FLANKER SIZE AFFECTS VISUAL LATERAL INTERACTIONS

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BACKGROUND

- Laterally displaced masks (flankers) can facilitate contrast detection of Gabor patches (Polat and Sagi, 1993, 1994). They claimed that the effect was independent of the size of the patches.
- We (Woods et al., 2002) found that spatial frequency (λ^{-1}) and patch bandwidth (size, σ) altered the lateral interactions (i.e. no spatial scaling; figure 1).
- A "bandwidth" effect (Gabor $\sigma = 0.5\lambda$ to 1.5λ) was demonstrated using changes to both flanker and test stimulus (figure 1D and 1E).
- It is possible that those "bandwidth" effects were not a consequence of bandwidth alone, since larger patches overlap more.

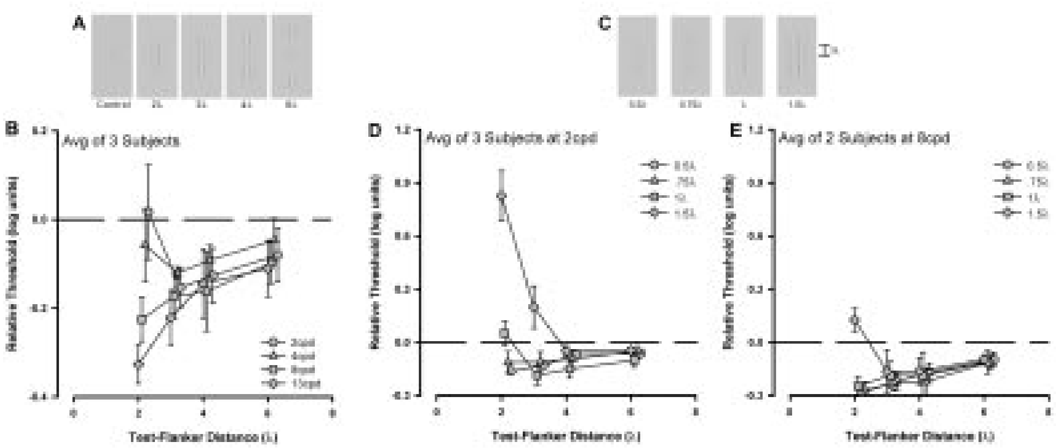


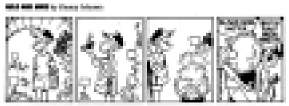
Figure 1. Summary of results from previous study (Woods et al., 2002). Example images for (A) experiment 1; and (C) experiment 2. At close flanker-test distances (2 and 3λ) the lateral interactions varied with (B) spatial frequency and with bandwidth for (D) 2 cycles/deg. and (E) 8 cycles/deg. Note how larger patches (greater σ) overlap more at closer test-flanker distances (C). Horizontal position of some data points are offset from 2, 3, 4 and 6λ so that error bars (95% confidence limits) are seen more easily.

PURPOSE

To examine the possible effect of this potential confound between patch bandwidth and patch overlap, we varied independently the vertical size (σ_y) – masking effect - and horizontal size (σ_x) – bandwidth effect - of the flankers while keeping the size of the test stimulus fixed.

Does the bandwidth of the flanker affect visual lateral interactions?

Is it independent of flanker-stimulus overlap?



ABSTRACT

Purpose: Polat and Sagi (1993, 1994) showed that laterally displaced masks (flankers) could facilitate contrast detection of Gabor patches, independent of the size of the patches. However, when spatial scaling of these flanker effects was investigated, stimulus bandwidth was confounded with spatial frequency. In a previous study (Woods et al., in press), we varied the bandwidth (Gabor patch size from $\sigma = 0.5\lambda$ to 1.5λ) of both flanker and test stimulus and showed that bandwidth affected facilitation.

However, since we altered both stimulus and flanker size, it is possible that the effects were not a consequence of bandwidth alone. The results may have been influenced by the greater overlap of the test stimulus and flankers when the patches were larger (masking). To examine this confound we varied the vertical and horizontal size, separately, of the flankers while keeping the size of the test stimulus fixed.

Methods: In the first experiment, the height of the flankers was varied from $\sigma_y = 0.5\lambda$ to 3λ. In the second experiment, the width of the flankers was varied from $\sigma_x = 0.125\lambda$ to 2λ. All conditions were tested at 2, 4, and 8 cycles/degree.

Results: With flanker heights $\sigma_y = 0.5\lambda$ to 1.5λ (no overlap with test patch) facilitation was about equal. As the flankers began to overlap the test stimulus ($\sigma_y = 2\lambda$ to 3λ) detection contrast thresholds increased dramatically. When flanker width was varied, maximum facilitation was found at $\sigma_x = 0.75\lambda$ and facilitation decreased as flanker width increased. All these effects were more pronounced at the lower spatial frequency (2 cycles/degree).

Conclusion: Masking was a major component of the effects found in our previous study, as illustrated by the effects of flanker height. However, there is a bandwidth component, such that a smaller bandwidth (i.e. a wider flanker) decreased facilitation. This is not consistent with simple additive rules that could be derived from the results of previous studies. These results need to be reconciled with proposed models of lateral interactions.

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GENERAL METHODS

- Measured contrast detection threshold of a Gabor patch with and without flanking Gabor patches. Gratings were aligned vertically (e.g. figure 3).
- Flankers (40% contrast) equidistant above and below test patch
- Test-flanker distance = center to center (in wavelength, λ, or visual angle, minarc)
- Each Gabor patch:

$$L(x,y,\theta)=L_0\left\{1+C\cos\left(\frac{2\pi}{\lambda}\left[(x-x_0)\cos\theta+(y-y_0)\sin\theta\right]\right)\exp\left(-\left[(x-x_0)^2/\sigma_x^2+(y-y_0)^2/\sigma_y^2\right]\right)\right\}$$

where λ, σ_x and σ_y were varied independently.

- VisionWorks system & Nanao Eizo monitor [120 Hz, 1024 X 600 pixels, 23.4 X 40cm, 12-bit, average luminance 37cd/m^2]
- Stimulus and flankers were shown in alternate frames, hence additive luminance.
- Four subjects (two naïve)
- Temporal 2 AFC (figure 2), 3/1 staircase with unequal step sizes. Initial contrast was 25%
- One staircase was either 4 X (2 practice +10 reversals) OR (2 practice + 40 reversals). Each data point is the average of 3 to 6 staircases per subject.

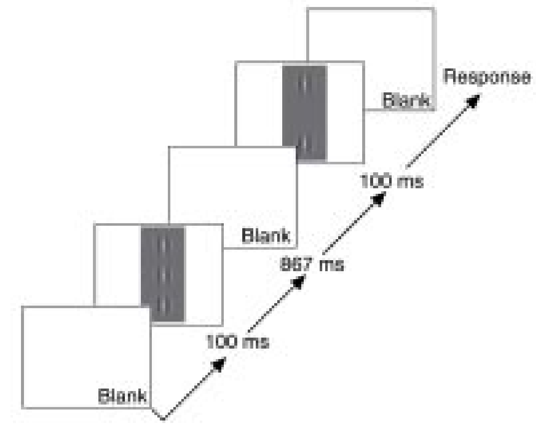

Figure 2. The temporal sequence of the 2 AFC presentation.

EXP. 1 – EFFECT OF FLANKER WIDTH (BANDWIDTH)

<u>QUESTION:</u> How does varying the horizontal size (bandwidth) of the flankers, while keeping the height (overlap/masking) constant, affect contrast detection?

<u>METHODS:</u>

- Flanker σ_x = 0.125λ to 2λ; σ_y = λ
- Test-to-flanker distance was 3λ [1] (figure 3)
- 3 spatial frequencies: 2, 4 and 8 cycles/degree
- Three subjects (one naïve)

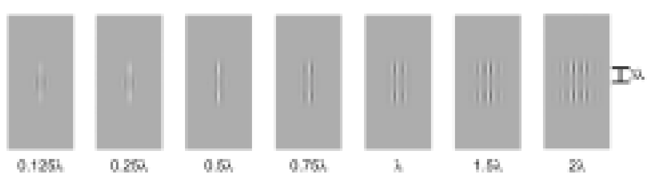

Figure 3. Examples of stimuli used in Experiment 1.

[1] Note that maximum facilitation was found at about 3λ separation (e.g. figure 1) and that with 3λ separation there was no overlap of the flankers with the stimulus (figure 3).

EXP. 1 RESULTS

- Maximum facilitation was found at about σ_x = 0.5 to 0.75λ and facilitation decreased as flanker width increased (figure 4).
- Higher spatial frequencies produced slightly more facilitation/less suppression – in agreement with our previous study (Woods et al, 2002; figure 1).

<u>SUMMARY</u>: Flanker bandwidth affects lateral interactions.

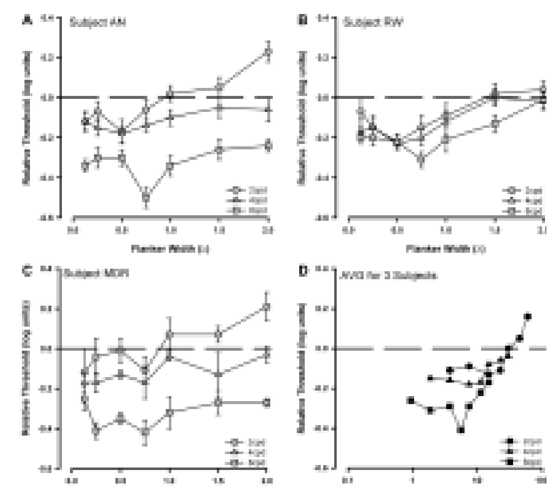
Figure 4. Data for subjects (A) AN; (B) RW; and (C) MDR; and (D) averaged data for the three subjects. Error bars show 95% confidence limits.

EXP. 2 – EFFECT OF FLANKER HEIGHT (OVERLAP)

QUESTION: How does varying the vertical size of the flankers, while keeping the width constant, affect contrast detection?

METHODS:

- Flanker $\sigma_y = 0.5\lambda$ to 3λ [2]; $\sigma_x = \lambda$
- Test-to-flanker distance was 6λ[3] (overlap shown in figure 5)
- 3 spatial frequencies: 2, 4 and 8 cycles/degree
- Three subjects (one naïve)

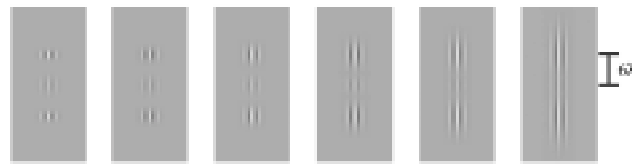

Figure 5. Examples of stimuli used in Experiment 2.

[2] 3λ was chosen because it was the largest flanker possible with a 6λ separation. 0.5λ was considered sufficiently short, and preliminary results with 0.25λ were apparently not different.
[3] No overlap of flankers with tallest flankers.

EXP. 2 RESULTS

- When there was no overlap ($\sigma_y = 0.5\lambda$ to 1.5λ), facilitation was about equal for all three spatial frequencies (figure 6).
- With overlap ($\sigma_y = 2\lambda$ and 3λ), detection contrast thresholds increased dramatically (suppression) and varied with spatial frequency.

SUMMARY: Overlap of flankers and test stimulus affects lateral interactions. This effect is larger than the facilitation effect.

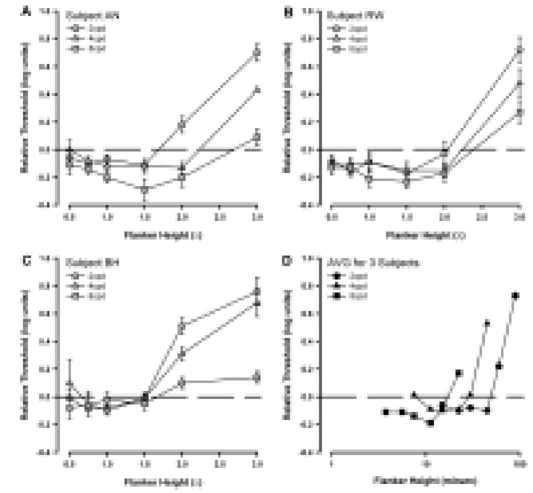
Figure 6. Data for subjects (A) AN; (B) RW; and (C) BH; and (D) averaged data for the three subjects. Error bars show 95% confidence limits.

SUMMARY OF RESULTS

- More facilitation found with relatively narrow flankers (i.e. wide bandwidth).
- Suppression increased as flankers began to overlap with the stimulus.

Hence:

Flanker bandwidth affects visual lateral interactions.

Overlap of stimulus and flanker affects lateral interactions.

These results need to be reconciled with current models of lateral interactions and have implications for image enhancement.

CONCLUSIONS

- To maximize facilitation, use wide bandwidth (narrow) flankers that do not overlap with the stimulus.
- In most real world situations overlap is not expected and thus the effect of facilitation may be of value for both normal and impaired sight.
- The existence of the effect in peripheral vision needs further investigation

ACKNOWLEDGMENTS

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