Visual sensitivity to achromatic gradients with different luminance profiles

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Introduction

Gradients (smooth spatial variations in luminance and/or chromaticity) are all around us as shading or other illumination phenomena. They provide cues to light-source positions, object shape and the spatial layout of scenes. However, not much is known about how the visual system processes gradients.

Question of the present study

Does the visual system have mechanisms to effectively detect or discriminate gradients or does it just rely on the edge detection at the boundary between the gradient and its background?

Methods

A calibrated monitor controlled by a 42-bit graphics card (CRS VISAGE) was used to display the stimuli.

Detection experiment (3 observers)

•There were 6 conditions:

3 types of stimuli with different luminance profiles (Figure 2) were used with 2 different types of background (uniform or non-uniform; Figure 1).

•At each presentation of the stimuli, the little squares of the non-uniform background changed randomly.

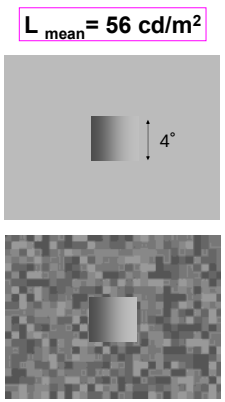


Figure 1: Backgrounds

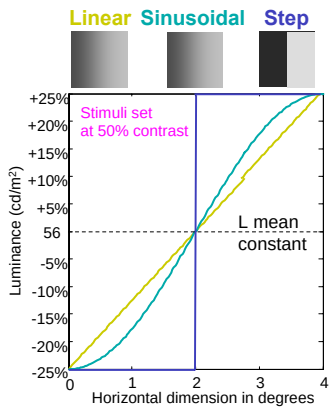


Figure 2: Luminance profiles

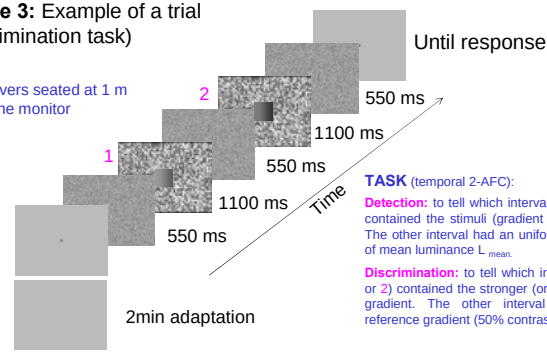
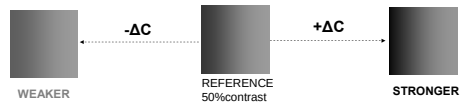


Figure 3: Example of a trial (discrimination task)

Discrimination experiment (4 observers)

•There were 4 conditions presented only against non-uniform backgrounds:

2 types of gradients (**linear** or **sinusoidal**; Figure2) and 2 discrimination tasks ('weaker' or '**stronger**').



Procedure

•A temporal 2-AFC task with an adaptive staircase QUEST procedure was used to determine detection and discrimination thresholds for each condition (Figure 3).

•For each observer, the final threshold and its associated SD resulted from applying the QUEST on the total number of 200 trials (40 trials per condition repeated 5 times).

Results

Detection experiment (Graphs A, B and C)

•Observers' performance in the gradient detection task was significantly better with the uniform background than with the non-uniform background. **grad > grad**

•No significant difference was found on the detection thresholds for the step against either background types. =

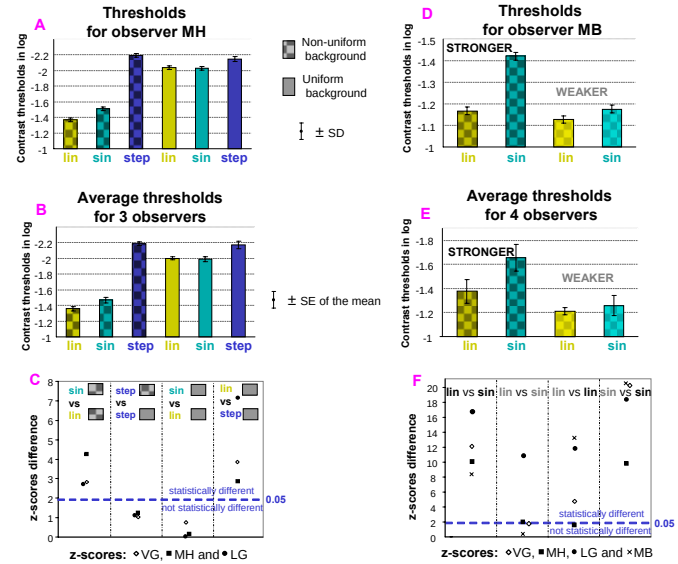
•Sinusoidal gradients were significantly easier to detect than linear gradients. **sin > lin**

Discrimination experiment (Graphs D, E and F)

•There is an asymmetry between the stronger (**S**) and weaker (**W**) conditions, the stronger condition being significantly easier (**S > W**).

•Sinusoidal gradients were also significantly easier to discriminate compared to linear gradients (**sin > lin**) for all observers in the stronger condition and for two observers in the weaker condition.

Detection results **Discrimination results**



Conclusions

•Using non-uniform backgrounds effectively minimizes the use of edges between the stimulus and background (= and **grad > grad**).

•The visual system is able to actually use the information within a gradient to either detect or discriminate it (**sin > lin**).

•The asymmetry found between the stronger and weaker conditions (**S > W**) suggests that contrast increments and decrements might be processed differently and non-linearly.

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