Measuring brightness induction during brief stimulus displays

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Background

Question: What is the time course of brightness perception and brightness induction?

Prior research: Temporal modulation of the surround influences the strength of brightness induction; above 5Hz the illusion disappears. (De Valois et al., 1986; Rossi & Paradiso 1996)

Surround bars are modulated sinusoidally over time between black and white, inducing an illusory brightness change in the central gray stripes.

As modulation rate increased, the illusion strength decreased (results not shown).

Above some cut-off illusion disappeared.

Cut-off increases with spatial frequency of illusion, suggesting slow filling-in is involved.

Conclusion: brightness induction is a slow process, which takes at least 100ms to develop.

Our experiment: Will brief presentations and masking reveal the same temporal dynamics?

The previous result could be due to several possible issues:

• Brightness could be computed quickly, but the final percept could be averaged over time.

• Viewing the modulating brightness may have led to visual adaptation, which would reduce sensitivity to both actual and induced brightness.

Methods & Procedure

Pre-stimulus blank, 306 ms

Adjustment patch (1° x 2°) visible on all frames

Stimulus, [58, 82, 117 or 1120] ms

Dot above the target stripe indicates which stripe subject should try to match

Noise mask, 894 ms

Stimulus details:

• We tested two spatial frequencies (1° and 10.6° wide stripes) to assess filling-in.

• We measured the appearance of the gray target stripe when bordered by white stripes (101 cd/m²), and when bordered by dark gray stripes (12 cd/m²); the difference between these two conditions is the strength of the illusion.

Methodological details:

• The actual brightness of target stripe varied between trials to prevent subjects from memorizing the appropriate response.

• The stimulus was designed so that each pixel was an increment relative to the pre-stimulus blank screen, since the visual system is more sensitive to changes.

• The mask was constructed so that any region that includes 2 lines of the mask will have an average luminance of 51 cd/m².

Results

Experiment 1 results:

• Illusion present at all presentation durations.

• Illusion appears stronger for short presentations.

• Effect of spatial frequency does not support slow filling-in hypothesis.

Experiment 2:

• Replicate Experiment 1, focusing on shortest presentation times.

• Test two significantly different target stripe brightnesses to make sure subjects could track real luminance differences at this speed.

Results:

• Illusion seen at all presentation durations.

• Subjects remain sensitive to differences in target strip brightness, suggesting that they are not guessing.

Conclusions

Brightness perception is influenced by the surrounding context, even at 58ms.

Perceived brightness evolves over time, rather than being "all or nothing".

Filling-in does not appear to play a role in the temporal limits of brightness perception.

Future work: does the speed of brightness perception decrease or otherwise change after adapting to modulated brightness?