Testing and Refining a Computational Model of Neural Responses in Area MT
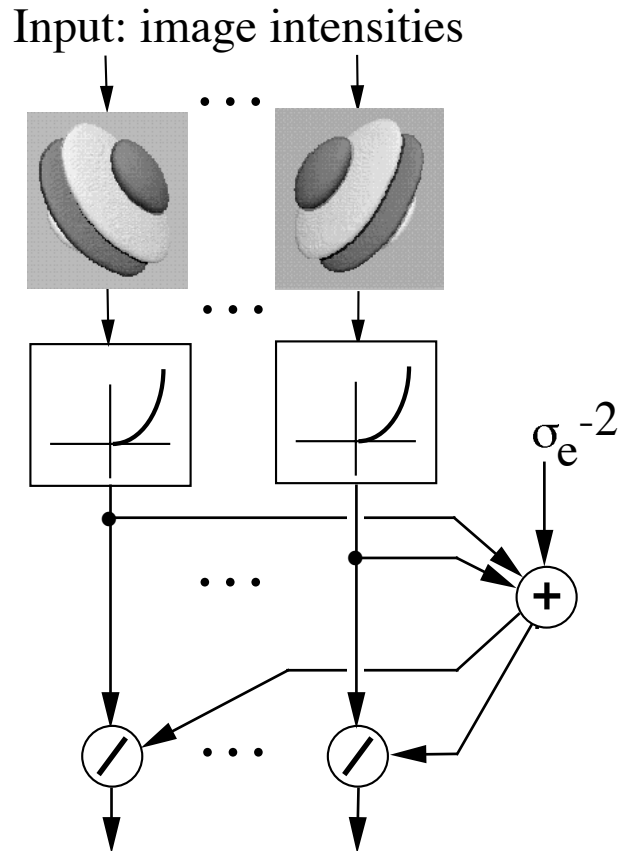
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Stage I: V1 Simple Cells

Input: image intensities

$$\sigma_e^{-2}$$

- Combines image intensities via space-time oriented linear filters.
- Response tuned for spatio-temporal frequency.
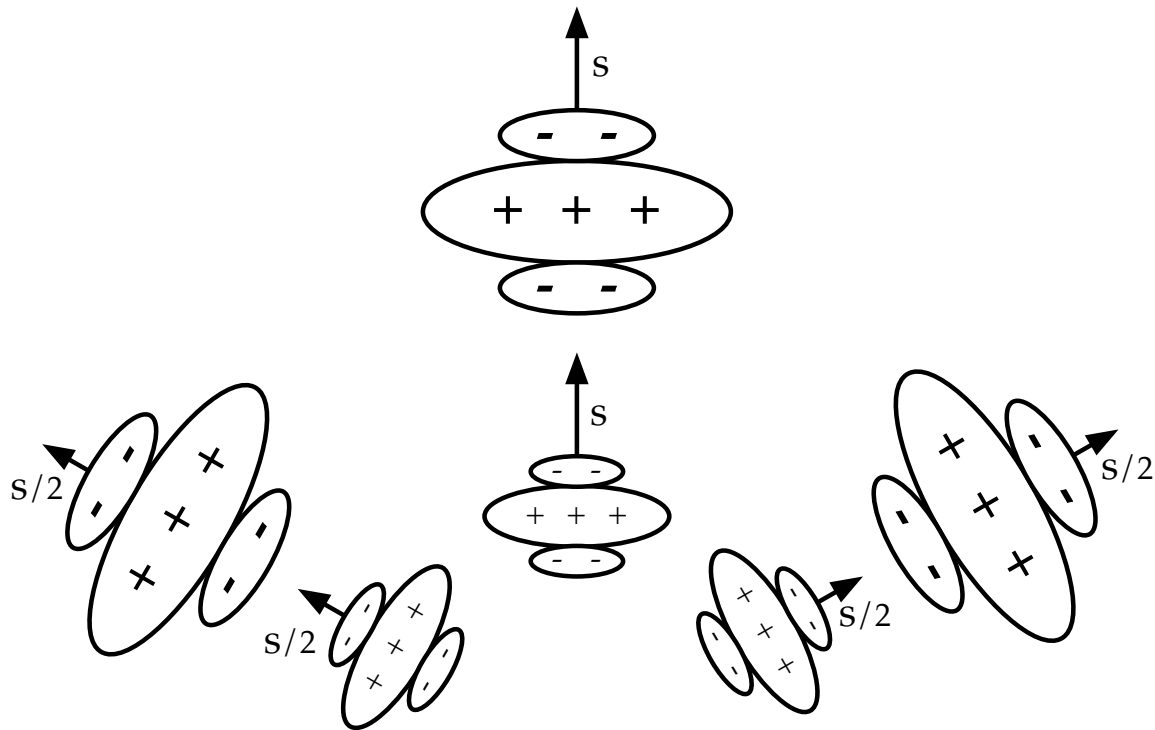
MT Component Cell Construction
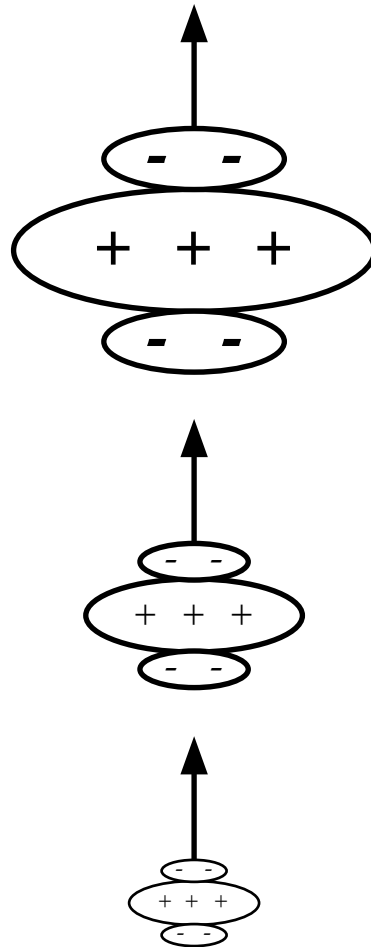
- Linear Combination of V1 Cells tuned for:
  - range of spatial frequencies / R.F. positions
  - fixed *orientation* and *speed*
- Rectification / Normalization

MT Component Cells
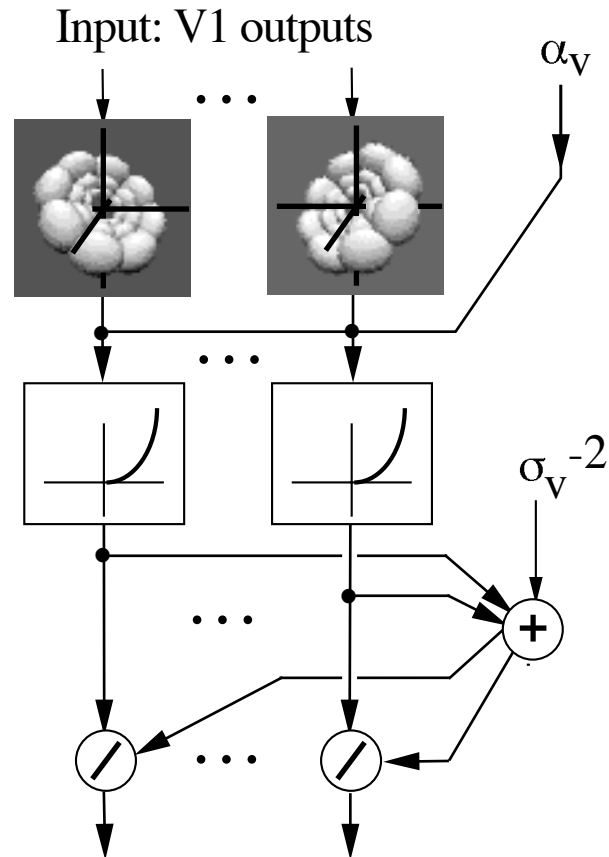
Input: stage I outputs α_c

σ_c^{-2}
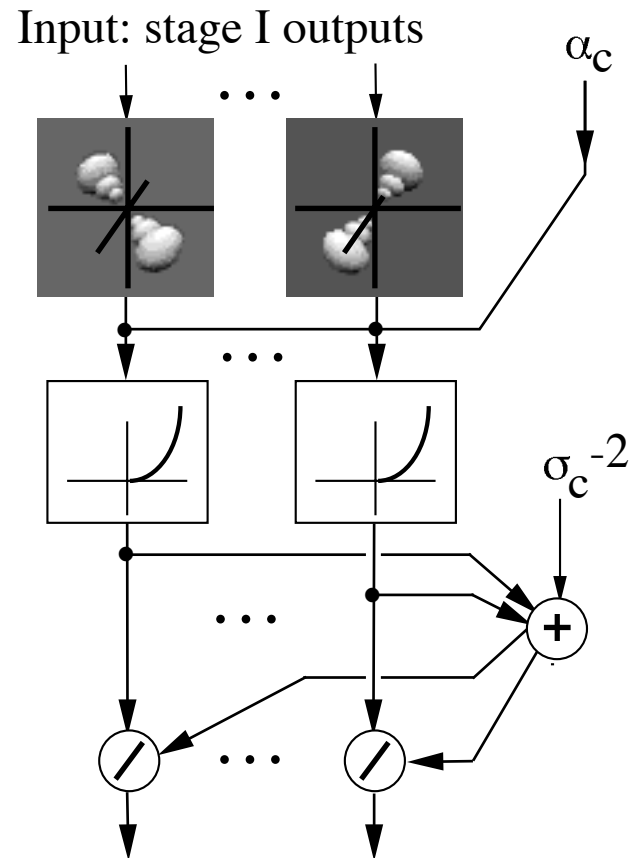
- Combines outputs of V1 units tuned for different spatial and temporal frequencies, and RF positions.
- Response tuned for orientation and speed of 1D patterns (stripes).

MT Pattern Cell Construction

- Linear Combination of V1 Cells tuned for:
  - range of spatial frequencies / R.F. positions
  - speed / orientation combinations *consistent with pattern motion*
- Rectification / Normalization

MT Pattern Cells

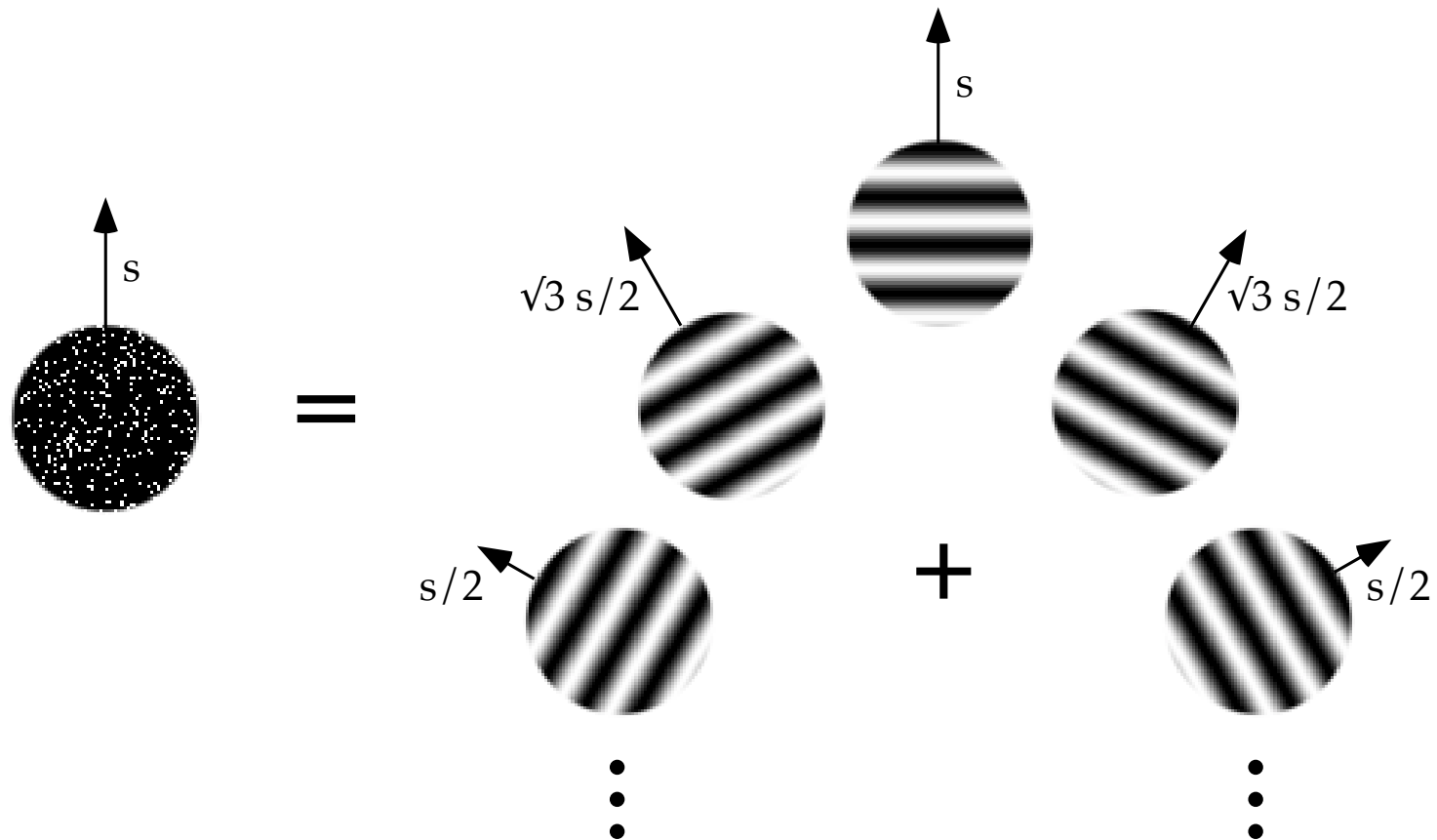
Input: V1 outputs

α_v

σ_v^{-2}

- Combines outputs of V1 units tuned for different orientations, spatial/temporal frequencies, and RF positions.
- Response tuned for 2D image pattern velocity (speed & direction).
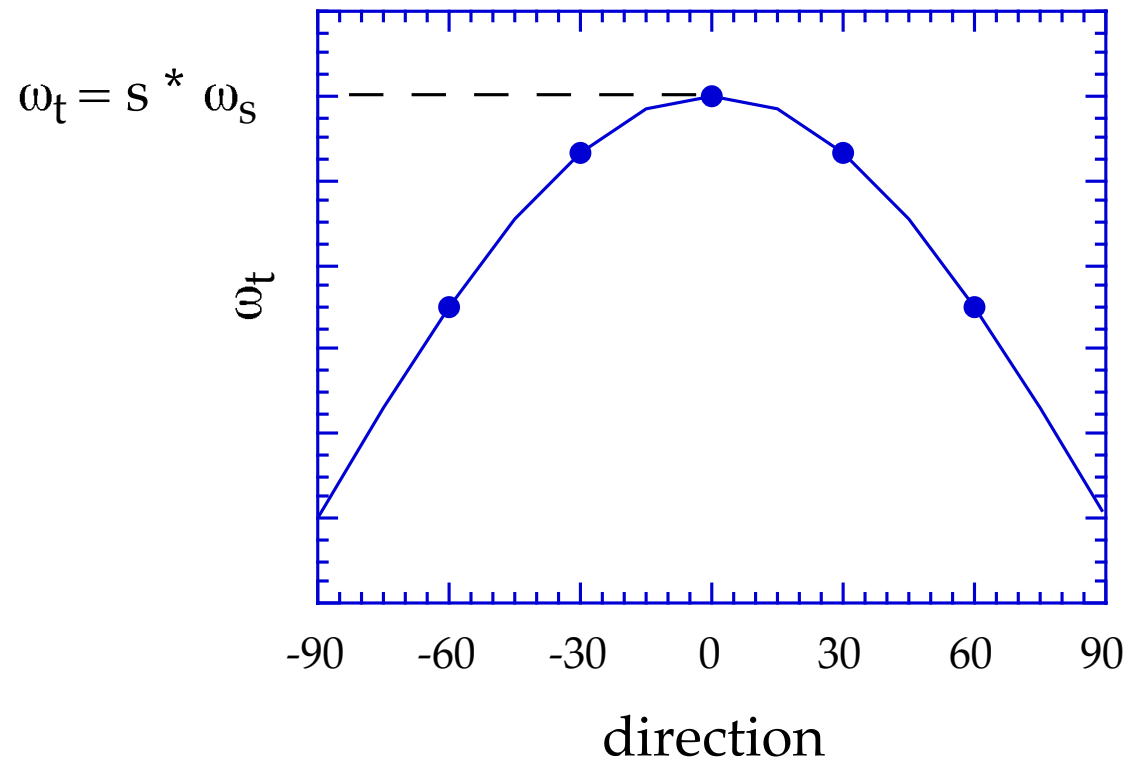
Component vs. Pattern

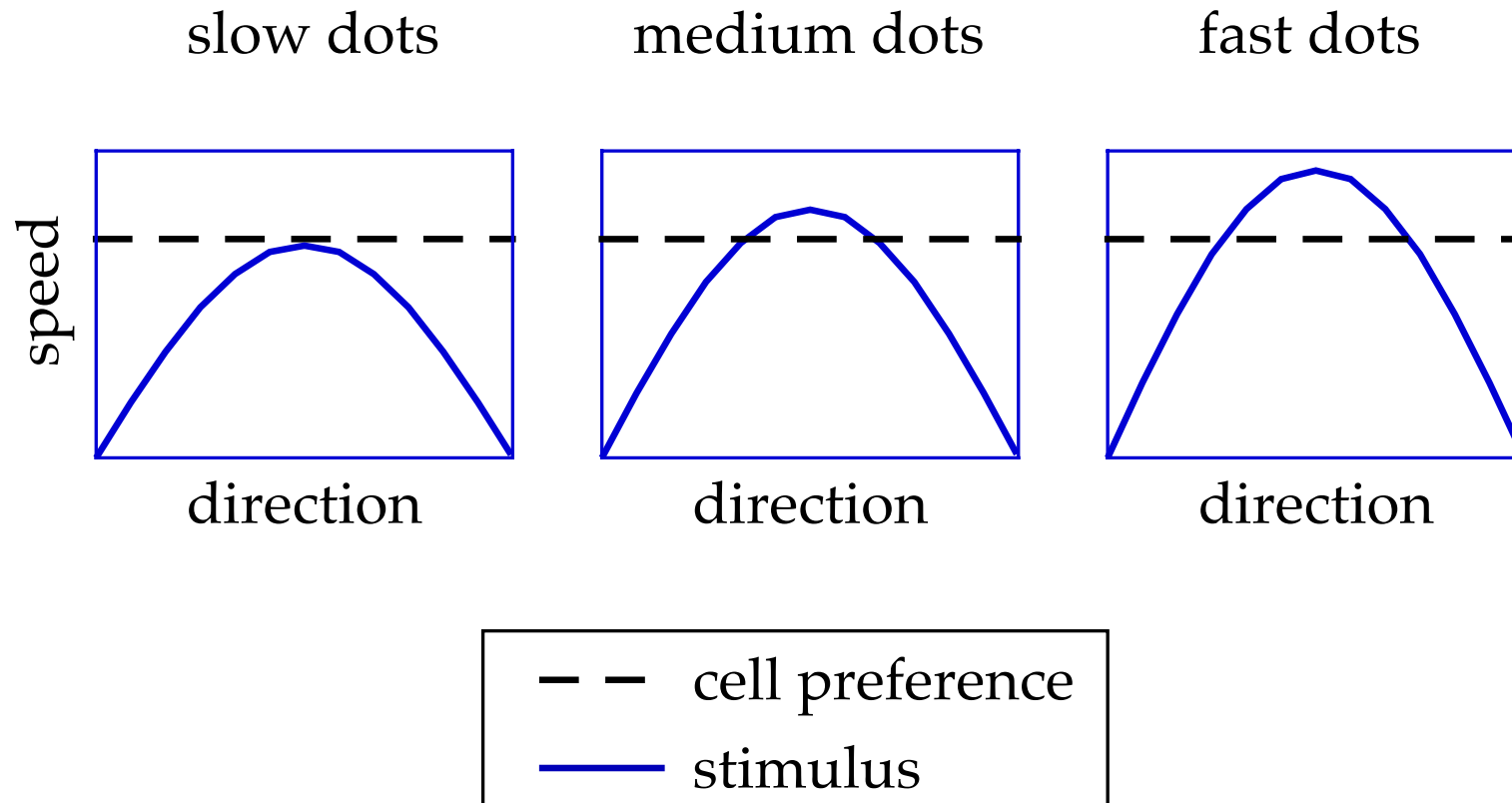Component Cell   Pattern Cell

Grating

Plaid
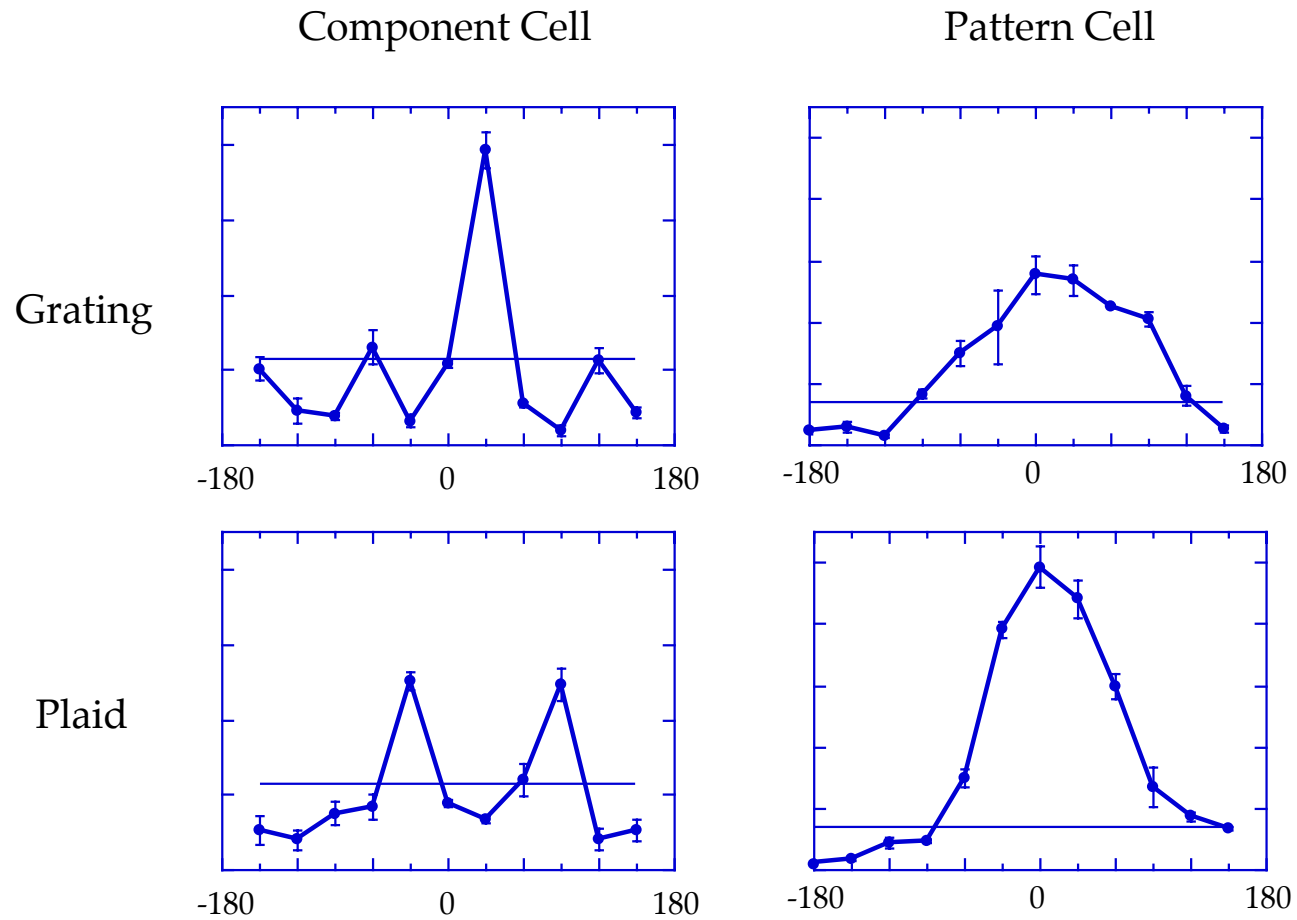
Movshon et. al., 1986

Drifting Dot Stimulus = Sum of Gratings

Drifting Dot Stimulus = Sum of Gratings

$$\omega_t = s * \omega_s$$

ω_t

direction

-90   -60   -30   0   30   60   90

Component Cell / Drifting Dots

slow dots   medium dots   fast dots

speed

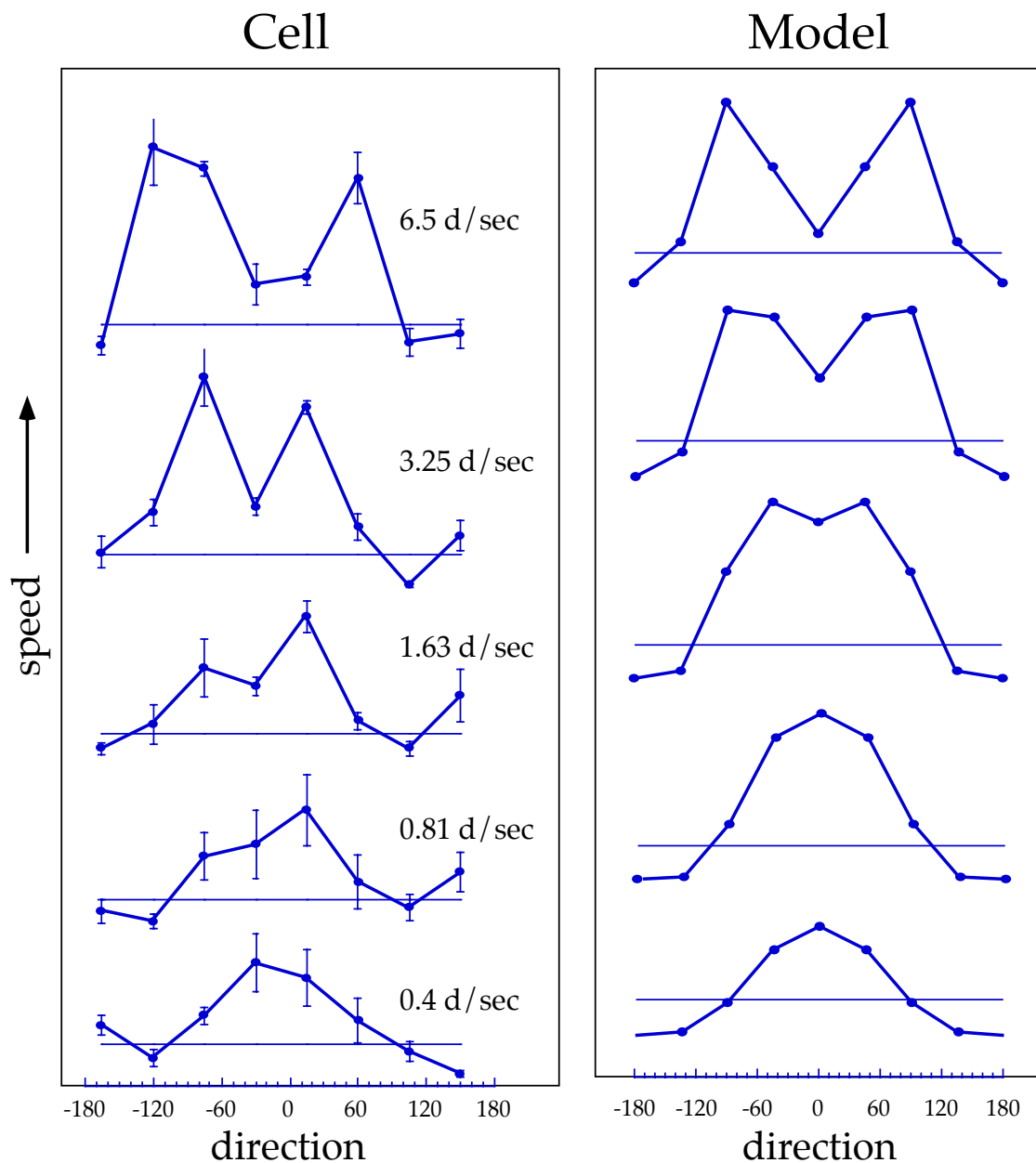direction   direction   direction

— — cell preference
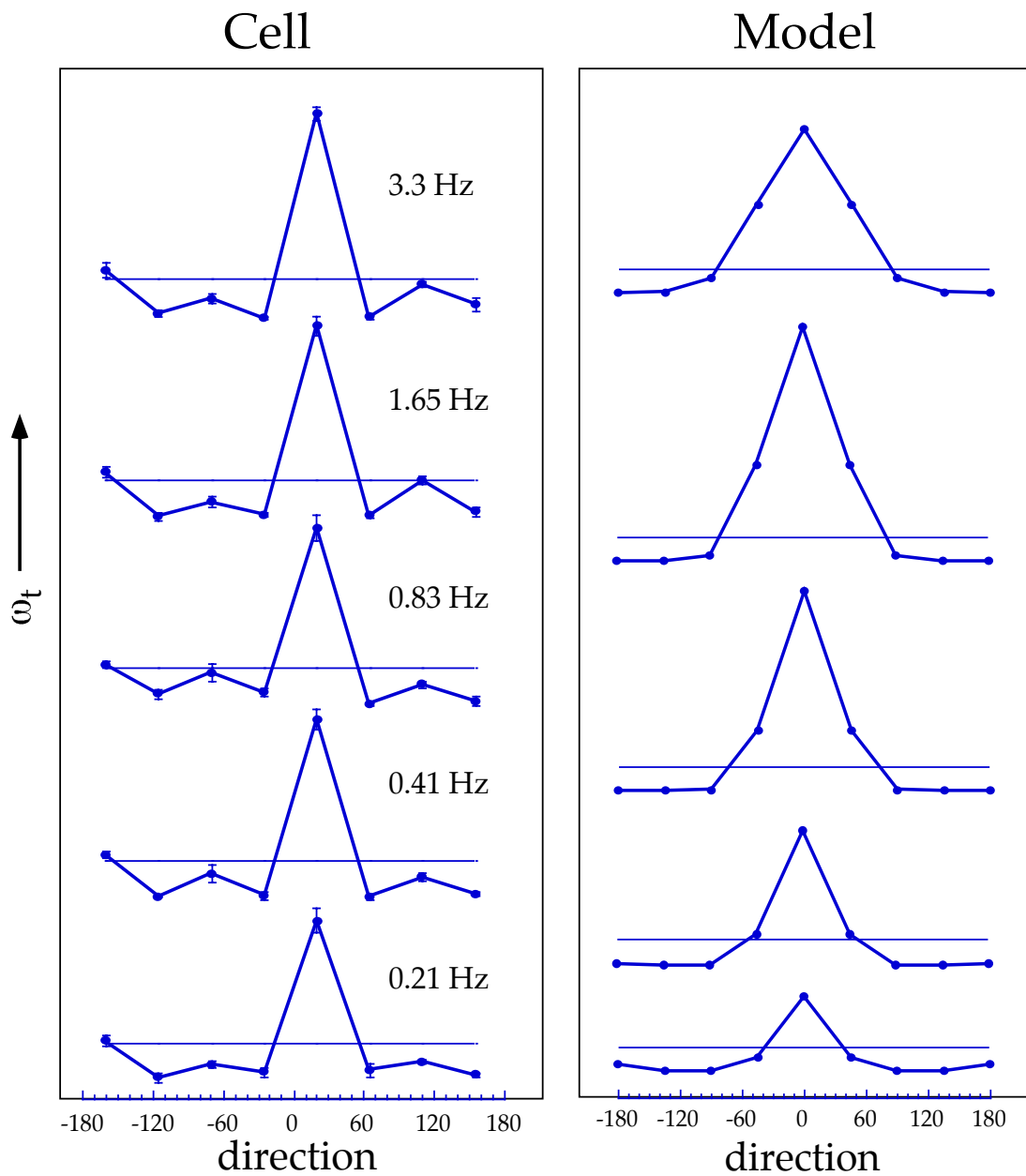
—— stimulus

• Prediction: direction-tuning for dots becomes bimodal at *high* speeds.
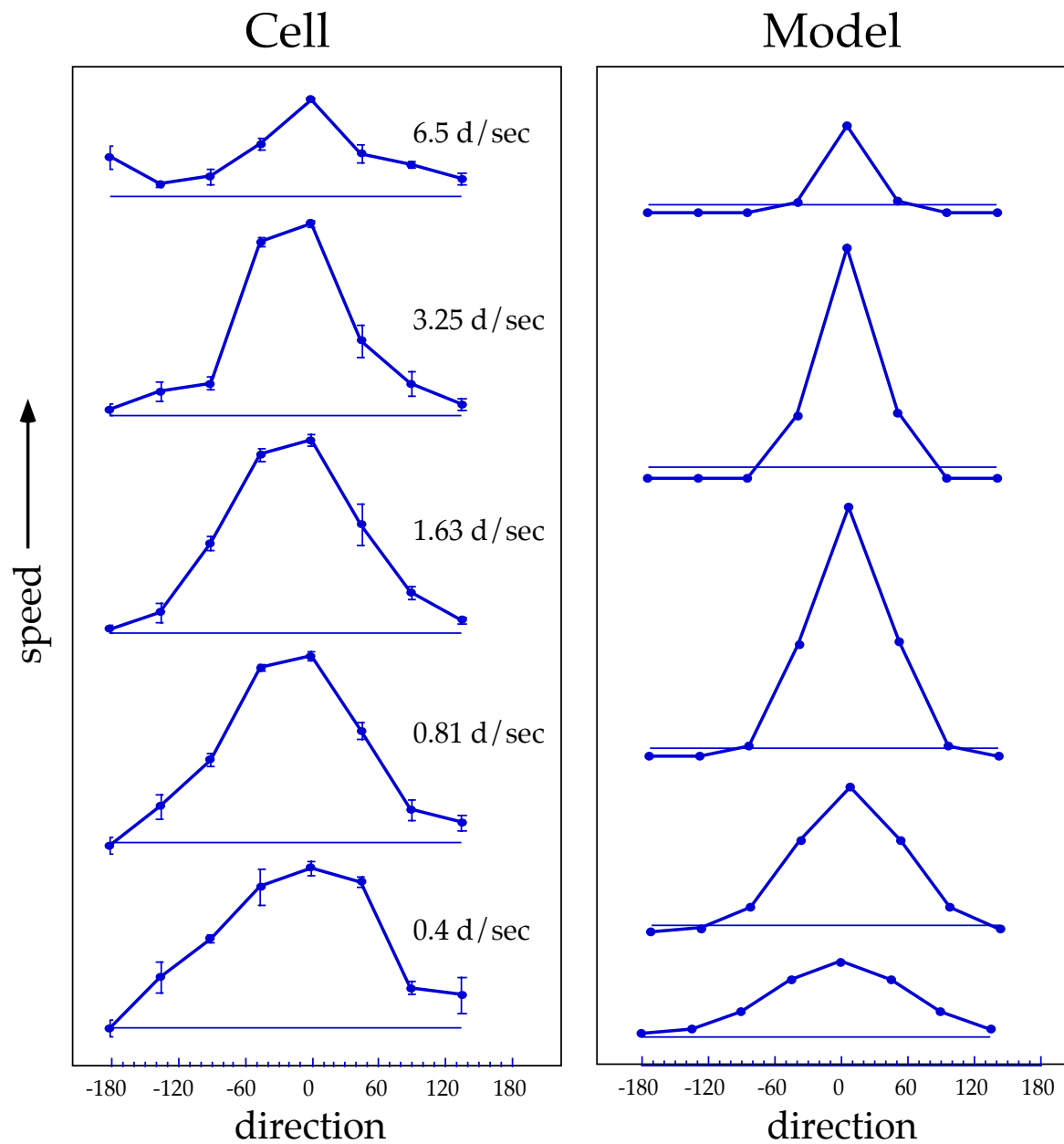
Component Cell / Drifting Dots

Cell

Model

- Bimodality at high speeds (as predicted).
- Similar behavior in V1 complex cells (Movshon, et. al., 1980).

Component Cell / Sine Grating

Cell   Model

ω_t

3.3 Hz

1.65 Hz

0.83 Hz

0.41 Hz

0.21 Hz

-180   -120   -60   0   60   120   180   -180   -120   -60   0   60   120   180
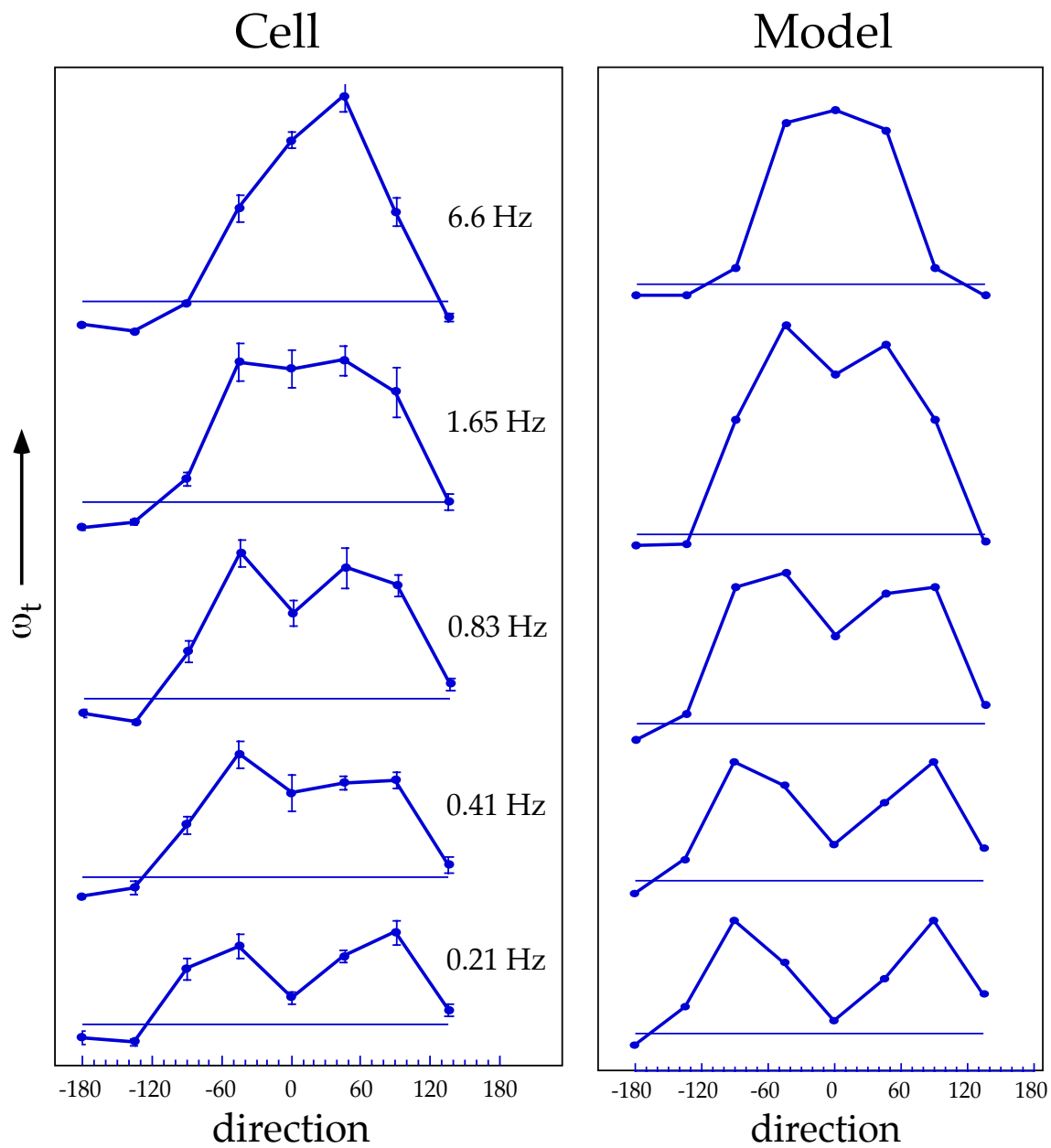
direction   direction

● Direction-tuning curves independent of speed.

Pattern Cell / Drifting Dots

• Direction-tuning curves independent of speed.

Pattern Cell / Sine Grating

Cell

Model

- Bimodality at low speeds (as predicted).
- Bimodality *not* found for single drifting bars (Rodman & Albright, 1987).

Conclusions

Stimulus \ Cell Type	Component	Pattern
Grating	Unimodal	Bimodal @ low speeds
Dots	Bimodal @ high speeds	Unimodal