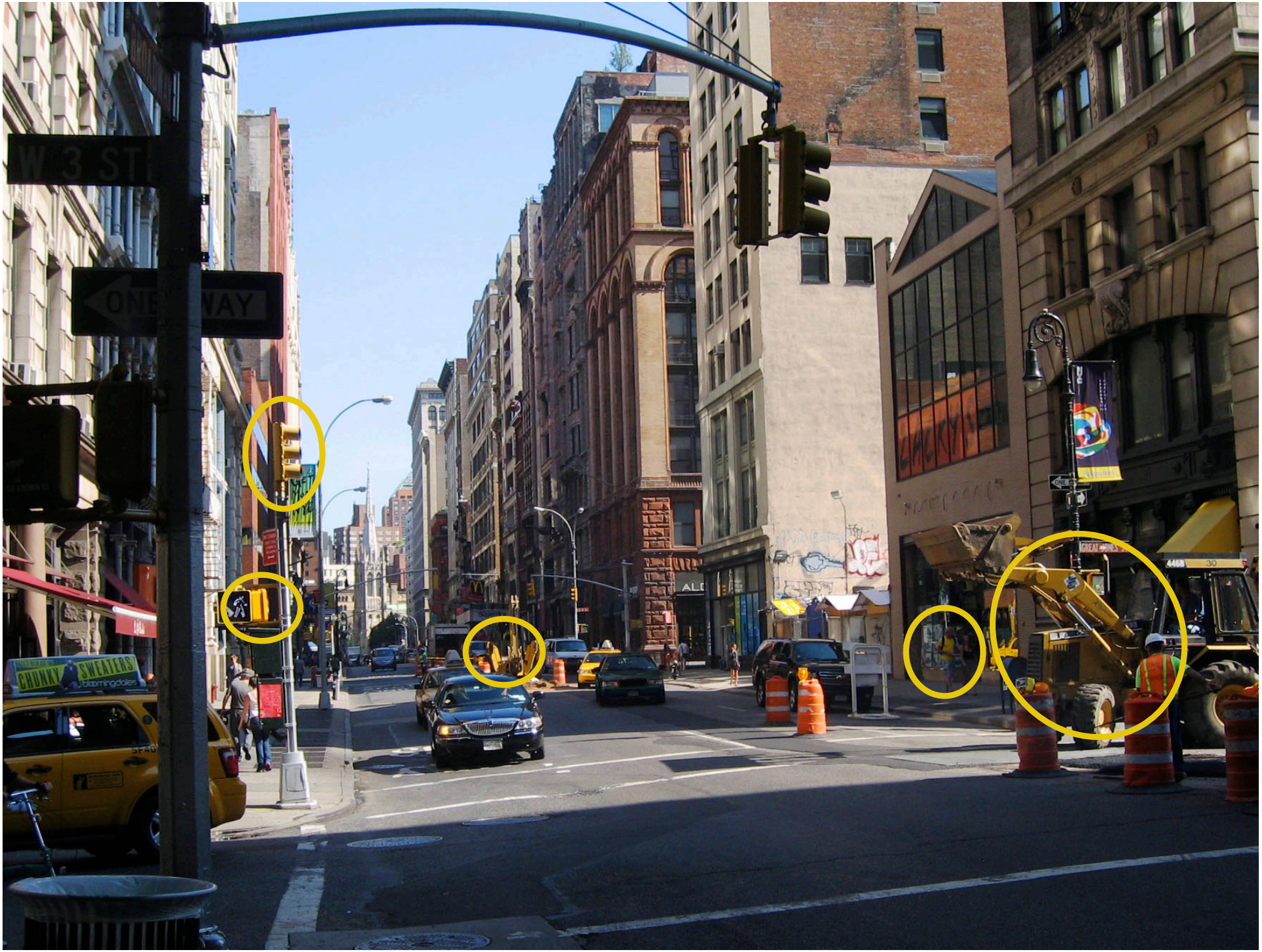
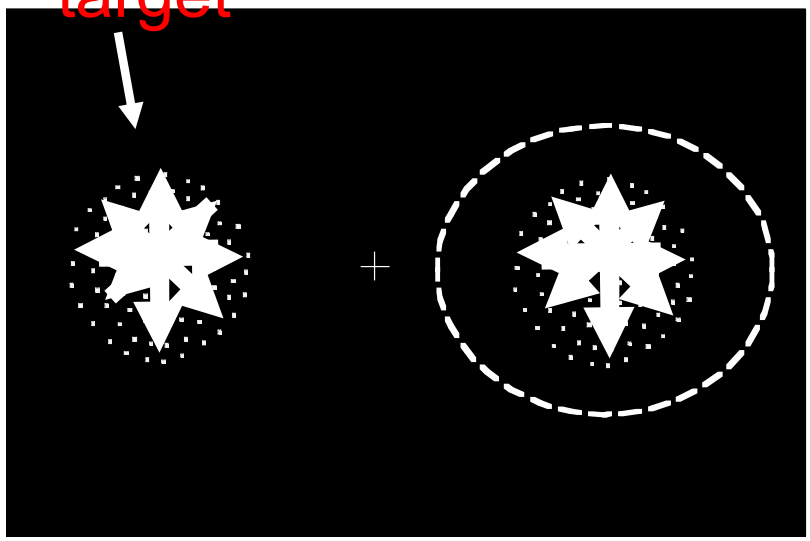
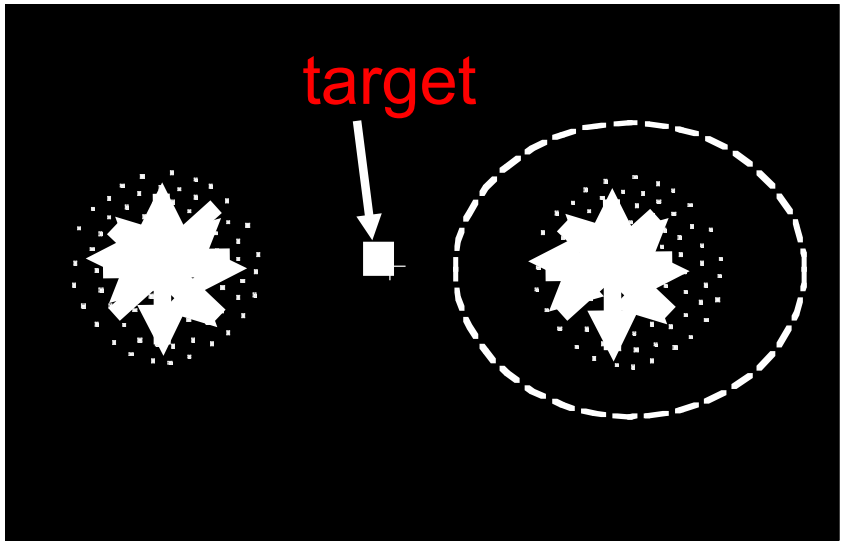

W 3 ST
ONE WAY
CHUNKY SWEATERS
bloomingdales

Measuring feature-similarity gain

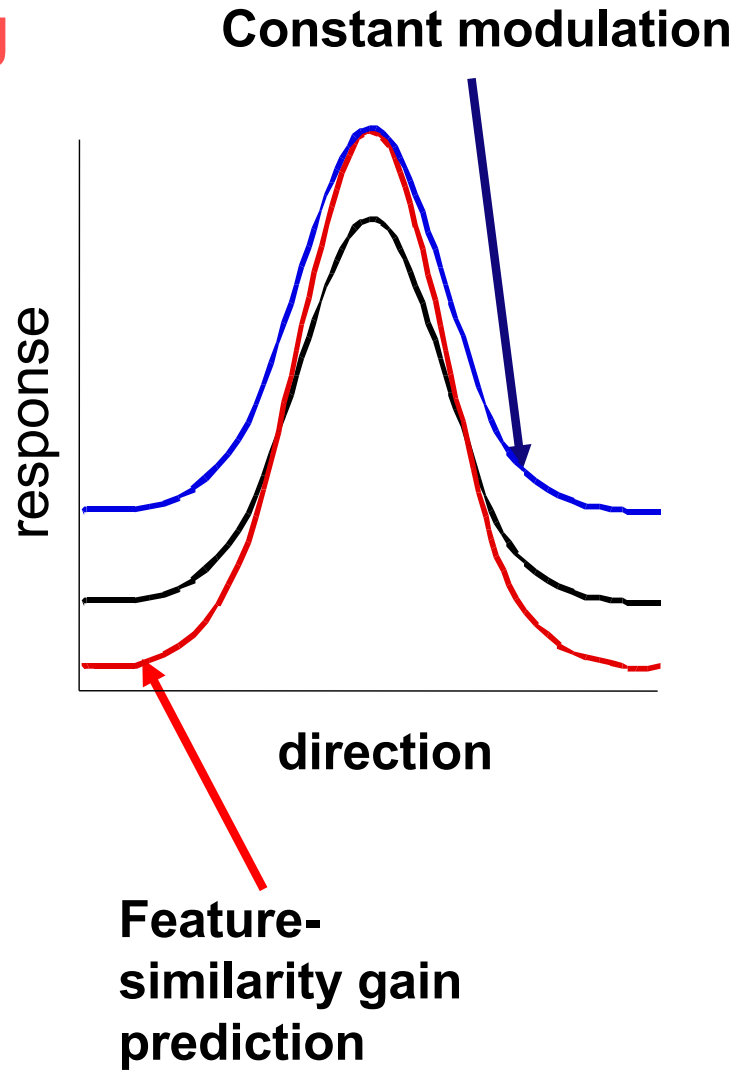
Martinez-Trujillo & Treue



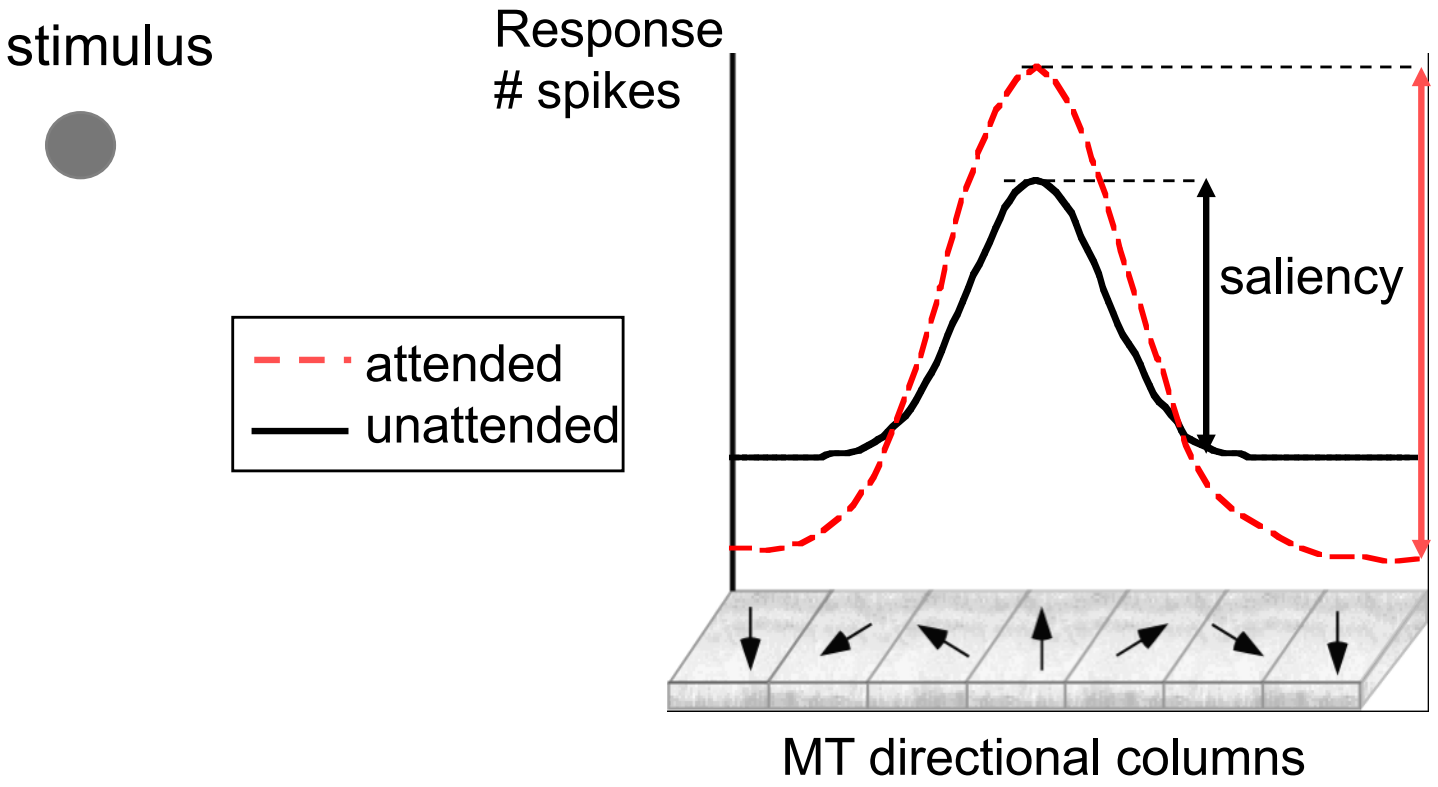
Attending



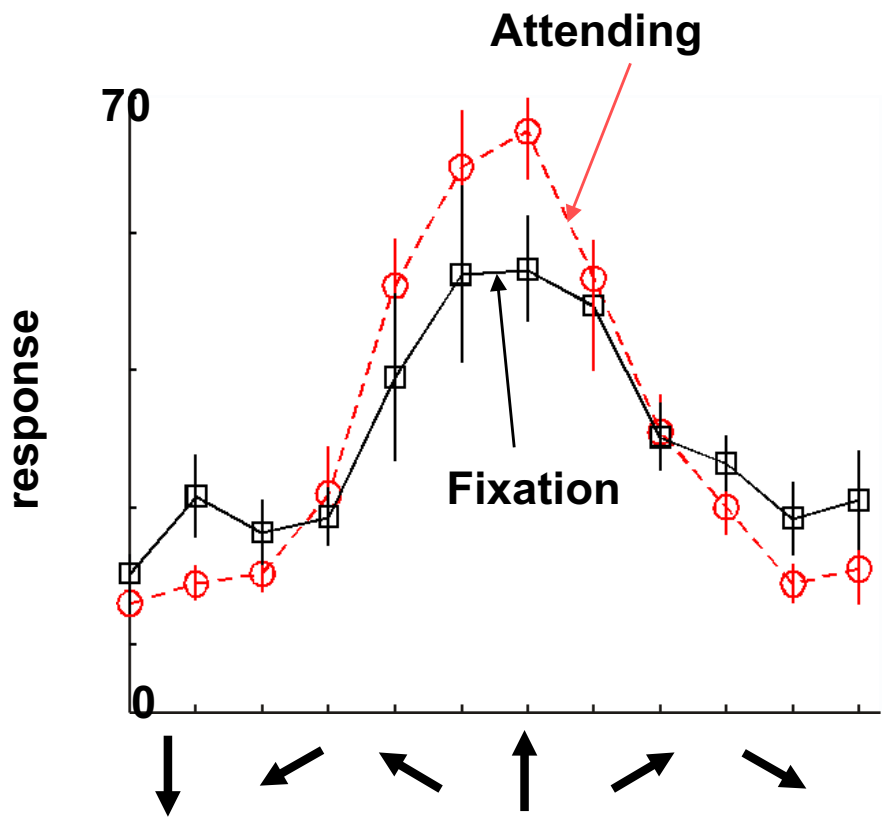
Fixation



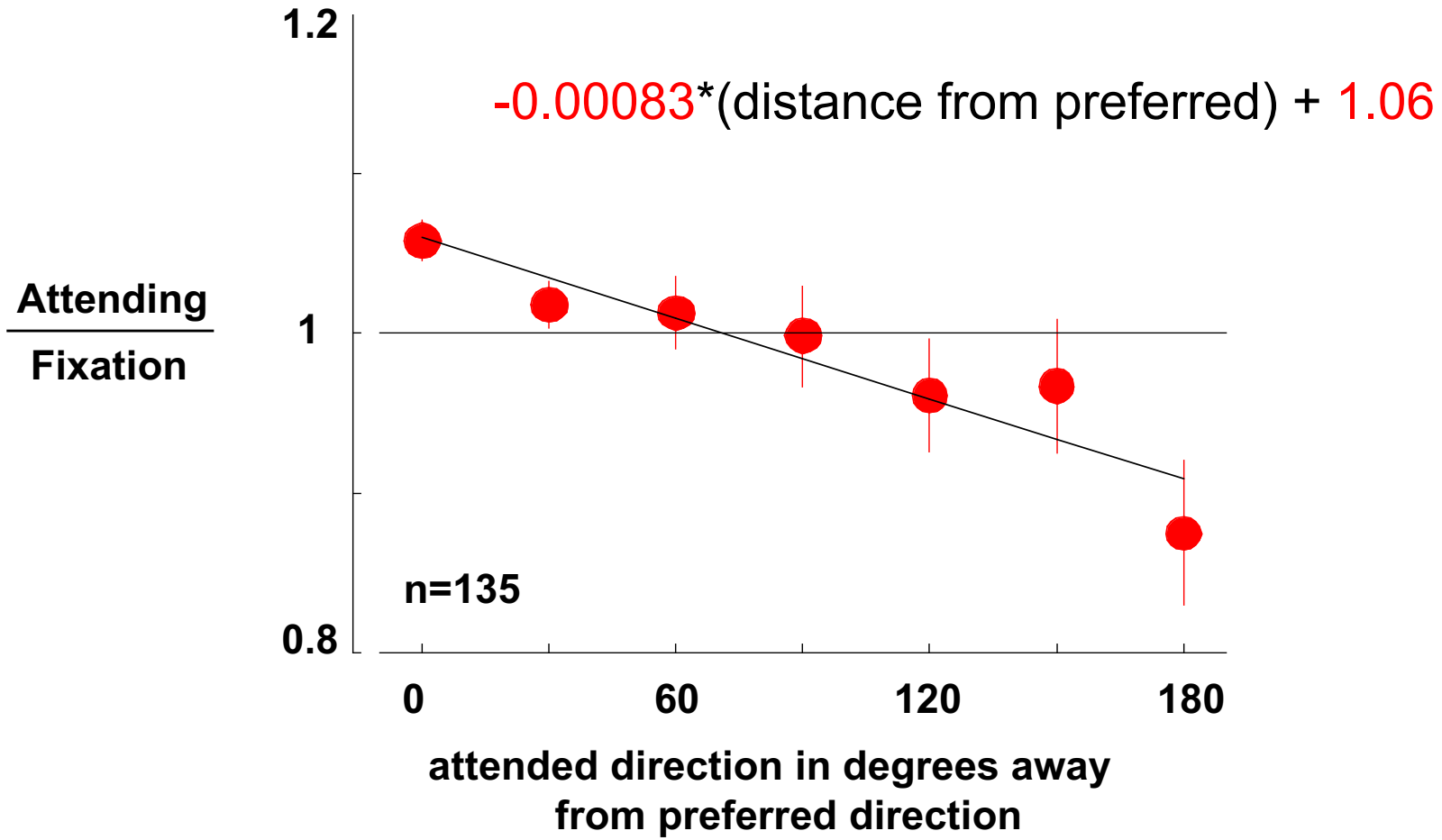
Attention and stimulus saliency



Measuring feature-similarity gain (Example MT neuron)



Measuring feature-similarity gain (Population data)

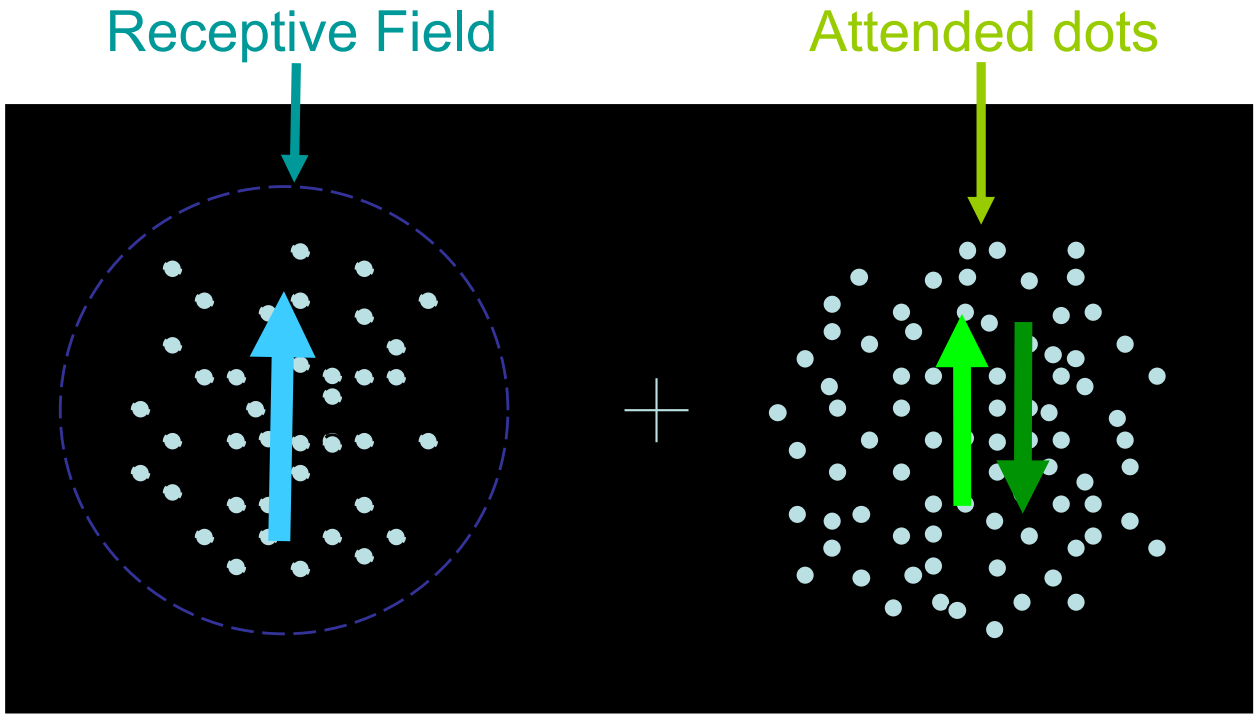


the attentional modulation is a function of the similarity between the cell's preferred feature and the attended feature

global spread: neurophysiology

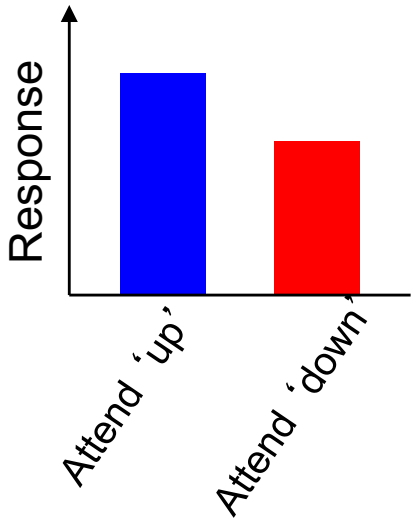
neural responses are modulated by features of distant attended stimuli

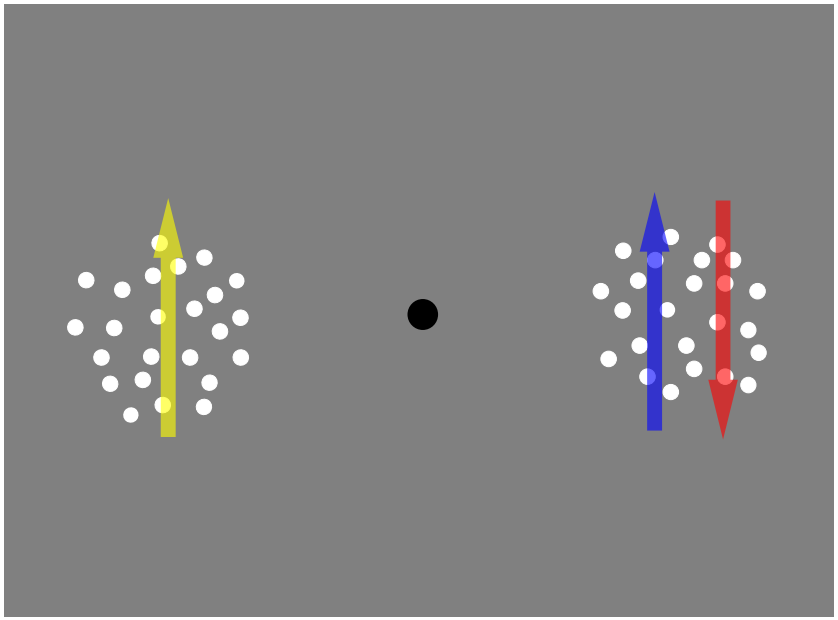
e.g., Treue & Martinez-Trujillo, 2004; Saenz et al, 2002; Boynton & Serences, 2007



neurons that prefer the attended feature value are ‘boosted’ across the visual field, even at task-irrelevant locations

spread of feature-based attention



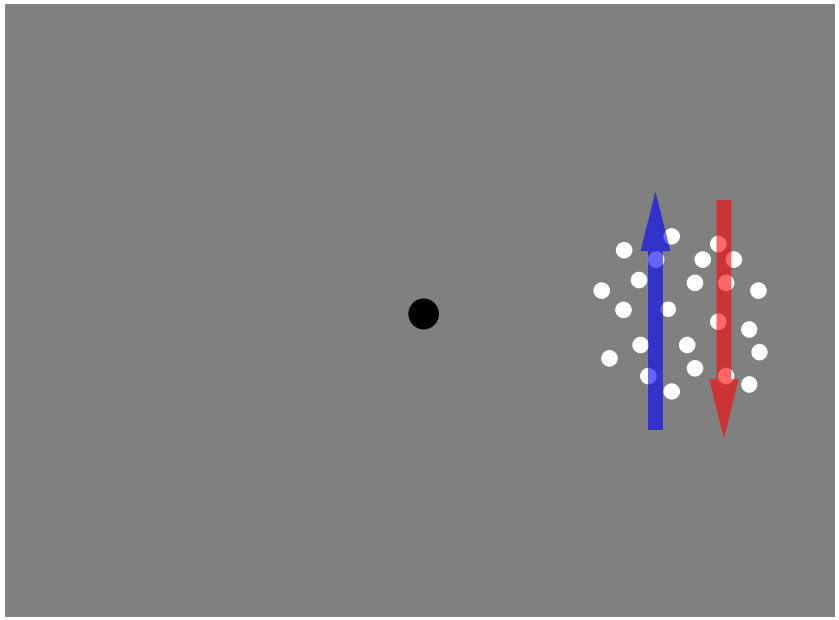


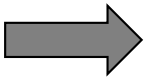
?

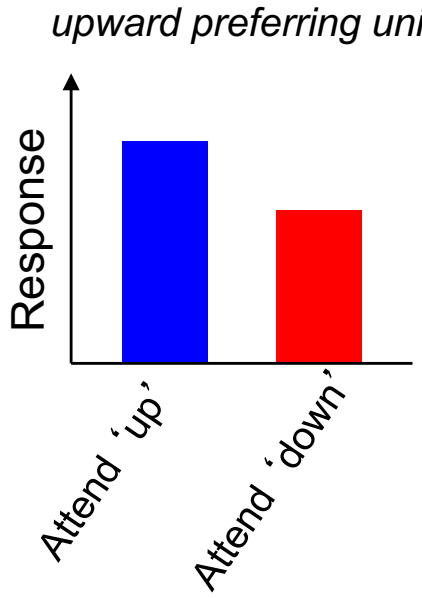
Does feature-based attention modulate neuronal subpopulations in the attended location?

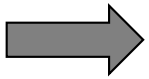
Treue & Martinez-Trujillo, 1999
Saenz, Buracas, & Boynton, 2002

Use adaptation to assess feature selectivity

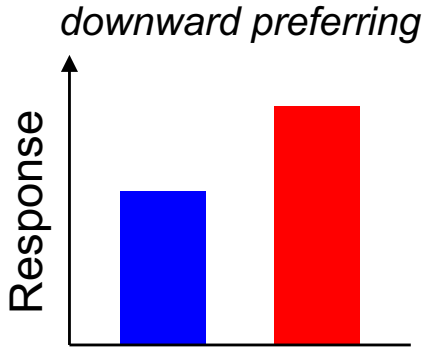




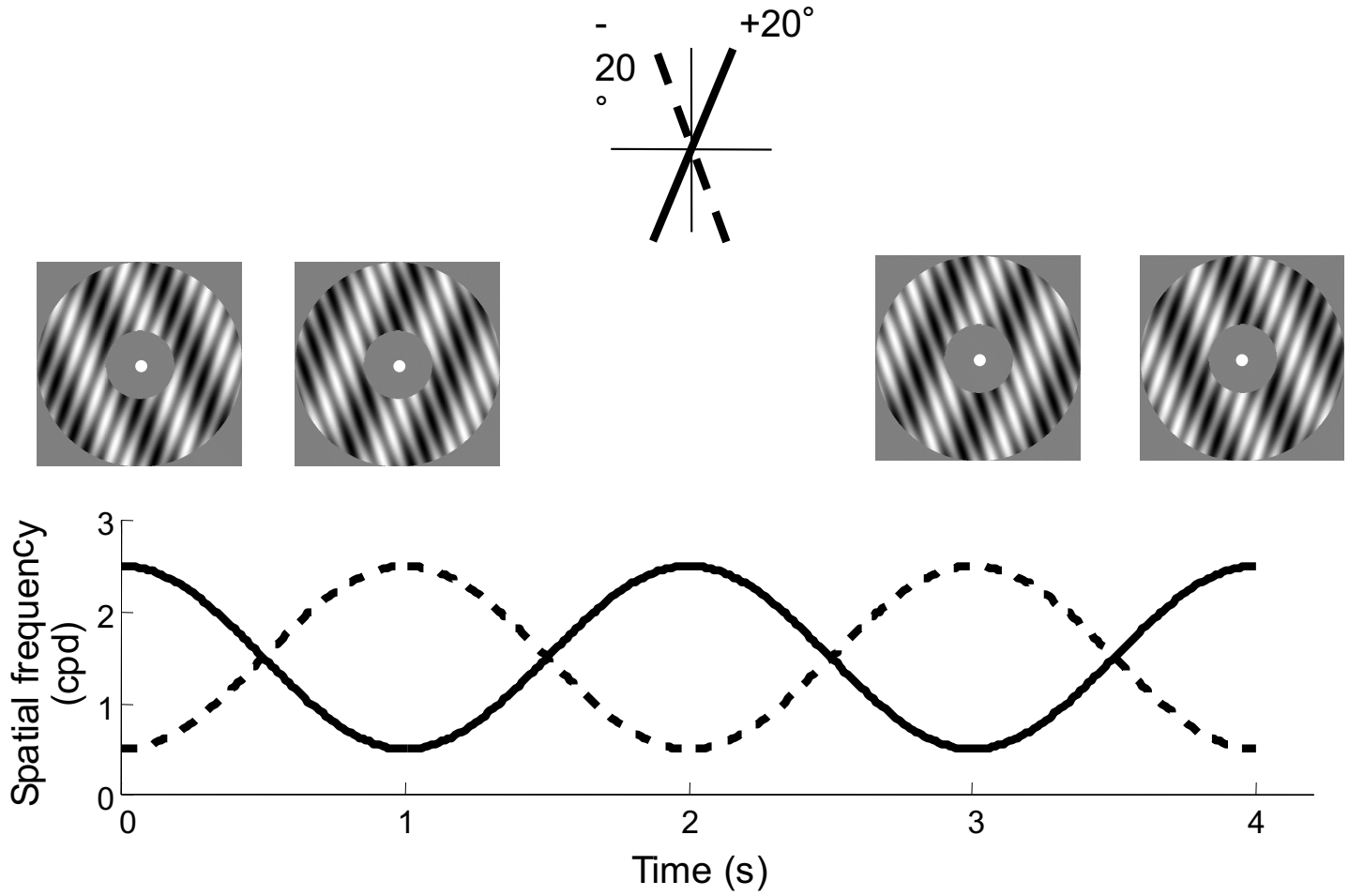




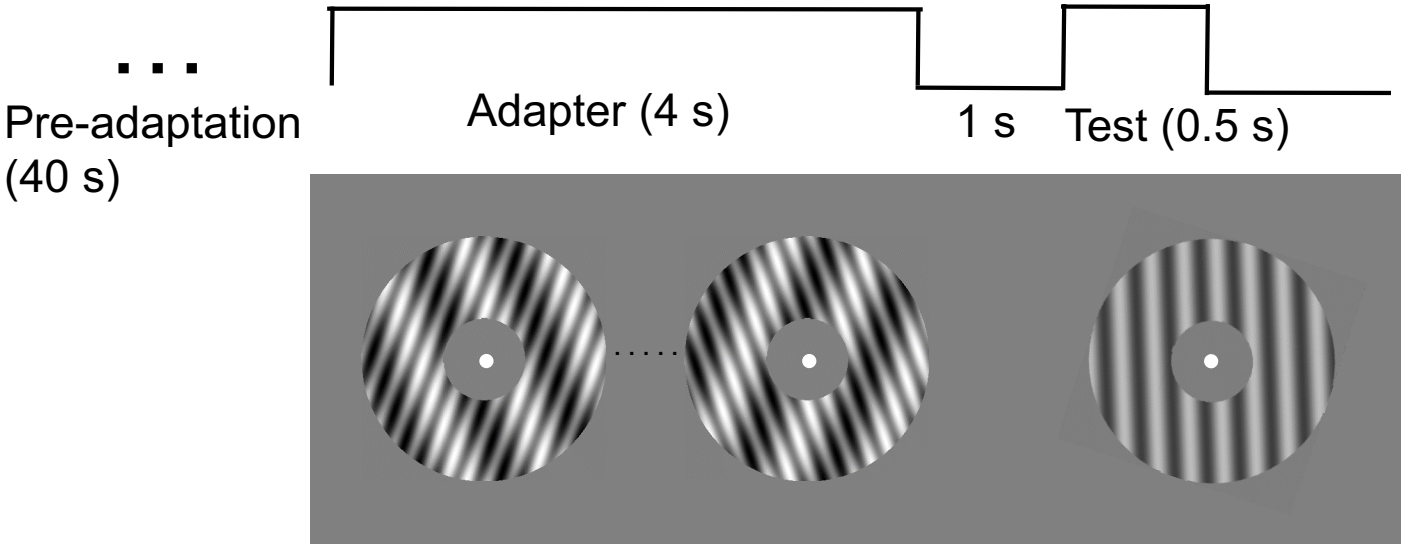
More adaptation for an *upward test* stimulus when attending ‘up’ vs. ‘down’

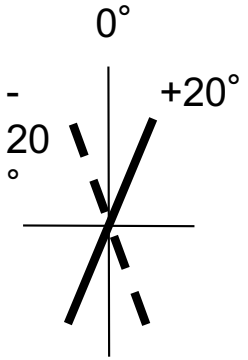


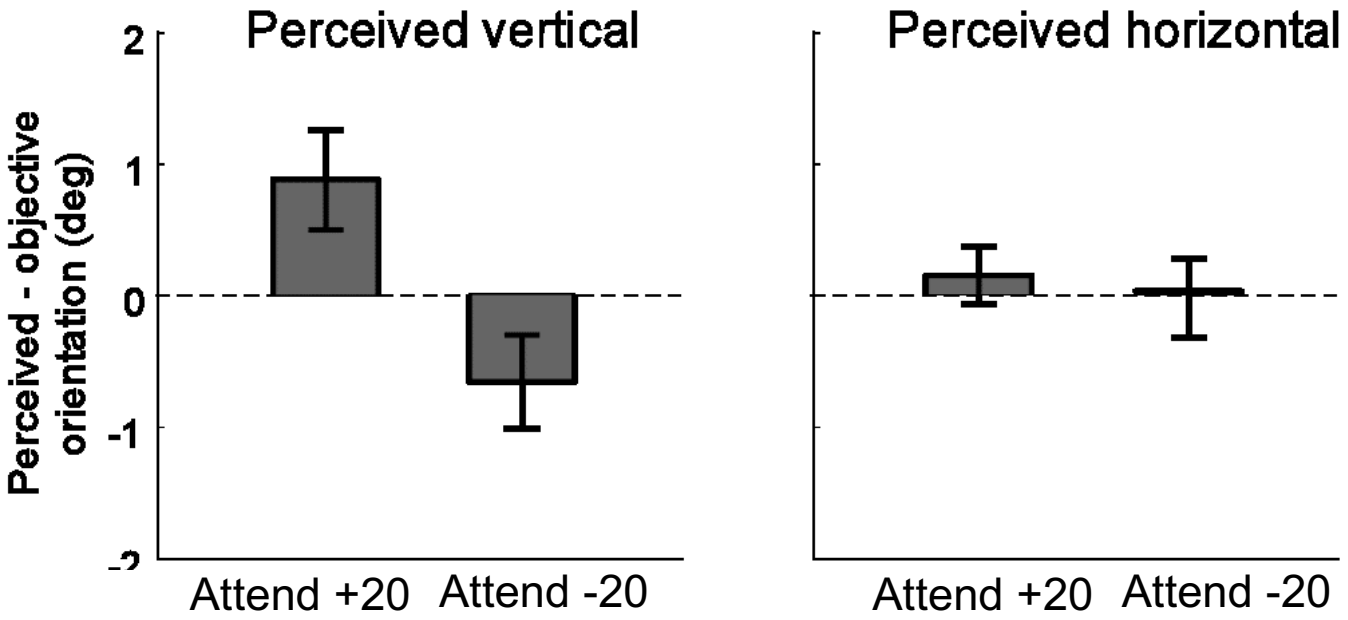
Adapting stimulus



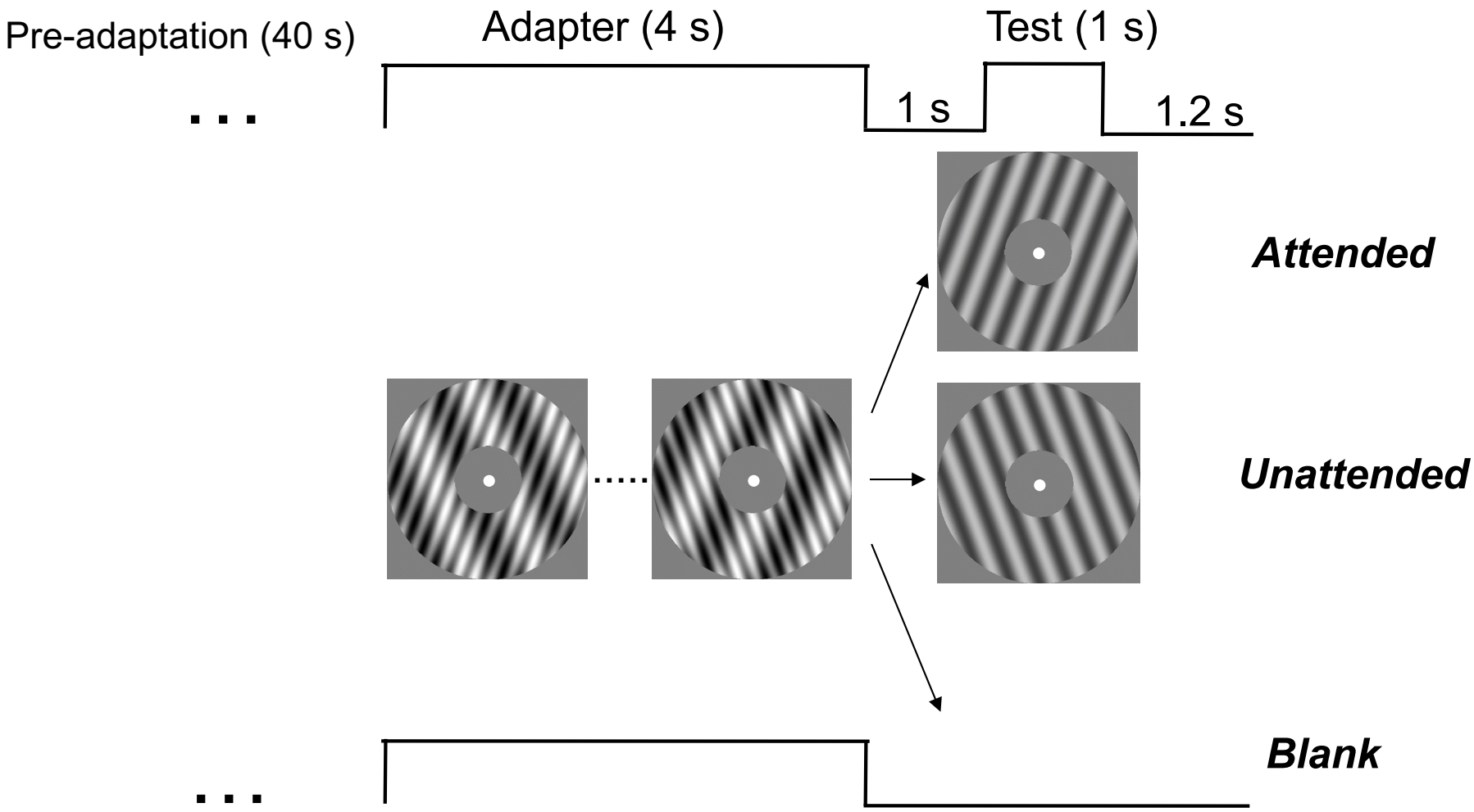
Behavior: tilt aftereffect (n=8)





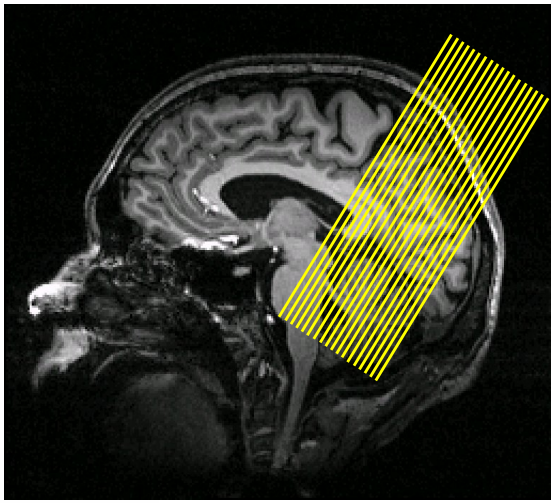


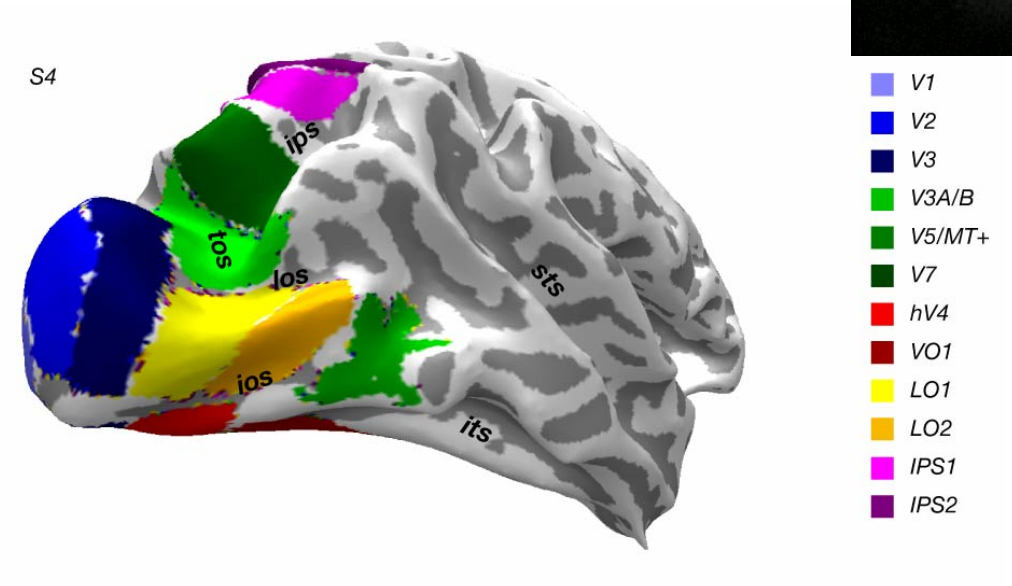
fMRI: adaptation procedure



fMRI data acquisition and retinotopic mapping

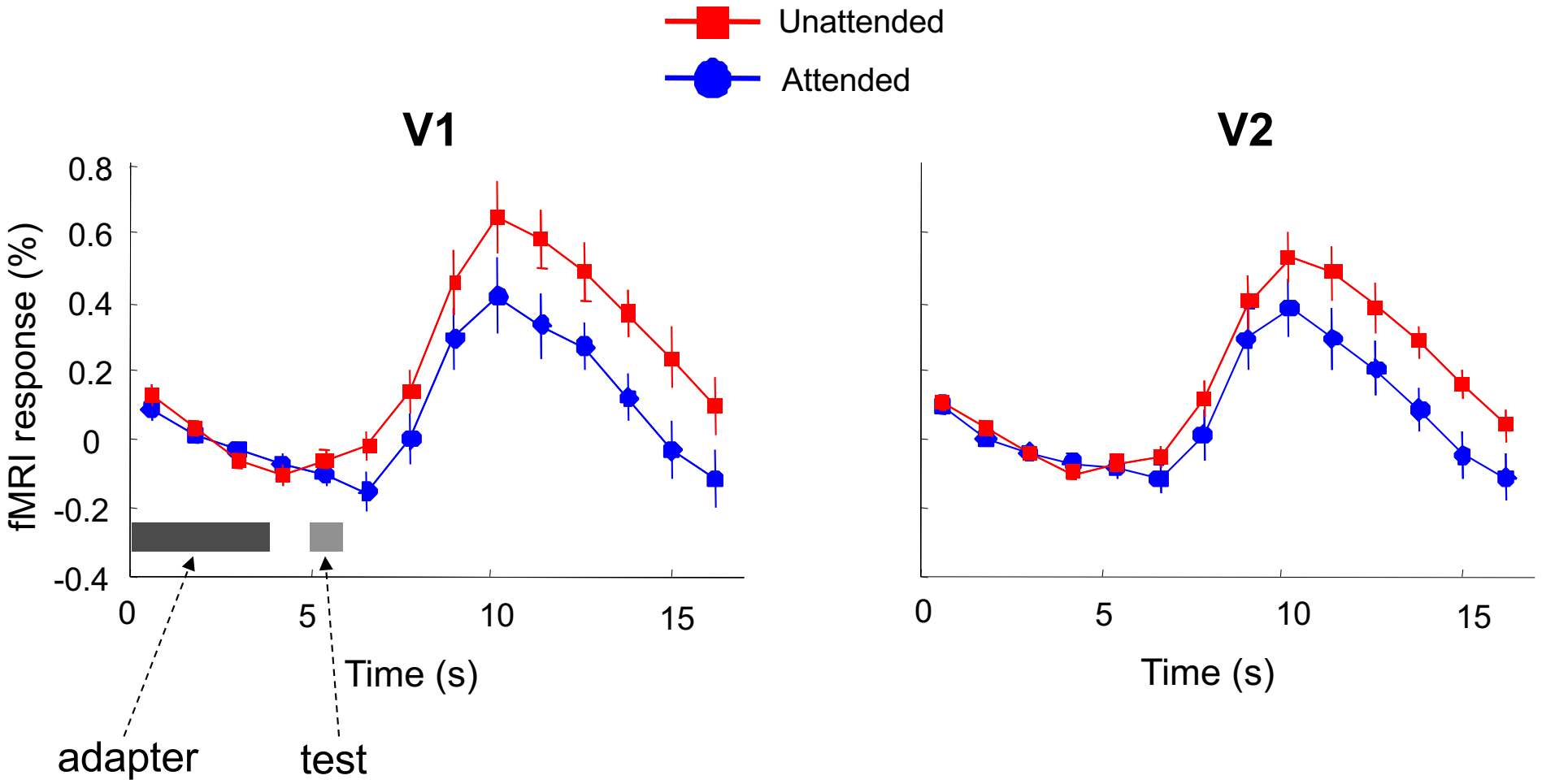
- Siemens 3T Allegra
- Surface coil
- TR = 1.2 s, 22 slices

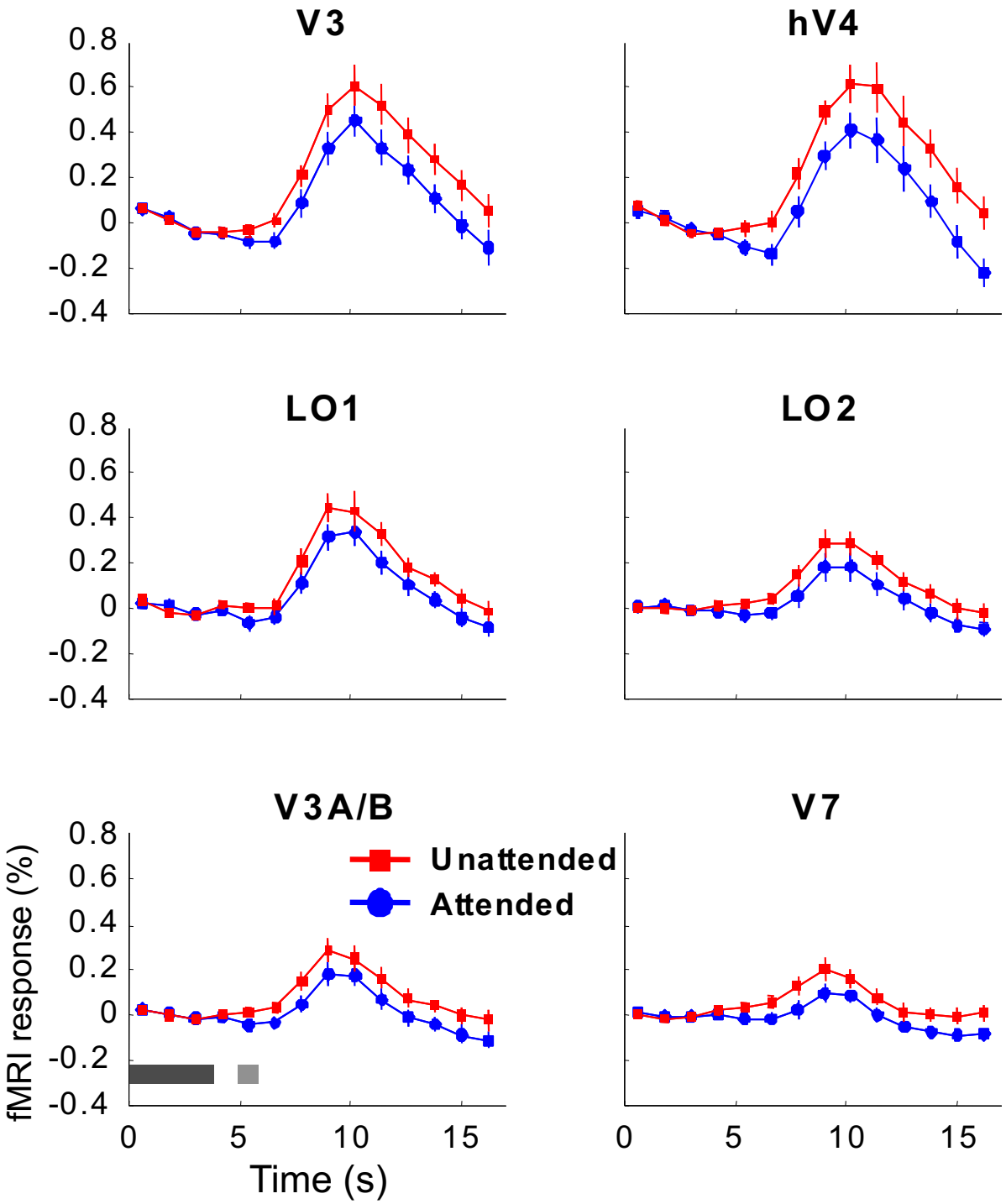




- V1
- V2
- V3
- V3A/B
- V5/MT+
- V7
- hV4
- VO1
- LO1
- LO2
- IPS1
- IPS2

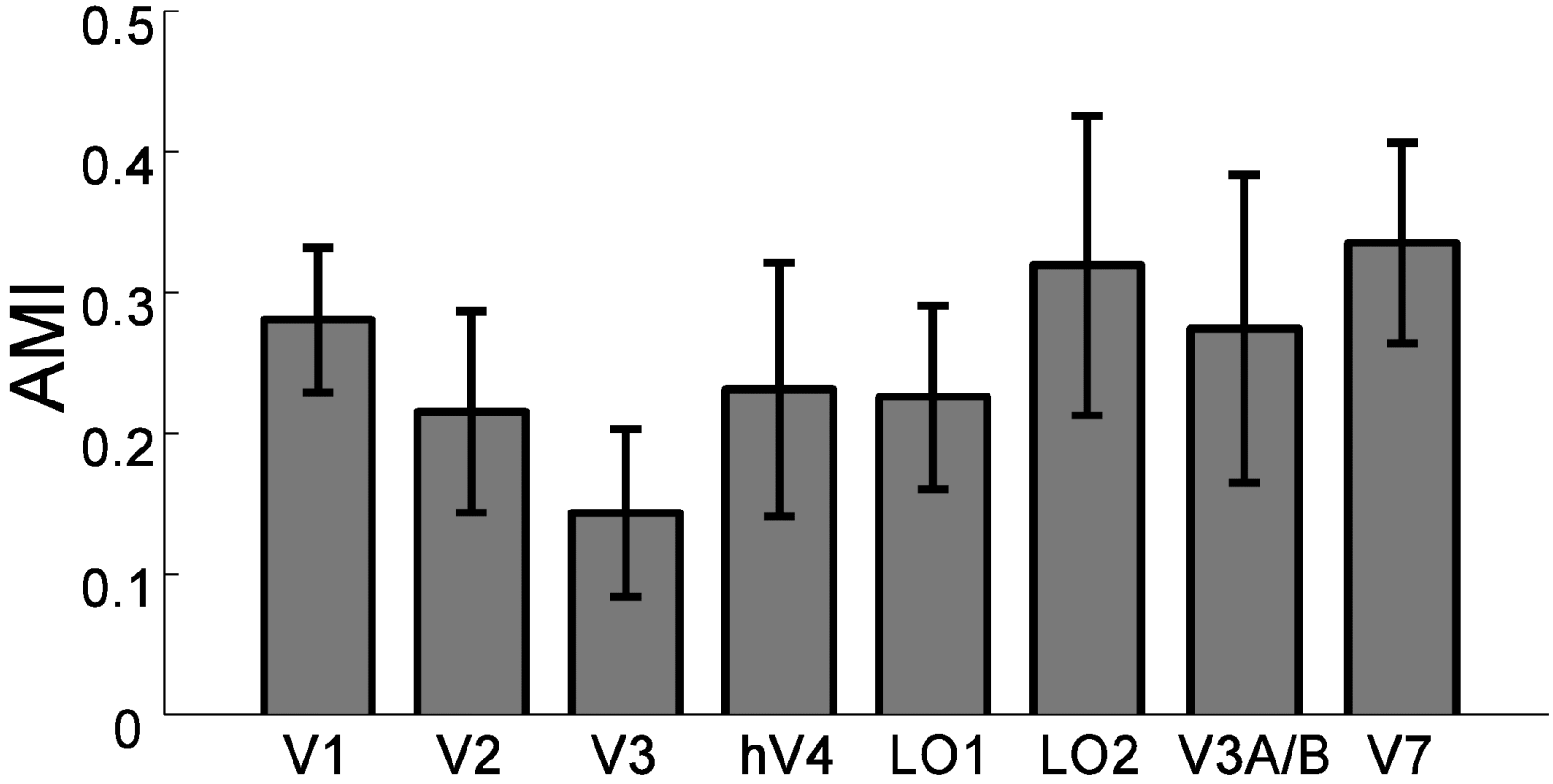
fMRI response to the test stimulus (n=8)



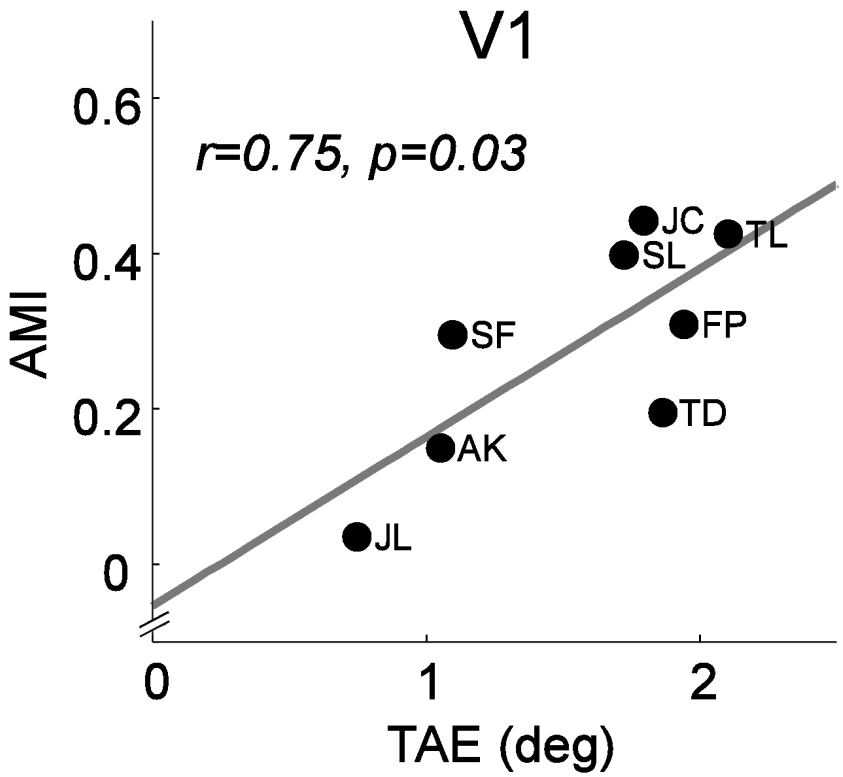

V3
hV4
LO1
LO2
V3A/B
V7
Unattended
Attended
fMRI response (%)
Time (s)
0.8
0.6
0.4
0.2
0
-0.2
-0.4
0
5
10
15

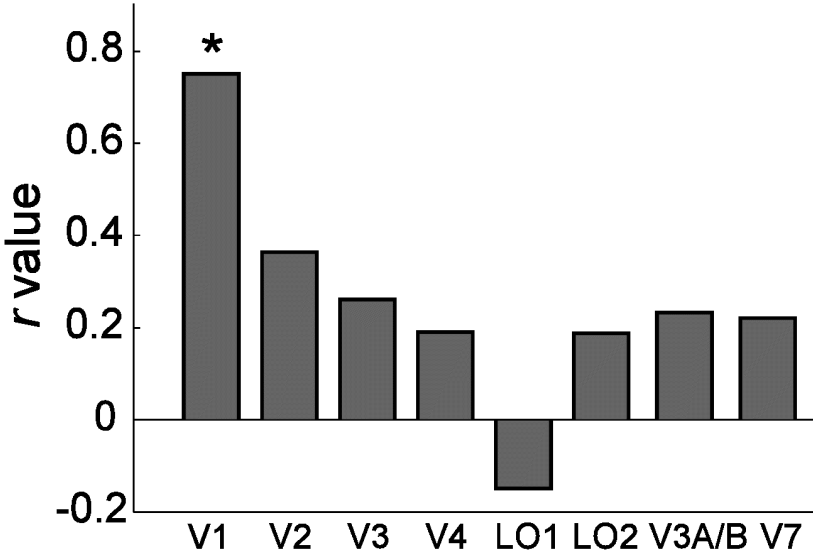
Attention Modulation Index

$$\frac{R_{attn} - R_{unattn}}{R_{attn} + R_{unattn}}$$



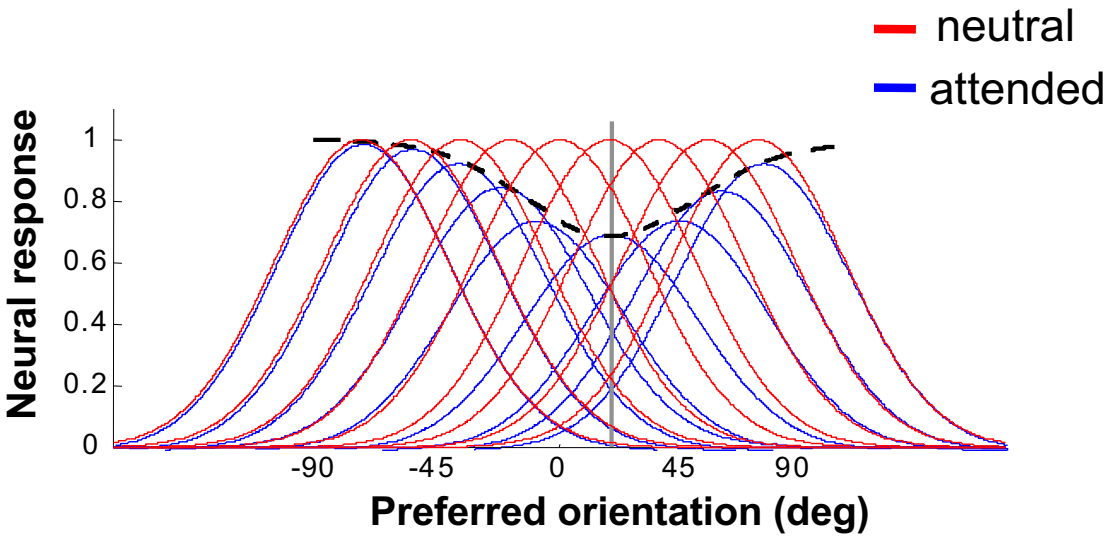
correlation between behavior and imaging results

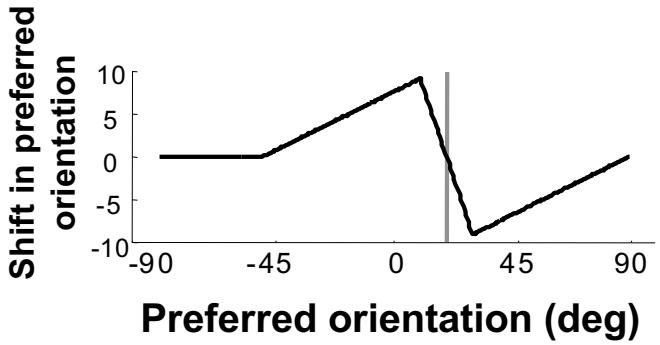




A model relating behavioral and imaging results

model assumptions

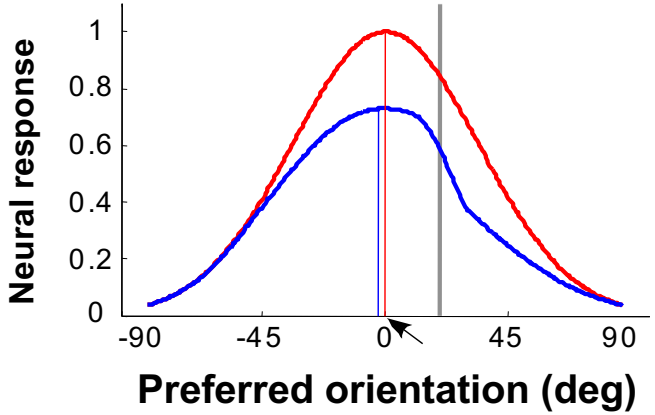




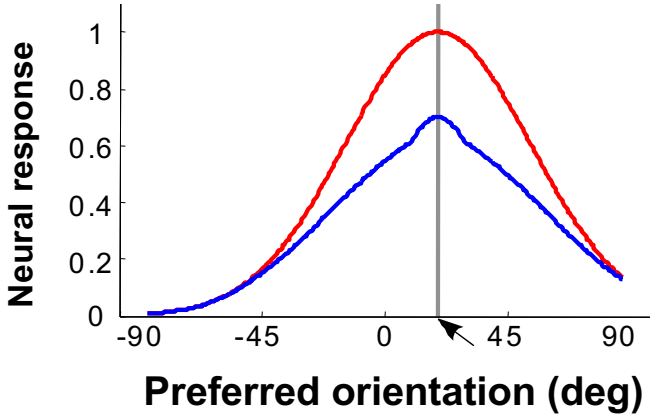
Dragoi et al, 2000, 2001

model predictions

Psychophysics



fMRI



Conclusions

- Combination of psychophysics and imaging to investigate the selective power, perceptual consequences, and neural basis of FBA at the location of spatial attention.

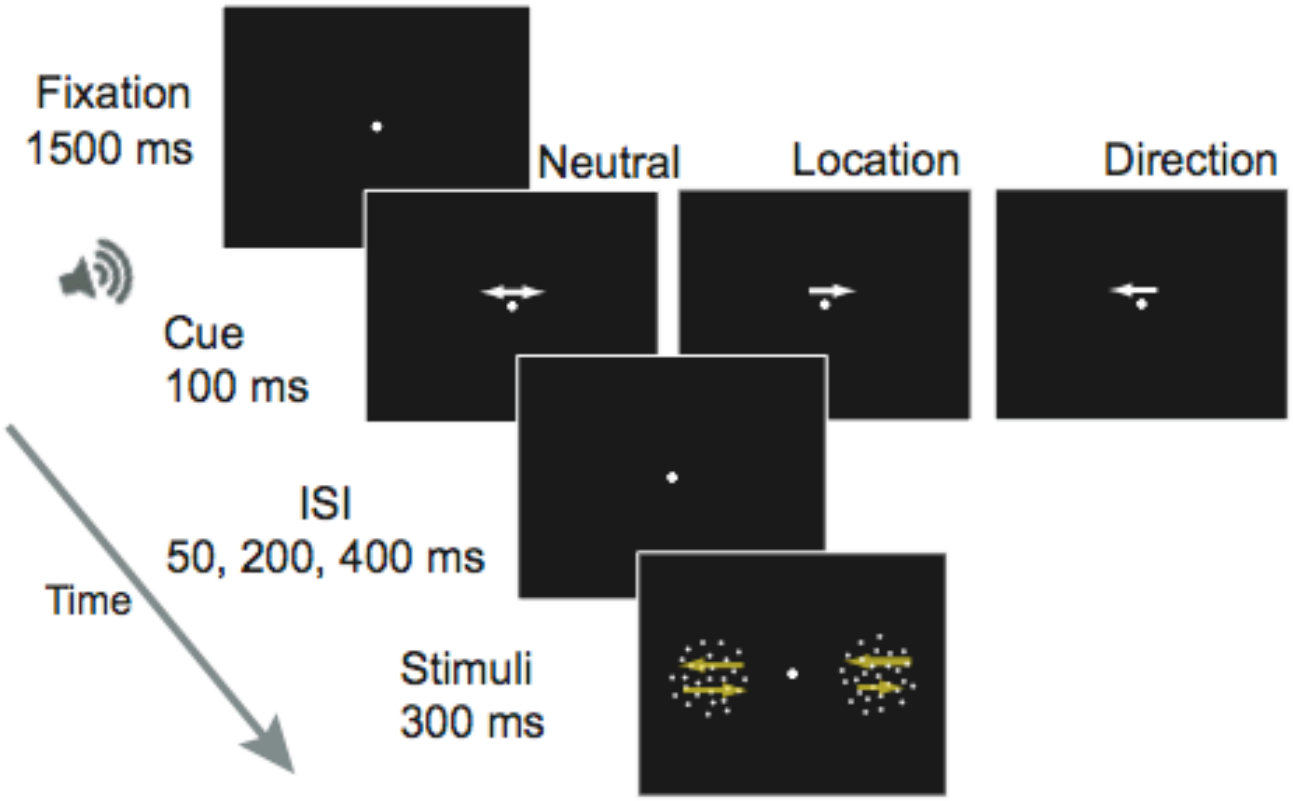
- FBA enhances activity of neuronal subpopulations when the attended and unattended features are processed in the *same retinotopic region*.

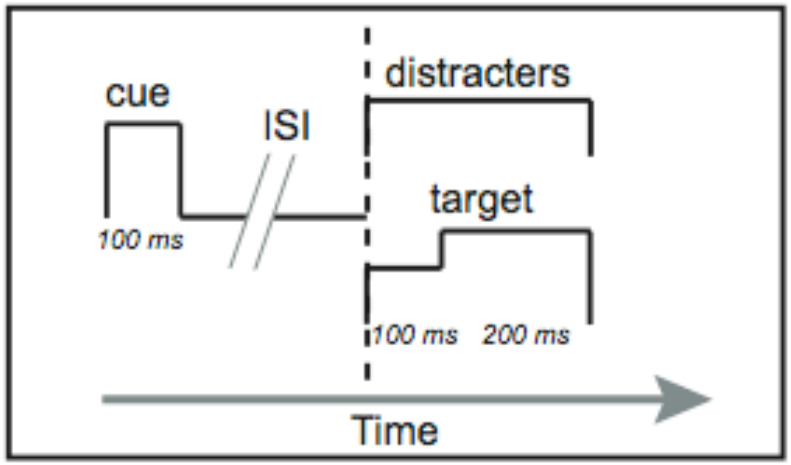
  – attentional modulation of orientation-selective fMRI response adaptation.

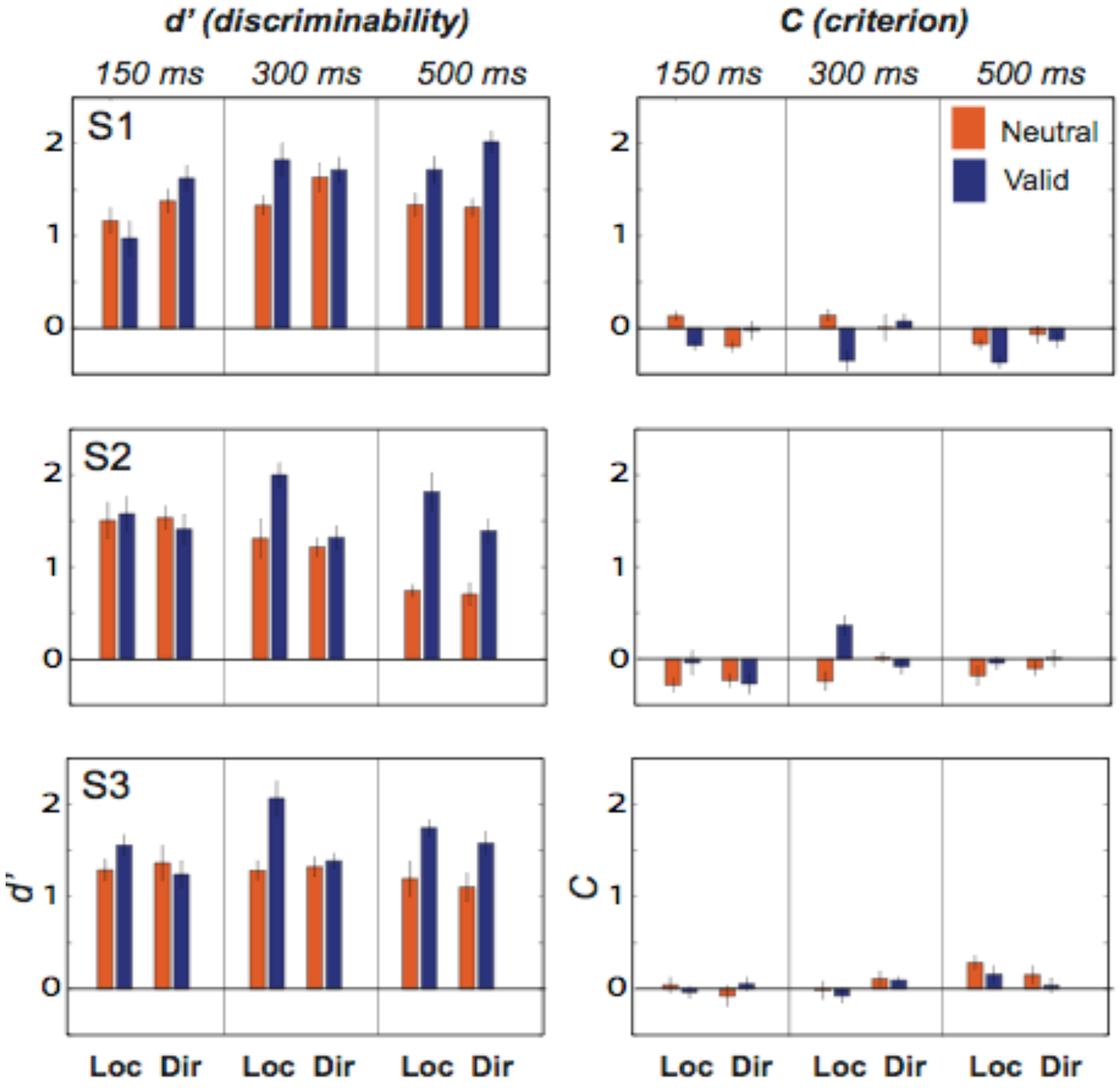
  – attentional modulation constant across visual areas, suggesting a feed-forward mechanism.

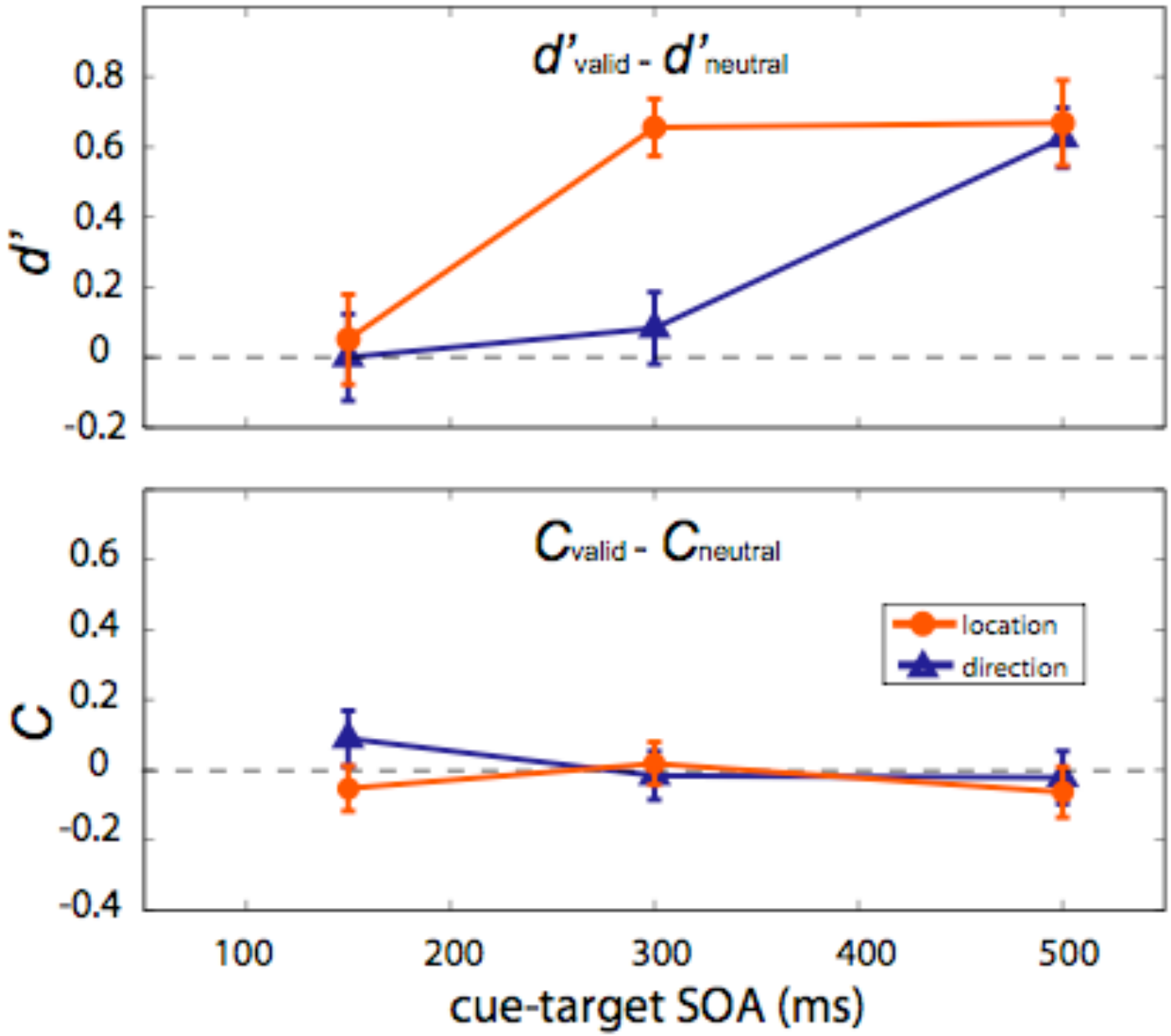
  – significant correlation between TAE and AMI only in V1.

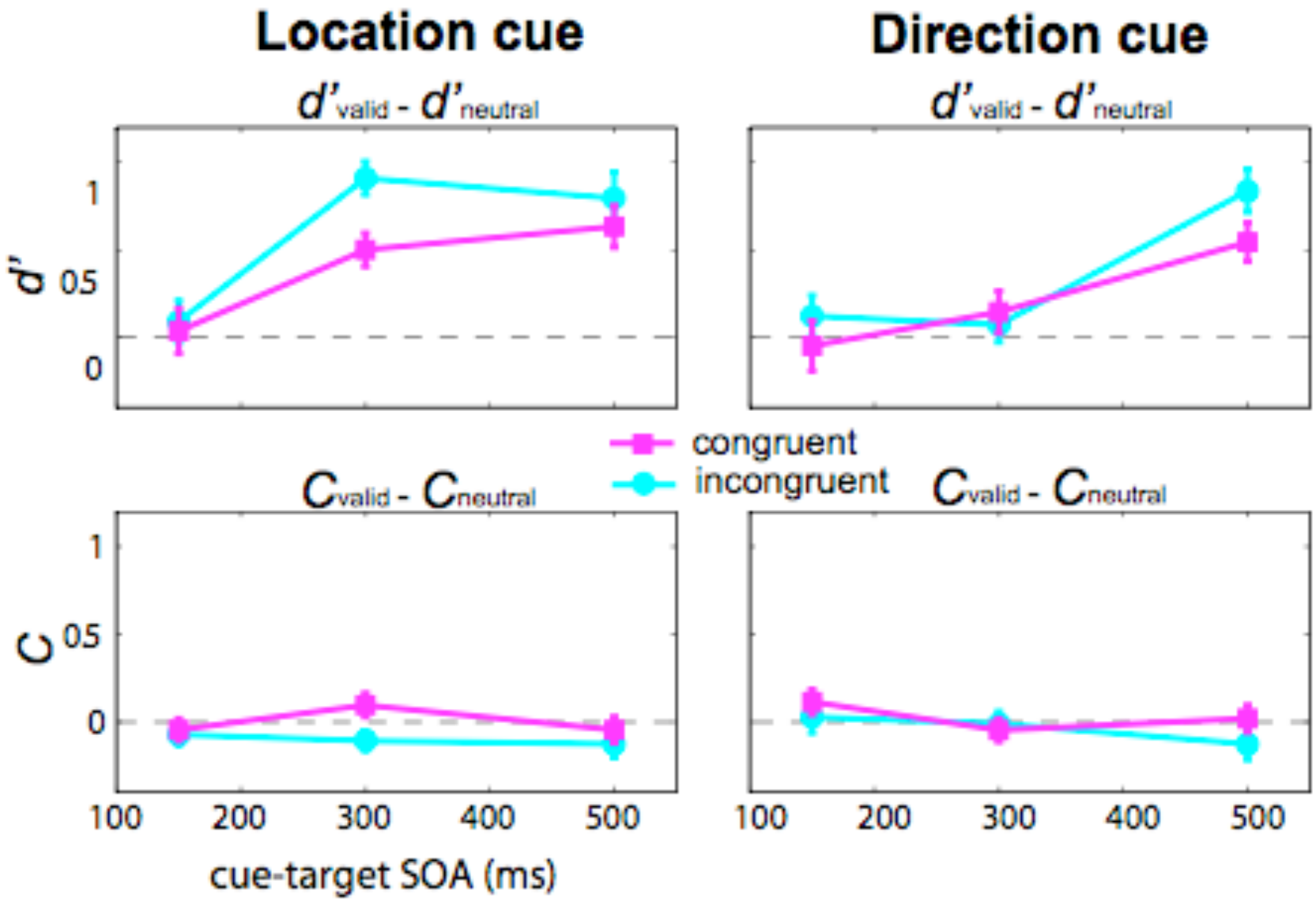
Trial sequence






d' (discriminability)
C (criterion)
150 ms
300 ms
500 ms
S1
S2
S3
Neutral
Valid
d'
C
0
1
2
Loc
Dir


d'valid - d'neutral
d'
0.8
0.6
0.4
0.2
0
-0.2
Cvalid - Cneutral
C
0.6
0.4
0.2
0
-0.2
-0.4
location
direction
100
200
300
400
500
cue-target SOA (ms)


Location cue
Direction cue
d'valid - d'neutral
d'valid - d'neutral
d'
1
05
0
congruent
incongruent
Cvalid - Cneutral
Cvalid - Cneutral
C
1
05
0
100
200
300
400
500
100
200
300
400
500
cue-target SOA (ms)

With identical stimuli and tasks:

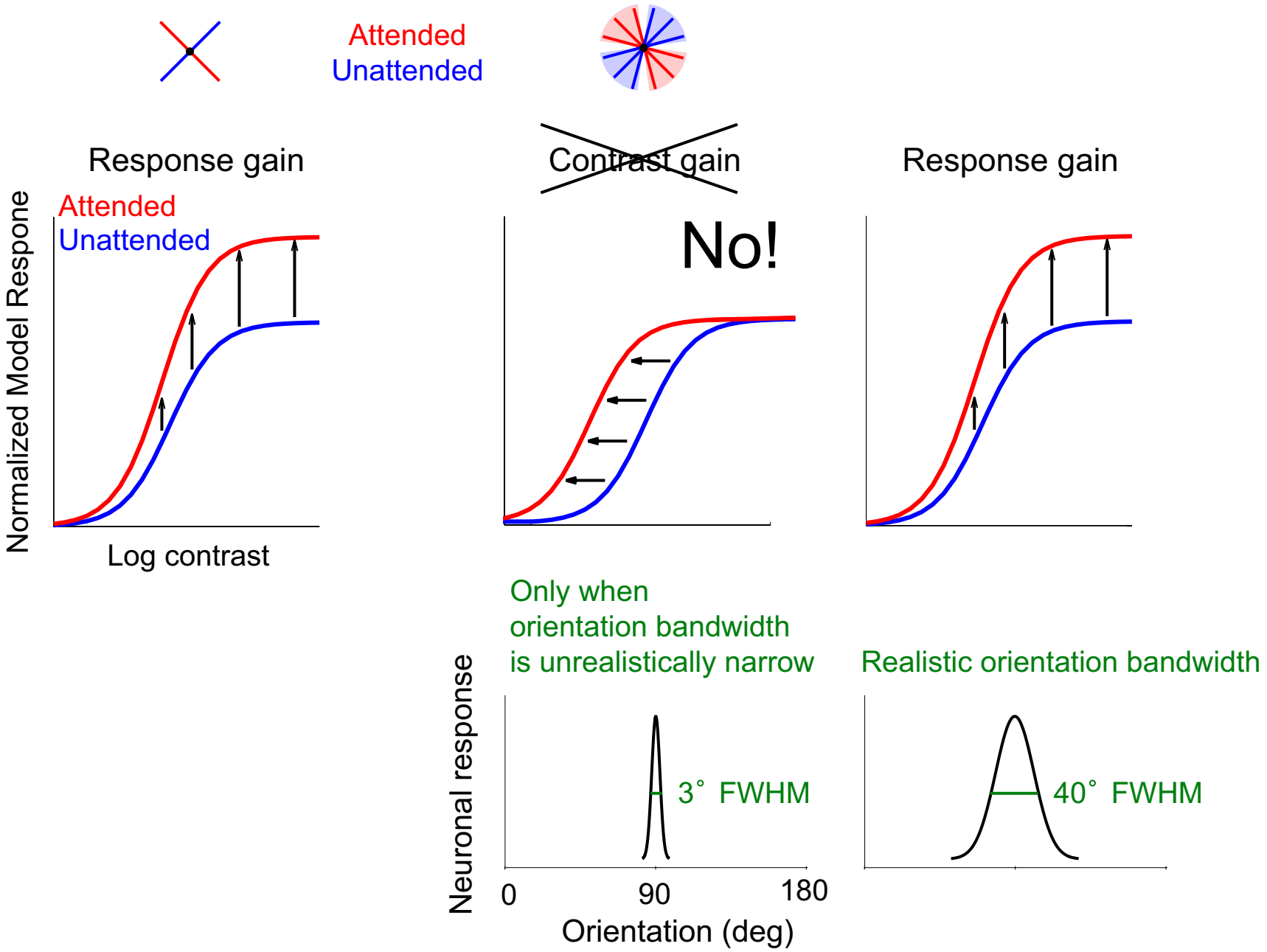
Spatial attention affects the selection process earlier than feature-based attention

Given sufficient time between the cue and target, feature-based attention can be as effective as spatial attention

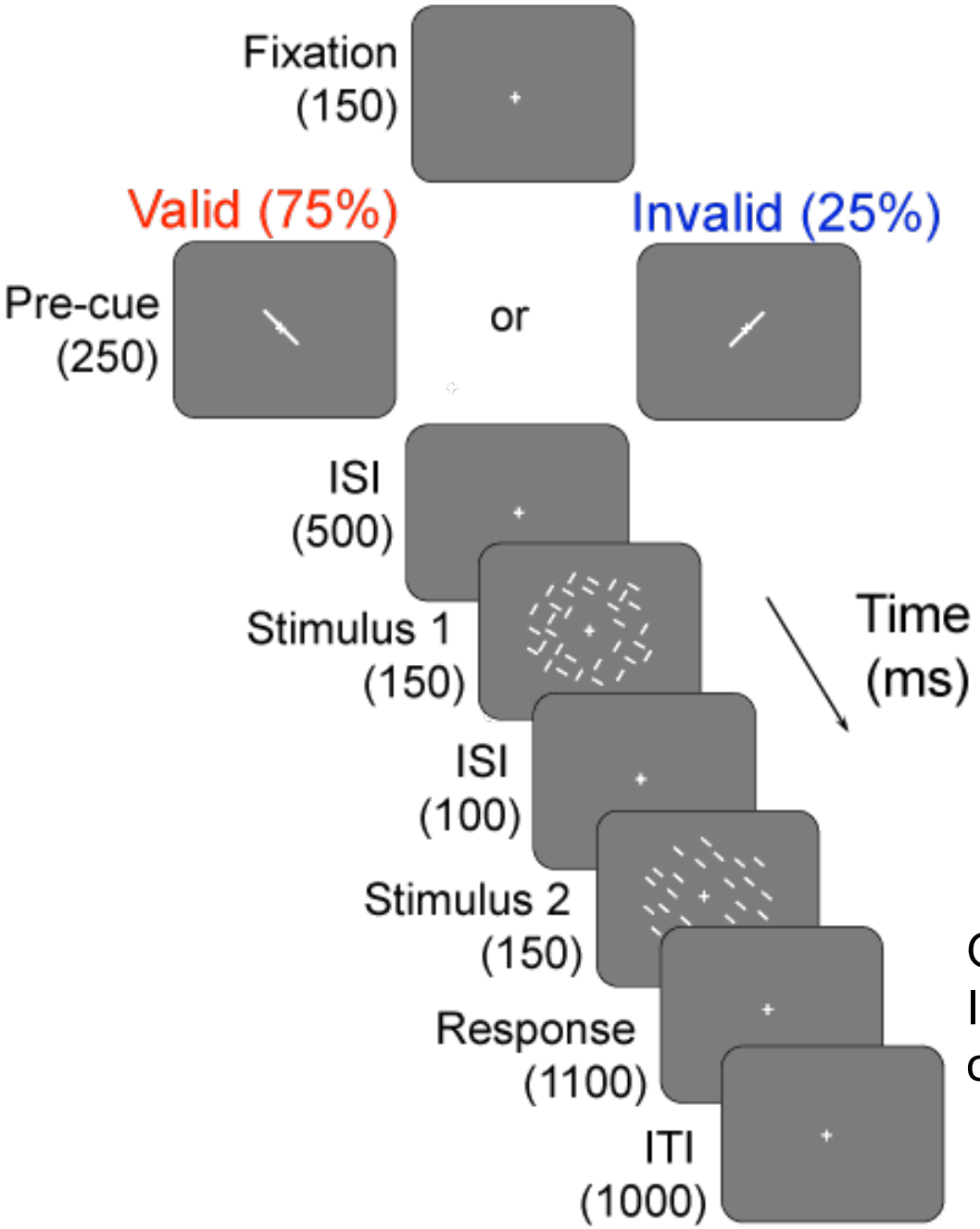
Liu, Stevens & Carrasco, Vis.Res. 07

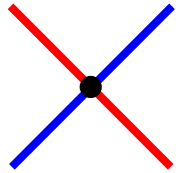
Feature-based attention

Normalization model of attention predicts response gain in both cases



Experimental protocol

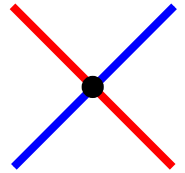




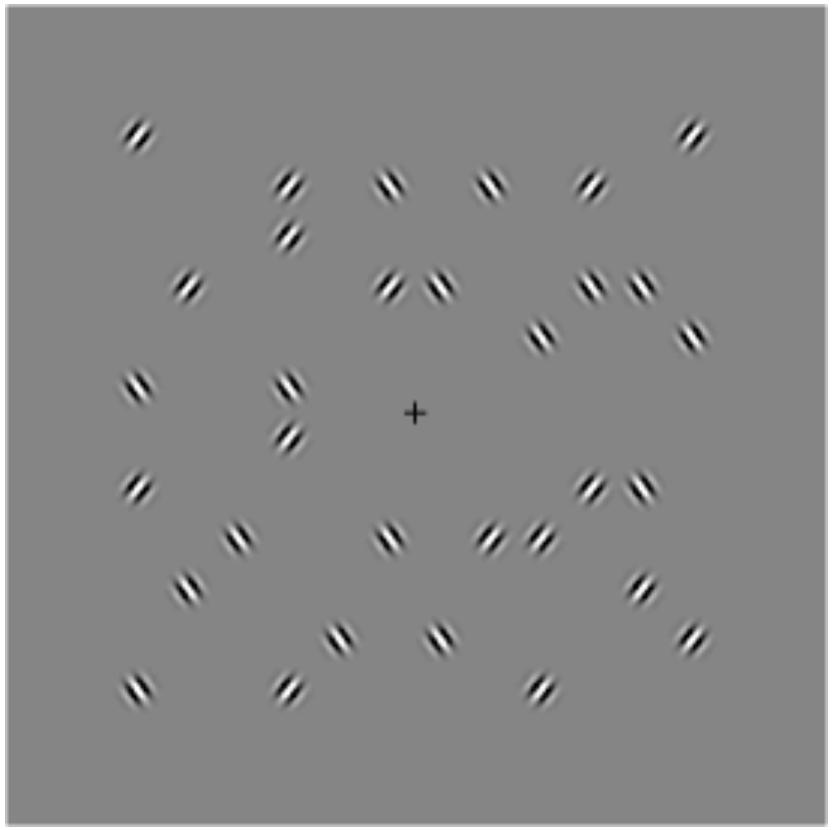
Orientation discrimination task:
Is orientation of Stimulus 2 CW or CCW of closest orientation in Stimulus 1?

Pre-cue

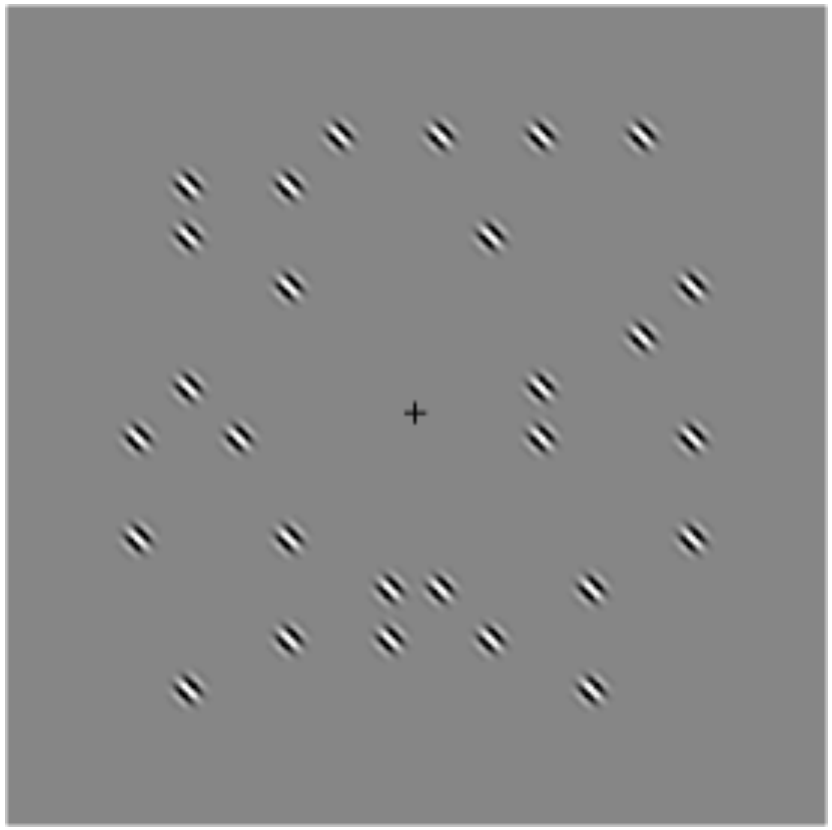
Low-uncertainty experiment (small attention field)



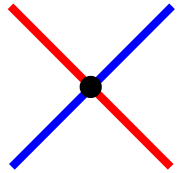
Stimulus display 1

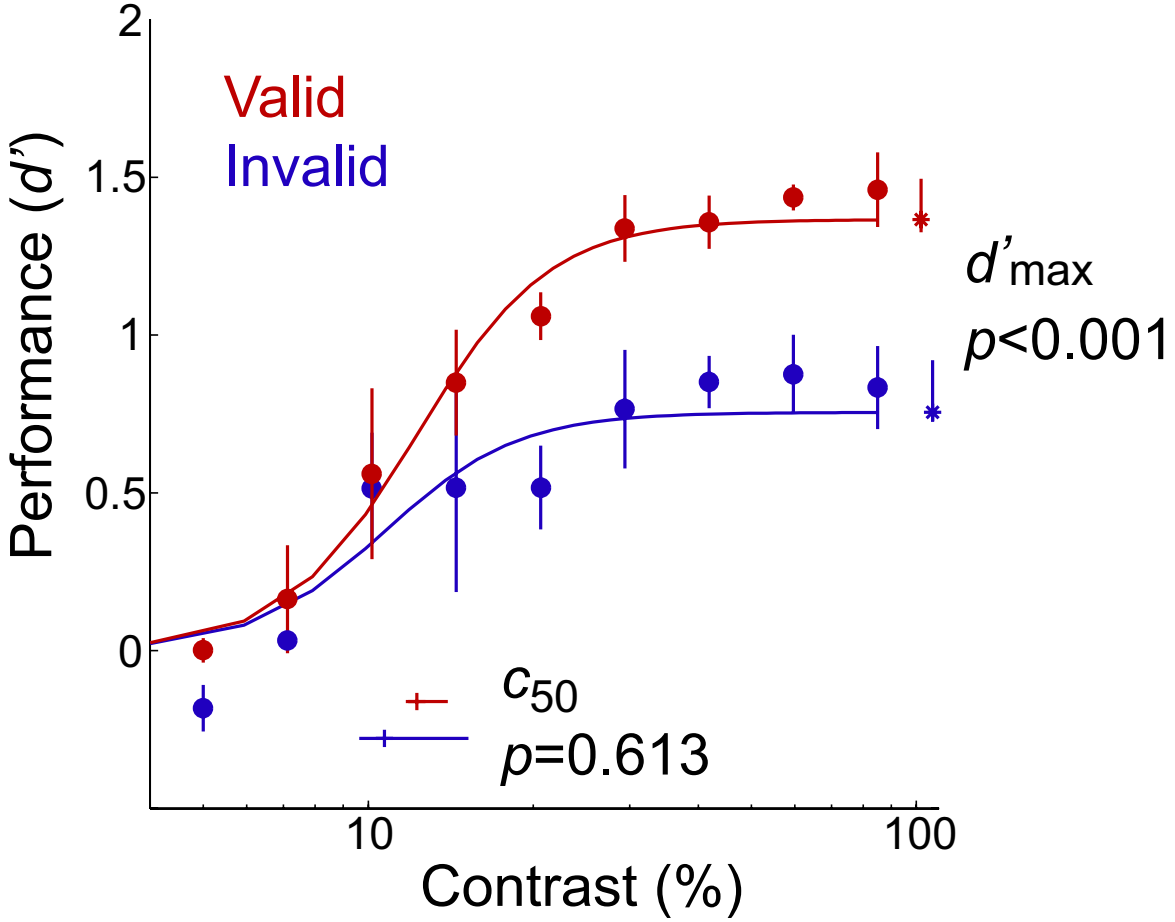


Stimulus display 2



Response gain change with low uncertainty

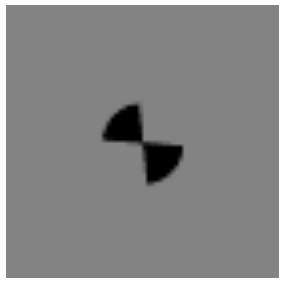




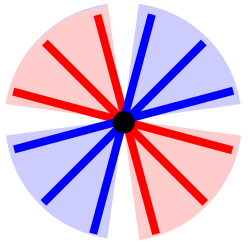
4 observers
~3200 trials each
$R^2 = 0.94$

$$d'(c) = d'_{max} \frac{c^n}{c^n + c_{50}^n}$$

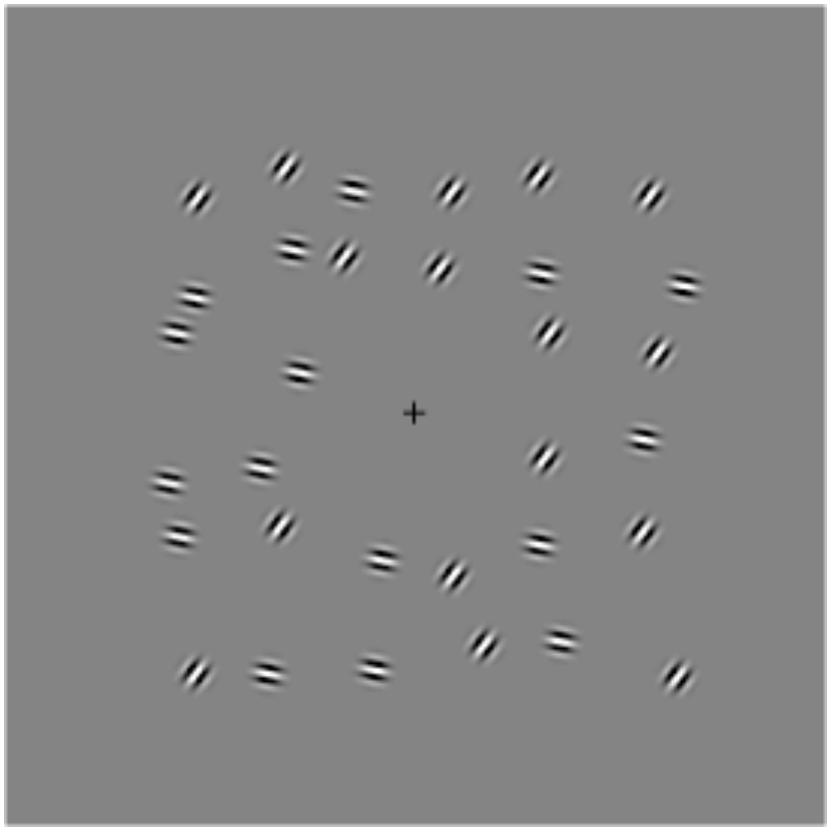
Pre-cue



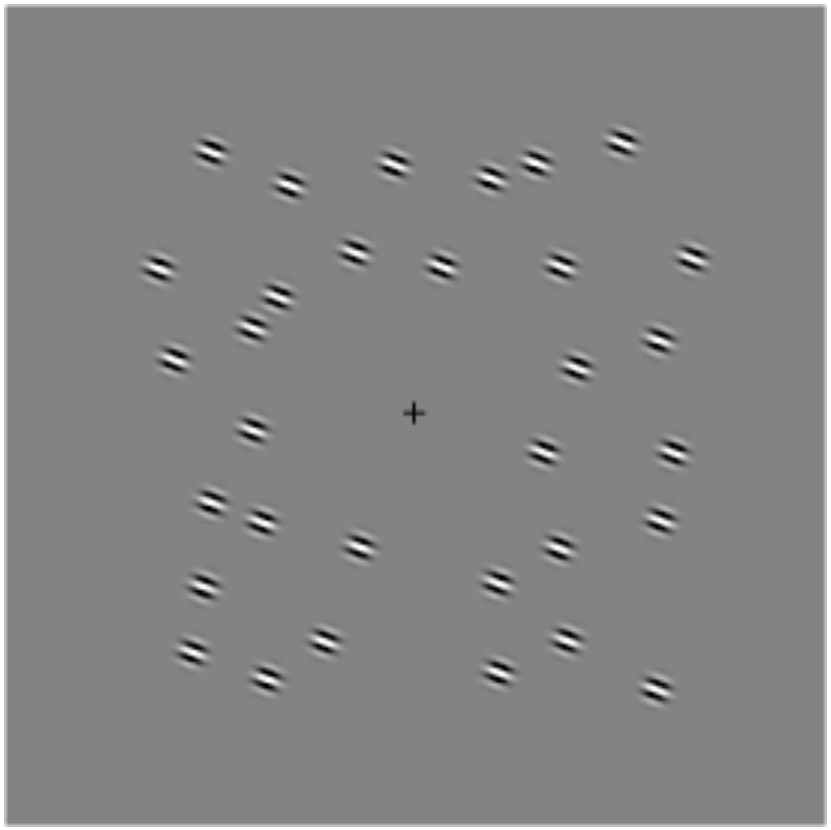
High-uncertainty experiment (large attention field)



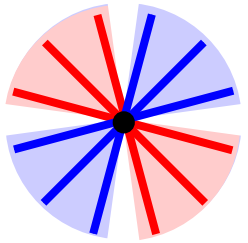
Stimulus display 1



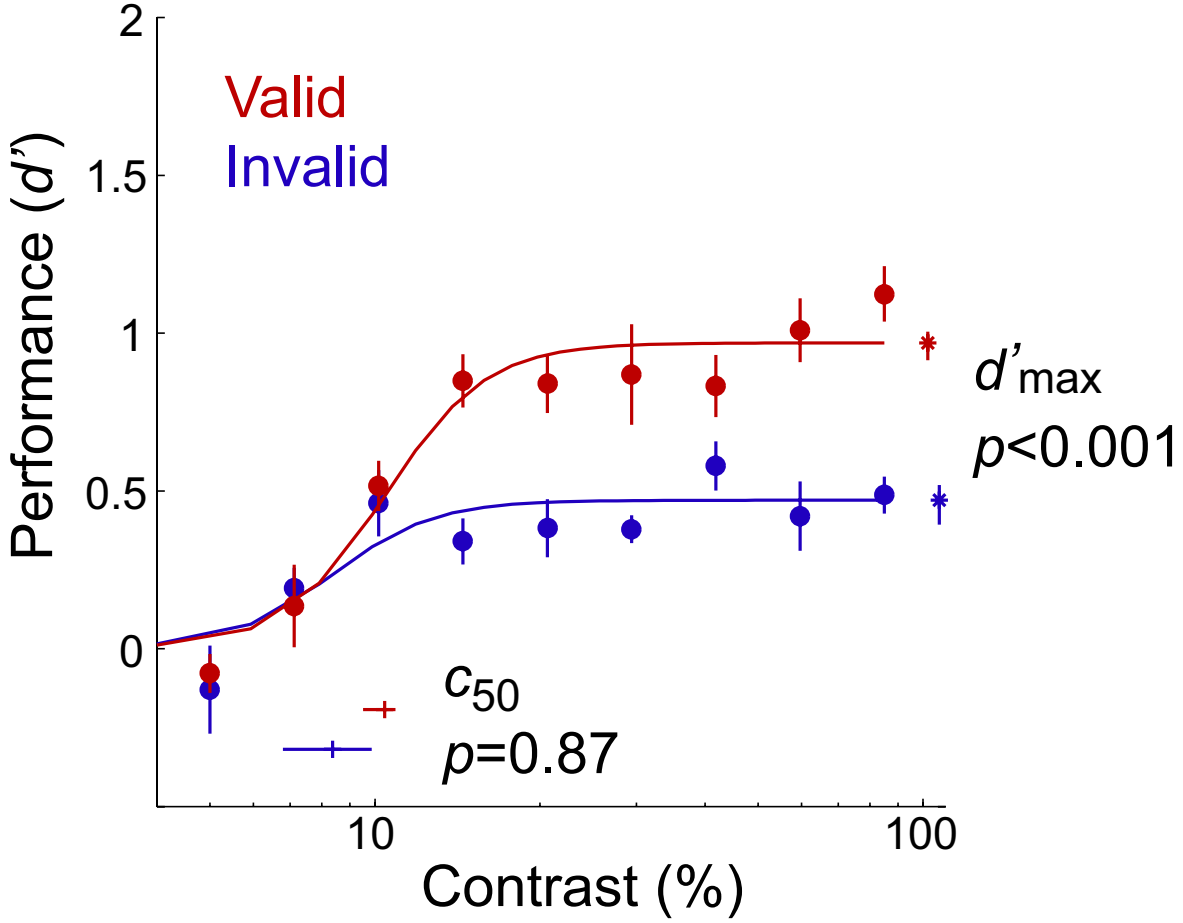
Stimulus display 2



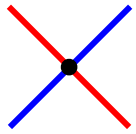
Response gain change with high uncertainty



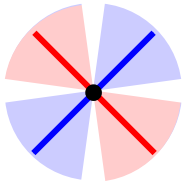
4 observers
~3200 trials each
R^2 = 0.9



Did observers spread their attention in the high-uncertainty experiment?



Attended
Unattended

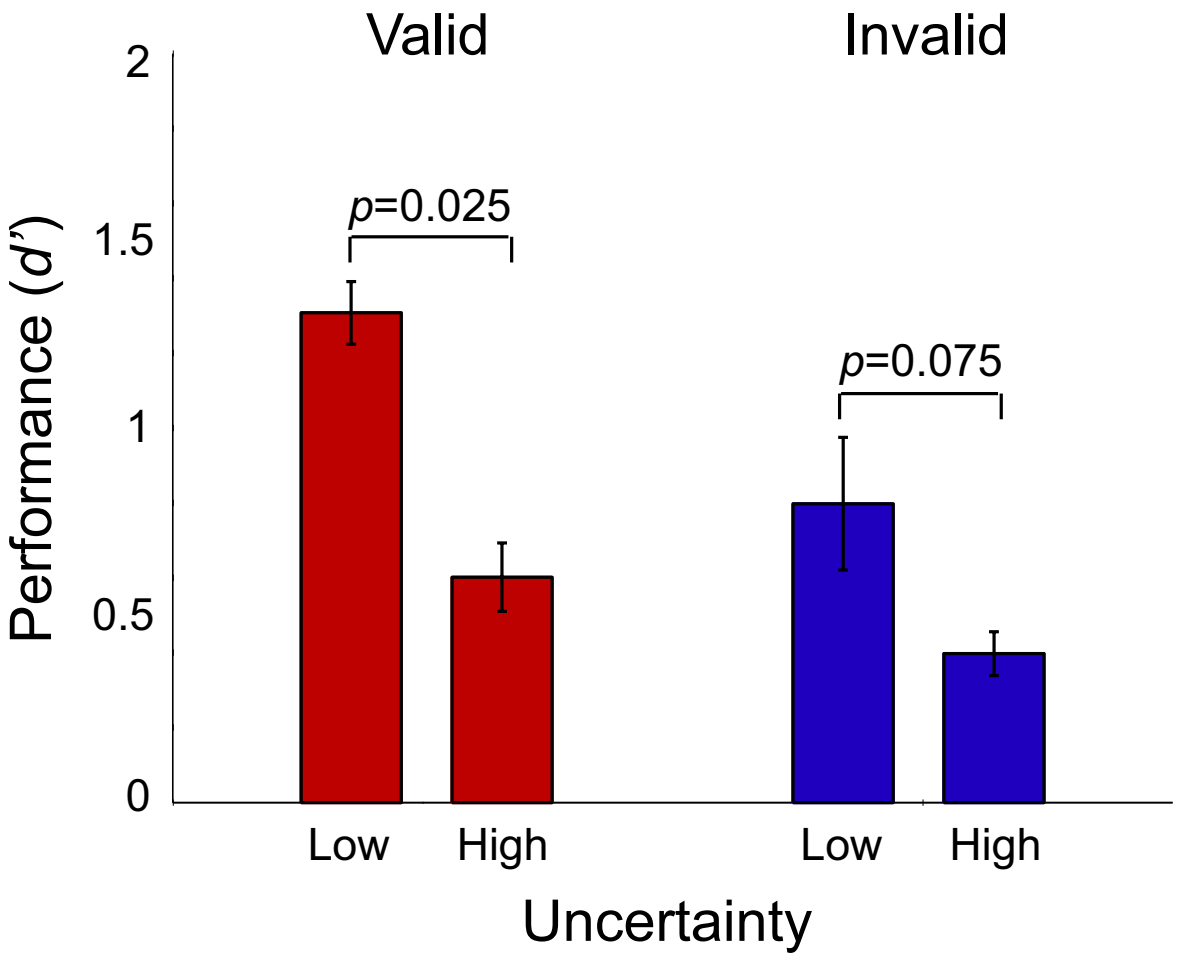


Control experiment:

- high- and low-uncertainty blocks interleaved
- constant orientation tilt and constant contrast (85%)
- analysis of same orientation trials

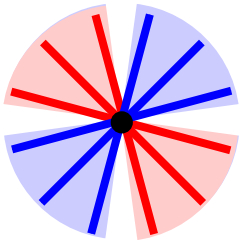
If observers spread their attention,
performance high-uncertainty < low-uncertainty

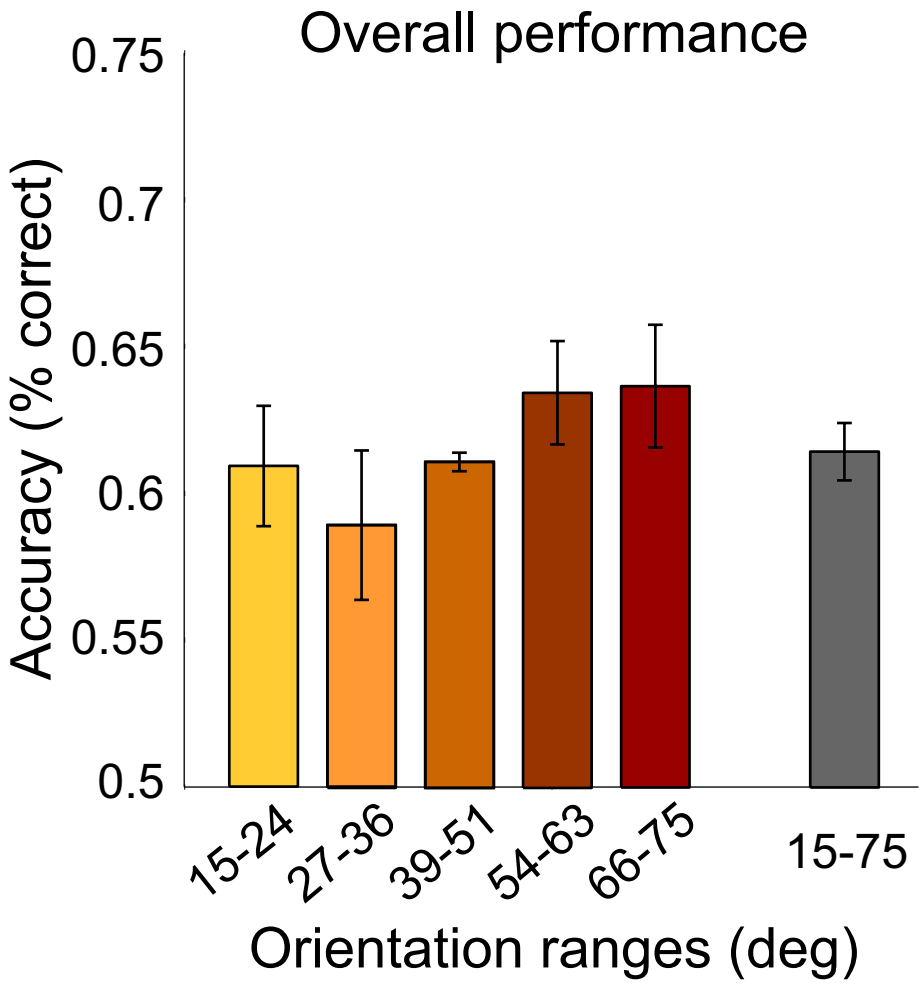
higher uncertainty decreases performance



4 observers
~3200 trials each

Similar performance across orientations

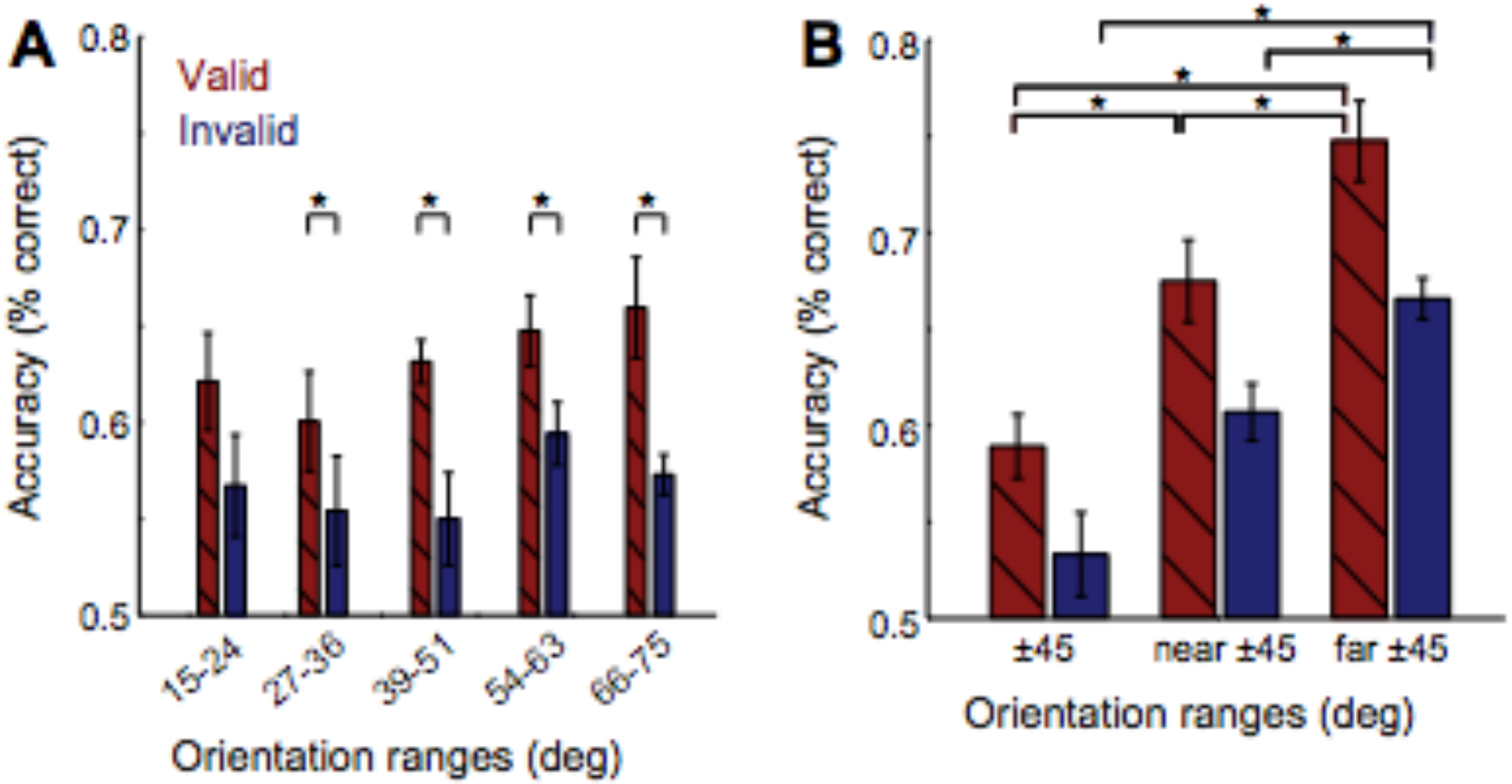




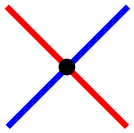
Attention effects for

large small

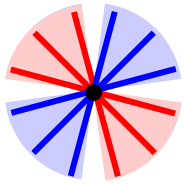
attention field

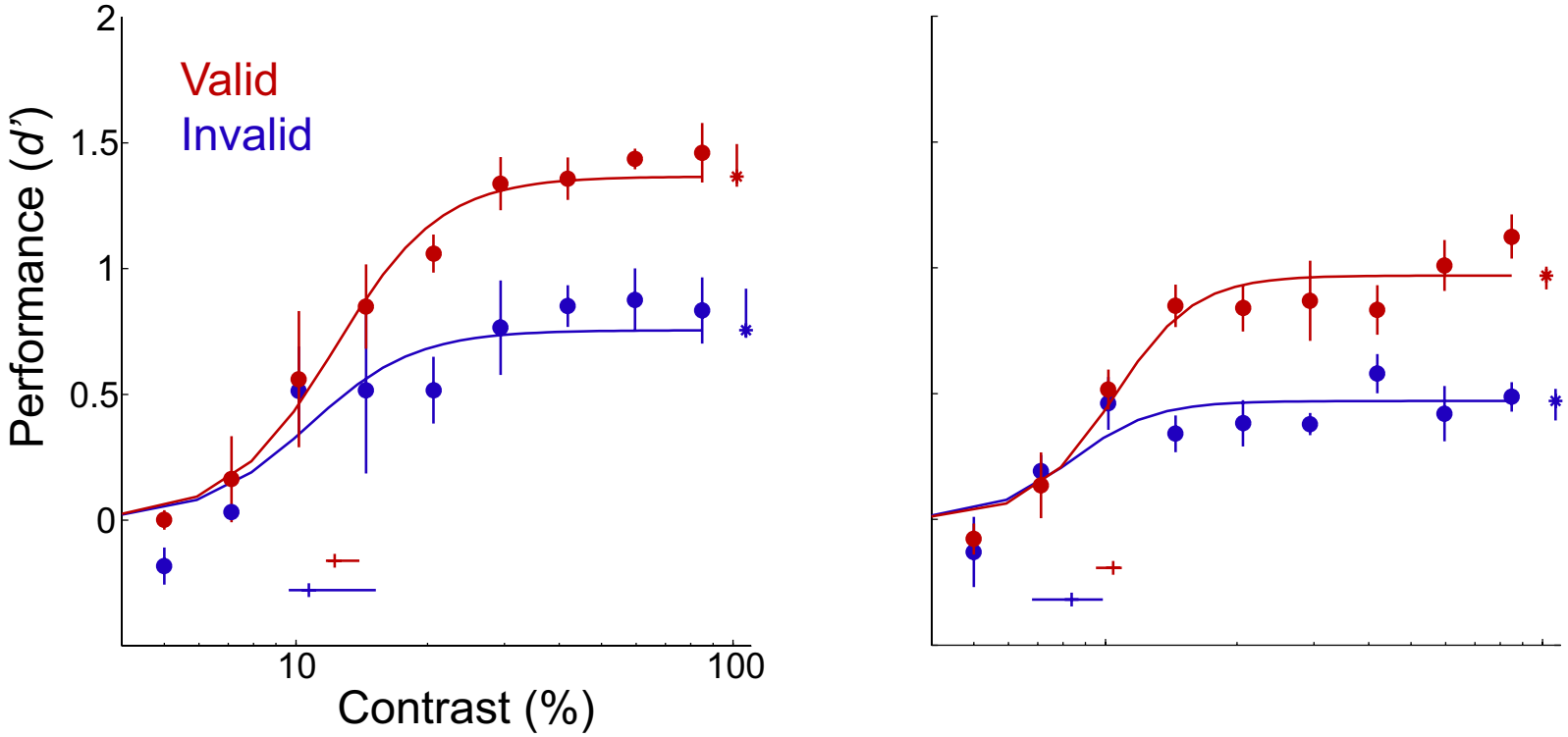


Feature-based attention enhances performance by increasing response gain, supporting NMA



Attended
Unattended





Empirical support for the NMA (RH, 09)

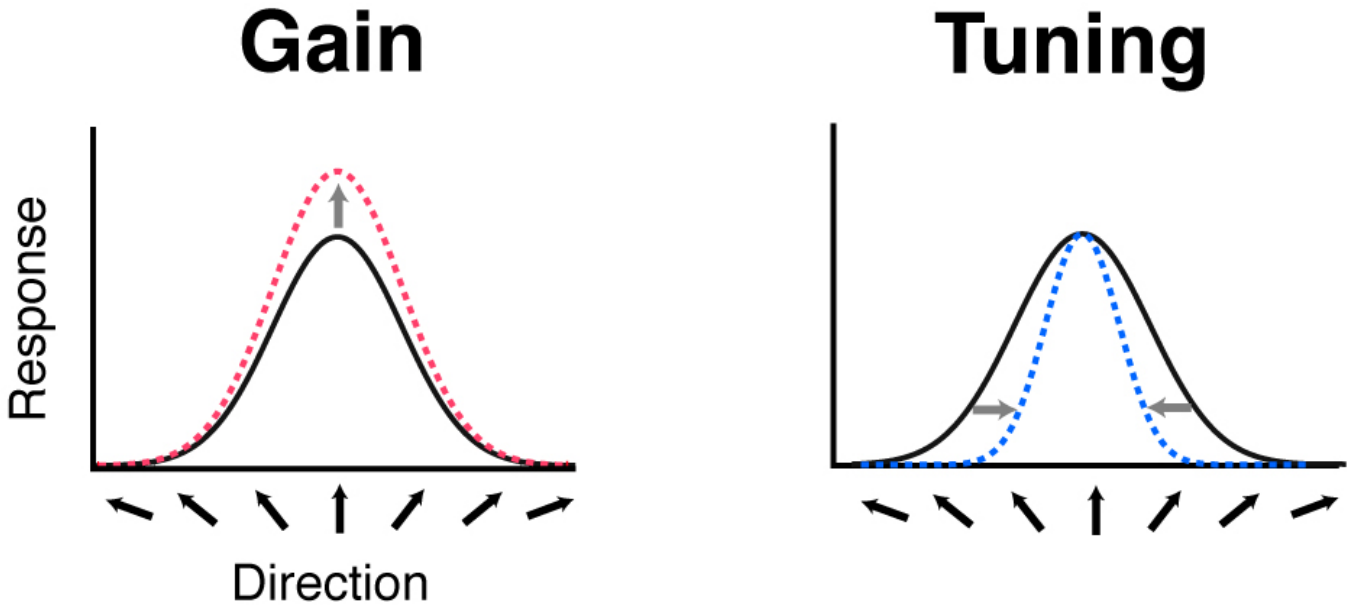
- FBA enhances performance, via RG, regardless of the stimulus size and attention field size

- Feature uncertainty manipulation was effective:
  Attention field was larger with than without uncertainty, and performance was similar for all orientations

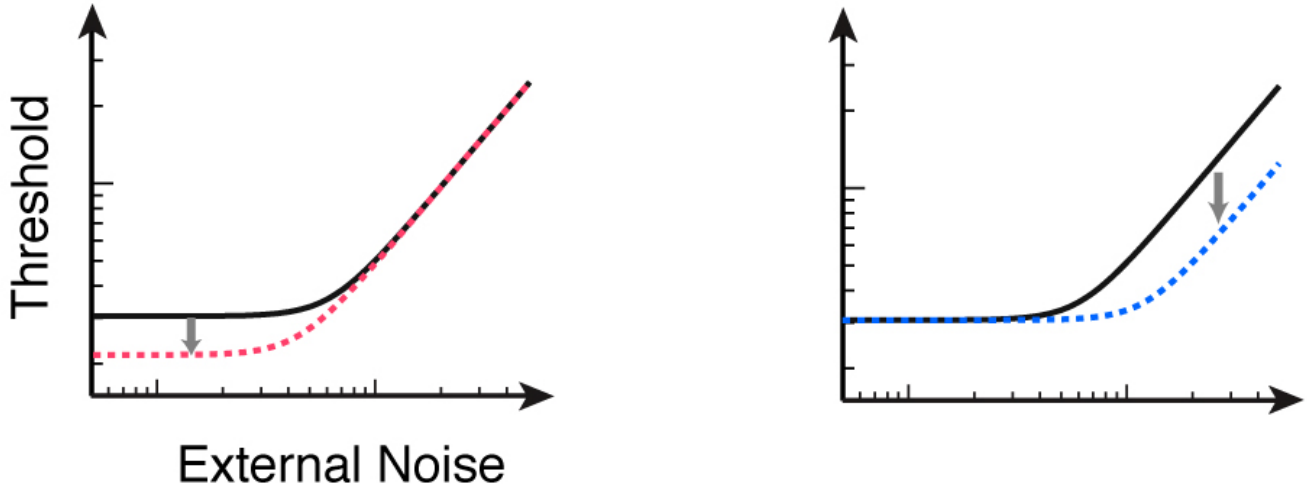
- Results support the predictions of the NMA

Herrmann, Heeger & Carrasco
Vis Res 2012

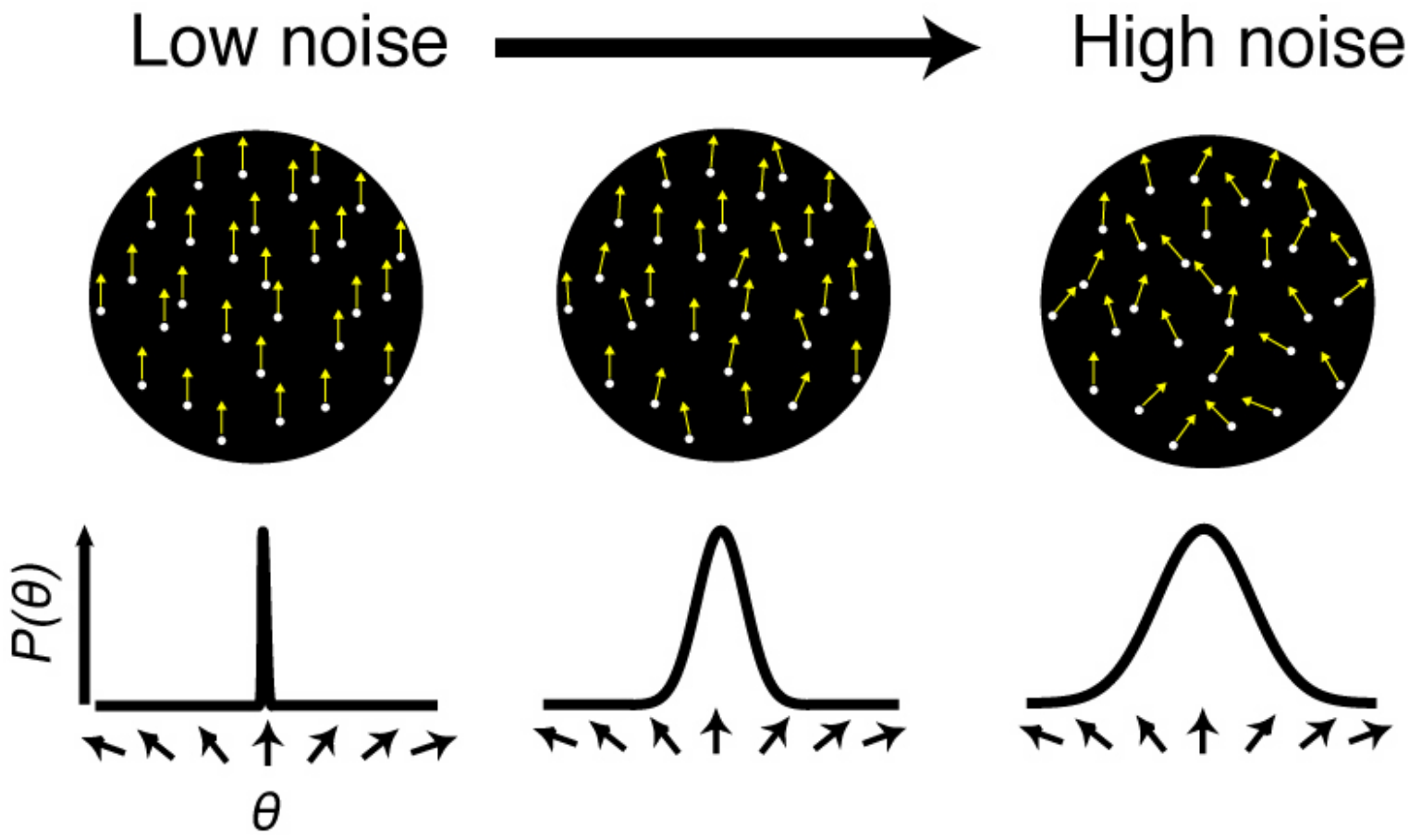
Neural population response



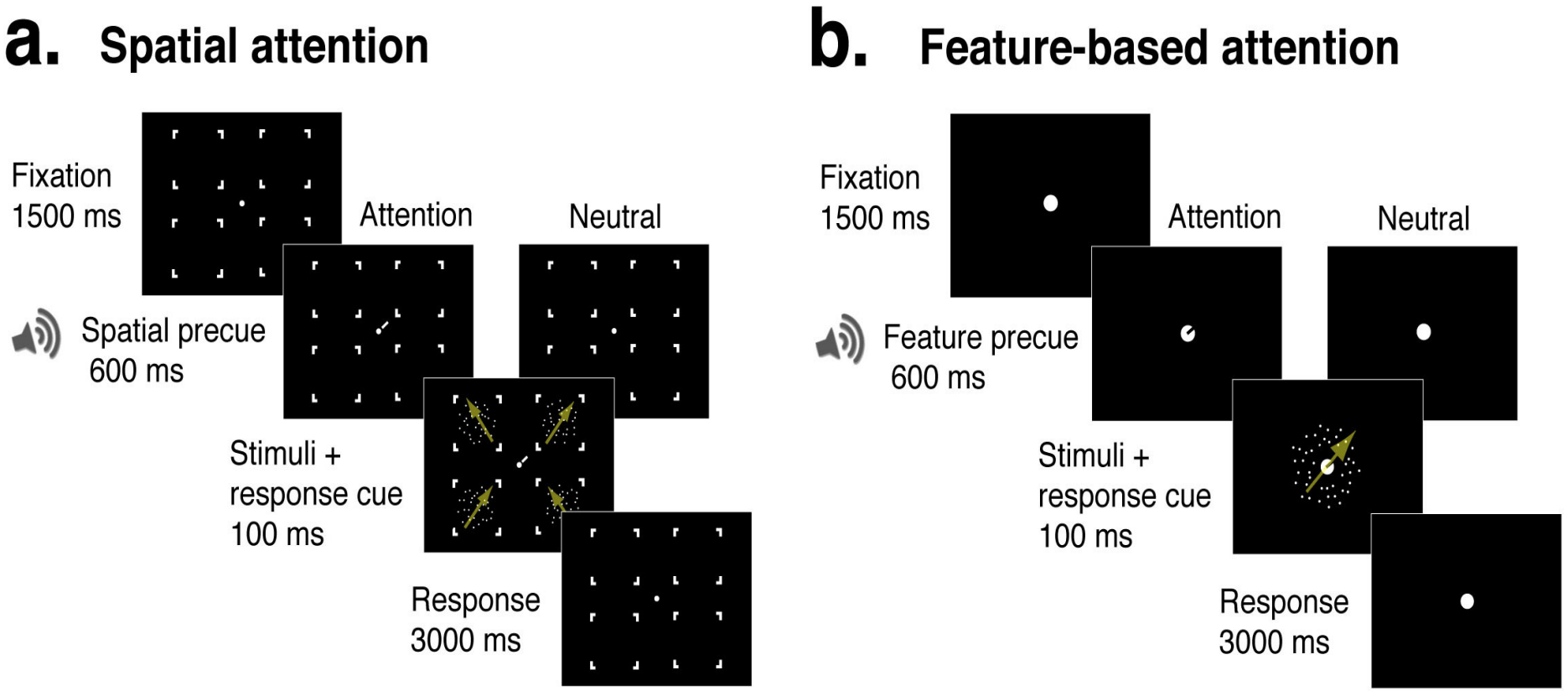
Equivalent noise curves



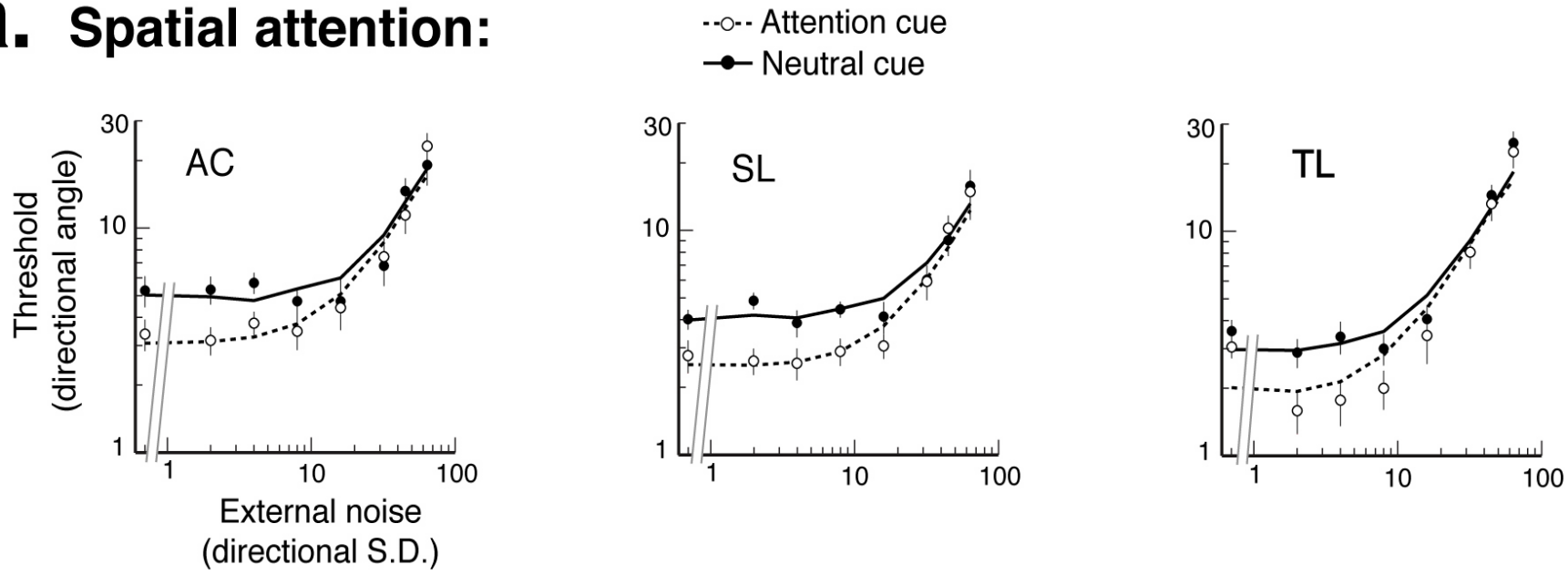
External noise with global motion



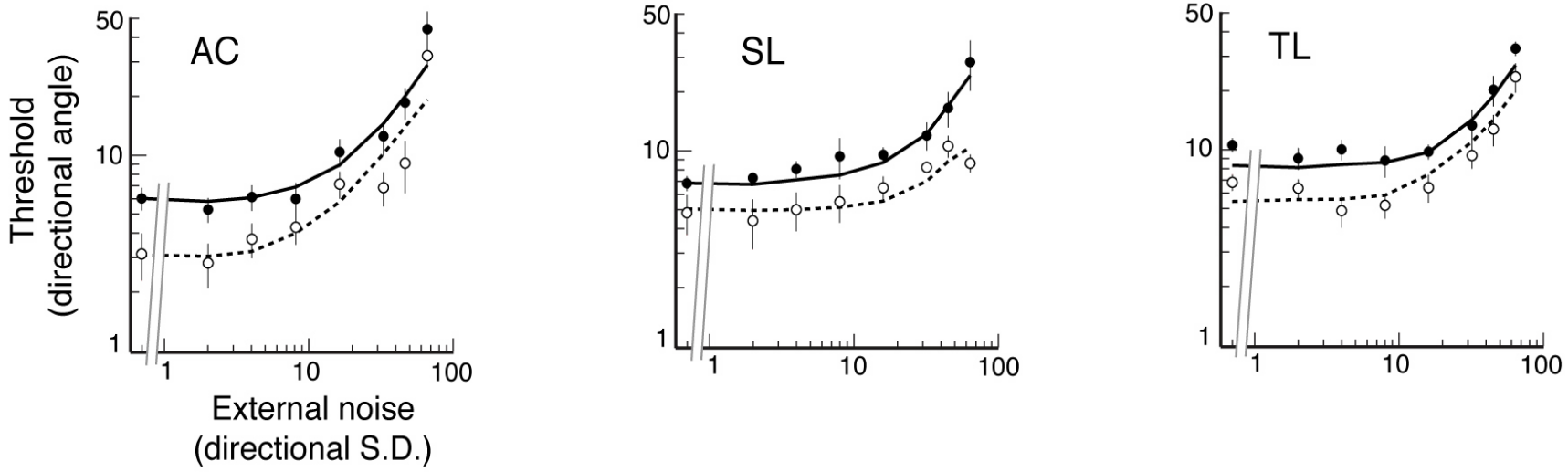
Sequence of events in a single trial



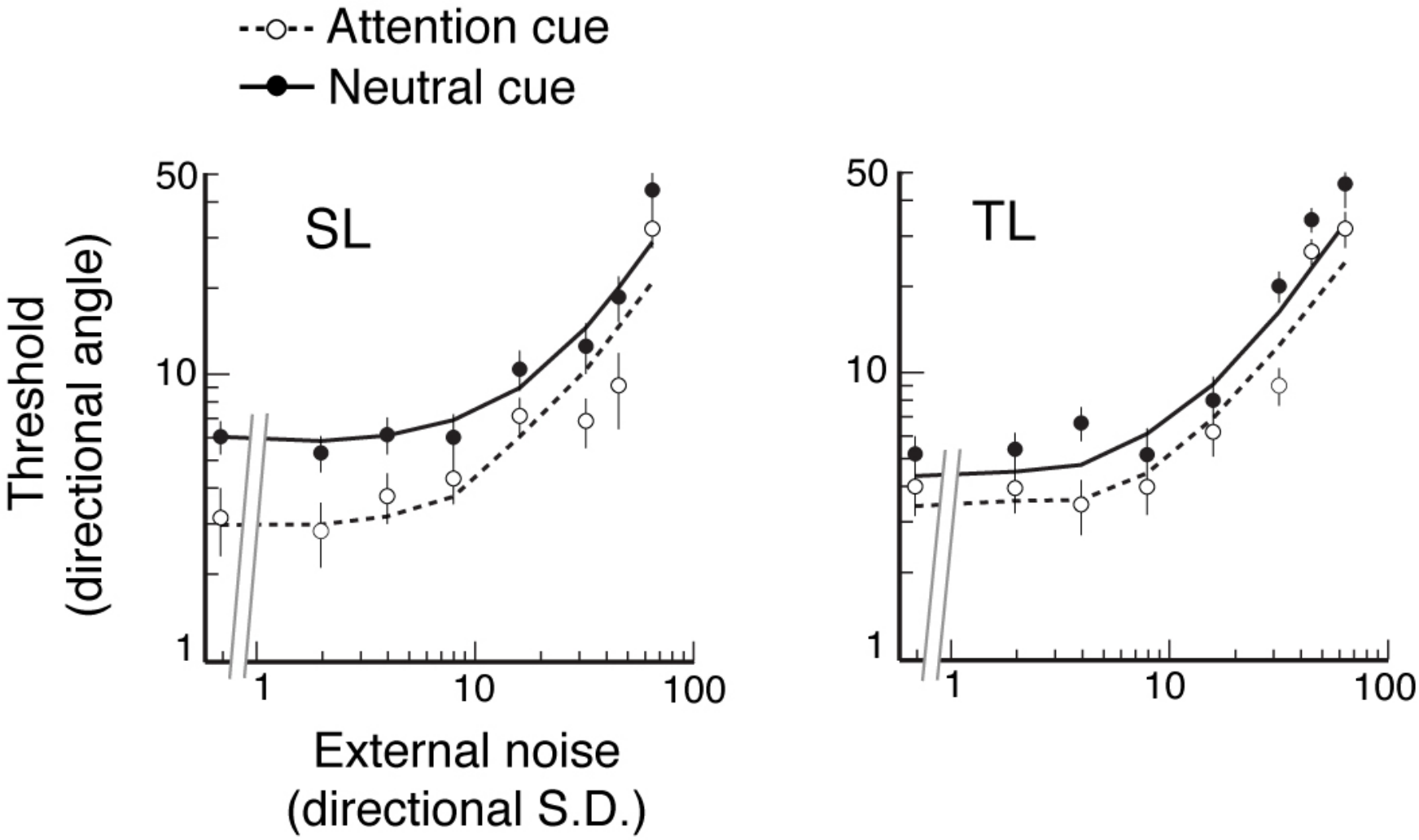
a. Spatial attention:



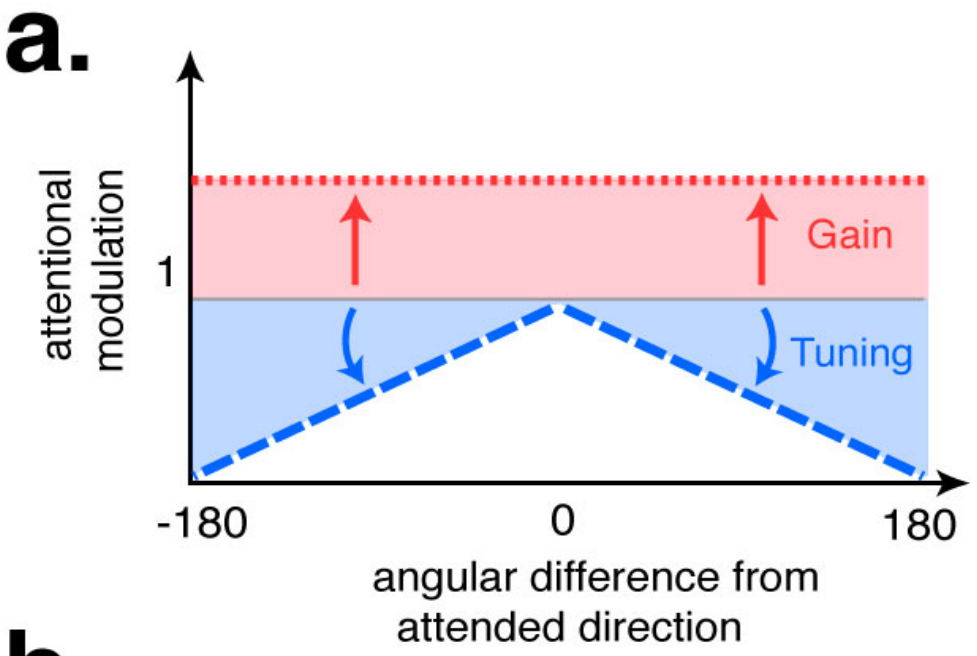
b. Feature-based attention:

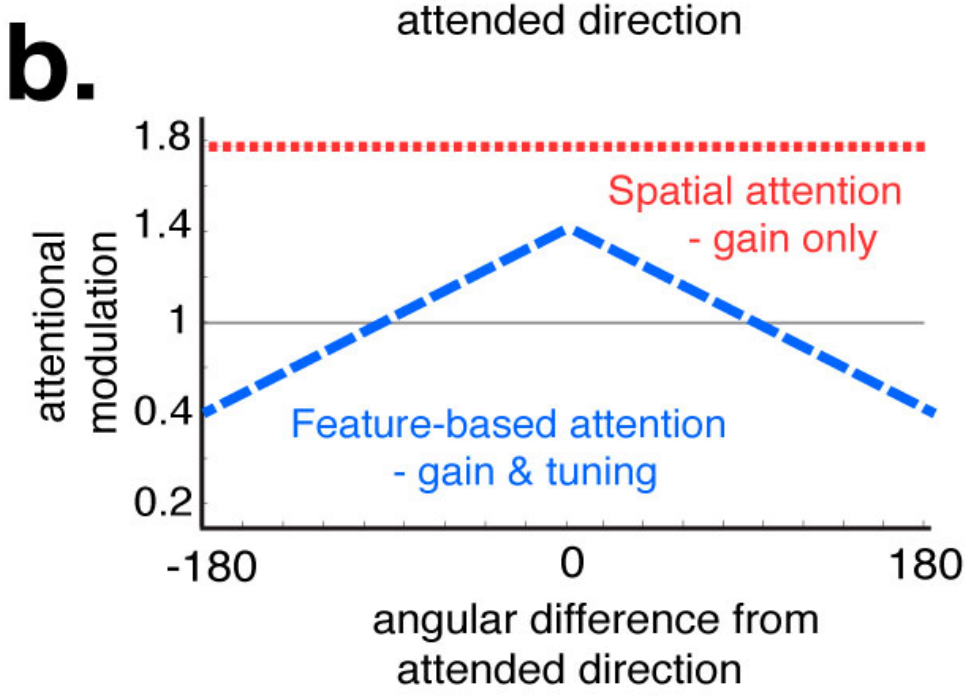


Feature-based attention at a peripheral location



Attentional filters





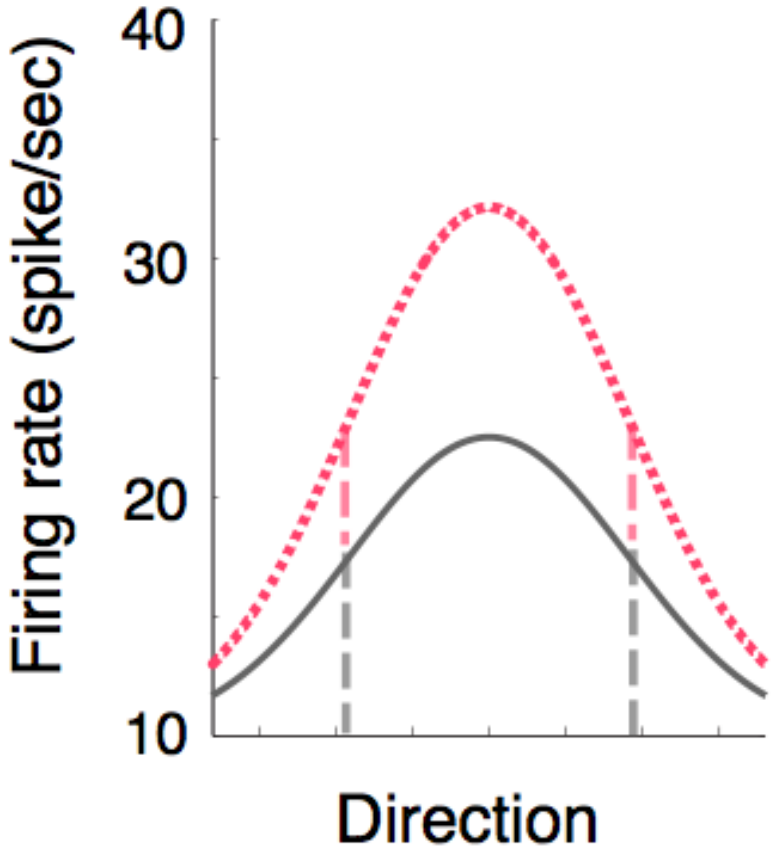
gain= 1.77

gain= 1.44^{-1}

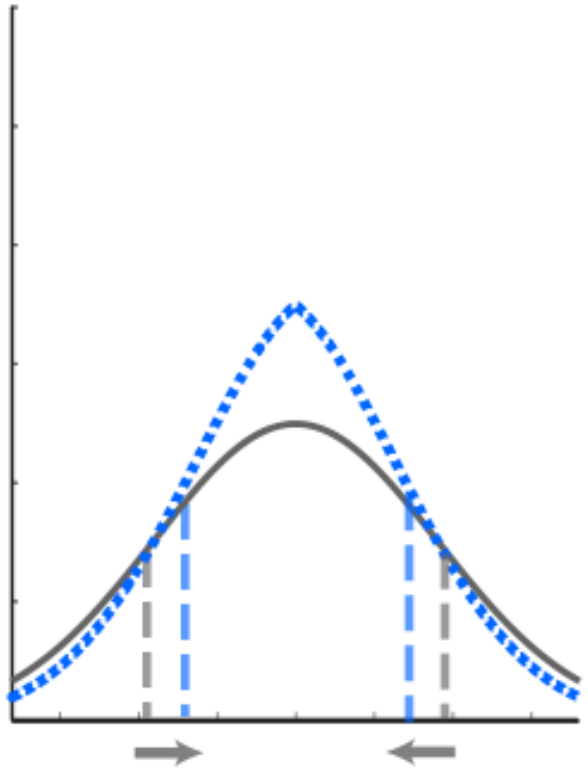
slope=.0032 deg

How attention modulates population response

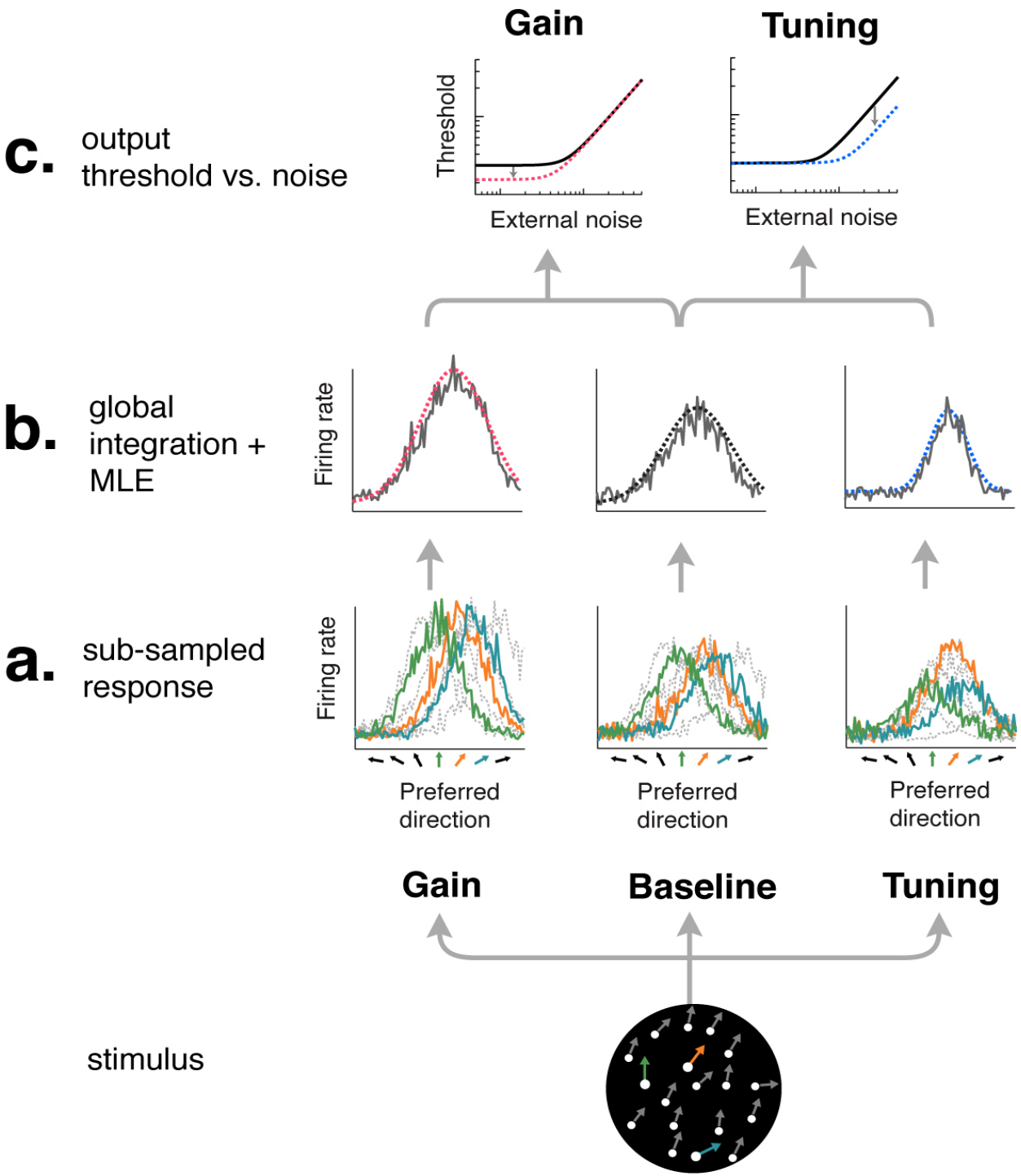
Spatial attention:



Feature-based attention:



Ling, Liu & Carrasco, Vis Res 09


c.
output
threshold vs. noise
Gain
Tuning
Threshold
External noise
External noise
b.
global
integration +
MLE
Firing rate
a.
sub-sampled
response
Firing rate
Preferred
direction
Preferred
direction
Preferred
direction
Gain
Baseline
Tuning
stimulus

FBA

- Effective across the visual field, even at unattended or irrelevant locations
- Temporal dynamics are slower than for spatial attention
- NMA: for orientation, responses are mediated by RG
- Gain and tuning