INTRODUCTION

We investigated perception of motion in depth using a well known stereo-motion phenomenon - the Pulfrich effect. The classical phenomenon refers to the observation that an object oscillating back and forth in the frontal plane appears to move on an elliptical path in depth when images are delayed in one eye.

Previous results using simple sine-wave gratings revealed band-pass temporal frequency tuning independent of spatial frequency (see plots below from Lages, Mamassian & Graf, VSS 2002).

Here we investigate tuning characteristics of sine-wave gratings defined on random-dot patterns. The following questions were addressed.

(1) Is contrast-defined (second order) motion in depth visible?
(2) If yes, what are the tuning characteristics?
(3) How does performance compare with luminance-defined patterns?

EXPERIMENT

We reproduced the Pulfrich effect with luminance- and contrast-modulated gratings on random-dot patterns. Phase-sensitivity of the binocular motion system was measured by systematically varying interocular phase difference.

STIMULI. Stimuli were presented to the left and right eye on a calibrated CRT flat screen with a refresh rate of 120 Hz, mean luminance of 34 cd/sqm and 25% Michelson contrast in a split-screen Wheatstone configuration. The vertically oriented luminance-defined and contrast-defined sine-wave gratings oscillated sinusoidally for 2 sec behind a Gaussian envelope.

DESIGN. Direction of motion (left and right) and interocular phase difference (-π/4 to +π/4) was systematically varied across trials in randomly intermixed order. Stimulus type (luminance and contrast), temporal frequency (0.5 to 15 Hz) and spatial frequency (1 and 3 c/deg) were manipulated in a series of sessions.

SUBJECTS. Two experienced (EG and ML) and one naive observer (MW) participated.

PROCEDURE. On each trial Ss converged on a fixation cross flanked by nonius lines before the stimulus was presented. After each presentation Ss were asked to indicate direction of motion in depth (CW or CCW when viewed from above). No feedback was given.

Data were fitted to a Gaussian cdf using a constrained maximum likelihood procedure. The standard deviation served as phase threshold.

RESULTS

For each observer phase thresholds are plotted against temporal frequency.

Note: Observer ML had similar thresholds when luminance- and contrast-defined gratings moved over dynamic random dot patterns.

CONCLUSIONS

(1) The visual system can detect contrast-defined motion in depth.
(2) Temporal frequency tuning for contrast-defined patterns is low-pass or band-pass between 0.5 and 7 Hz.
(3) Temporal frequency tuning curve for broad-band luminance-defined stimuli describes an envelope for contrast-defined stimuli. Contrast-defined (second-order) motion in depth is probably due to pooling of residual luminance (first-order) activation.

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