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Report

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The Detection of Colored Glass Patterns in the Presence of Chromatic Noise

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Introduction:

Glass patterns (i.e., patterns made by juxtaposing two identical arrays of random dots) are detected by mechanisms believed to be important for object perception and recognition. In circular Glass patterns, locally correlated dot pairs are integrated at high levels in the visual system, forming a compelling, global perception of concentric rings. We investigated the chromatic properties of the mechanisms detecting these patterns.

Methods:

Fig. 1 shows the Derrington, Krauskopf, and Lennie (1984) color space (DKL color space) used to define our stimuli. **Any stimulus can be defined by two parameters:**

- 1) The **azimuth** (Φ), or “color,” which is the angle formed by a stimulus vector’s projection onto the isoluminant plane and the L-M axis.
- 2) The **elevation** (Θ), or “luminance,” which is the angle it forms with its projection onto the isoluminant plane.

We used a **two-interval, forced choice task** to measure the pattern detection thresholds as a function of the **proportion of the signal dot pairs** constituting the circular pattern.

- Examples of the stimuli are shown in **Fig. 2**.
- The stimuli were made of a fixed number of signal and noise dot pairs (500 and 1000 respectively).
- The fixation point is shown at the center of each panel.
- All signal and noise dots were isoluminant.
- The color of the noise dots could be varied independently of the signal and we measured thresholds using a staircase procedure (2 staircases, 6 reversals each) in various combinations of signal and noise colors.
- The number of signal dot pairs was the same in each quadrant of the display.
- We varied the proportion of the signal pairs that made up the circular pattern. For example, a 50% coherent stimulus would be made of 250 pairs making the pattern, 250 randomly oriented pairs with the same color as the pattern, and 1000 randomly oriented noise pairs with a different color.
- Other parameters of the stimulus are shown in **Table 1**.

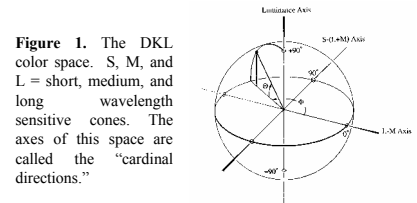


Figure 1. The DKL color space. S, M, and L = short, medium, and long wavelength sensitive cones. The axes of this space are called the “cardinal directions.”

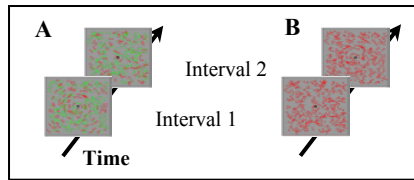


Figure 2. Schematic representations of the stimuli. **A** shows a 180 degree difference between the signal and noise azimuths. In **B**, the azimuths are the same.

Table 1. Parameters of the Stimulus

Dot size (min.)	6.9 x 6.9
Number of Signal Dot Pairs	500
Number of Noise Dot Pairs	1000
Panel Size (deg)	20.5
Background Luminance (cd/m ²)	17.5
Signal Dot Luminance (cd/m)	17.5
Noise Dot Luminance (cd/m)	17.5
Interval Duration (ms)	100

Results:

Fig. 3A shows the results for signals in the **cardinal** directions for one of the subjects. The abscissa shows the angle difference between the noise and signal azimuths. In general, the thresholds vary as a function of the noise azimuth, revealing the chromatic properties of the mechanisms detecting the signal.

Fig. 3B shows the results for signals in **intermediate** directions.

Fig. 4 shows examples from the data in **Fig. 3** with the thresholds normalized to their minimum and maximum. The dotted curves show the best cosine fit to the data. **Because of the color space we use, a cosine modulation of the thresholds as a function of the difference between noise and signal azimuths is expected if the detecting mechanisms combine their inputs linearly.**

Fig. 5 shows the results for all directions tested so far (N=11) from 3 subjects, normalized and averaged together, in the same format as **Fig. 4**.

Summary:

When the directions (azimuths) of the signal and noise are independently varied in DKL color space, we observe two things:

- 1) **The noise is most effective when it is in the same direction as the signal.**
- 2) **The thresholds increase proportionally to the cosine of the angle between the respective azimuths of signal and noise.**

Conclusions:

- 1) **A cosine function describes these data relatively well, suggesting that the high-level mechanisms responsible for the detection of colored Glass patterns sum their inputs linearly.**
- 2) **Because the noise is most effective when it is in the same direction as the signal, we conclude that for most directions tested there exists a mechanism whose sensitivity is highest in that particular direction.**
- 3) **Because the above is true for intermediate directions as well, we conclude that there are multiple (i.e. not restricted to the cardinal axes), linear chromatic mechanisms mediating the detection of colored Glass patterns.**

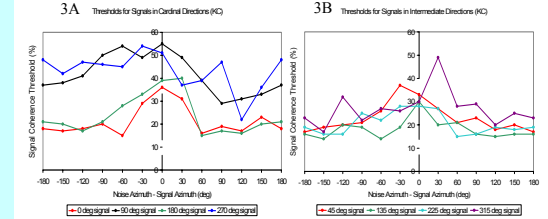


Figure 3. A) One subject’s thresholds for all four cardinal directions, plot against the difference between noise and signal azimuths. **B)** Thresholds from the same subject for all four intermediate directions.

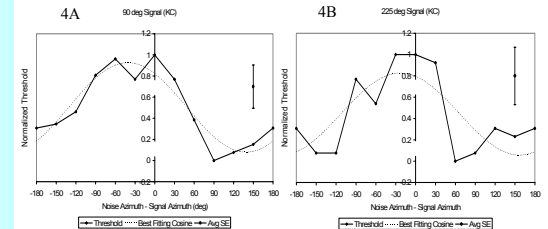


Figure 4. A) Thresholds for the 90 deg (cardinal) signal from **Fig. 3A**, plot against the difference between noise and signal azimuths. The dotted curves indicate the best cosine fit. **B)** Thresholds for the 225 deg (intermediate) signal. Percentage of variance accounted for by the fit: **A)** 87.8%; **B)** 56.1%.

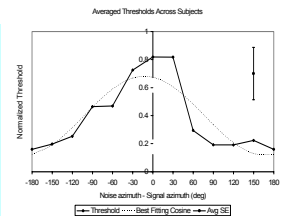


Figure 5. Average change in threshold for 11 directions tested from 3 subjects. Same format as **Fig. 4**. Percentage of variance accounted for by the fit: 78.4%.