Visual Perception of Gradients: the role of direct and mutual illumination

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Introduction

• Gradients are smooth spatial variations in image luminance and chromaticity, such as shading or mutual illumination (MI; light reflected between surfaces).

• They bring cues (3-D shape, motion in depth, spatial layout of a scene) to the visual system for recovering the three-dimensionality of the natural world[1,2,3].

• Aim of this study: how sensitive is the visual system to differences in luminance and/or chromatic gradients that occur naturally within a scene?

Methods

• A monitor controlled by a 42-bit graphics card was used to display the complex scene (Figure 2).

• The gradient stimulus was created on a white card (Figure 1 and 2) due to the combination of direct illumination from the light source (Figure 1) and indirect illumination from MI of a green card and surrounding objects (Figure 2).

• The different gradients were created by varying the light source position from 30° to 44° (Figure 1).

• We manipulated the gradient such that in some conditions only the chromaticity (or luminance) of the gradient varied from trial to trial, while the luminance (or chromaticity) was kept constant (conditions D and E in Figure 4).

Figure 1

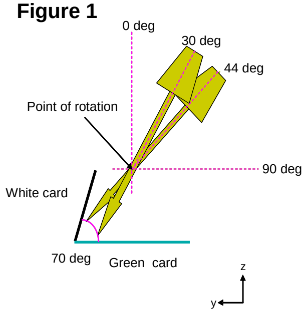


Figure 2

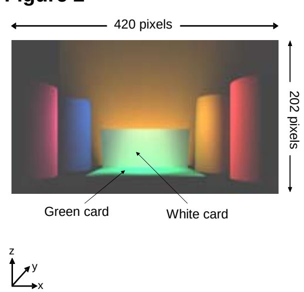
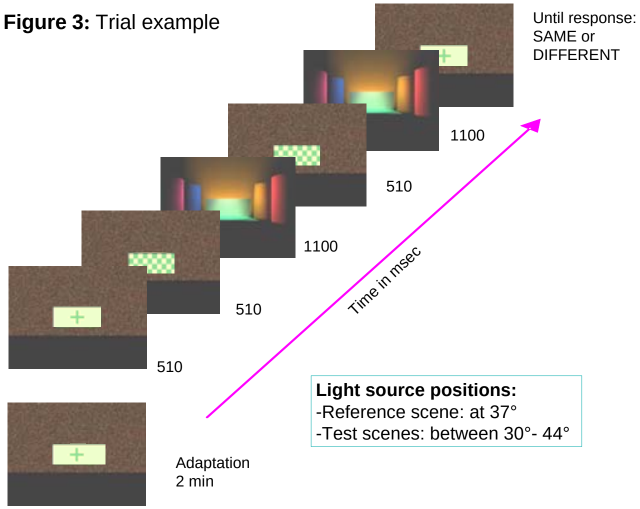


Figure 3: Trial example



• The contributions to sensitivity for direct and indirect illumination were measured together (condition C) and separately (conditions A and B), as well as to chromaticity and luminance variations separately (conditions D and E). This resulted in 5 conditions.

• A discrimination task (Figure 3) consisted of reporting if the pair of gradients were the same or different for each trial.

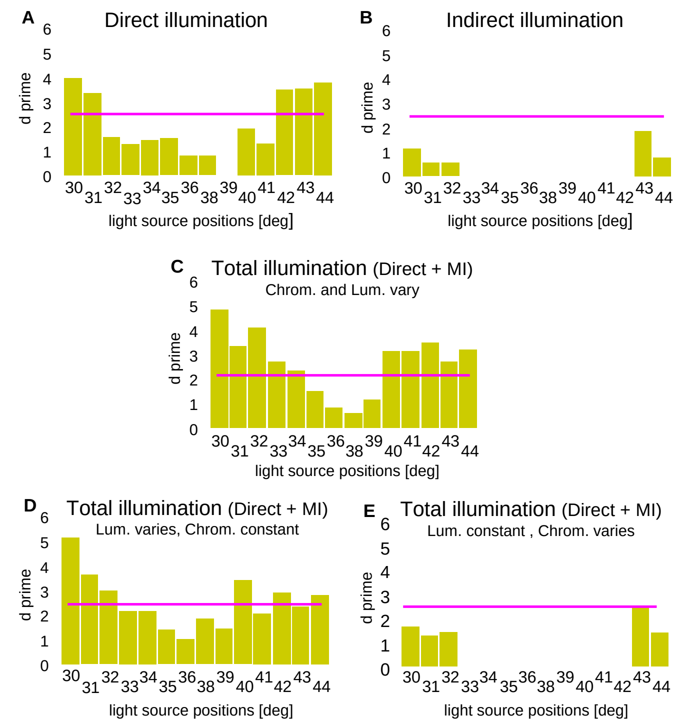
Results and Conclusions

• For all observers, luminance variations were the main contribution to gradient discrimination (Figure 4C, D and E).

• Discrimination based solely on variations in chromaticity was unreliable across observers (Figure 4E) and impossible in the case of indirect illumination only (Figure 4B).

• Yet, for 3 out of 4 observers, performance improved either when chromaticity variations were added to luminance variations (Figure 4C and D) or when indirect (MI) was added to direct illumination (Figure 4A and C).
The fourth observer's performance was unaffected by either combination.

Figure 4: Results of 1 observer out of 4 tested and paired t-tests (one-tailed) between conditions



t-test / Observers	C-D		C-E		C-A	
	t(13) one-tailed	p	t(5) one-tailed	p	t(13) one-tailed	p
MH	2.62	0.021	4.57	0.006	2.61	0.022
LG	4.34	<0.001	14.49	<0.001	3.50	0.004
AR	1.32	0.209	5.56	0.003	2.73	0.017
GP	1.57	0.139	6.77	0.001	0.83	0.422

References

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