

**SPATIAL, FEATURE, AND
OBJECT-BASED ATTENTION IN
AREA MT**

Stefan Treue

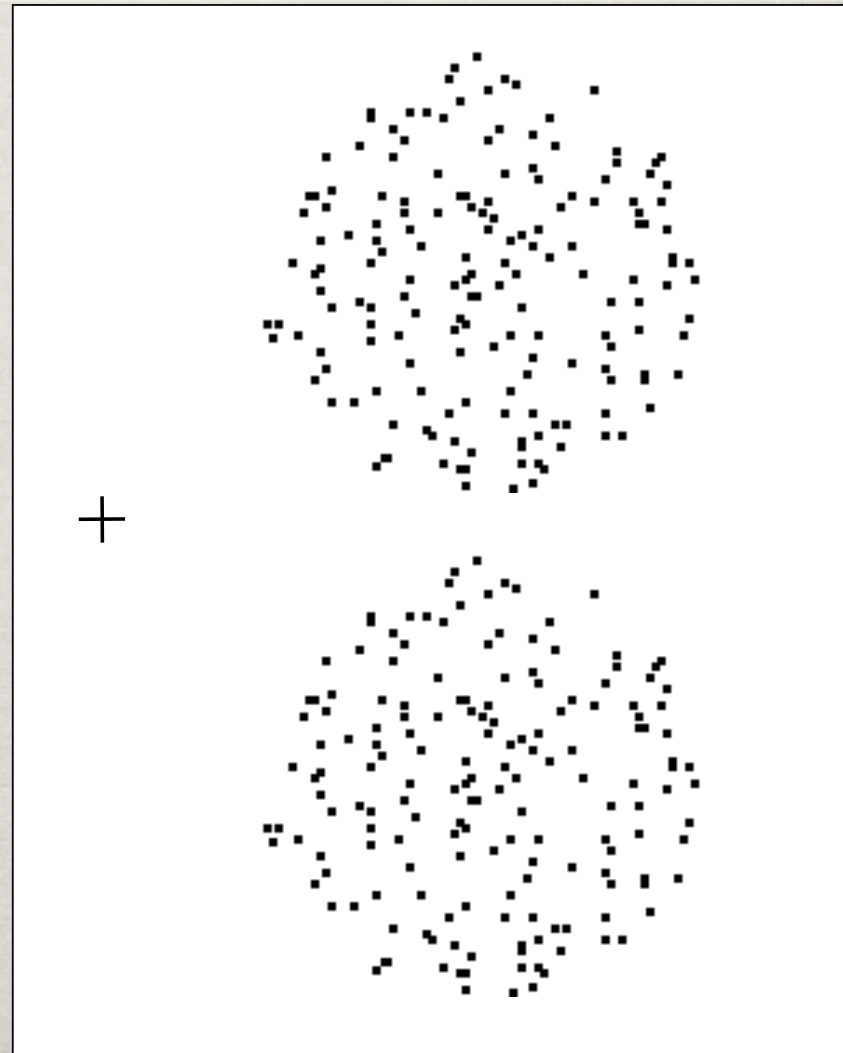
Cognitive Neuroscience Laboratory

German Primate Center

THE EXPERIMENTAL PARADIGM

Identical sensory stimulation - different attentional conditions

- Stimuli: moving random dot patterns
- Extracellular recording from MT & MST neurons in macaque monkeys
- Animal is trained to maintain fixation and is rewarded for detecting speed or direction change in target stimulus while ignoring changes in distractor stimulus

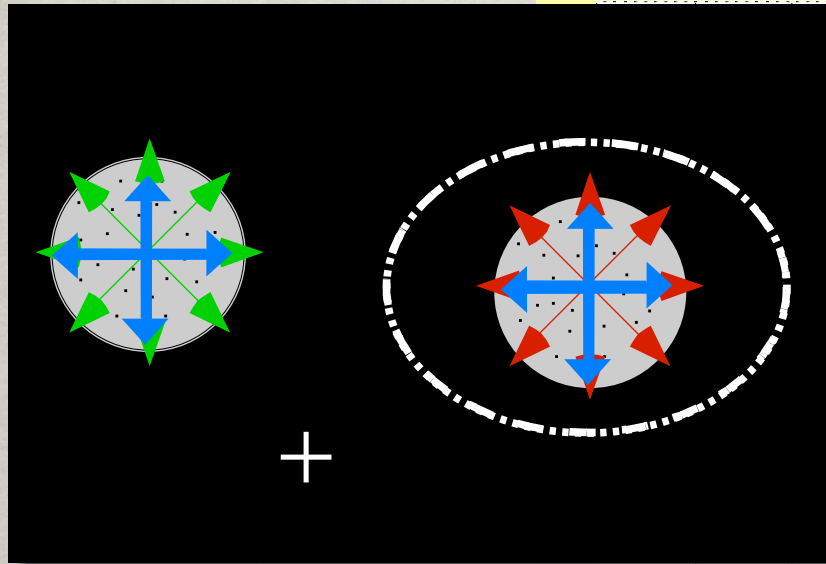


Spatial attention

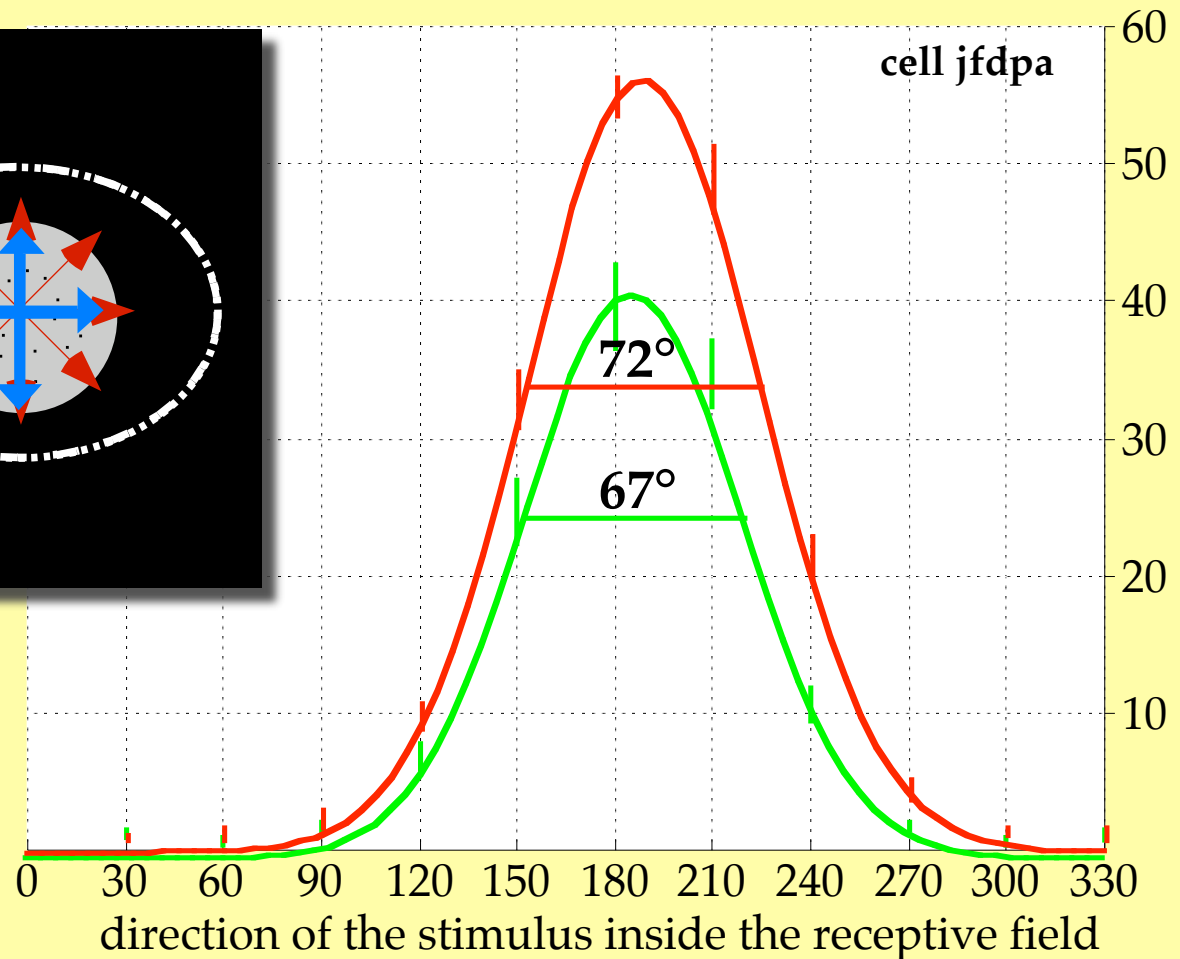
Effects of attentional selection and modulation based on spatial location

The 'spotlight of attention'

TUNING CURVES WITH ATTENTION INSIDE AND OUTSIDE THE RECEPTIVE FIELD

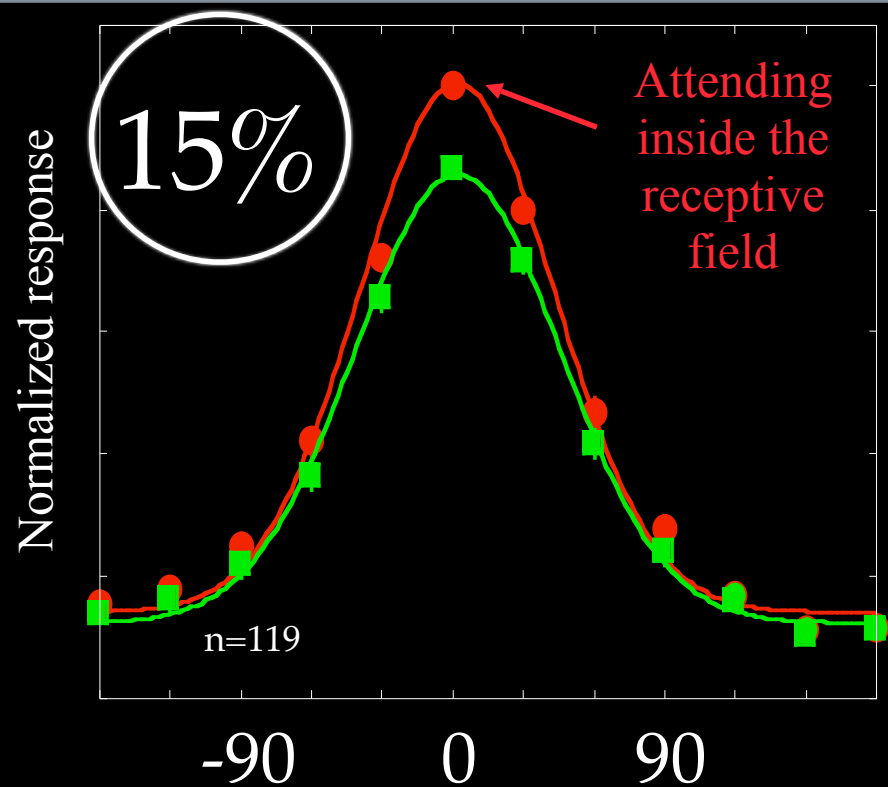


The two stimuli
always move in the
same direction

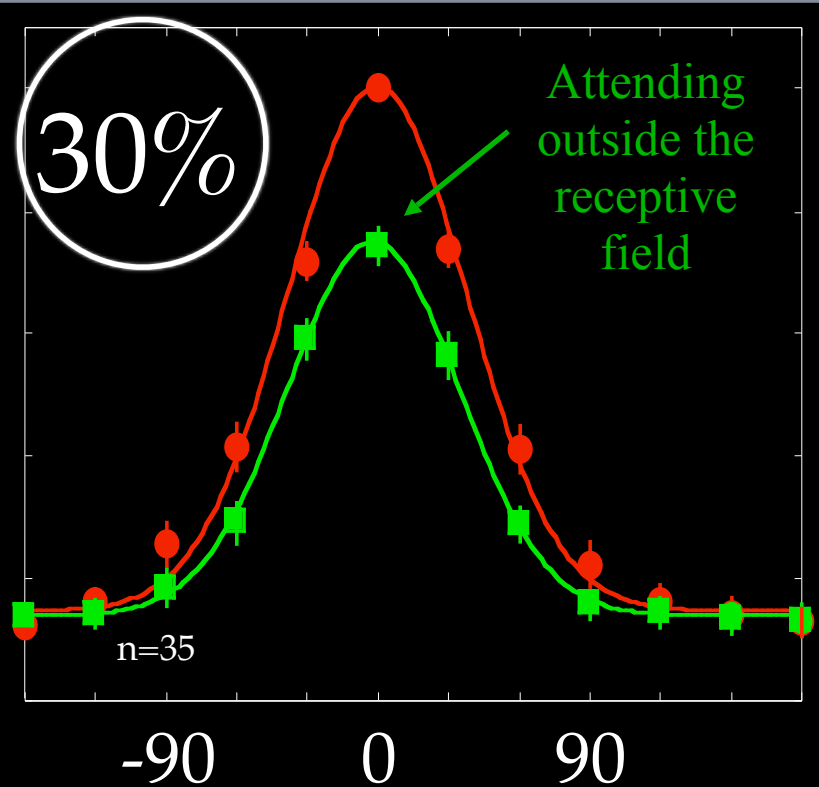


AVERAGE EFFECT OF A CHANGE IN THE POSITION OF THE 'SPOTLIGHT OF ATTENTION'

MT

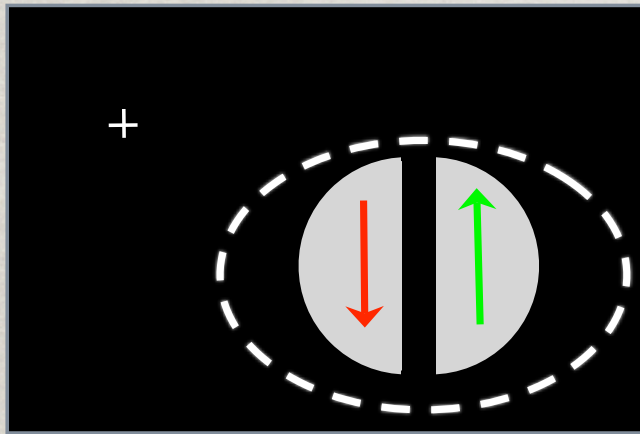


MST

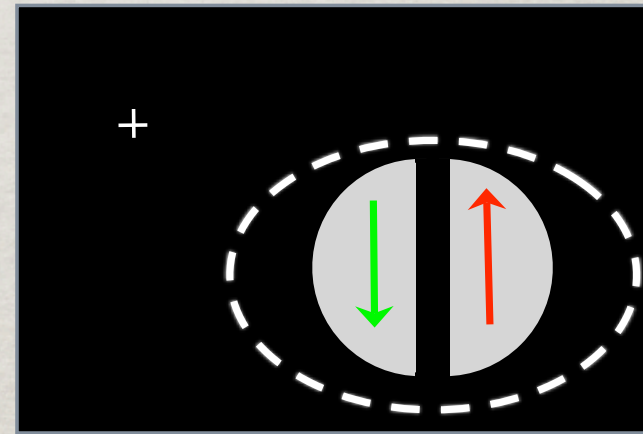


Direction of motion
(degrees away from preferred)

ATTENDING TO ONE OF TWO STIMULI INSIDE THE RECEPTIVE FIELD



Attending to the anti-
preferred stimulus



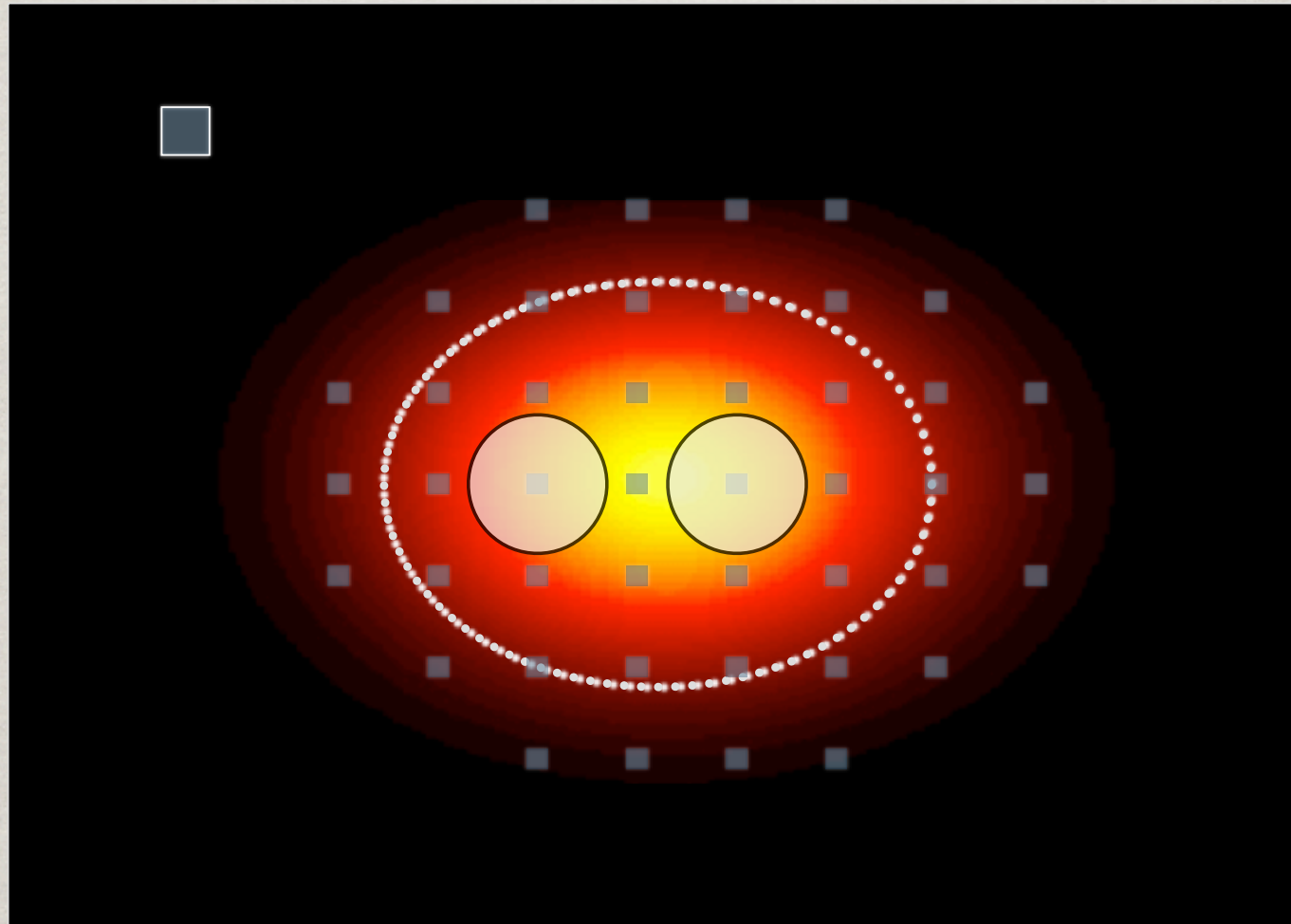
Attending to the
preferred stimulus

Attentional modulation of the shape of receptive fields ?

„When attention is directed to one of two stimuli in the receptive field of a V4 cell, the effect of the unattended stimulus is attenuated, almost as if the receptive field has contracted around the attended stimulus.“

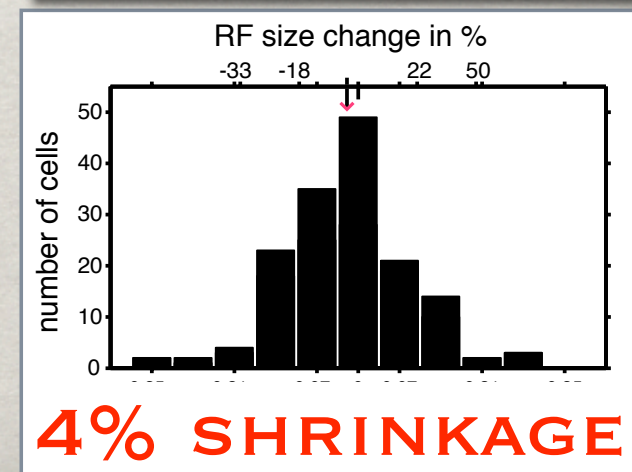
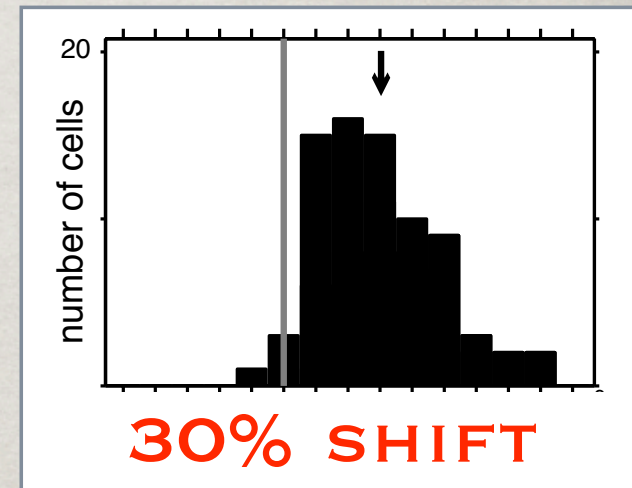
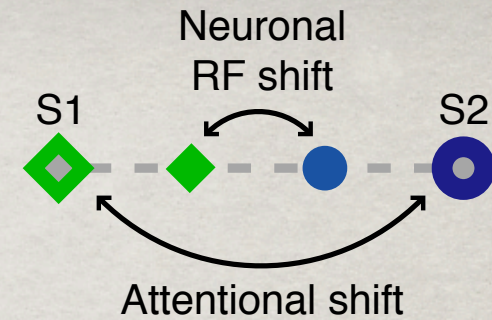
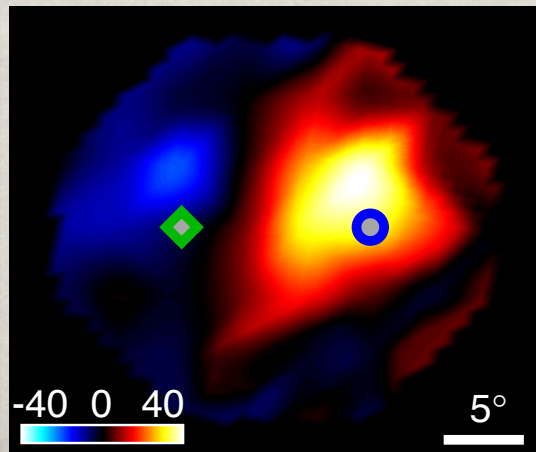
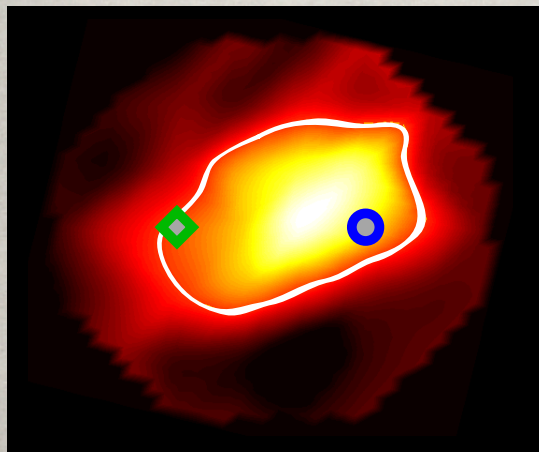
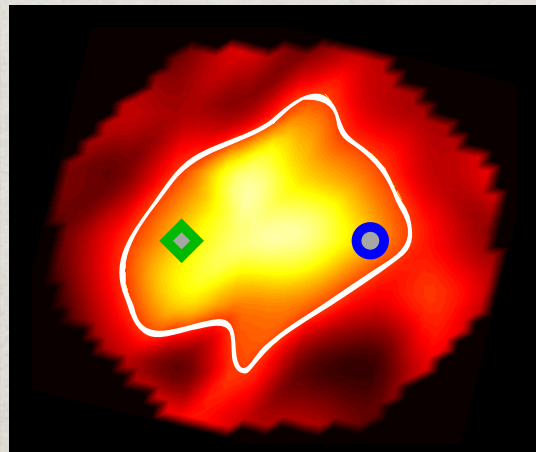
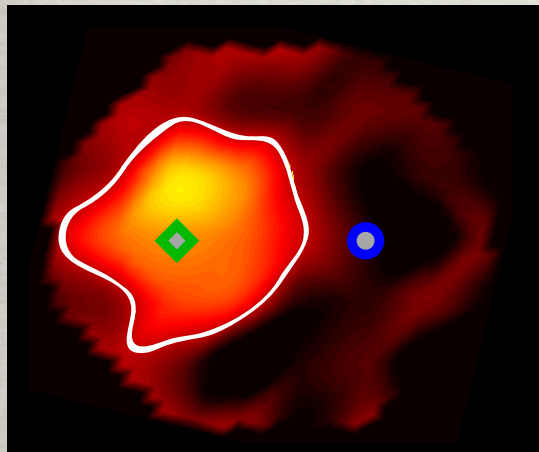
Moran & Desimone, Science, 1985

MAPPING THE RECEPTIVE FIELD

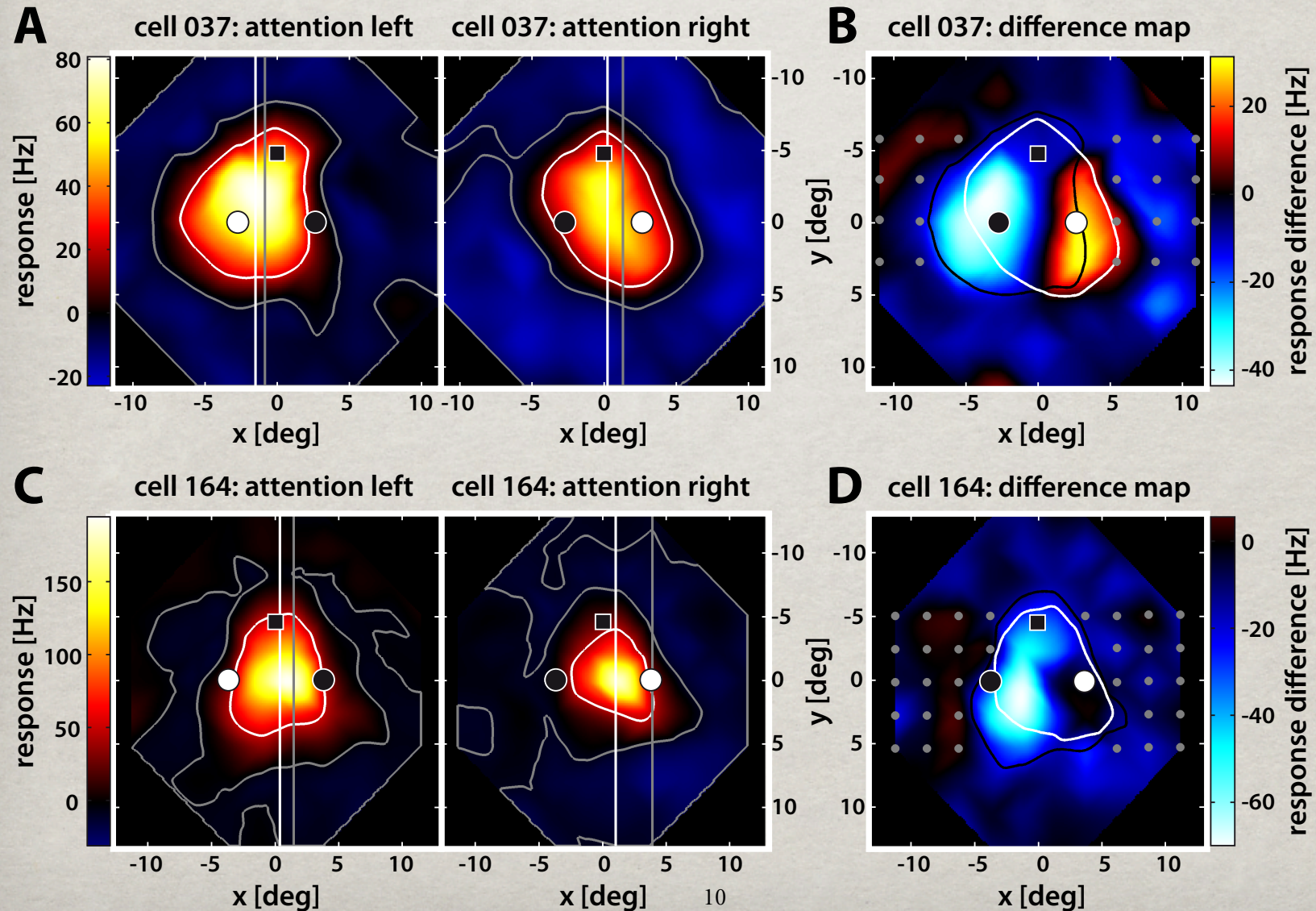


MAPPING THE RF DURING AN ATTENTIONAL TASK

◆ S1 ○ S2 0  50 spikes / sec.



IS THE SURROUND ALSO SHIFTING ?

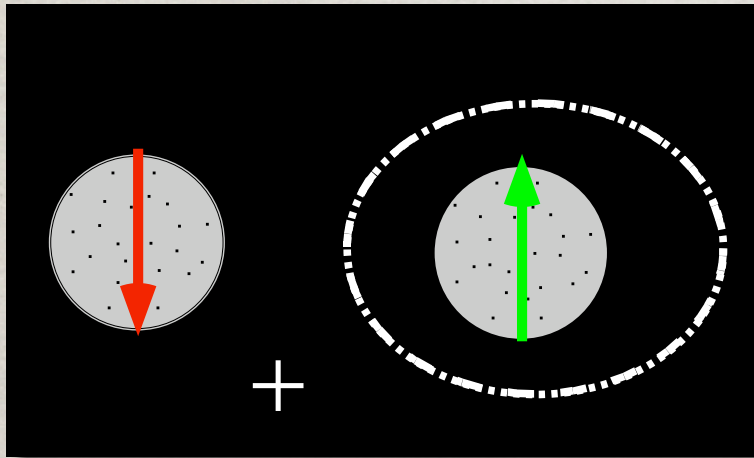
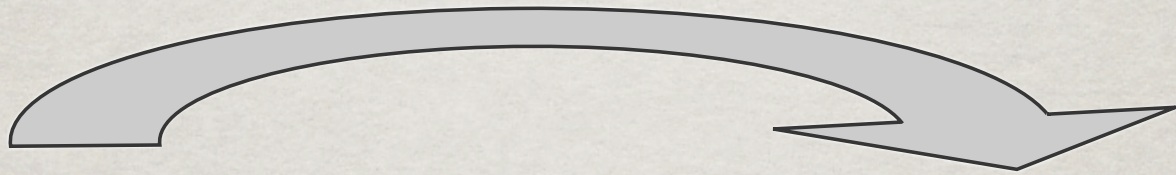


Feature-based attention:

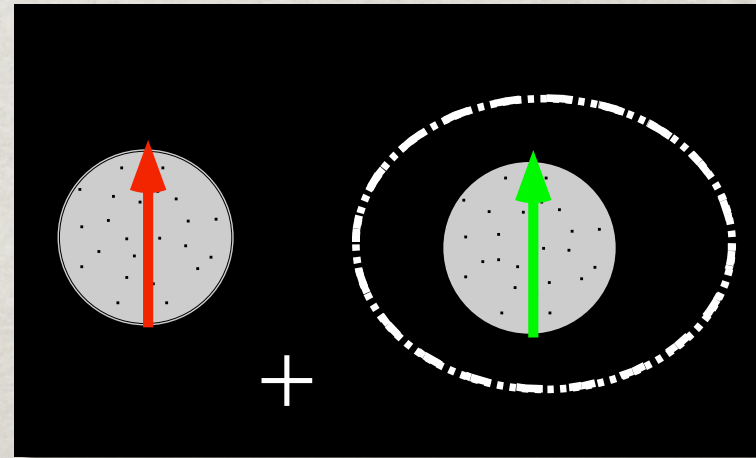
Attentional modulation
without spatial shifts in
the attended location ?

ATTENTIONAL MODULATION IN MT BASED ON THE ATTENDED FEATURE

+13%



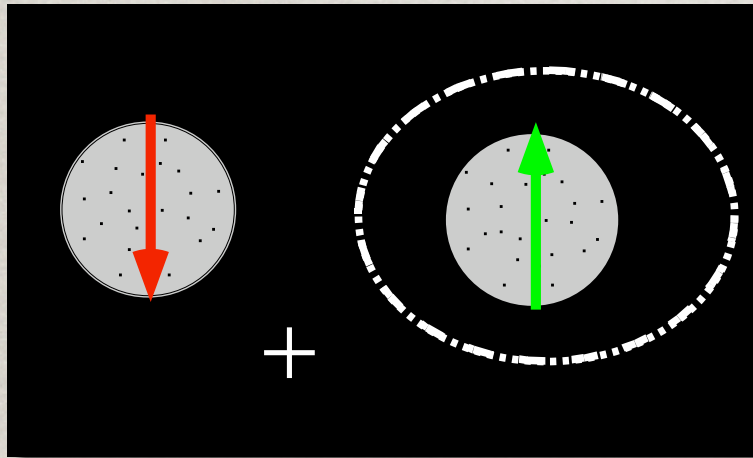
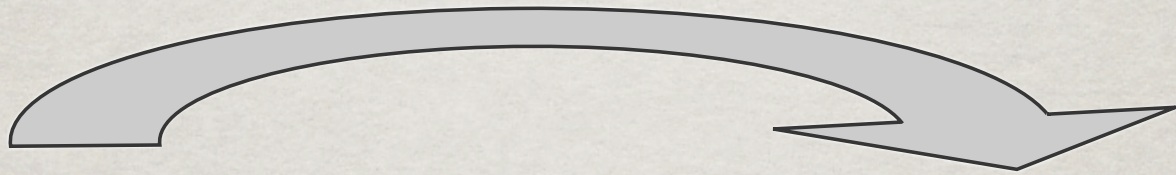
Attending to the null
direction outside the
receptive field



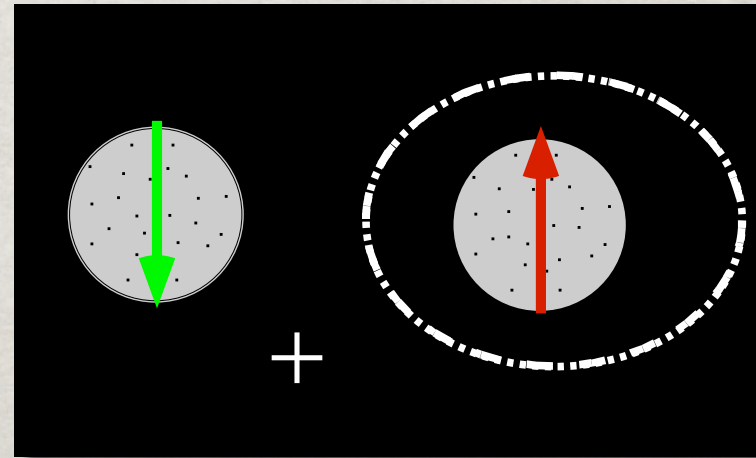
Attending to the preferred
direction outside the
receptive field

COMBINING SPATIAL- AND FEATURE-BASED ATTENTION

+25%



Attending to the null
direction outside the
receptive field

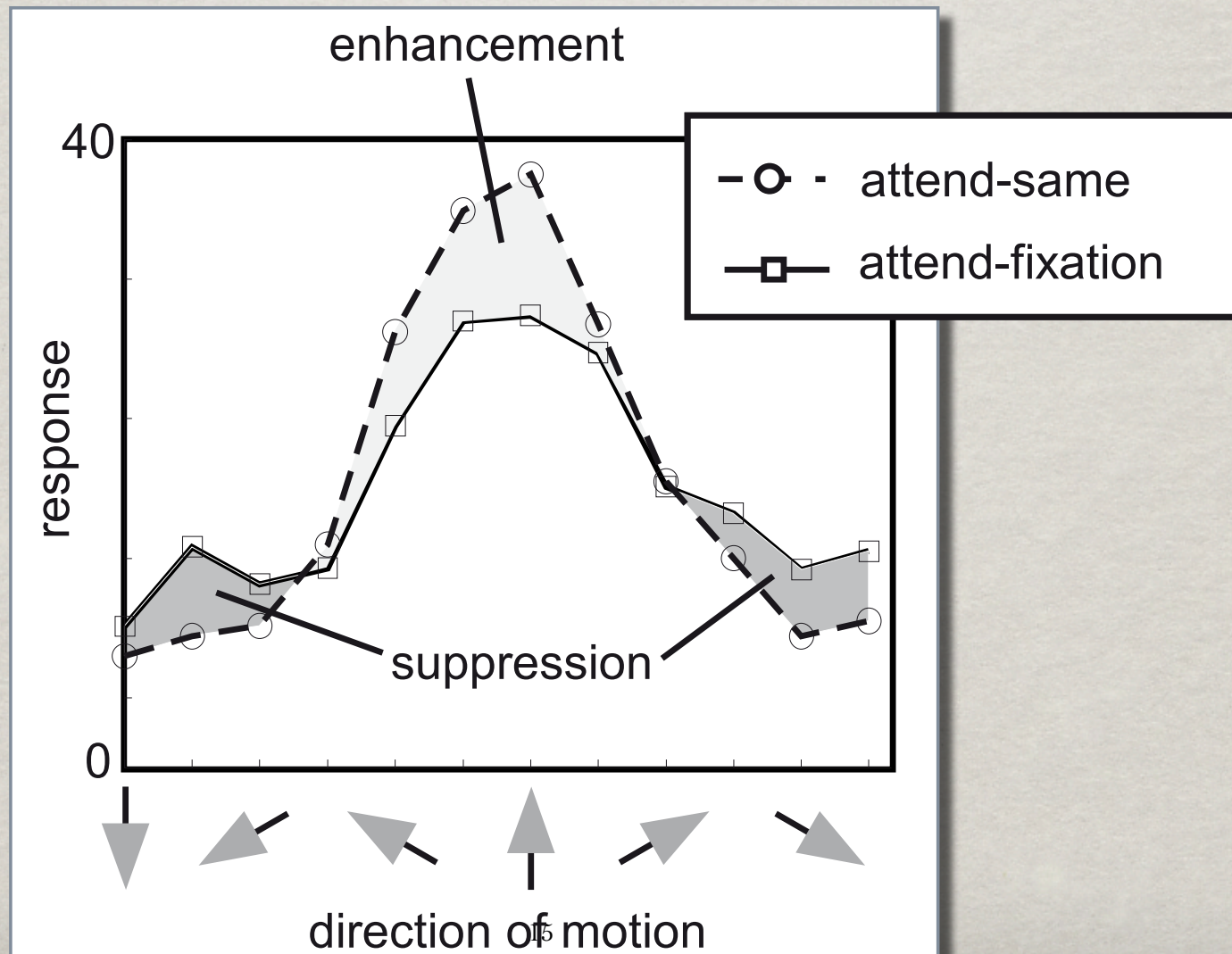


Attending to the preferred
direction inside the
receptive field

THE FEATURE SIMILARITY GAIN 'MODEL'

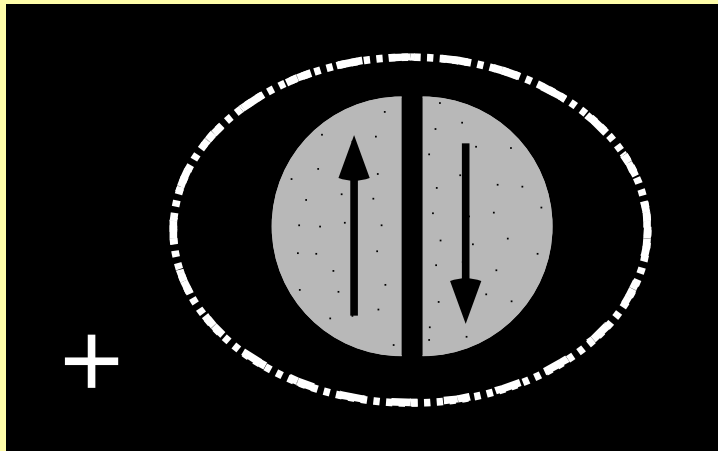
- The attentional modulation of the activity of a neuron is a gain change.
- Its sign and magnitude reflects the similarity between the attended feature values (incl. location) and the feature preference of the neuron.

POPULATION RESPONSE TO VARIOUS DIRECTIONS WHEN ATTENDING TO UPWARD MOTION



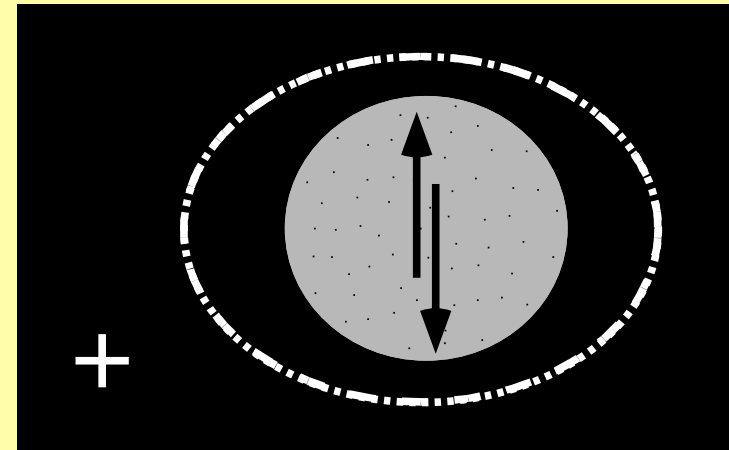
RECEPTIVE FIELD CHANGES AND NON-SPATIAL ATTENTION

Spatial attention task



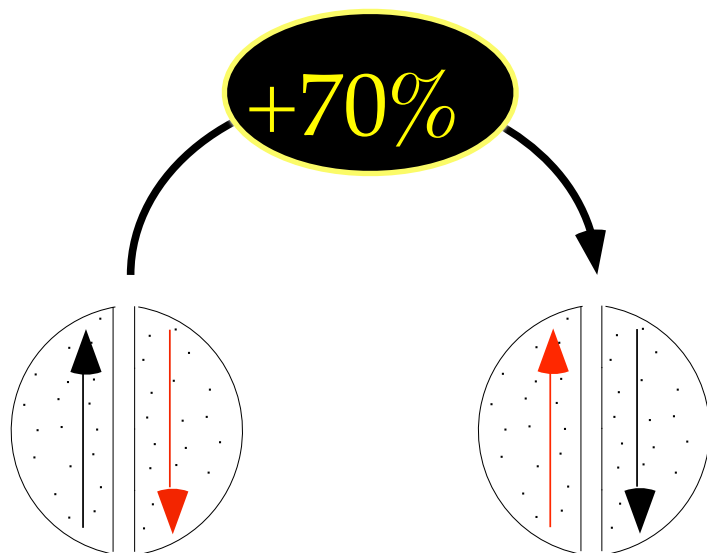
attentional effects can be accounted for by a shrinking of the receptive field

Attentional task without spatial separation

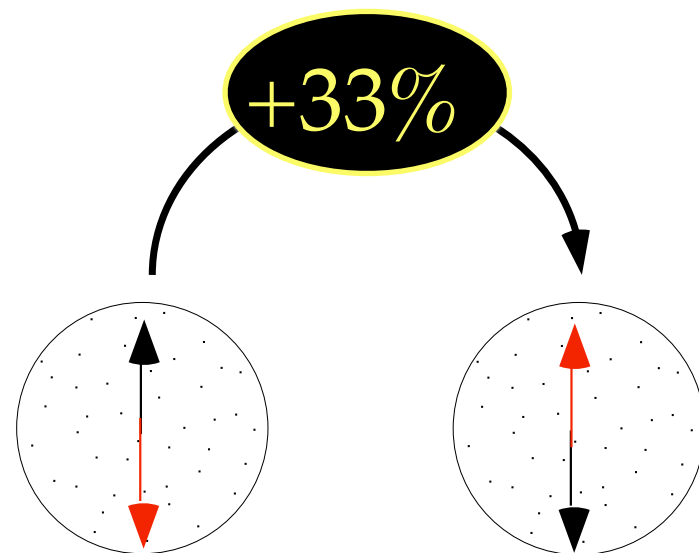


- stimuli are defined by opposite motion direction
- no difference in the spatial location of target and distractor

Attending to spatially separated stimuli



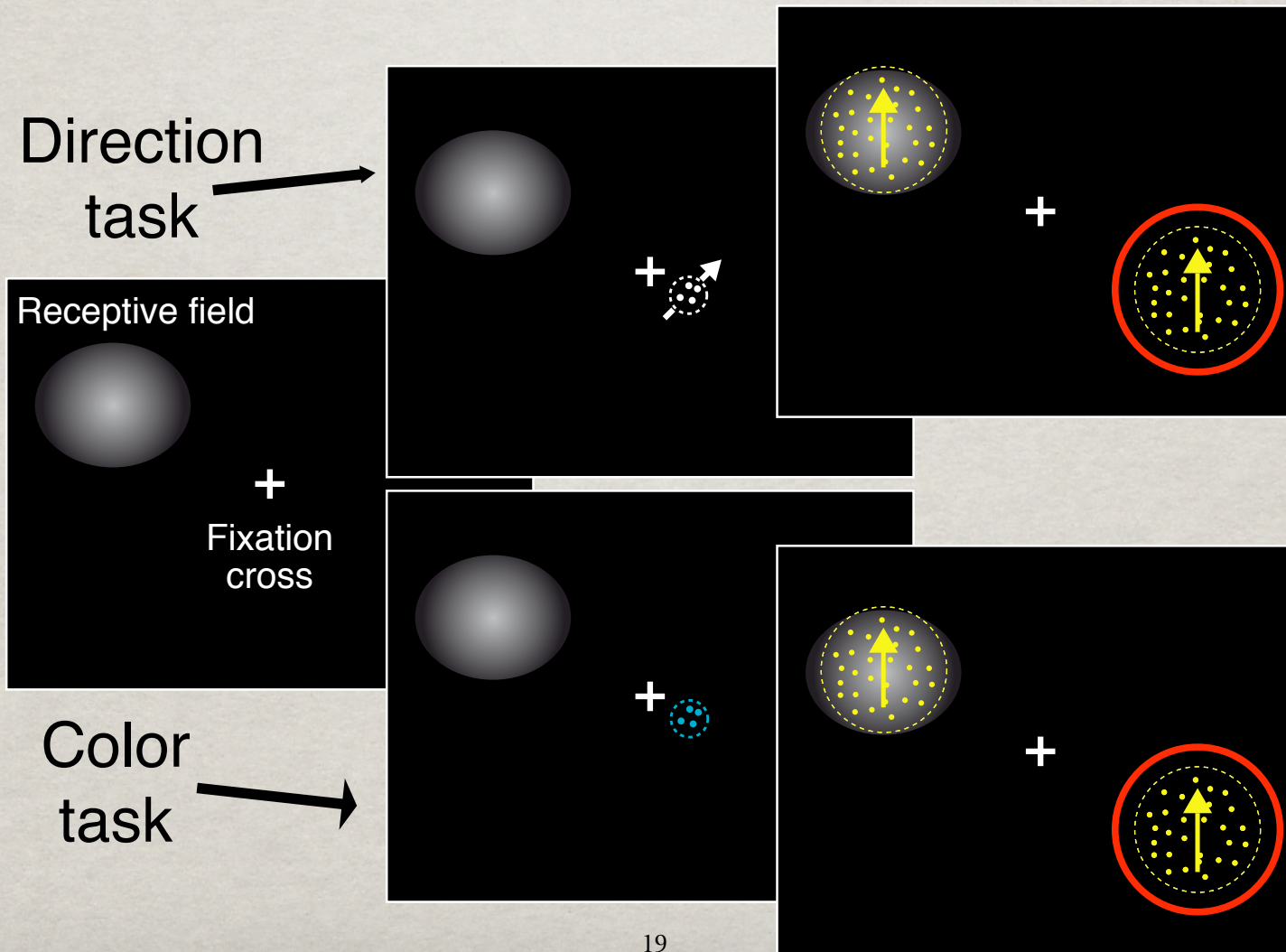
Attending to transparent stimuli



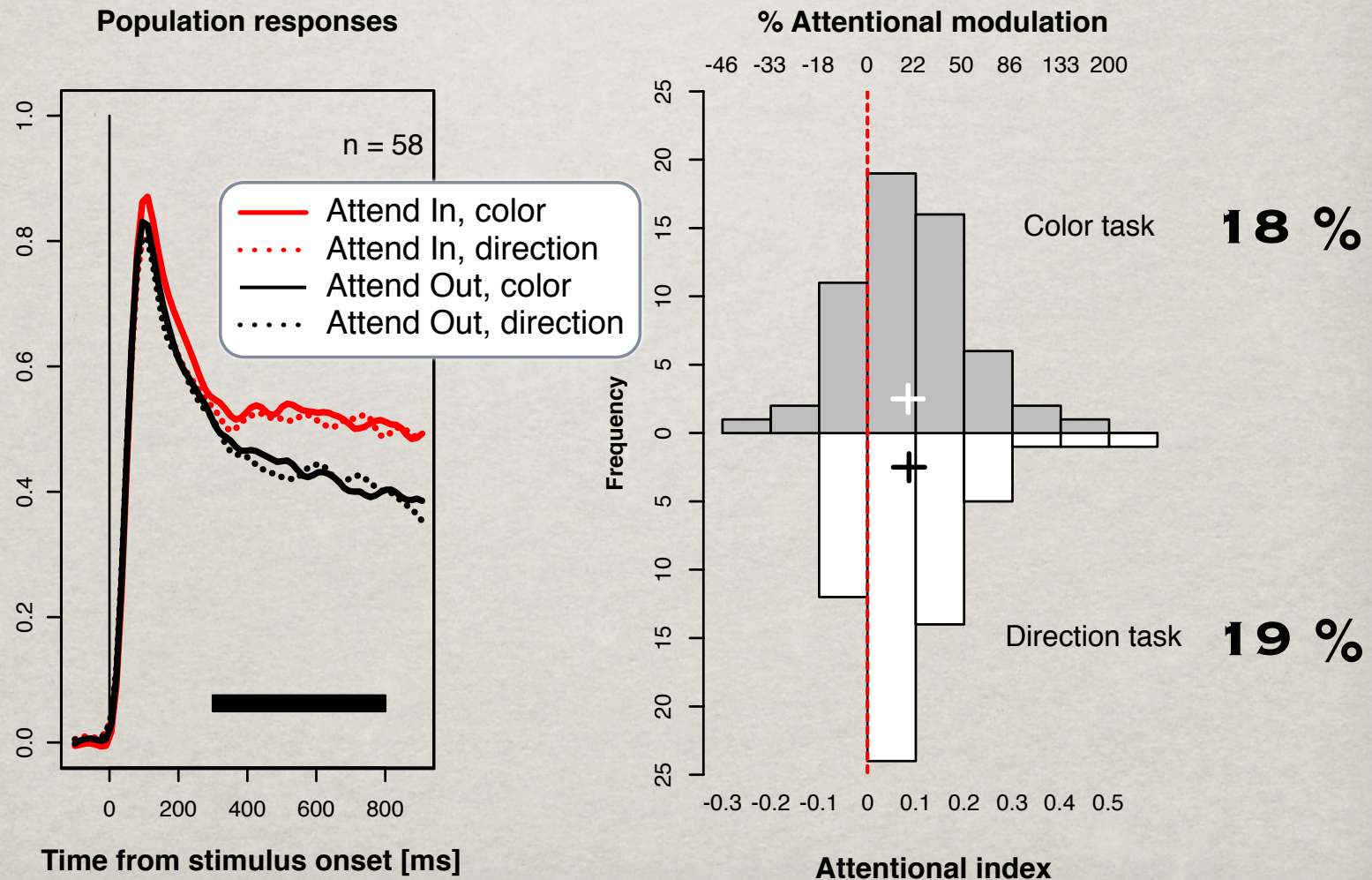
Object-based attention in MT ?

Attending to only a single feature of an object leads to the attentional enhancement of the processing of all object features.

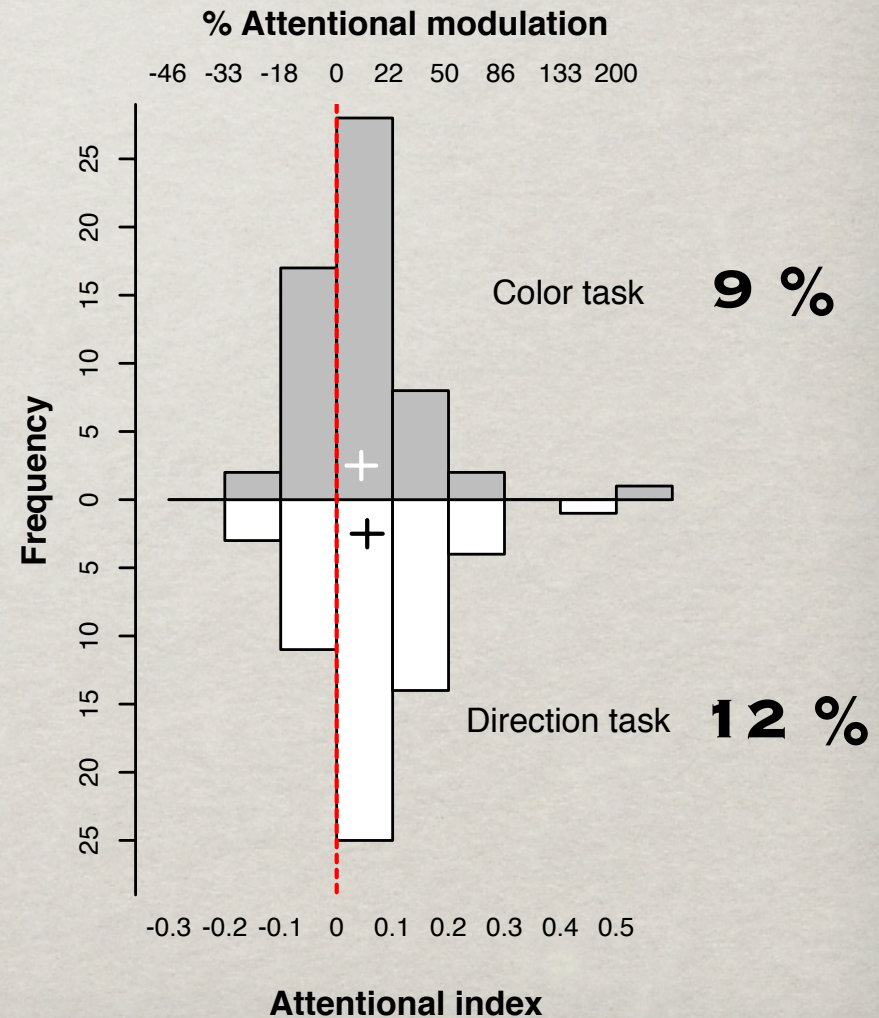
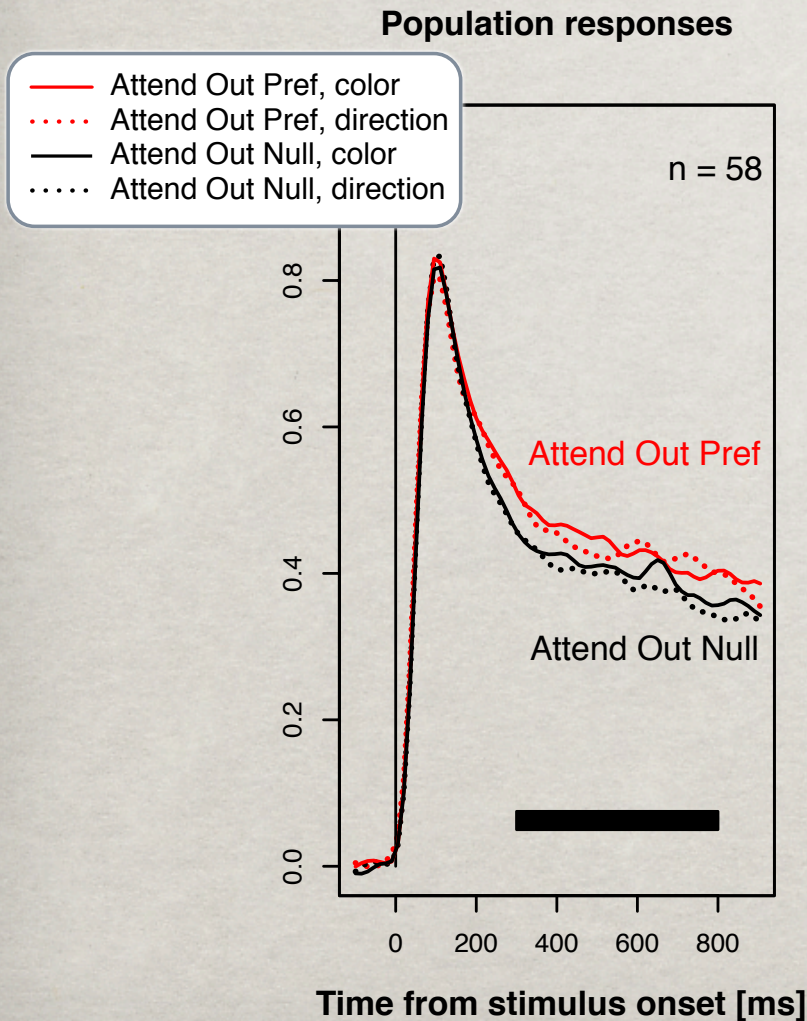
DIRECTING ATTENTION TO THE COLOR OR THE DIRECTION OF A STIMULUS



ATTENDING TO THE COLOR OR MOTION IN- OR OUTSIDE OF THE RECEPTIVE FIELD



ATTENDING TO THE COLOR OR MOTION OUTSIDE OF THE RECEPTIVE FIELD



Spatial attention

- Spatial attention can strongly modulate motion processing even in early extrastriate visual cortex. The modulation increases from MT to MST.
- Attention changes the directional gain but does not sharpen the tuning of direction-selective neurons (“multiplicative modulation”).
- *The timecourse of the modulation is well matched to the behavioral timecourse of shifts in attention.*
- Spatial attention can shift (and shrink) MT receptive fields. This shift also affects the surround.

Feature-based attention

- Feature-based attention exerts a multiplicative influence in MT. This can increase or decrease a cell's response. Such gain changes can create non-multiplicative effects.
- Feature-based attention works across the visual field and within the receptive field. It is comparable in magnitude to the effects of spatial attention and can be combined.
- *Even relatively small attentional changes in neuronal firing rates might reflect almost complete extinction of unattended stimuli. Attentional modulation has the same effect as a change in stimulus contrast.*
- “Feature-similarity gain model” of attention.

Object-based attention

- Attending to one feature of an object seems to enhance the representation of other features of the object as well as the representation of these features across the visual field.

General conclusions

- The attentional modulation observed in MT seems well suited to create an integrated saliency map, i.e. a representation of the visual input that modulates signals based on their physical and behavioral salience.

ATTENTIONAL MODULATION OF VISUAL INFORMATION PROCESSING

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Katharina Anton-
Erleben



Steffen Katzner



Laura Busse

