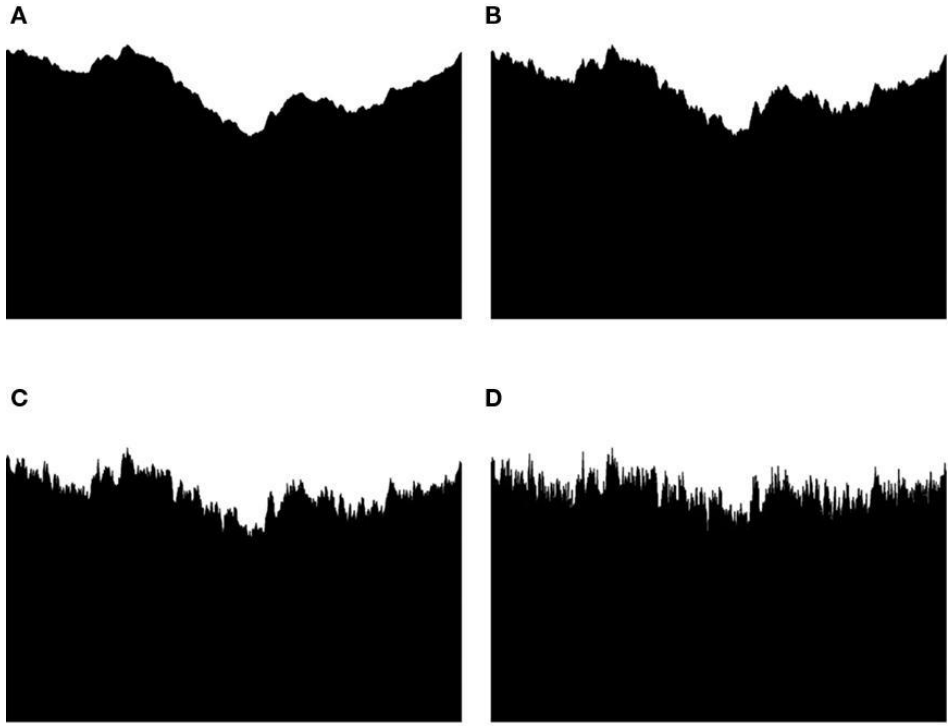
Images from the Forestry Commission Scotland Database

Summary of previous part



The aesthetic value of fractals

- Short, 1991, *the Aesthetic Value of Fractal Images*
  - Nature -> Art
  - Resonance to fractals
  - Universal preference
- Sprott, 1993, *Automatic Generation of Strange Attractors*
  - Preferred D = 1.3
- Aks and Sprott, 1996, *Quantifying aesthetic preference for chaotic patterns*
  - Most objects in Nature have D =1.3
- Haggerhall, Purcell & Taylor, 2004, *Fractal dimension of landscape silhouette outlines as a predictor of landscape preference*
  - Use of the silhouette outline as fractal image
  - Link between landscape preference and fractal properties



Silhouettes used in EEG study . From (Hagerhall et al., 2008, p.1491
Fractal Dimension a) D = 1.14; b) D = 1.32; c) D = 1.51; d) D = 1.70

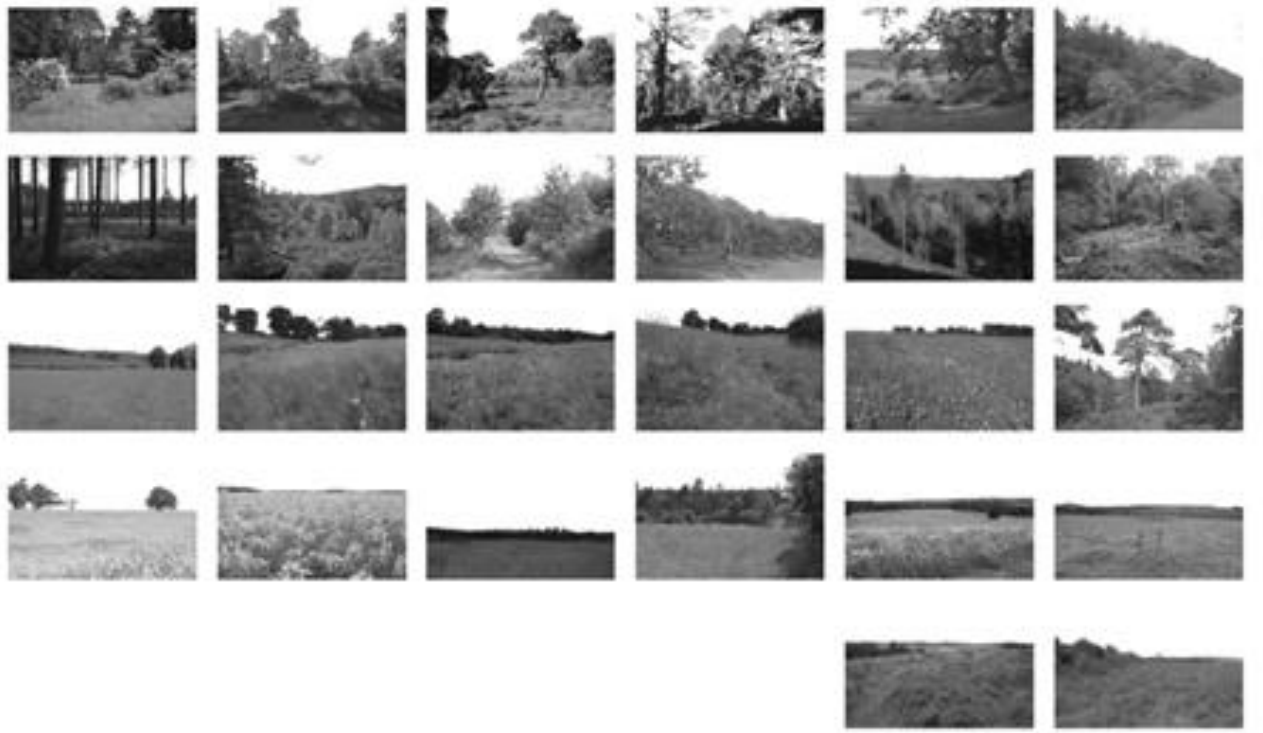
Aks, D. and J. C. Sprott (1996). Quantifying aesthetic preference for chaotic patterns. *Empirical studies of the arts* 14(1), 1–16.
Hagerhall, C. M., T. Laike, R. P. Taylor, M. Kuller, R. Kuller, and T. P. Martin (2008). Investigations of human EEG response to viewing fractal patterns. *Perception* 37(10), 1488–1494.
Hagerhall, C. M., T. Purcell, and R. P. Taylor (2004, jun). Fractal dimension of landscape silhouette outlines as a predictor of landscape preference. *Journal of Environmental Psychology* 24(2), 247–255.
Short, L. (1991). The Aesthetic Value of Fractal Images. *British Journal of Aesthetics* 31(4), 342–355.

Methodology: Online survey

Online survey, disseminated through personal and professionals contacts and university mailing lists

- Bilingual: France and the UK
- 26 images: 13 Forests/13 Meadows

- **Pilot study:** influence of colour and weather
- Demographic predictors:
  - Age, Sex, Nationality, Field of work/study, Location before the survey, Environment of childhood.



Picture set used in the survey (Patuano, 2018)
Images from the Forestry Commission Scotland Database

Lyons, E. E. (1983) Demographic correlators of preference. *Environment and Behavior* 15(4), pp. 487–511.

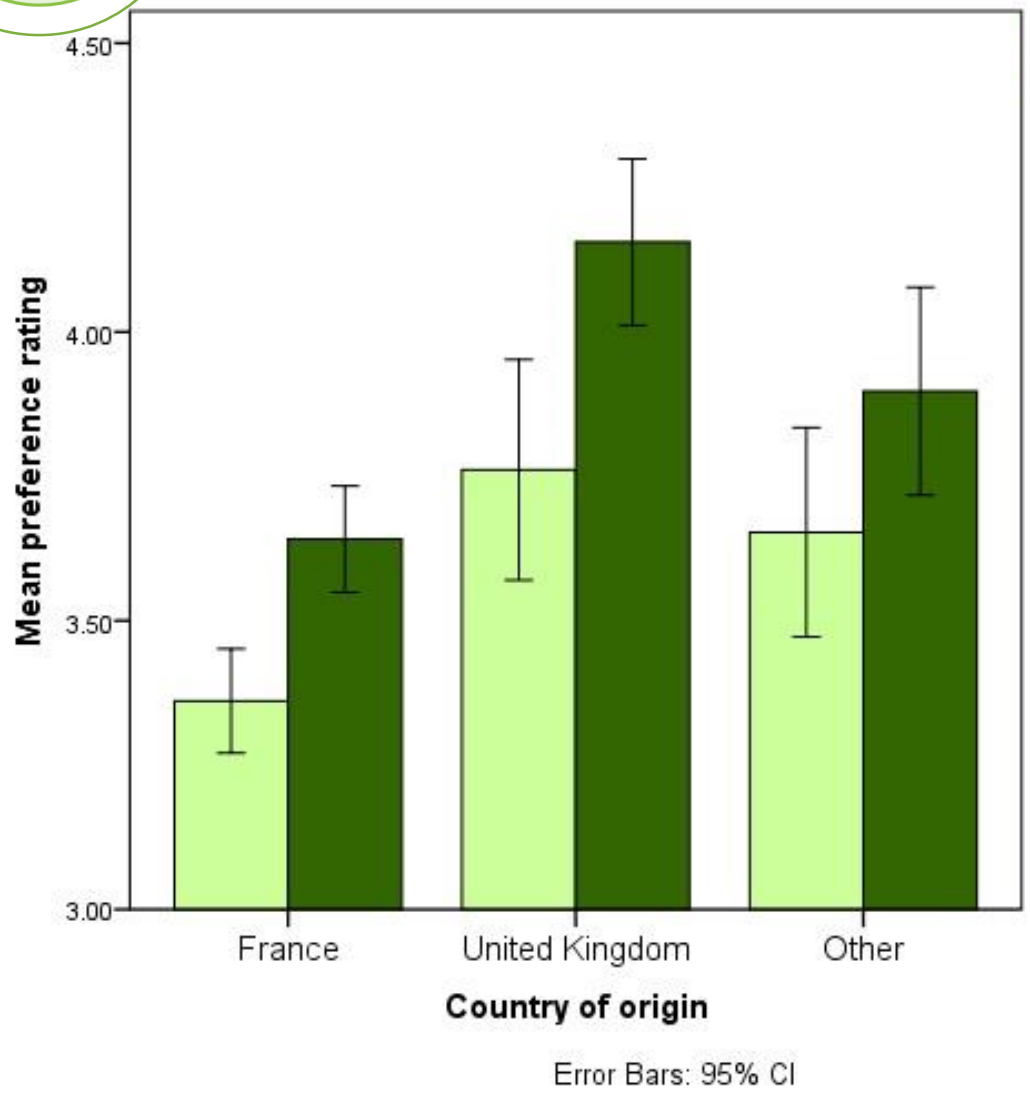
Methodology: Preference scales

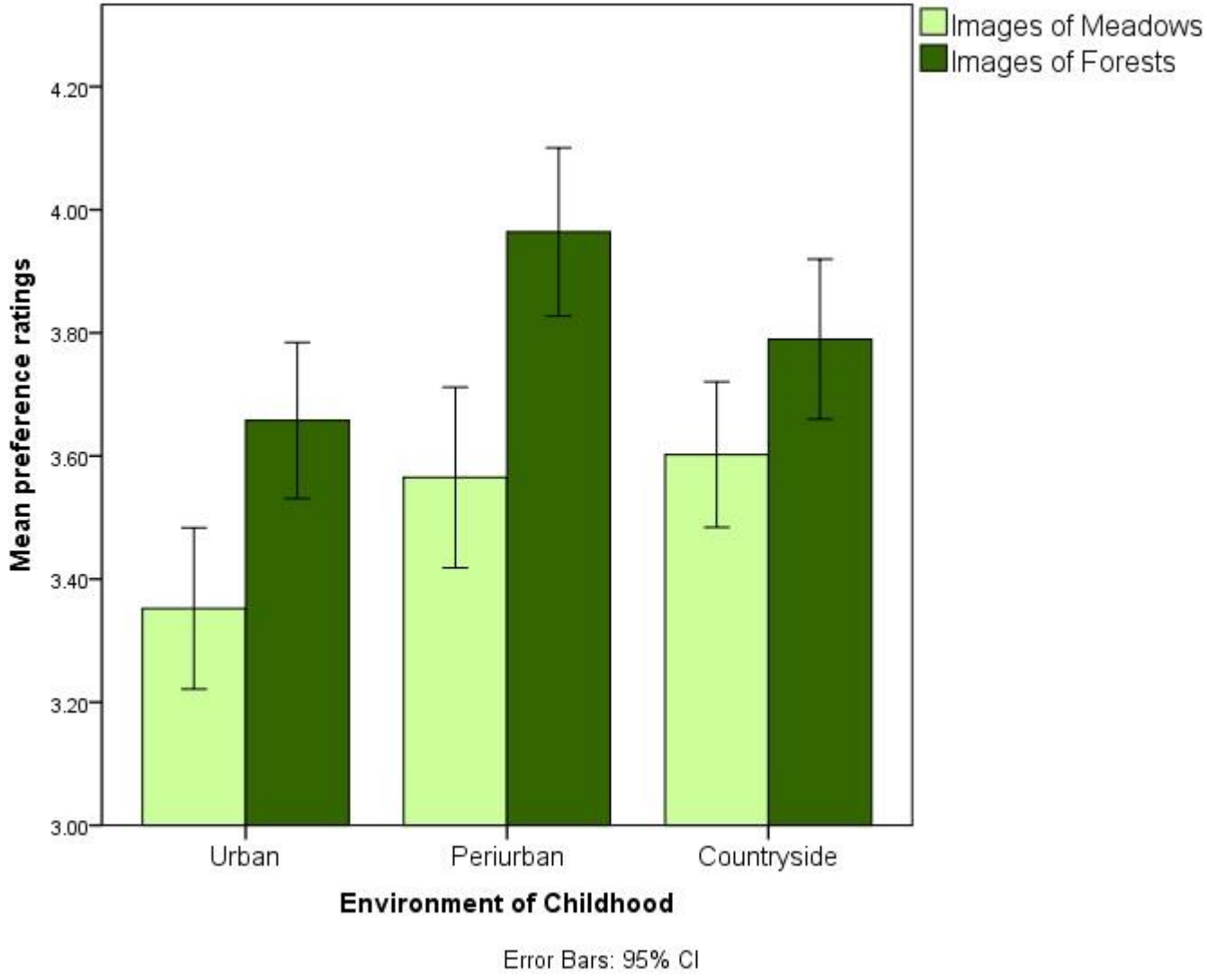
Inspired by the Perceived Restorativeness Scale (Hartig, 1994)

- **The aesthetic scale** measured a scenes' attractiveness in the viewers' mind: *How attractive do you find this scene?*
- **The interest scale** measured participants' willingness to explore a scene: *How willing would you be to explore this scene?*
- **The affective scale** measured the general liking for a scene, which corresponds to the more traditional aspect of landscape preference: *How much do you like this scene (for example as the view from your holiday house)?*

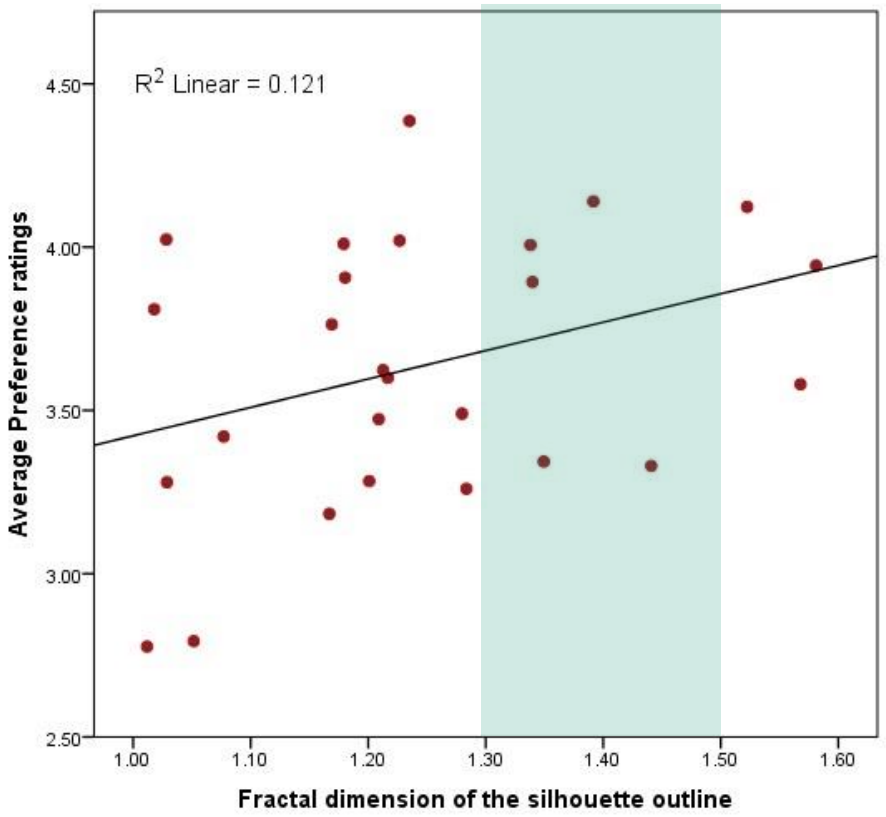
Hartig, T., K. Korpela, G. W. Evans, and T. Garling (1996). Validation of a Measure of Perceived Environmental Restorativeness. *Journal of Environmental Education* 32(1), 1–64.

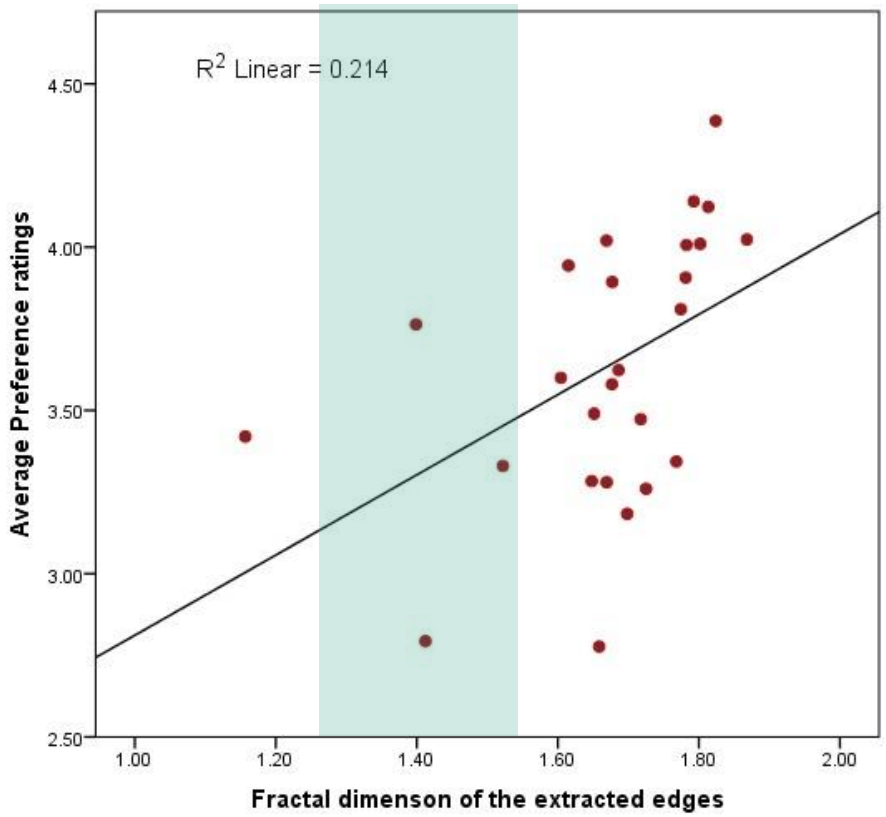
Results: Demographic predictors





Results: Correlation between fractal dimension and preference





Results: Correlation between fractal dimension and preference

Table 8.2: **Correlation table, between methods of fractal analysis and preference ratings (N = 26)**

		Average Aesthetic ratings	Average Interest ratings	Average Affective ratings
D of the silhouette outline	Correlation	.234	.312*	.173
	Sig. (2-tailed)	0.094	.026	.217
D of the extracted edges	Correlation	.444**	.435**	.413**
	Sig. (2-tailed)	.001	.002	.003
Minimum D from greyscale	Correlation	.243	.333*	.187
	Sig. (2-tailed)	.085	.018	.185
Maximum D from greyscale	Correlation	-.143	-.183	-.143
	Sig. (2-tailed)	.310	.193	.310
Average D from greyscale	Correlation	.164	.149	.108
	Sig. (2-tailed)	.242	.289	.440

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Results: Correlation between fractal dimension and preference

Table F.2: **Partial correlation table, between methods of fractal analysis and preference ratings, controlling for landscape type** The fractal dimension of the extracted edges is the only fractal measure to be correlated to some of the preference sub-scales, once the effect of the type of landscape has been accounted for.

		Average Aesthetic ratings	Average Interest ratings	Average Affective ratings
D of the silhouette outline	Correlation	.166	.141	.121
	Sig. (2-tailed)	.428	.502	.565
D of the extracted edges	Correlation	.419*	.458*	.375
	Sig. (2-tailed)	.037	.021	.065
Minimum D from greyscale	Correlation	.261	.256	.208
	Sig. (2-tailed)	.208	.217	.318
Maximum D from greyscale	Correlation	.064	.139	.020
	Sig. (2-tailed)	.762	.508	.924
Average fractal D from greyscale	Correlation	.102	.135	.029
	Sig. (2-tailed)	.627	.52	.889

*. Correlation is significant at the 0.05 level (2-tailed, df = 23).

Results: Predicting preference

- **Preference profiles:**
  - **Nationality:** British preference more correlated than French ($\tau = .471$, $p < .01$; $\tau = .391$, $p < .05$)*
  - **Environment of Childhood:** Correlation for participants who grew up in rural and peri-urban areas ($\tau = .507$, $p < .05$)* but **not for participants from urban backgrounds.**

- **Predicting preference:**
  - Interest = $.811 + .972 \times$ (D_edges) + $.958 \times$ (D_greymin)
    - For the population of the survey, the model accounts for 33.7% of the variation in interest scores. (for British participants: 48.6% of the variance)
  - **For Forest scenes:** Interest = $-.463 + 2.494 \times$ (D_edges)
    - For the population of the survey, the model accounts for 35.2% of the variation in interest scores.

*Correlations measured between average preference and the fractal dimension of extracted edges, controlling for landscape type.

Discussion: Complexity, Naturalness and the Information Processing Theory

Information Processing Theory: Evolution depends not only on resources but also on cognitive processes (Kaplan & Kaplan, 1989)

Complexity: Diversity, visual variety, richness of the elements and features of the landscape, roughness, information content.

	Understanding	Exploration
Immediate	**Coherence**	**Complexity**
Inferred	**Legibility**	**Mystery**

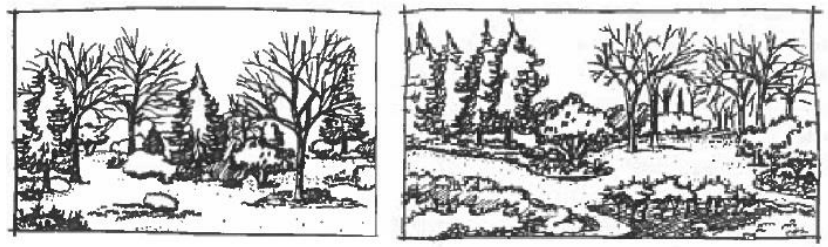
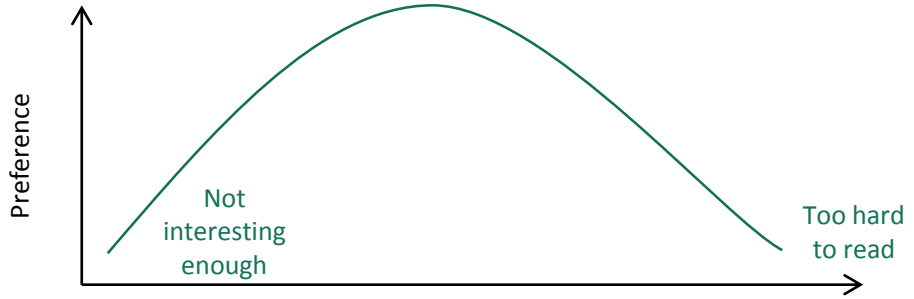


Image on the left is high in complexity and low in coherence; Image on the right is high in both.
From Kaplan et al. (1998)



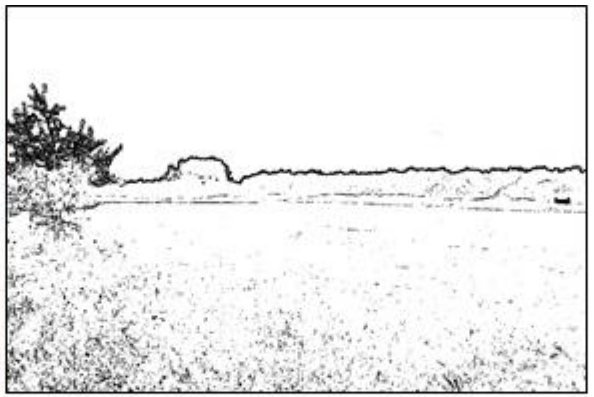
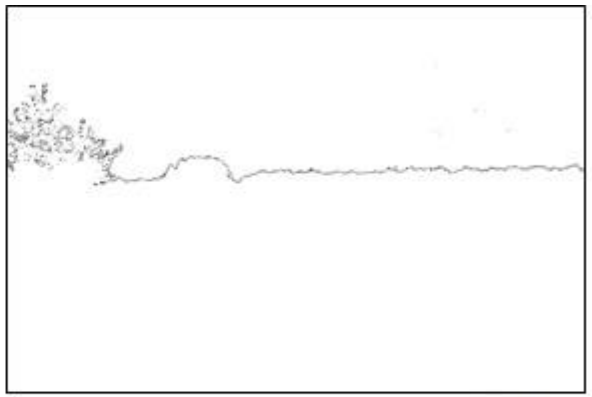
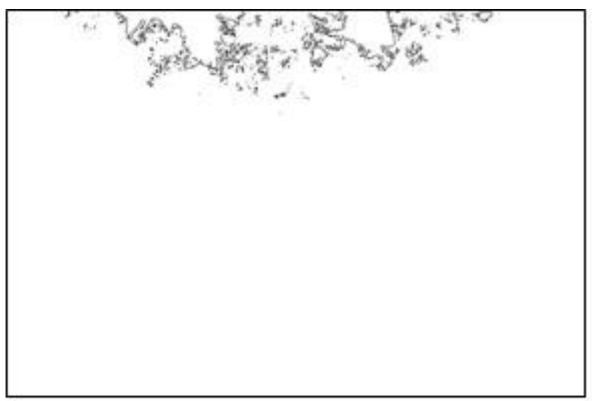
Stamps, A. E. (2004). Mystery, complexity, legibility and coherence: A meta-analysis. *Journal of Environmental Psychology*, 24(1), 1–16.
Kaplan, R., Kaplan, S., & Ryan, R. L. (1998). *With people in mind: Design and management of everyday nature*. Island Press.
Kaplan, R., S. Kaplan, and T. Brown (1989). Environmental preference: A comparison of four domains of predictors. *Environment and Behavior* 21(5), 509–530.

Conclusion

The fractal dimensions of landscape photographs as predictors of landscape preference.

- **Fractal dimension of the extracted edges** correlates with preference, particularly with the **interest subscale**
- Interest correlates also with **the fractal dimension of the silhouette outline** but **not when controlling for landscape type**.
- The effect is not universal and depends on demographics such as Nationality and Environment of Childhood
- No correlation for participants who grew up in an urban areas.

Image from the Forestry Commission Scotland Database

		Extracted edges	Silhouette outline
Meadow		 • D_HarFA = 1.58 • D_BENOIT = 1.43	 • D_HarFA = 1.23 • D_BENOIT = 1.18
Forest		 • D_HarFA = 1.83 • D_BENOIT = 1.71	 • D_HarFA = 1.34 • D_BENOIT = 1.36