Sub-threshold Binocular Contrast Summation Varies with Interocular Phase Disparity

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Introduction

- The magnitude of sub-threshold binocular contrast summation varies inversely with binocular disparity, and the disparity range over which binocular summation occurs varies inversely with spatial frequency. [1,2]
- The upper disparity limit of stereopsis and the range of sensory fusion exhibit dependence on interocular phase disparities of narrow band targets. [1, 3-5]
- This study aimed to demonstrate that sub-threshold binocular contrast summation is also dependent on interocular phase disparity. It investigated how target spatial frequency and induced vertical and horizontal phase disparity affects the magnitude of binocular summation.

Methods

- Contrast detection thresholds were measured using a two-interval forced choice method-of-constant stimuli psychophysical procedure. The stimulus was presented during one of two temporal intervals which were demarcated by auditory tones. The subject reported whether they detected the stimulus in the first or second interval. The stimulus duration of each temporal interval was 150ms, with an inter-stimulus duration of 1 second. The sequence of the testing condition (monocular or binocular) was randomized between experimental sessions.
- Vertical and horizontal fixation disparity was measured at the beginning and end of binocular contrast detection threshold determination for each trial.

Subjects:

- Nine participants were involved in the study; each had best corrected acuity of at least 20/20 in each eye and normal binocularity.

Stimuli:

- The stimulus for contrast detection threshold for each eye was a 2.13 x 2.13 Gabor grating with one of three cosine carrier spatial frequency gratings (1, 3, and 9 cpd) and one of five interocular phase disparities (0, +/-90, +/-180 degrees) (horizontal and vertical). This was surrounded by a 32' random dot border fusion lock.
- The stimulus was viewed through a phoropter with cross polarizing filters over the viewing apertures and the monitor to ensure dichoptic viewing of the stimulus.

Results

Vertical Phase Disparity

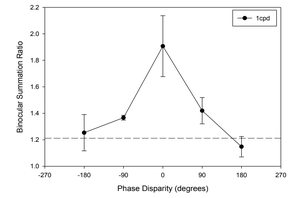

Figure 1

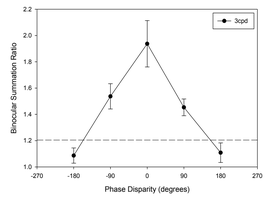

Figure 2

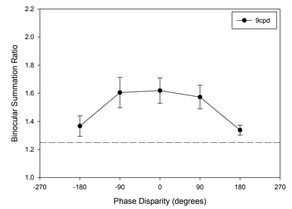

Figure 3

Figures 1, 2, and 3 show the mean of the vertical phase disparity combined data vs. mean binocular summation ratio for the 1, 3, and 9 cpd spatial frequencies, respectively.

Horizontal Phase Disparity

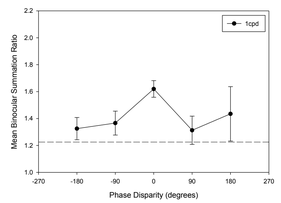

Figure 4

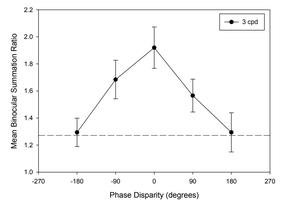

Figure 5

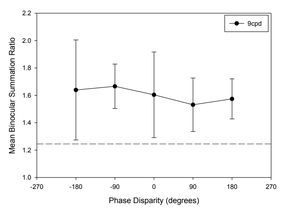

Figure 6

Figures 4, 5, and 6 show the mean of the horizontal phase disparity combined data vs. mean binocular summation ratio for the 1, 3, and 9 cpd spatial frequencies, respectively.

- Binocular summation exceeded probability summation in nearly all of the testing.
- Binocular summation is scaled according to interocular phase disparity at least up to 9 cpd for vertical disparities and 3 cpd for horizontal disparities.

Conclusions

- The relationship between binocular summation magnitude and phase disparities supports the idea that spatial frequency-phase tuned mechanisms are operating in binocular summation as well as there being horizontal-vertical anisotropy.
- Interocular phase disparity must feed into binocular contrast summation mechanisms prior to detection stages of processing. [1,4,5]
- The lack of phase-dependent binocular summation at the vertical 9 cpd carrier spatial frequency could be due to the role of horizontal vergence noise which limits reliable phase disparity computation.
- We also propose that binocular summative mechanisms comprise at least two parallel sub-systems: phase specific and phase-independent binocular contrast summation mechanisms.
- We also speculate that the transition from one sub-system to the next is dependent on the reliability of phase disparity computation.

References

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