

A Computational Model for Perception of Two-dimensional Pattern Velocities

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Outline

- Computational model: Bayesian velocity estimator
- Simple two-stage model implementation
- Model response to plaid stimuli
- Comparison to psychophysical data:
 - Ferrera & Wilson, 1990, 1991
 - Stone, Watson, Mulligan, 1990

Bayesian Velocity Estimator

- Gradient measurement equation, with noise model:

$$I_x (v - n_1) + I_t + n_2 = 0$$

- Prior probability distribution on velocity:

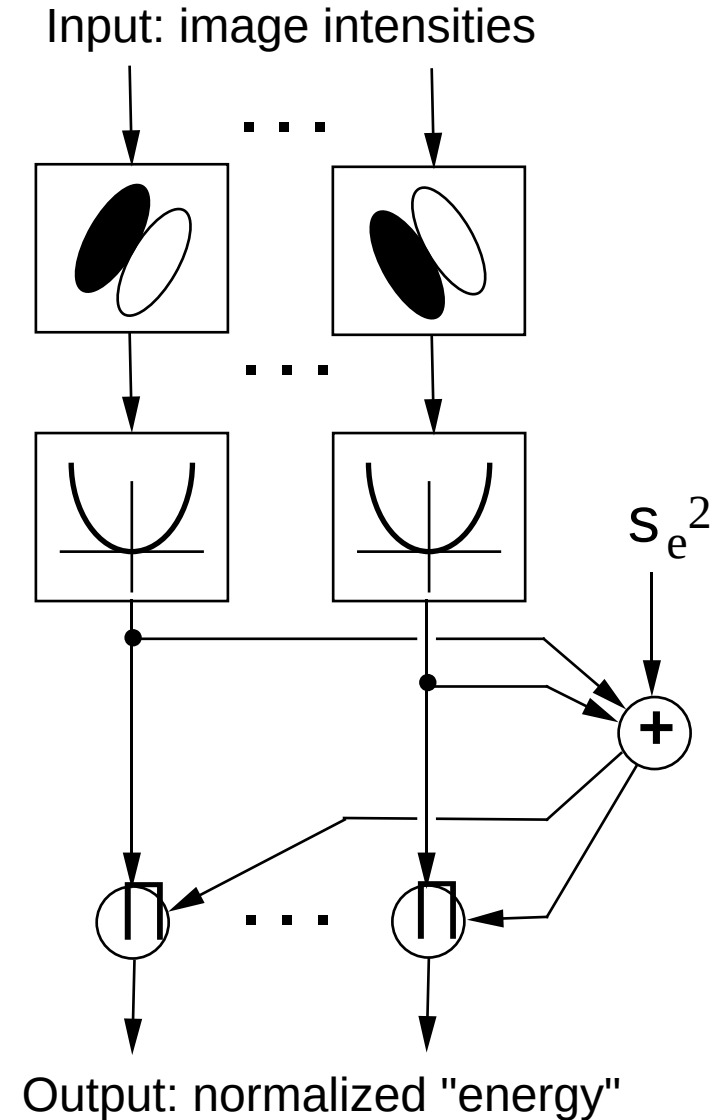
$$P(v) \sim N(0, s_v^2)$$

- Bayes' rule gives probability distribution on velocity:

$$\log P(v | I) = \mu - \frac{(I_x v + I_t)^2}{(s_e^2 + I_x^2)} - \frac{v^2}{s_v^2}$$

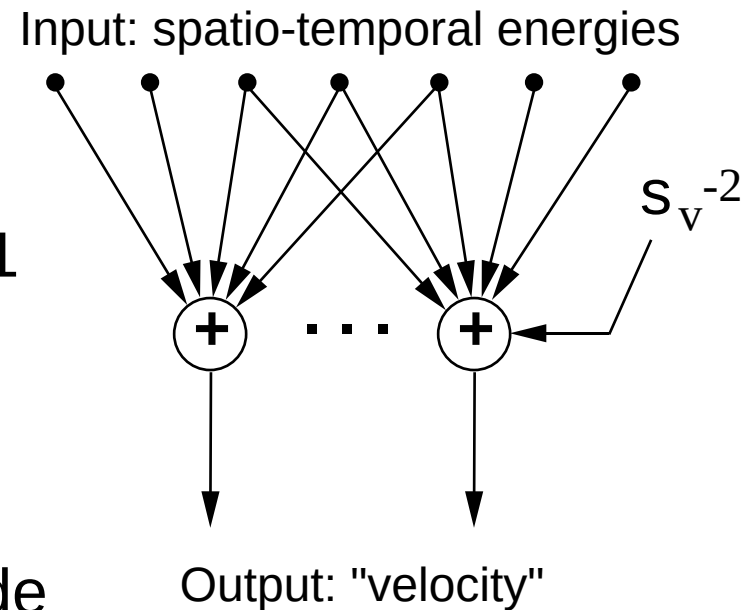
Implementation: Stage 1

- Linear filtering, using spatio-temporally oriented operators
- Energy computation (squaring)
- Divisive normalization, with semi-saturation parameter, s_e
- Outputs are spatio-temporally tuned



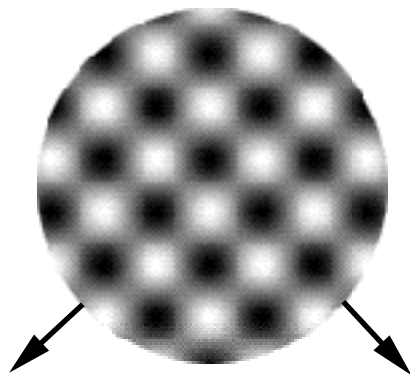
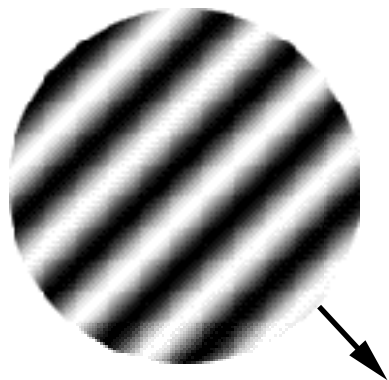
Implementation: Stage 2

- Weighted summation of stage 1 energies over space, frequency bands
- Some of the summations include prior variance parameter, s_v
- Outputs are velocity tuned

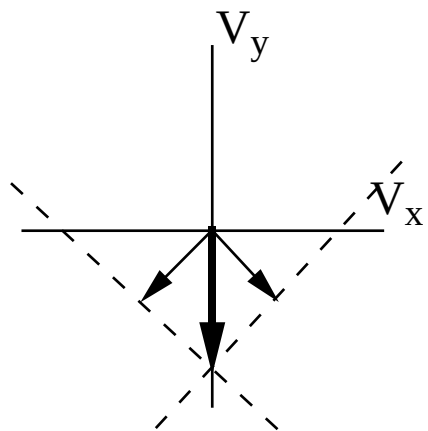
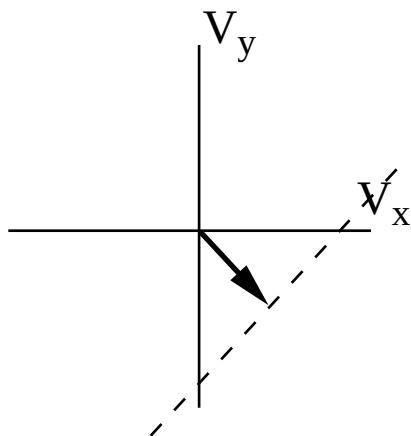


Grating Examples

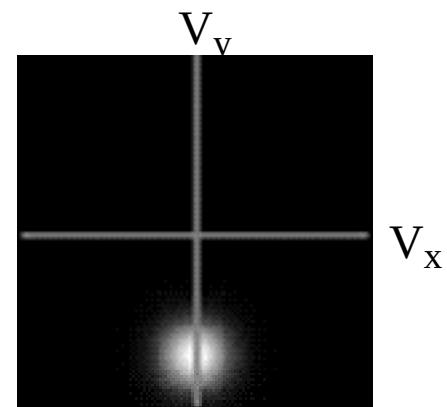
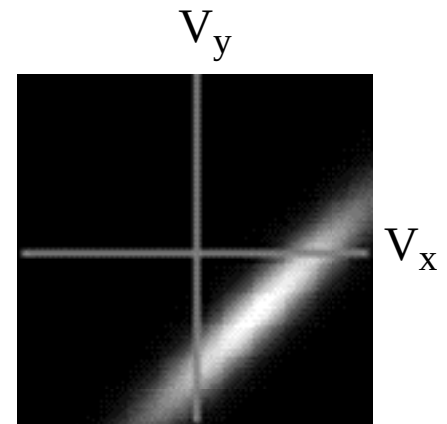
stimulus



idealization

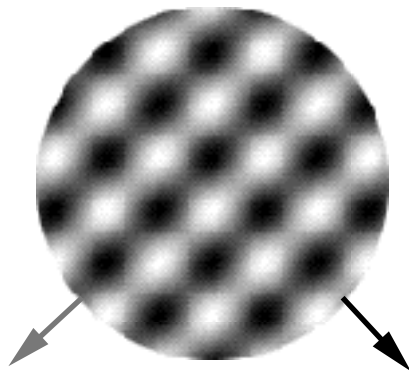


model

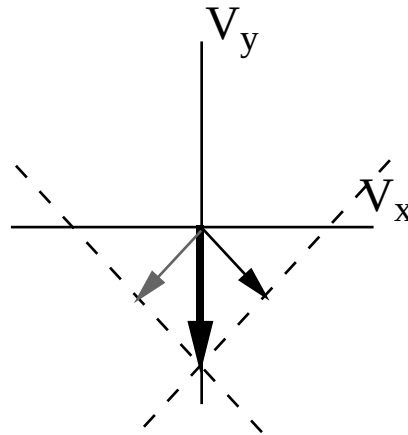


Plaids: Effect of Relative Contrast

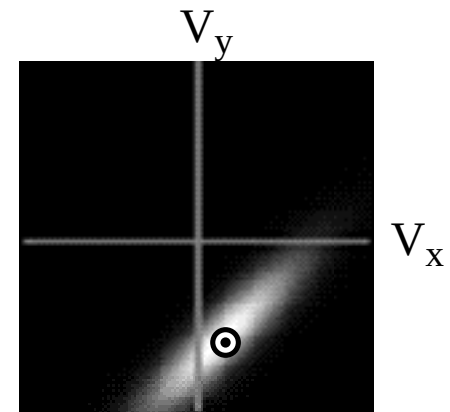
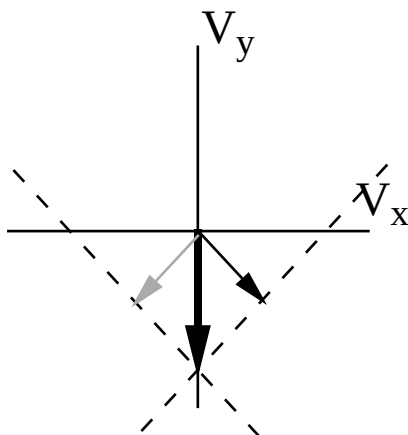
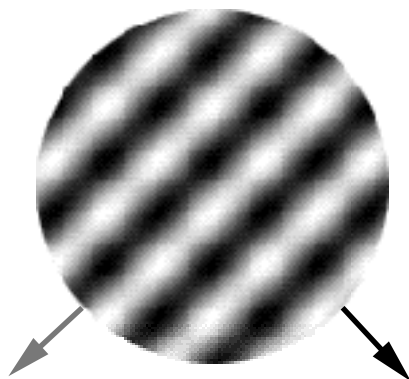
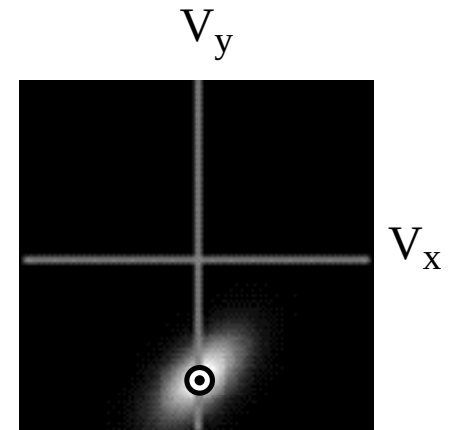
stimulus



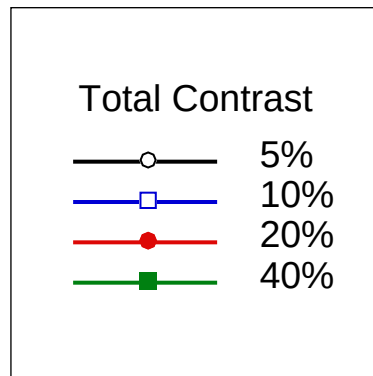
idealization



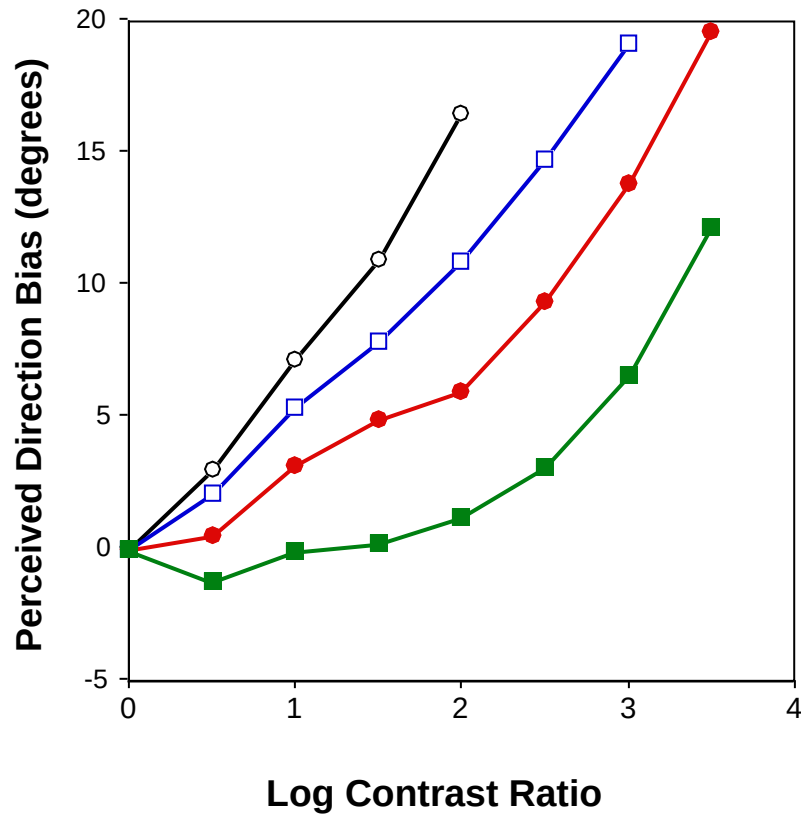
model



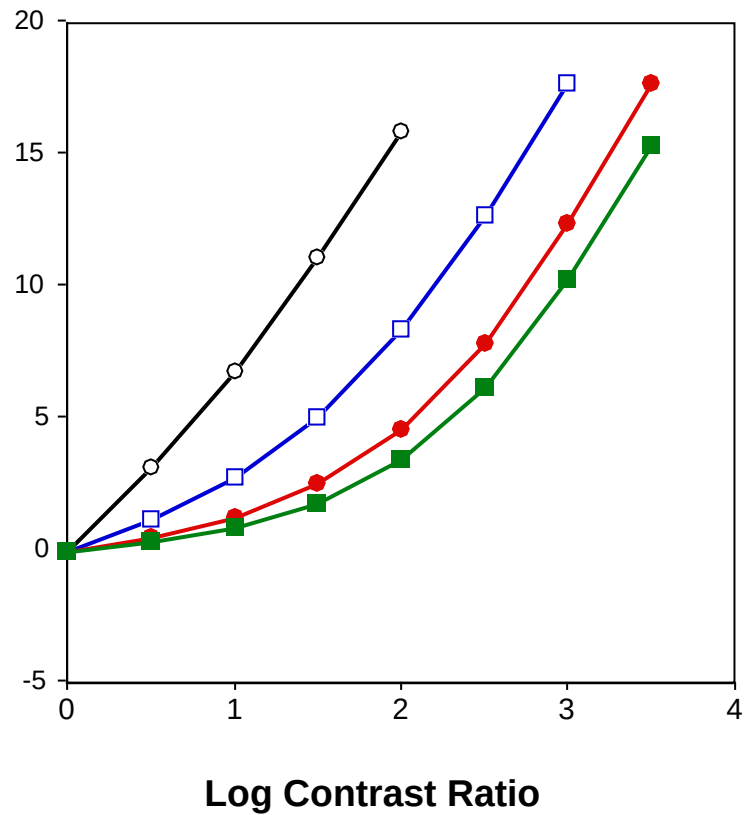
Stone et al. 1990



Subject

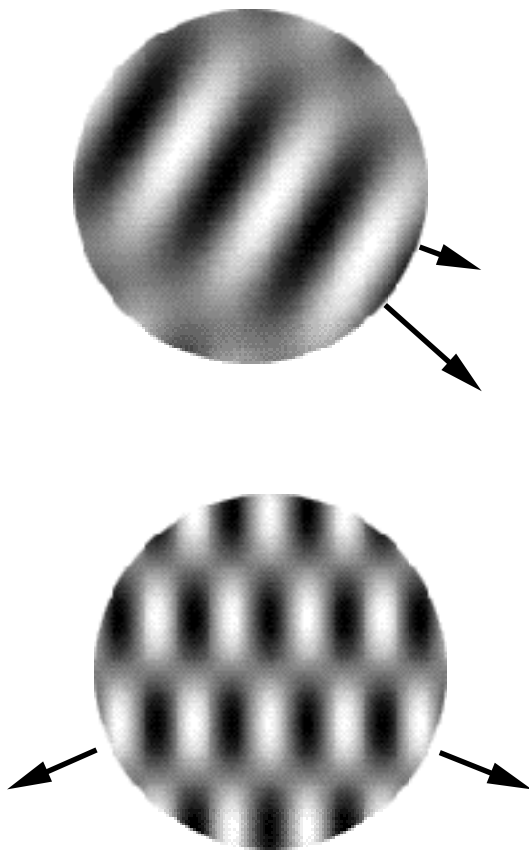


Model

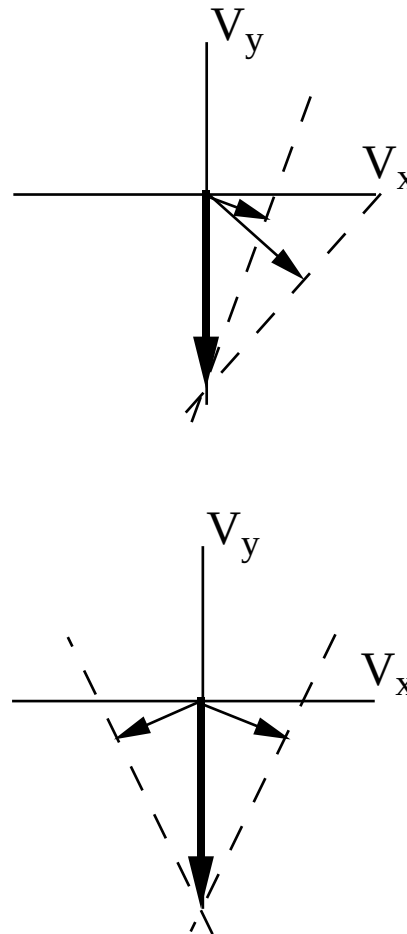


Plaids: Effect of Grating Angles

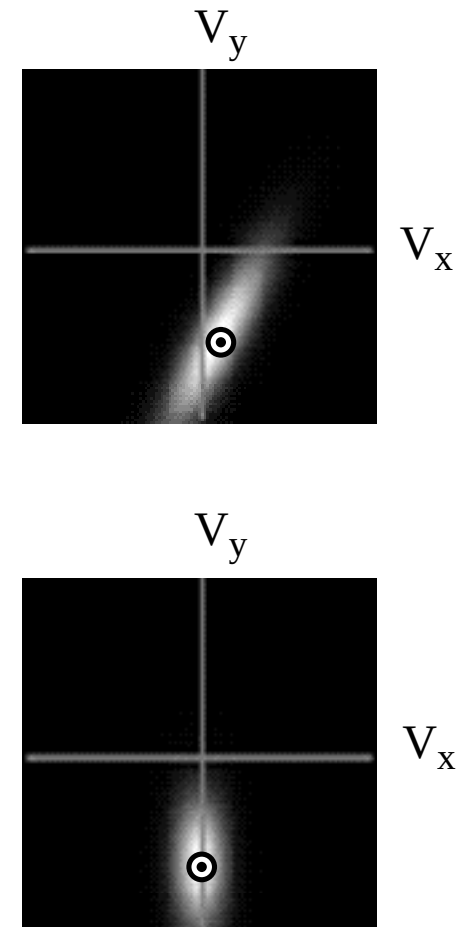
stimulus



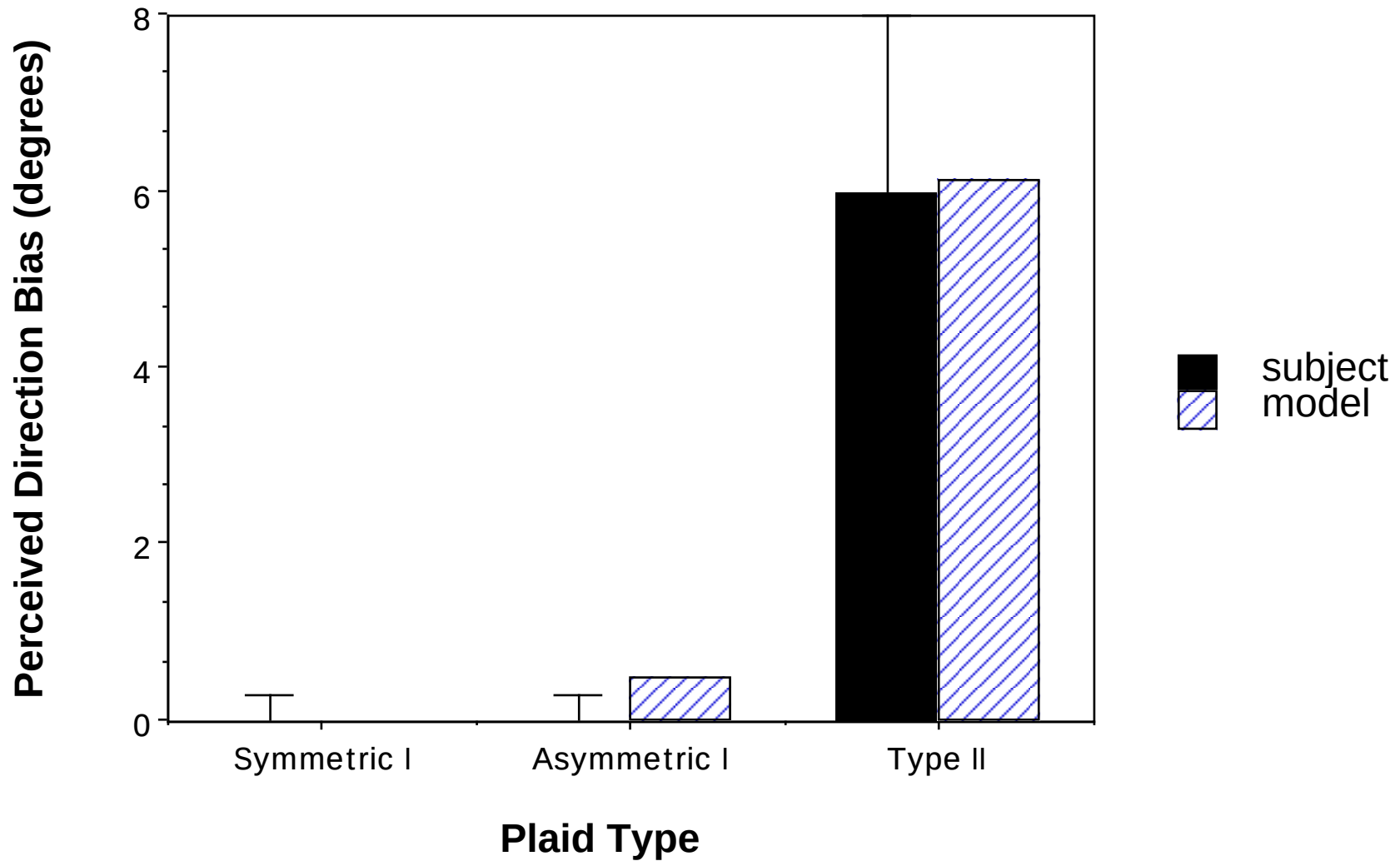
idealization



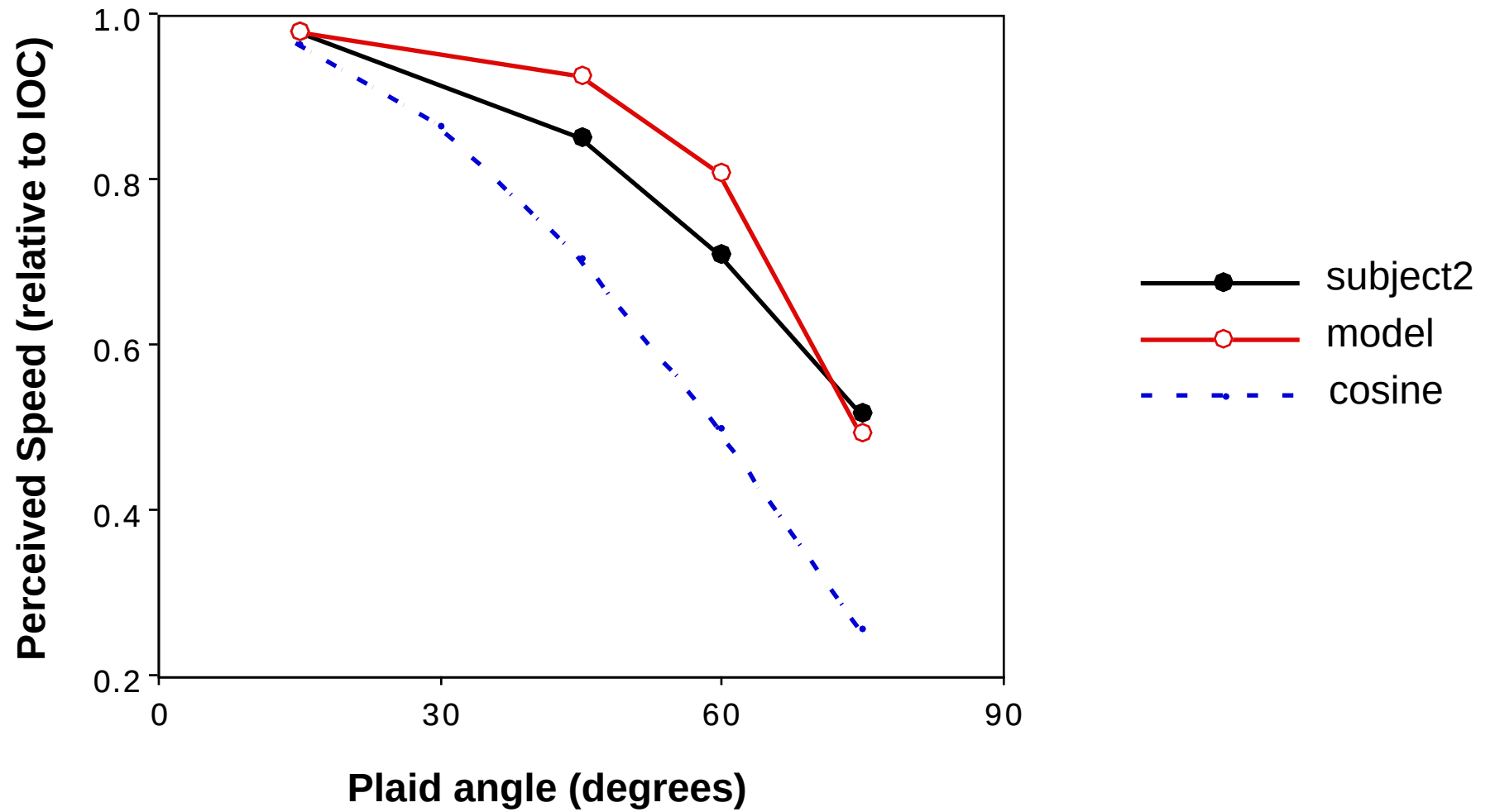
model



Ferrera & Wilson, 1990



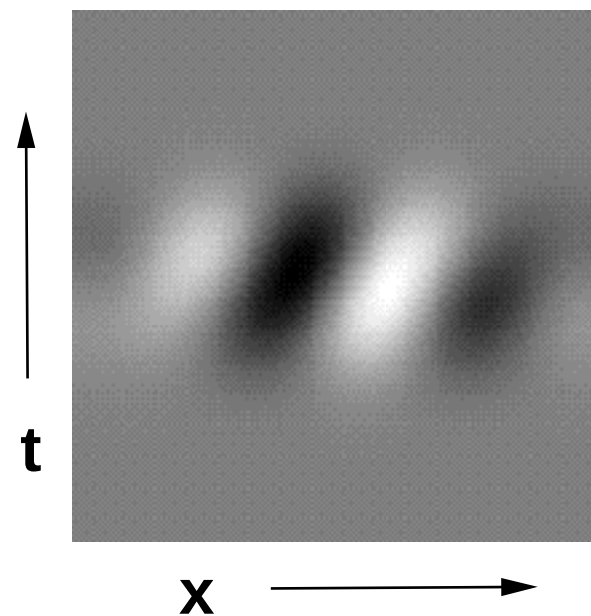
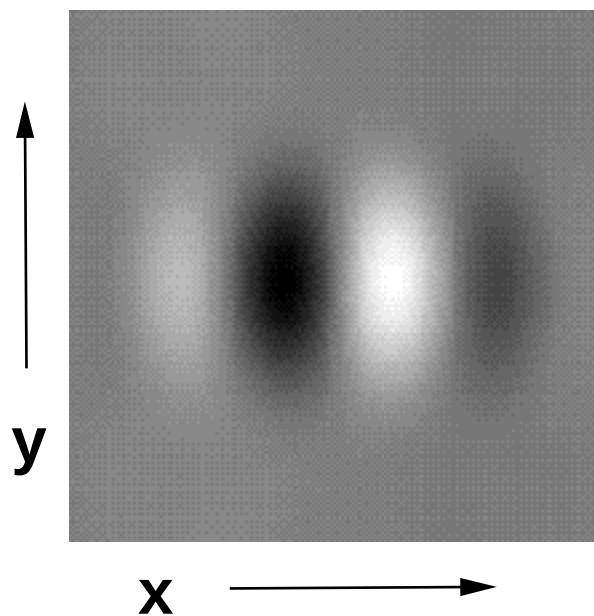
Ferrera & Wilson, 1991



Summary of Model

- Derived as a Bayesian estimator
- Starting from image intensities, computes response of a population of velocity-tuned units
- Implemented in two simple stages of computation
- Velocity estimates are consistent with psychophysics of plaid perception

Example Receptive Field



Spatio-temporal Filter Bank

