Neural coding depends on spatial and temporal frequency in direction selective cells in V1 and MT/V5

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One simple model for direction selectivity

Adelson and Bergen (1985)
One simple model for direction selectivity

Adelson and Bergen (1985)
Preferred (P)

[Image of a circle with a right arrow]
Preferred (P)

Antipreferred (A)
Preferred (P)

Antiprefered (A)

binary, random sequence

10ms
Spike-triggered Average (STA)
Motion detection

Visual stimulus
$s(x,y,t)$

motion energy

(pref) $g_{ex}(t)$

(anti) $g_{in}(t)$
Motion detection

Visual stimulus $s(x,y,t)$

- Pref
  - $g_{ex}(t)$
- Anti
  - $g_{in}(t)$

Spiking: integrate-and-fire

$$C \frac{dV}{dt} = g_{ex}(V_{ex} - V) + g_{in}(V_{in} - V) + g_{leak}(V_{rest} - V)$$
STAs from model
STAs from model
Filter from model

STAs from model

Time relative to spike (ms)

Velocity (normalized)
V1 complex DS cell

[Graph with the following axes:
- Y-axis: Velocity (normalized)
- X-axis: Time relative to spike (ms)
- TF (Hz) on another axis]

The graph shows the relationship between velocity (normalized) and time relative to a spike. The TF (Hz) axis is shown in the inset, illustrating the effect of frequency on the cell's response.
V1 complex DS cell

![Graph showing velocity and TF (Hz) relationship]

- Velocity (normalized)
- TF (Hz)
- Time relative to spike (ms)

Rate (spikes/s)
V1 complex DS cell
V1 complex DS cell

The graph shows the velocity (normalized) plotted against time relative to a spike (ms) for different TF (Hz) values. The rate (spikes/s) is represented on the inset graph.
V5/MT cell

![Graph depicting the relationship between velocity and time relative to spike for a V5/MT cell. The graph shows a series of overlapping traces indicating activity over time.]
V5/MT cell

Rate (spikes/s) vs. TF (Hz)

Velocity (normalized) vs. Time relative to spike (ms)

Height and Width measurements indicated.
STA width (ms)

STA height

Evoked response (spikes/sec)

Temporal frequency (Hz)
V1 complex DS

Velocity (normalized)

Time relative to spike (ms)

Rate (spikes/s)

SF (cyc/degr)
MT (n=13)  

V1 (n=19)

**STA width (ms)**

**STA height**

**Evoked response (spikes/sec)**

Spatial frequency (cycles/degree)
Velocity (normalized)

Contrast (%)

Rate (spk/s)

Time relative to spike (ms)

V1
TF    SF   contrast

MT
V1

STA width (ms)

STA height

0.8

0.5

0.2

10 30 50 70

fast

par.1.1.pp
STA height vs. STA width (ms)

- TF
- SF
- contrast

- MT
- V1

- fast
The graph shows the relationship between STA width (in ms) and STA height for two conditions: fast and STA. The lines represent different contrasts (MT and V1) for each condition. The x-axis represents STA width in milliseconds, ranging from 10 to 70 ms. The y-axis represents STA height, ranging from 0.2 to 0.8. The graph indicates that the STA height increases with increasing STA width initially, reaching a peak, and then decreases as the width continues to increase.
fast

STA height

STA width (ms)

0.8

0.5

0.2

10 30 50 70

MT

V1

TF SF contrast
Fast


![Graph showing STA height vs. STA width (ms) for different contrast levels and MT vs. V1](image)

- **STA height**
- **STA width (ms)**
- **Contrast Levels:**
  - Fast

**Legend:**
- **TF**
- **SF**
- **Contrast**
- **MT**
- **V1**

**Axes:**
- Y-axis: STA height
- X-axis: STA width (ms)
The graph shows the relationship between STA width (ms) and STA height for different contrast levels. Two types of contrasts are considered: fast and slow. Two different MT types are compared: MT and V1. The STA height is plotted on the y-axis, and the STA width (ms) is plotted on the x-axis. The graph indicates that the STA height decreases as the STA width increases, with different patterns observed for fast and slow contrasts.
The graph shows the relationship between STA width (ms) and STA height for different conditions. The x-axis represents STA width in milliseconds, ranging from 10 to 70 ms, while the y-axis represents STA height, ranging from 0.2 to 0.8.

- The STA width is labeled in increments of 10 ms (10, 30, 50, 70).
- The STA height is labeled with values 0.2, 0.5, and 0.8.

Three curves are plotted, each representing a different condition:

1. **Fast**
2. **Slow**
3. **Low C**

The graph includes a legend indicating the conditions:

- **TF**
- **SF**
- **MT**
- **V1**

The contrast levels for each condition are represented by different line styles:
- **TF** is represented by a solid line.
- **SF** is represented by a dashed line.
- **MT** is represented by a dotted line.
- **V1** is represented by a dashed-dotted line.
TF    SF   contrast
MT
V1

10 30 50 70
STA width (ms)

0.8
0.5
0.2

fast
hi SF
slow

low C
low SF

STA height
spatio-temporal filter

X →

T

MT/V5

DS

complex DS

V1

LGN

Retina
spatio-temporal filter

X

T

MT/V5

DS

complex DS

V1

LGN

Retina