569

Change in illuminant direction alters perceived surface roughness

Yun-Xian Ho[1], Michael S. Landy[1,2], and Laurence T. Maloney[1,2]

[1] Dept. of Psychology & [2] Center for Neural Science, New York University, NY

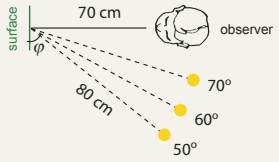
VSS, May 2005

INTRODUCTION

How does illuminant direction affect visual judgments of surface roughness?

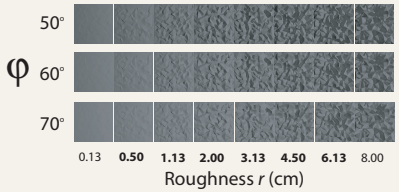
Illuminant Direction

We tested three illuminant directions φ:



Stimuli

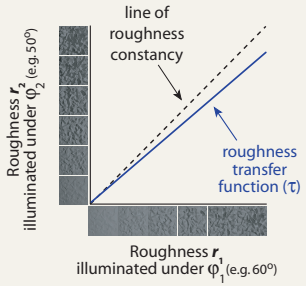
Roughness is defined here as the range of 3D surface facet heights chosen randomly from a uniform distribution [-r/2, r/2] where r = 0.125i^2 cm for i = 1, 2, ..., 8.



All stimuli were rendered binocularly using the Radiance software and displayed in a mirror stereoscope.

Roughness Transfer Function

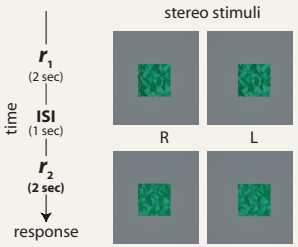
The roughness transfer function $\tau(r_1)=r_2$ gives the degree of roughness r_2 of a surface illuminated by φ_2 that appears equal in roughness to surface r_1 illuminated by φ_1.



EXPERIMENT I

How does perceived roughness change with varying illuminant direction?

Task



2-IFC Task: "Which one is rougher?"

2-up, 1-down/1-up, 2-down interleaved staircases varying match roughness (r_2)

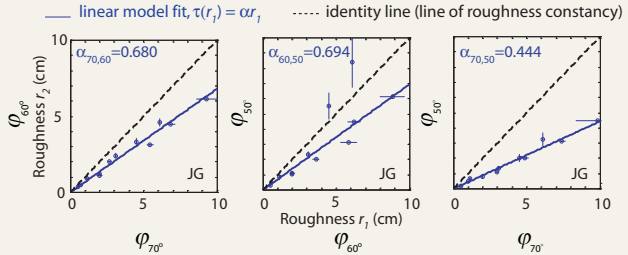
3 illuminant directions (φ=50°, 60°, 70°)

6 test roughness (r_1) levels (indicated in **bold** under *Stimuli*)

4 observers

Results

We fit psychometric functions to each observer's data to find the points of subjective equality for each condition (only one observer shown).



Observers are NOT roughness constant.

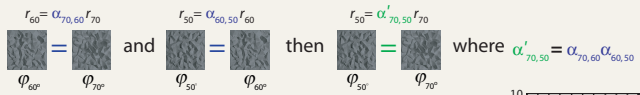
As illuminant angle φ decreases, subjective visual roughness increases.

Testing Transitivity

Is the roughness transfer function τ transitive?

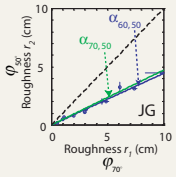
$$\tau_{70^\circ \to 50^\circ} \stackrel{?}{=} \tau_{70^\circ \to 60^\circ} \circ \tau_{60^\circ \to 50^\circ}$$

We represent τ parametrically as $\alpha_{i,j} r$:



$\alpha'_{70,50} \approx \alpha_{70,50}$ for all observers

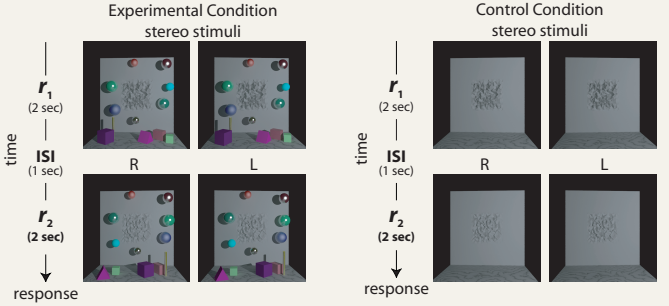
(with prediction error of 3.66%⁺)



EXPERIMENT II

Do roughness judgments become more veridical with more cues to the illuminant direction?

Task

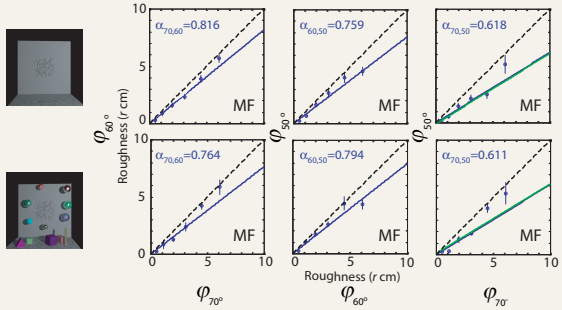


2-IFC Task: "Which one is rougher?"

(procedure similar to Experiment I; 6 observers)

Results

(Only one observer shown)



Cues to the illuminant do NOT improve the degree of roughness constancy ($p > 0.05^{*}$).

$\tau_{70^\circ \to 50^\circ}$ can again be predicted by combining $\tau_{70^\circ \to 60^\circ}$ and $\tau_{60^\circ \to 50^\circ}$ (with 5.3% pred. error⁺).

Bibliography

Doerschner, K. Boyaci, H. & Maloney, L.T. (2004). Estimating the glossiness transfer function induced by changing illumination and testing its transitivity. [Abstract]. *Journal of Vision, 4(8), 322a*, http://journalofvision.org/4/8/322/, doi: 10.1167/4.8.322.

Koenderink, J.J., Doorn, A.J. van, Kappers, A.M.L., Pas, S.F. te, & Pont, S.C. (2003). Illumination direction from texture shading. *Journal of the Optical Society of America A, 20*, 987-995.

Larson, G.W. & Shakespeare, R. (1996). *Rendering with radiance; the art and science of lighting and visualization.* San Francisco: Morgan Kaufmann Publishers, Inc.

Lederman, S.J. & Klatzky, R.L. (2004). *Multisensory Texture Perception.* In G. Calvert, C. Spence, and B. Stein (eds.), Handbook of Multisensory Processes, (Chap. 7, pp. 107-122). Cambridge: MIT Press.

Acknowledgements

All members of the Landy and Maloney Labs and all observers. Supported by NIH EY08266.

[Image (top left): Bryce Canyon hoodoos photographed by Frans Lanting, National Geographic, 2005.]

* Significance test conducted using Bonferroni-adjusted alpha level of 0.0028 per test (0.05/18). Reported p-value is overall across observers.

+ mean prediction error reported for all observers; prediction error = $\frac{\alpha'_{70,50} - \alpha_{70,50}}{\alpha'_{70,50}}$