Form Perception through Phase Relations of Retina Ganglion Cell Firing and Extraocular Muscle Contractions

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Background

We propose a way of understanding form perception that emphasizes the changes in eye movements relative to changes in firing on the retina; a critical ratio is formed between the frequency of retina ganglion cell firing and the frequency of extraocular muscle contractions (i.e., the muscles controlling eye movements).

These two multidimensional flows define both object and motion through the phase relations based on cell firing relative to eye motion.

Experiment 1

Do changes in eye movement frequencies alter perceived forms and their perceived movement?

We altered the critical ratio between eye movement and retinal firing frequencies by altering the natural movement of the eye (θ). Spinning participants around in a chair alters the natural movement of the eye in the direction opposite of spinning direction (Jacobson & Shepard, 2007).

• 27 participants examined a moving repeating dot pattern
• Ps were instructed to identify an object or repeating pattern
• Ps were then spun either clockwise or counterclockwise in the chair (Within Subjects; order randomized)
• Ps then reported if the object/repeating pattern and its motion had changed or stayed the same

Results: Experiment 1

Twenty-six out of twenty-seven participants reported drastic changes in the image after being spun

• Clockwise and Counterclockwise both altered form perception
• The change in image lasts for about 8 seconds and then returns to original perception when eye movement normalizes

Suggests eye movements is a part of form perception. This is consistent with the phase relations model.

Experiment 2

Are all motions/forms equally stable?

We examined whether critical ratios varied in stability for perceptions of form consistent with the circle map equation. One byproduct of the circle map is known as the Farey sequence which dictates the relative stability of each ratio.

Results: Experiment 2

Conducted a mixed model in SPSS 19

• Range (upper limit minus lower limit) treated as the dependent variable
• Stability (left side of Farey Tree), proximity to most stable ratio (24 fps in our experiment), and a stability by proximity interaction were predictors

As per the model the interaction between initial fps and stability reached conventional significance, t(248) = 2.338, p=.02

Discussion

Together, these experiments suggest that the perception of form is related to the critical ratio between retinal firing frequencies and extraocular muscle contraction frequencies.

Form perception through phase relations:

• Is not subject to the correspondence problem (Malloy, Butner, & Jensen, 2008)
• Integrates motion and form into a single model
• Integrates motion illusion perception with still image perception
• Operationalizes the potential influence of attention through K (kappa)
• Can be expanded to account for phase relations other than the extraocular muscle contraction

References


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