The effects of depth separation on lightness contrast and lightness assimilation

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The effects of Depth Separation on Lightness Contrast and Lightness Assimilation

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In lightness contrast, a grey target neighbouring white appears darker than a grey target neighbouring black, whereas in assimilation, a grey target neighbouring white appears *lighter* than a grey target neighbouring black. As shown in figure 1, spatial frequency (i.e. size and number) of inducers can determine whether contrast (top row) or assimilation (bottom row) occurs.

The interaction of the spatial frequency and colour of inducers with depth is less clear. With low-spatial-frequency inducers, Wolff (1933) reported that contrast disappears when the target is moved into a different depth plane to the inducers; whereas Julesz (1971) and Gibbs and Lawson (1974) reported that contrast continues to occur in depth conditions. With high-spatial-frequency inducers, although assimilation occurs when the target and inducers are coplanar, *contrast* occurs when the inducers are non-coplanar with the targets (e.g. Soranzo, Galmonte & Agostini, 2010).

One difference between these studies is that Wolff (1933) manipulated actual depth, whilst Julesz (1971), Gibbs and Lawson (1974), and Soranzo et al. (2010) manipulated stereoscopic depth.

To investigate the effects of depth separation on contrast and assimilation, the current study manipulated three variables:

- Actual distance between target and inducers (coplanar vs non-coplanar)
- Spatial frequency of inducers (high vs low)
- Colour of inducers (black vs white)

METHOD

Participants - 20 volunteers with normal (or corrected-to-normal) vision and no prior knowledge of the experiment.

Design and Stimuli - Eight conditions (2x2x2 within-participants design)

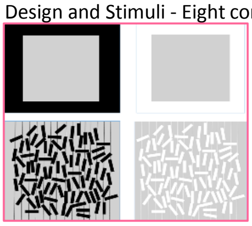


Figure 1. Example to illustrate the 8 conditions (not to scale): 'Colour': Black; and White; 'Spatial frequency': Low (top row); and High (bottom row). To include the third variable ('Distance'), each of these four configurations was presented in Coplanar (all parts of the display at the same distance from the observer); and Distance (the black/white inducing elements placed at a distance in front of the grey target).

Stimuli:

- A grey 'target' (31.9 cd/m^2)
- Inducers were either printed onto a grey target (coplanar condition); or cut from white or black paper and suspended from a frame placed 28cm in front of the target (distance condition)
- Inducers were either white (54.2 cd/m^2) or black (3.4 cd/m^2)
- Displays were viewed through a viewing window (10.3cm x 10.3cm)
- Equivalent visible surface area of the grey target across conditions.
- Low-spatial-frequency conditions: visible grey area (8cm x 8cm) surrounded by an inducer extending from the edge of the grey area.
- High-spatial-frequency inducers consisted of 88 small rectangles (1.2cm x 0.3cm) distributed across 15 thin lines.

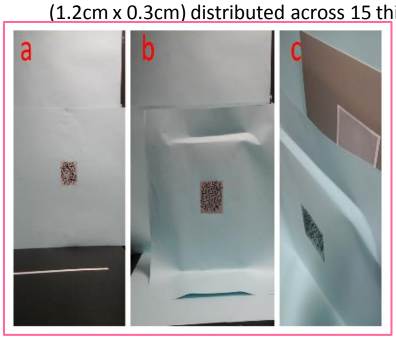


Figure 2. a) Photograph from the participant's viewpoint of the stimulus for the Black, High spatial frequency, Coplanar condition. b) Photograph from the participant's viewpoint of the stimulus for the Black, High spatial frequency, Distance condition. c) Photograph from the researcher's perspective, to illustrate the inducers suspended from the frame at a distance in front of the target grey against the wall.

- Matching charts containing twelve randomly-ordered patches ranging in equal steps from 14 cd/m^2 to 47 cd/m^2.

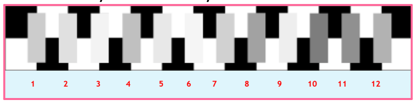


Figure 3. Example matching chart.

Procedure

- In a matching task, participants were required to indicate the patch on the matching chart that was printed with the same grey that the target was cut from.
- Between trials, participants turned away to allow the researcher to change the display and matching chart, according to a randomised list.
- Participants each responded to two repetitions of each stimulus, each presented alongside different versions of the matching chart.

RESULTS

Responses were converted as follows: log[lum (Match)/ lum (Target)] and an average of the two matches per condition was computed for each participant. See figure 4 below for the mean match in each condition across all participants

- There was a significant three-way interaction between spatial frequency, colour, and distance ($F(1,19)=39.15$, $p<.001$, $\eta_p^2=.67$).
- The two-way interaction between spatial frequency and colour was significant in the coplanar conditions ($F(1,19)=97.10$, $p<.001$, $\eta_p^2=.84$) but non-significant in the distance conditions ($F(1,19)=.172$, $p=.68$, $\eta_p^2=.01$).

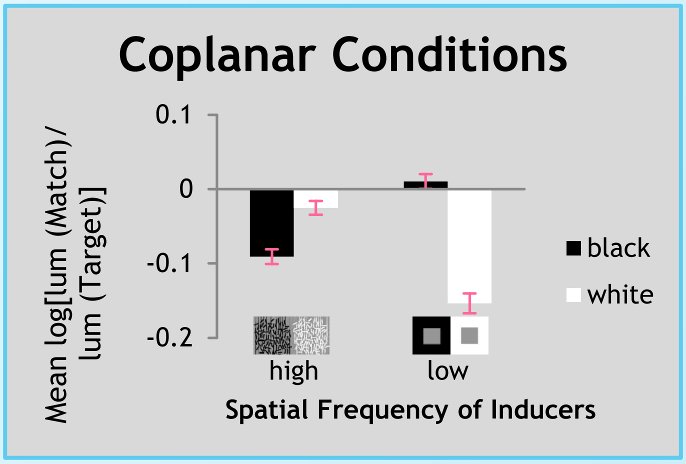
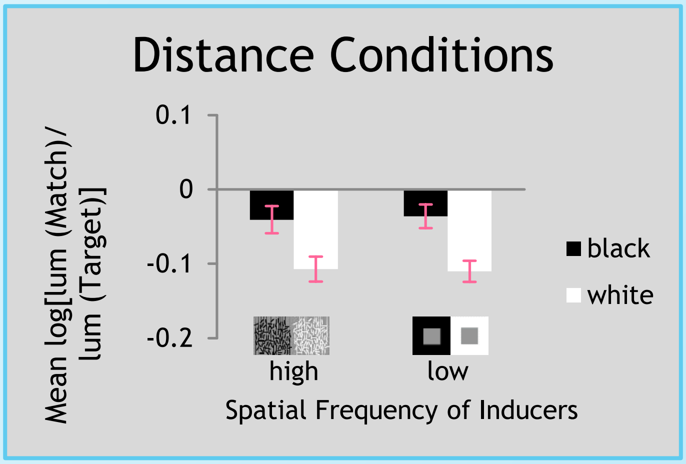


Figure 4. Mean match for each condition. Higher numbers represent a lighter perception of the grey target. Zero represents the actual luminance of the target.



CONCLUSIONS

- The results show that separating the inducers from the target by using depth:
  - *Reduces* the perceived difference between targets (for low-spatial-frequency stimuli)
  - *Reverses* the assimilation effect (high-spatial-frequency stimuli)
- Distance between inducers and target is important in determining the strength of the contrast effect, and the existence of an assimilation effect in coplanar conditions.
- Assimilation is more affected by depth separation than is contrast.

REFERENCES

Gibbs, T., & Lawson, R. B. (1974). Simultaneous brightness contrast in stereoscopic space. *Vision Research. 14,* 983-987.

Julesz, B. (1971). *Foundations of Cyclopean Pperception*. Chicago, IL: University of Chicago Press.

Soranzo, A., Galmonte, A., & Agostini, T. (2010). Von Bezold assimilation effect reverses in stereoscopic conditions. *Perception*, *39*(5), 592-605.

Wolff, W. (1933). Concerning the contrast-causing effect of transformed colors. *Psychologie Forschung, 18,* 90-97.