Mechanisms of feature-selective attention in area V4 of the macaque monkey

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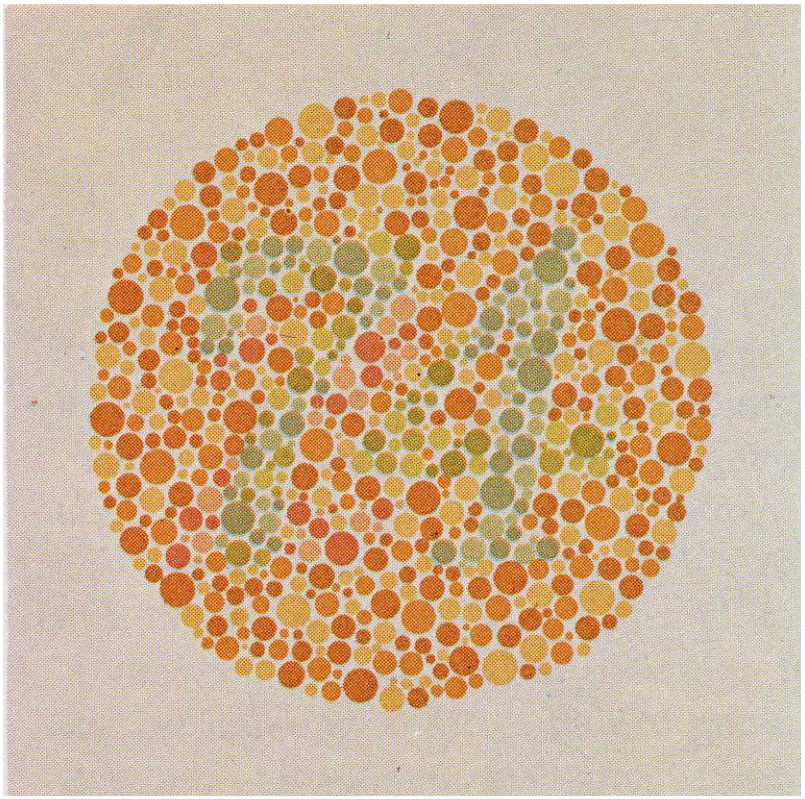
Two types of feature-based attention have been distinguished:

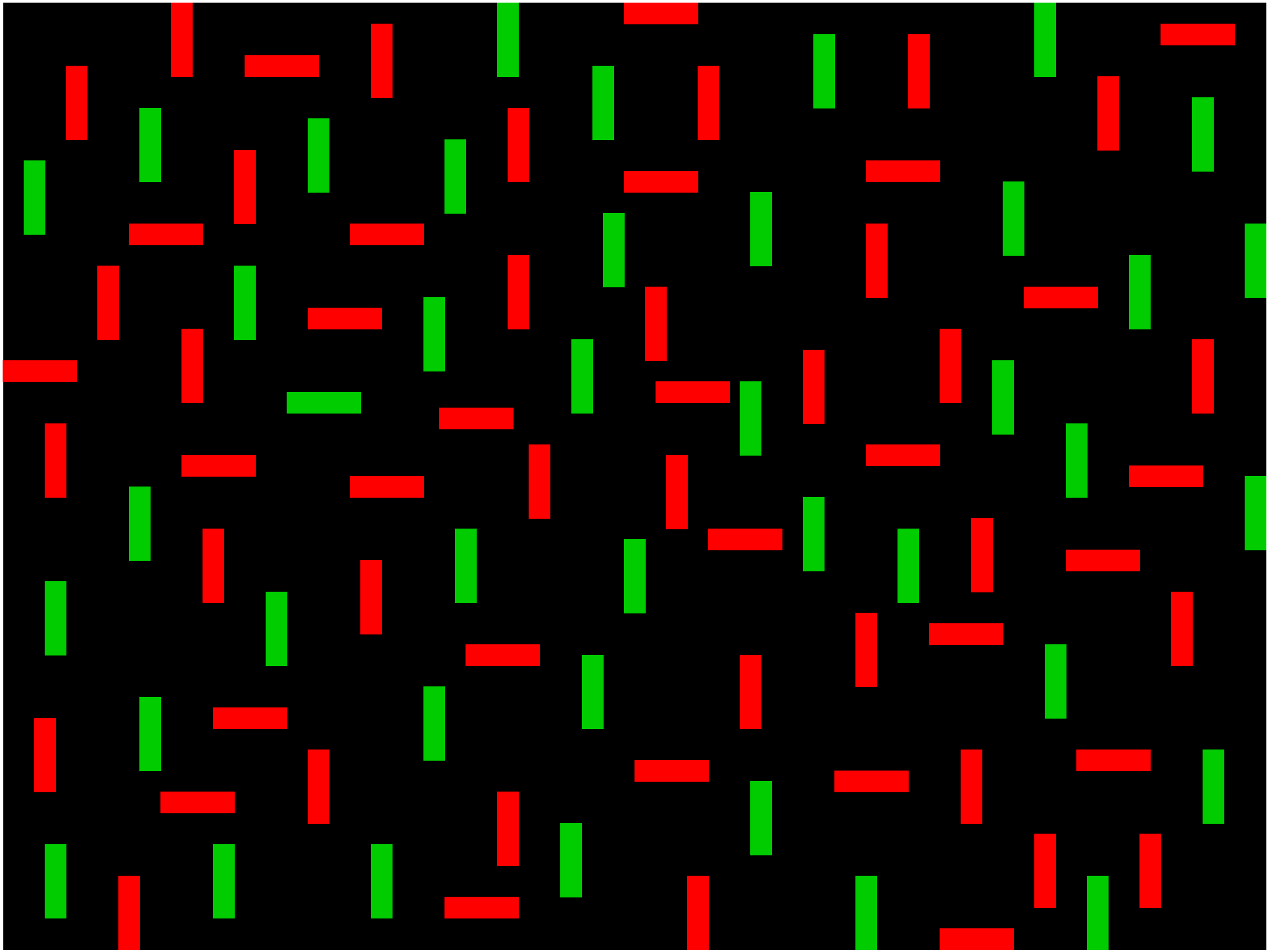
✍ When feature information aids selection of (local or spatially distributed) whole objects (e.g., like in Guided Search, *Wolfe et al., 1989*);

✍ When elemental object features must be selected, due to task demands (e.g., like in the Stroop task, *Fanini et al., 2006; Nobre et al., 2006*).

The first type of feature-based attention



Grouping and segmentation are largely pre-attentintive processes, but attention to a single element of a group may help select other elements of the same group

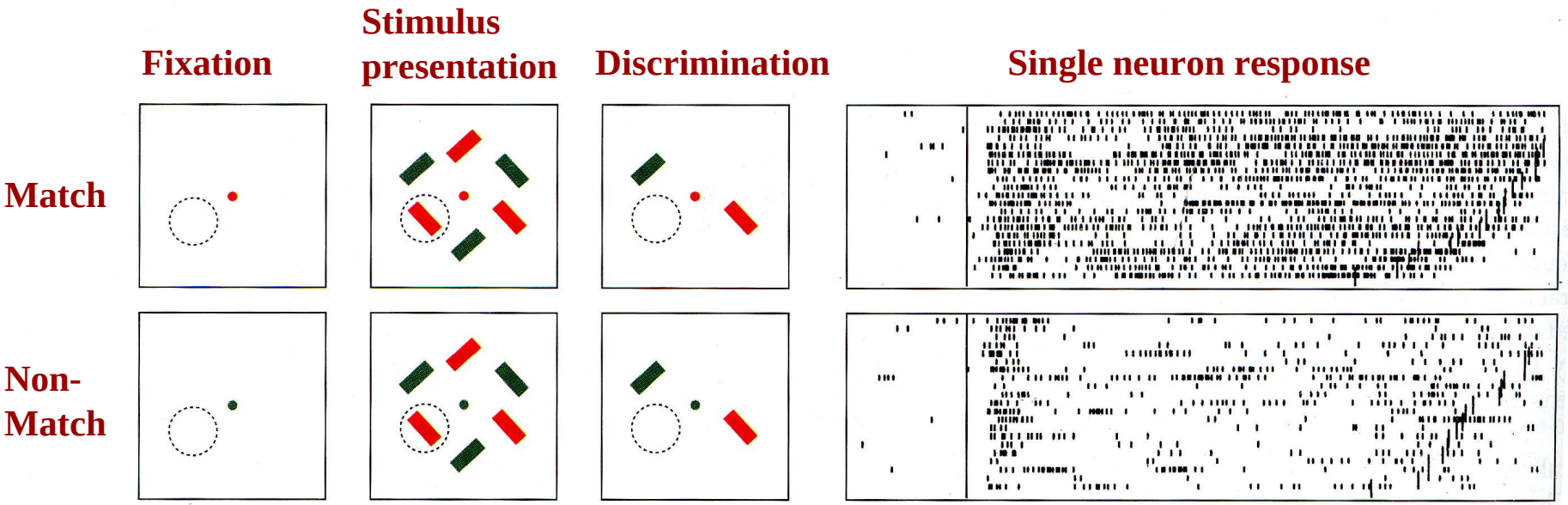


The first type of feature-based attention

To select individual objects, a feature-based pre-selection stage (by the yellow color, in this example) may be essential

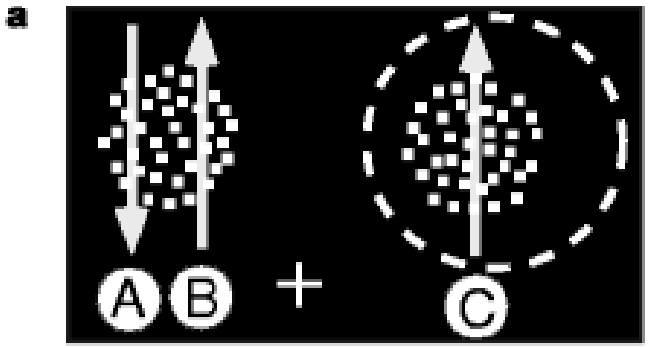
The first type of feature-based attention (Neural mechanisms)

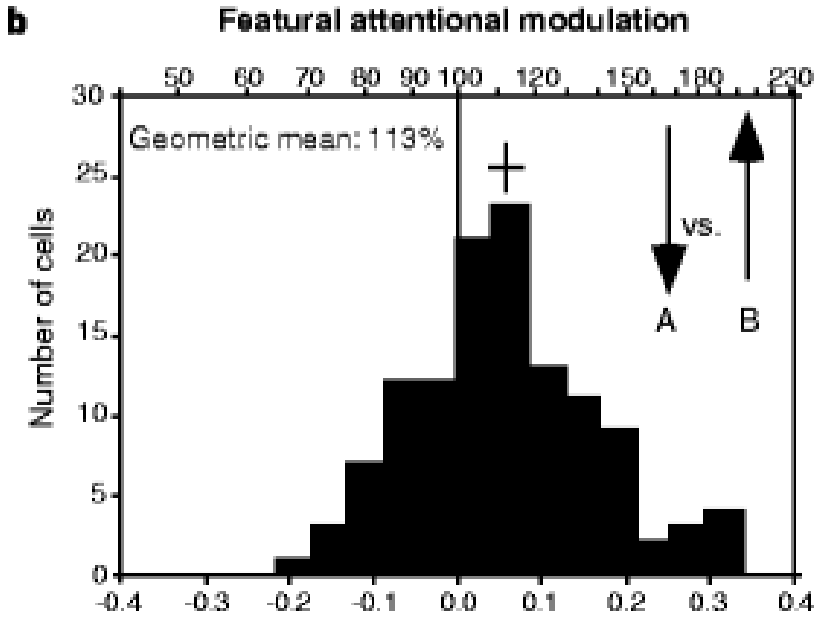
Feature-based global pre-selection of candidate target objects

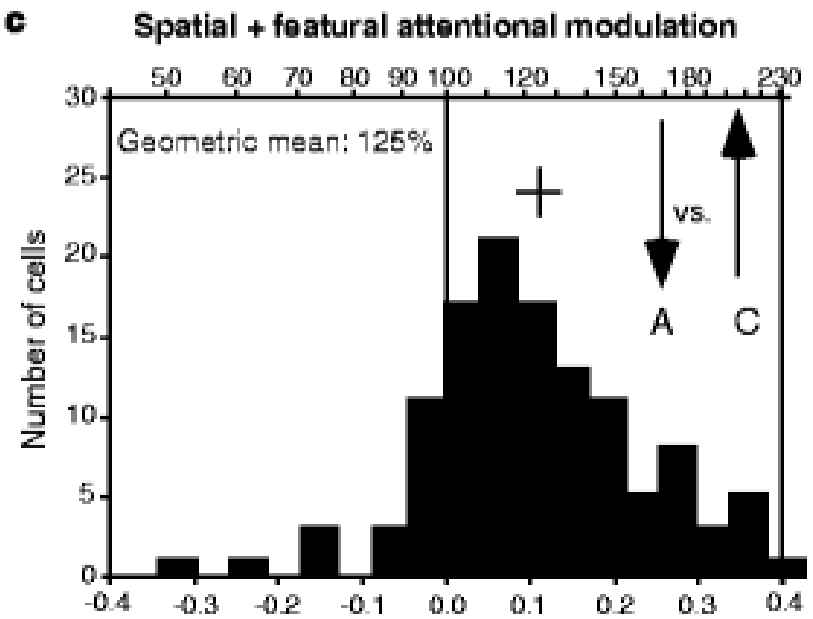


Motter, 1994

The first type of feature-based attention (Neural mechanisms)

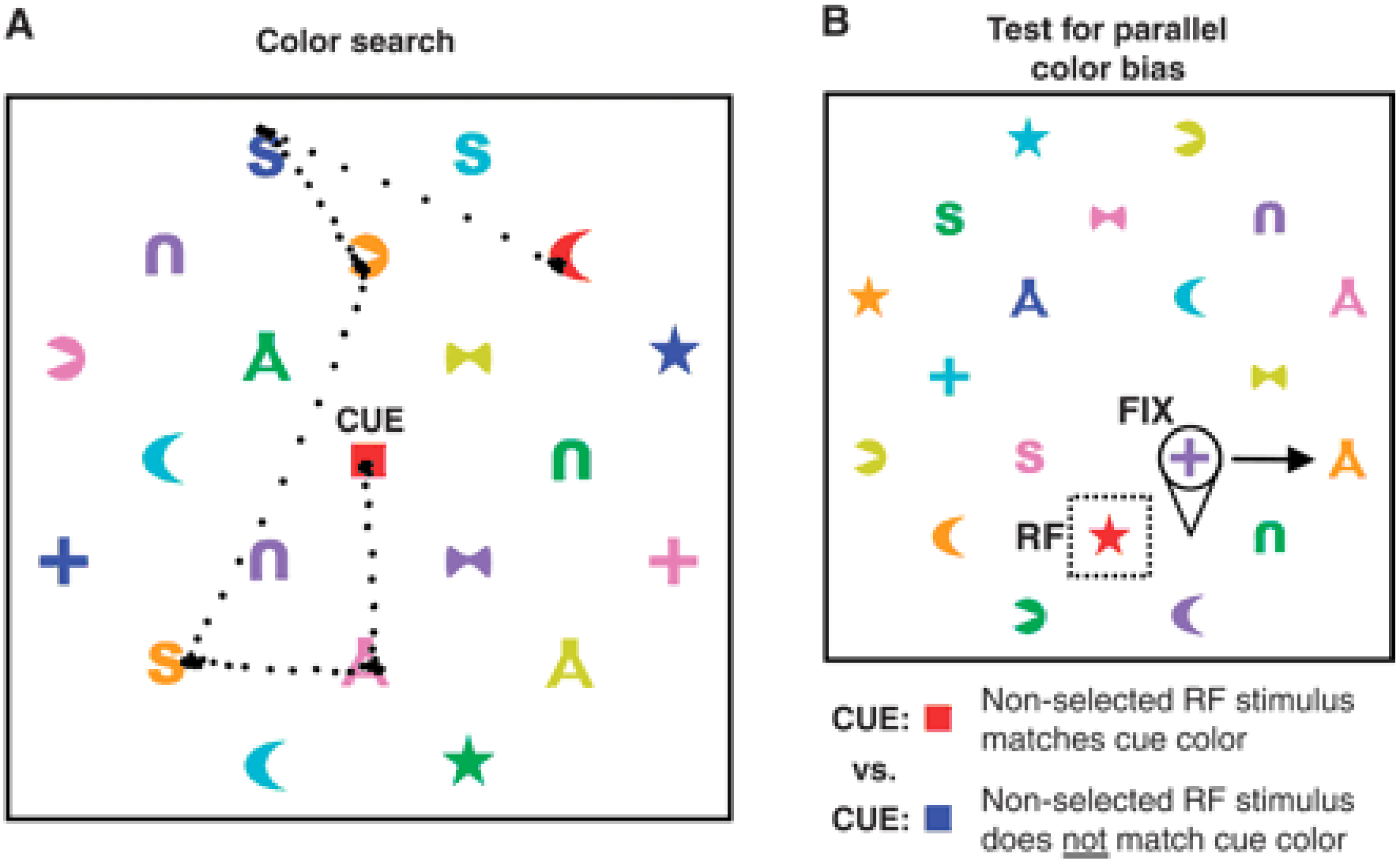




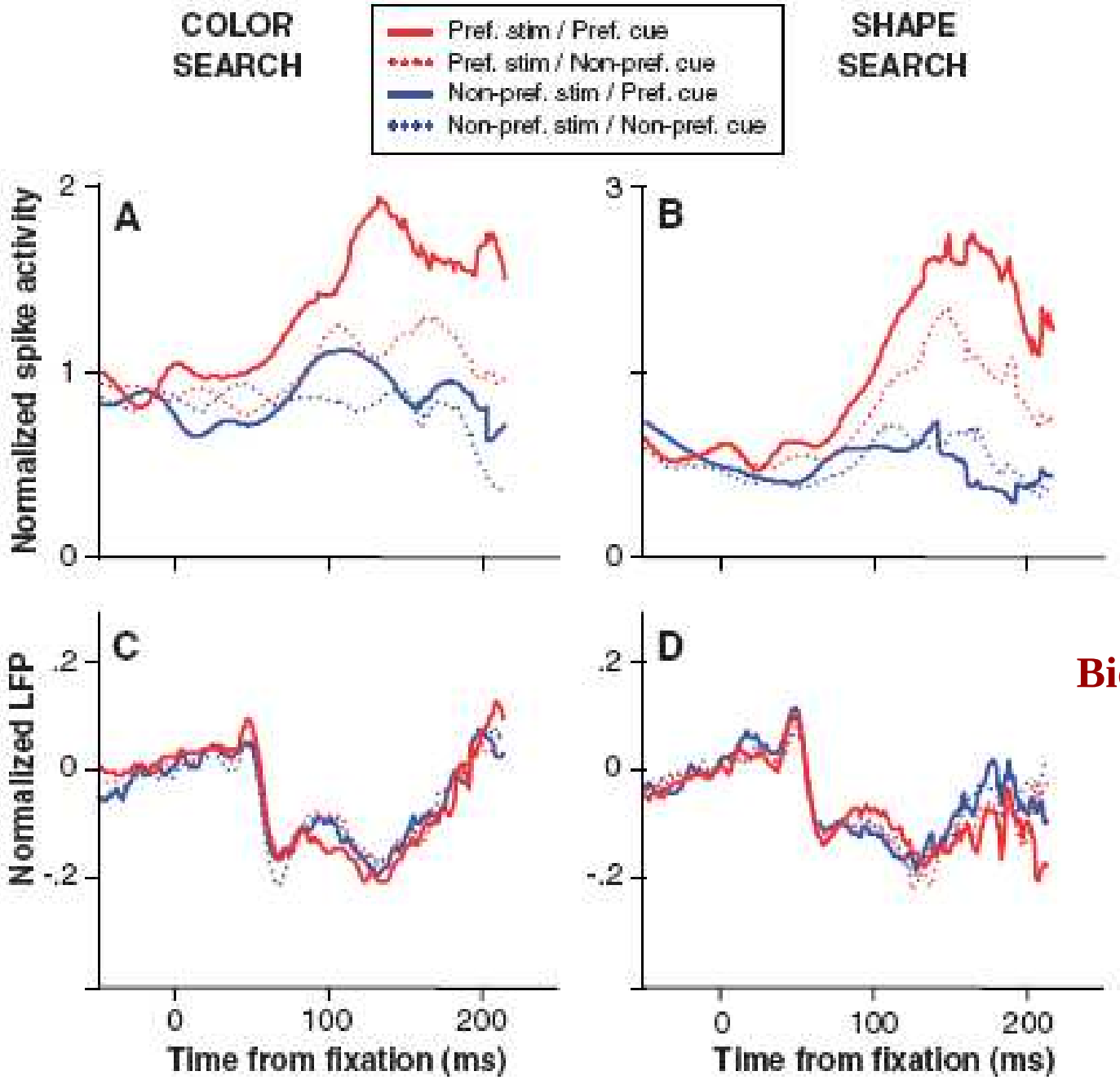


Treue and Martinez-Trujillo, 1999

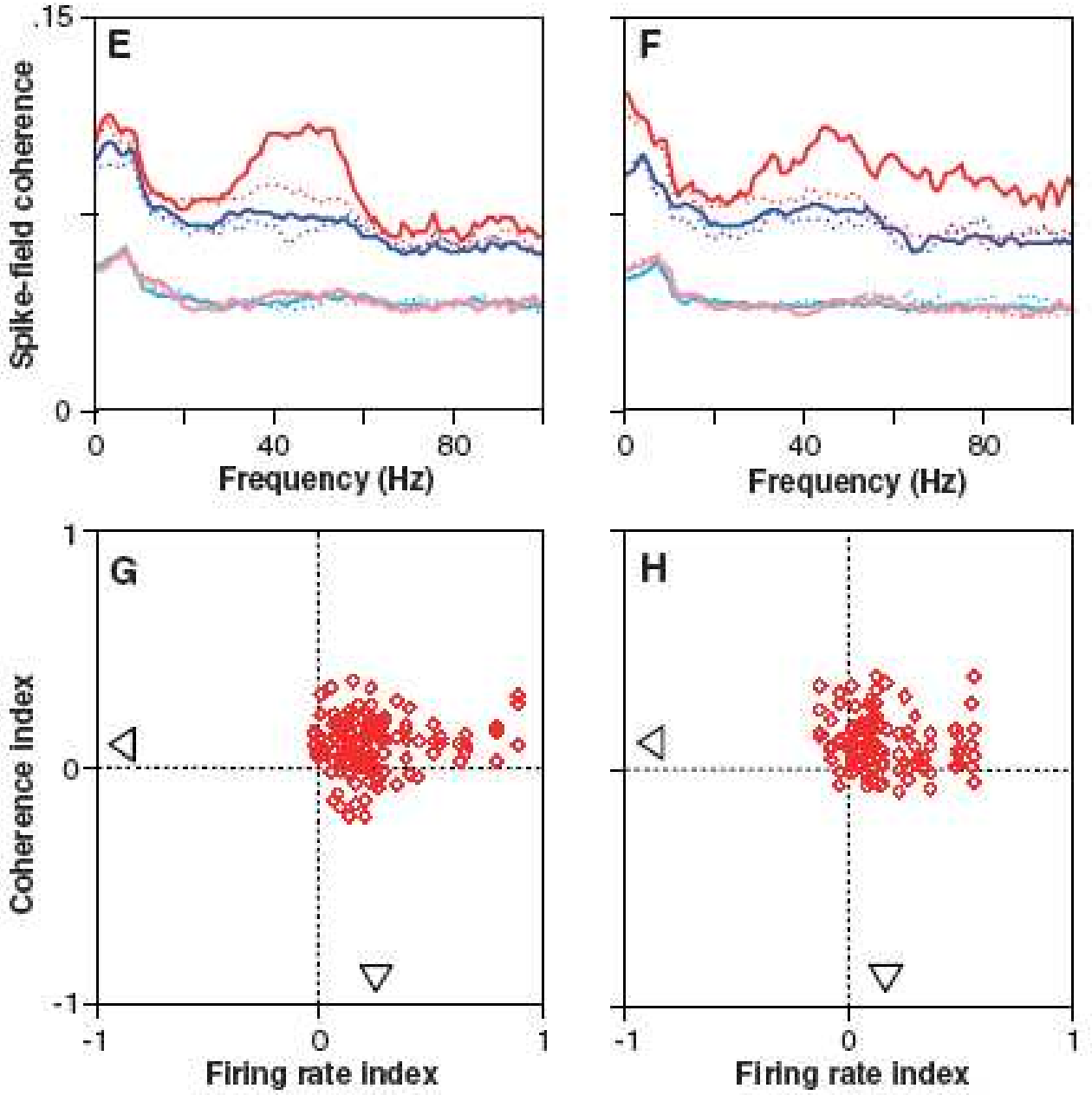
A parallel mechanism to help find the target object in visual search tasks



Bichot, Rossi & Desimone, 2005

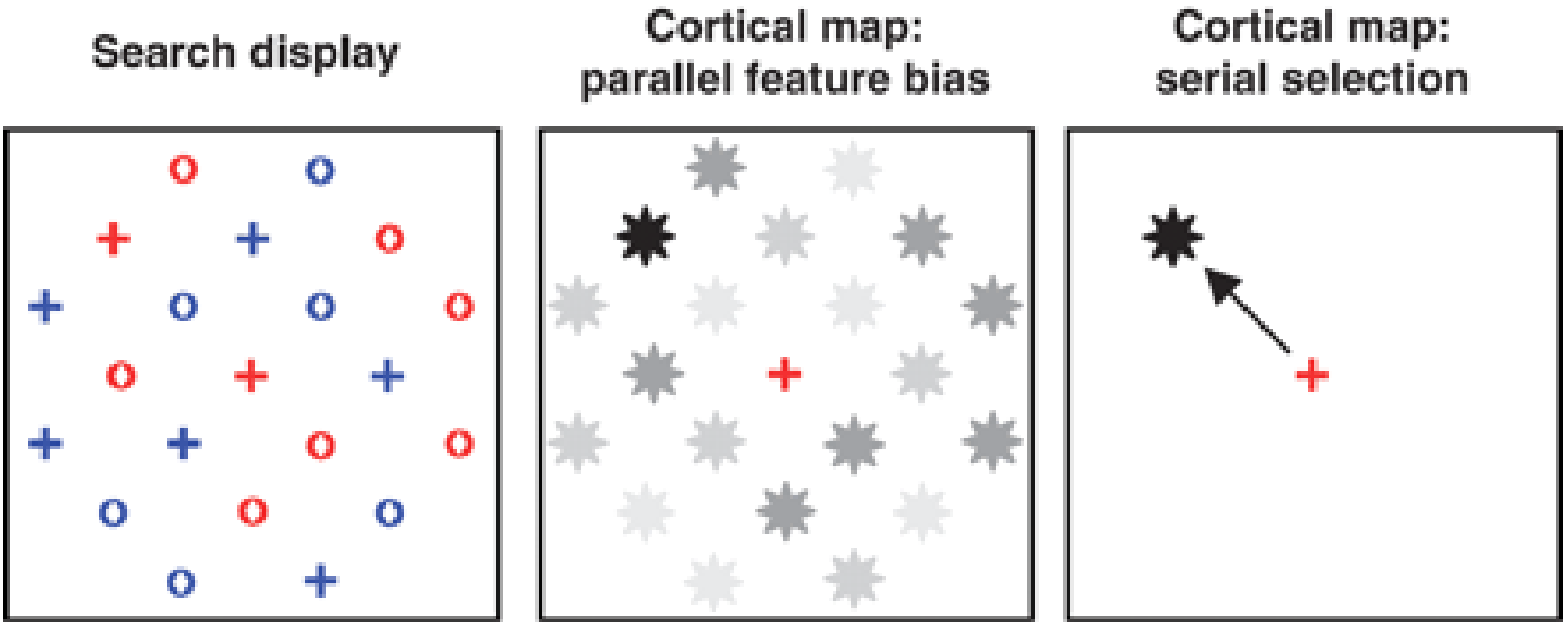


Bichot et al., 2005



Bichot et al., 2005

Highlighting potential targets



Bichot et al., 2005

But there is a completely different type of feature-based attention

The Stroop Task

Congruent

RED

GREEN

Incongruent

RED

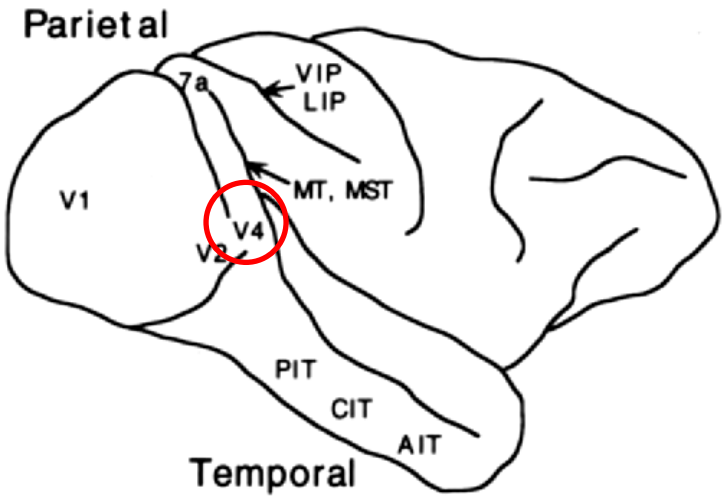
GREEN

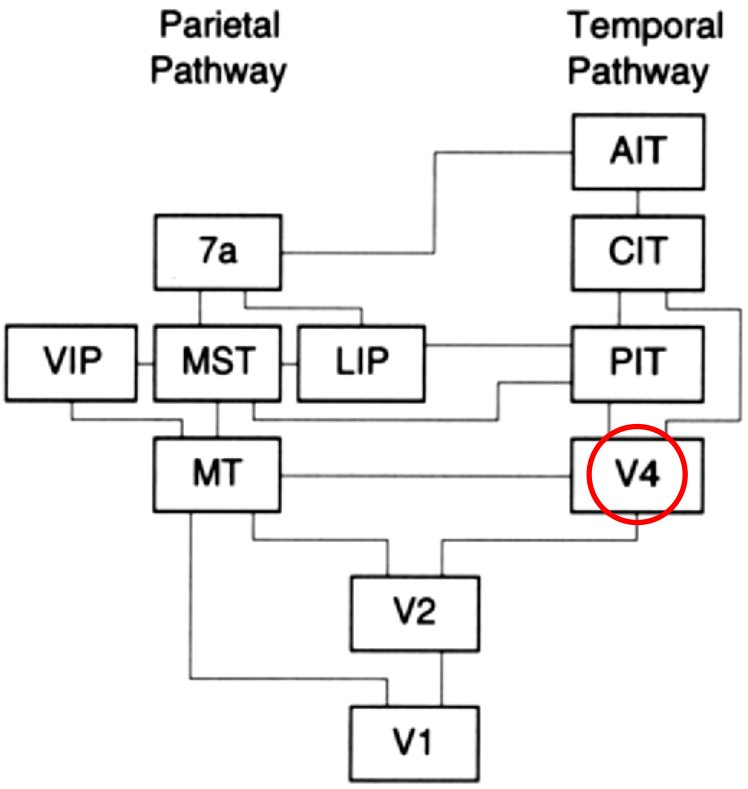
Sorting objects on the basis of one feature while disregarding other features – The Wisconsin card-sorting test

Sorting items: color or shape?

Our goal:

Explore the neural mechanisms of this form of feature selective attention in area V4, a critical node along the ventral pathway





Mirabella et al., 2007

Giovanni Mirabella

Bjoerg Kilavik

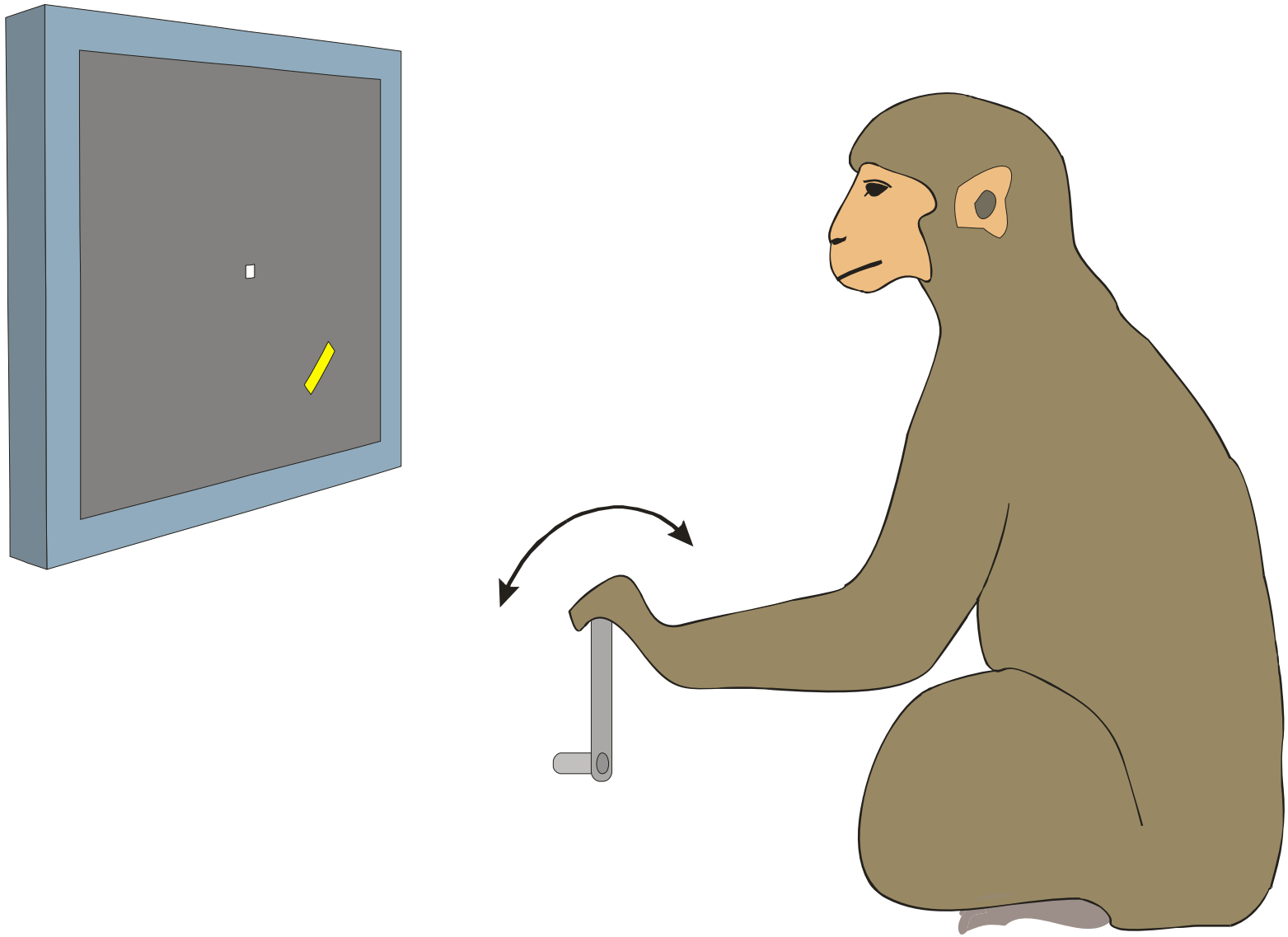
Giuseppe Bertini

Chiara Della Libera

Ines Samengo

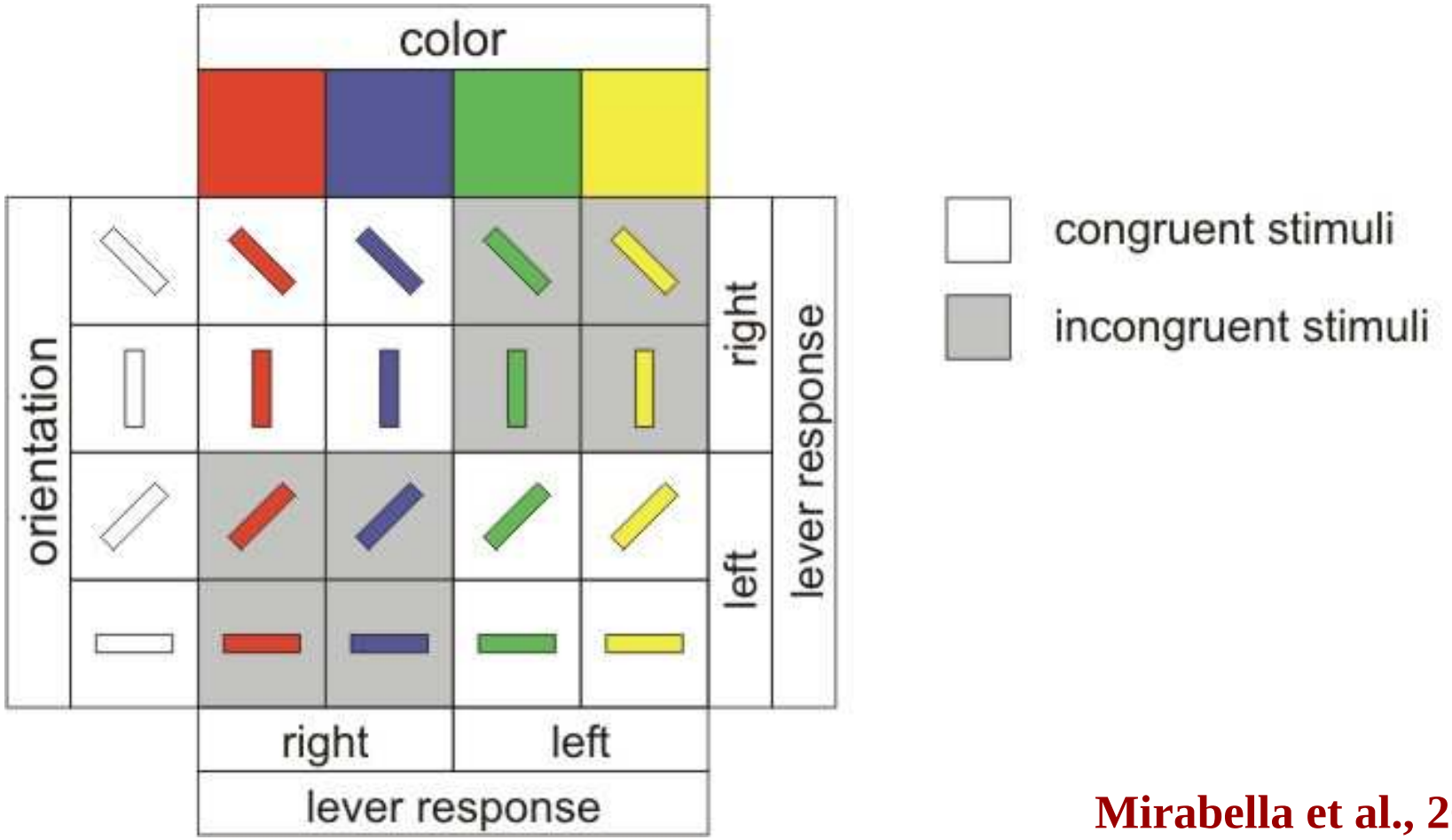
Deborah Frilli

The Stroop task made as simple as possible...



STIMULI and TASKS

One of 16 colored, oriented bars was presented inside the receptive field of the recorded neuron under 2 task conditions: Attend to Color and Attend to Orientation



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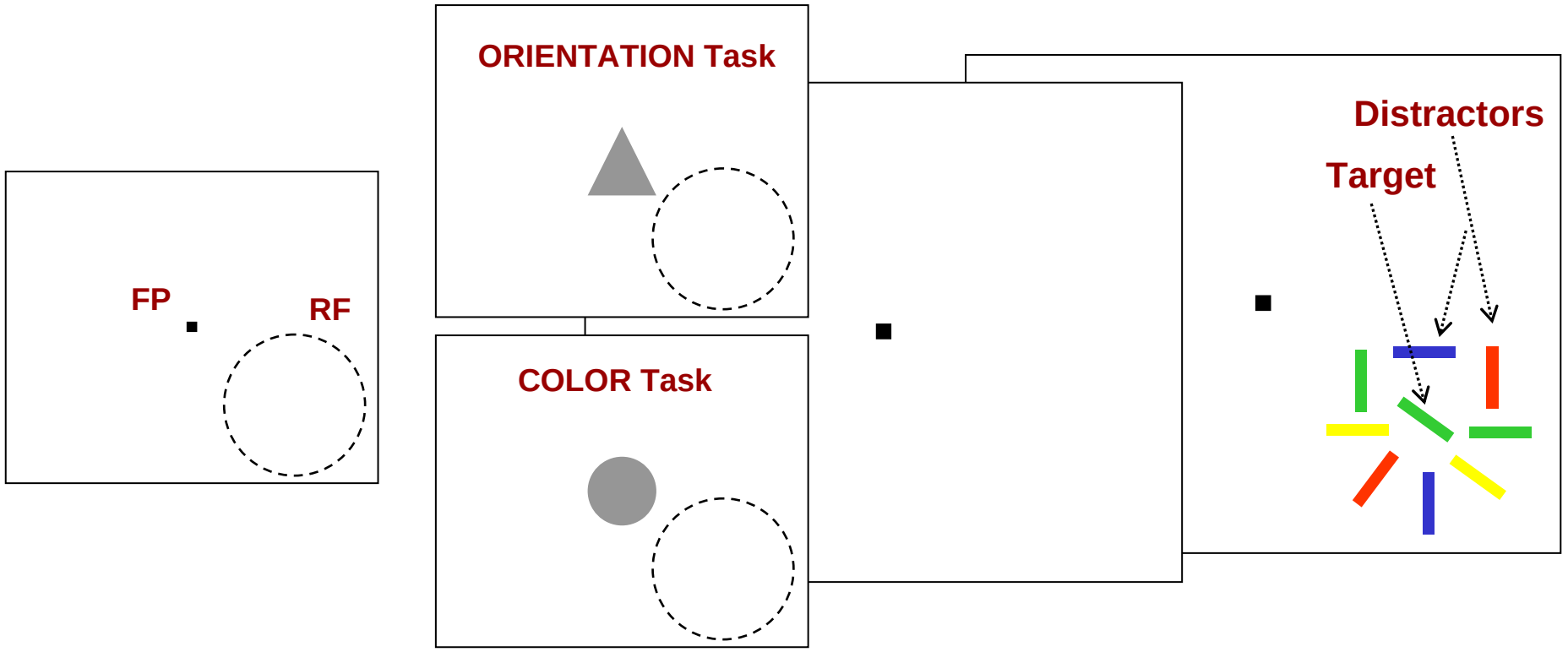
SEQUENCE OF STIMULUS EVENTS



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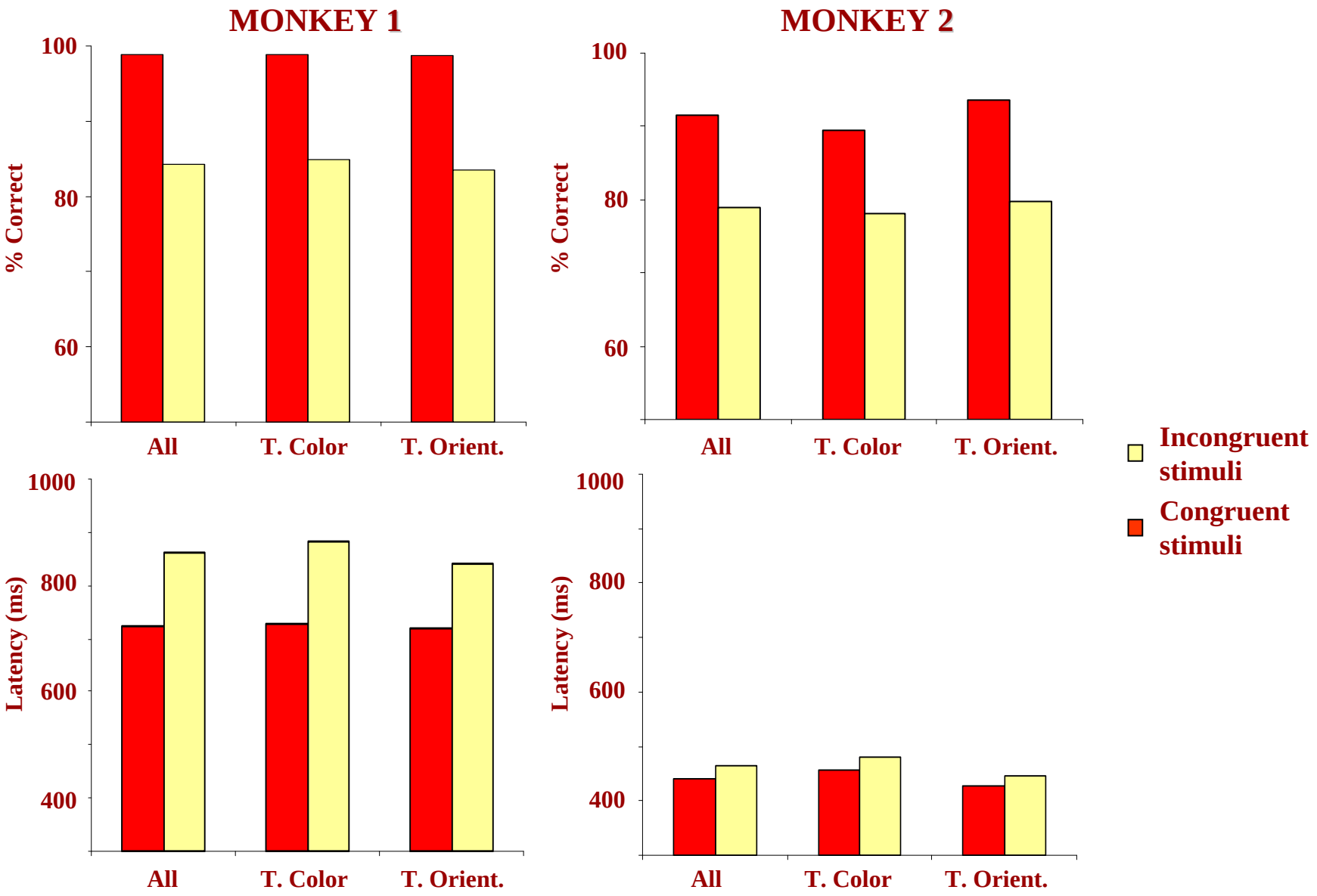
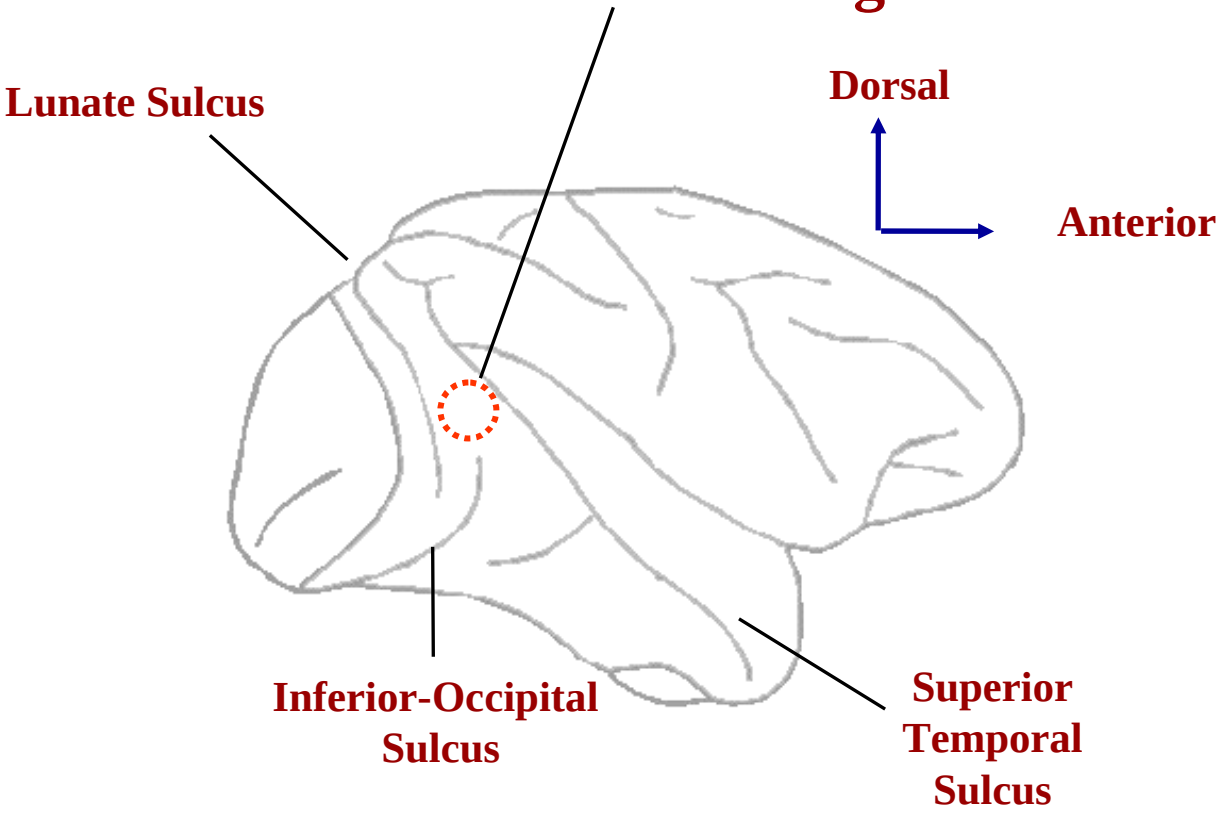
BEHAVIORAL PERFORMANCE FOR CONGRUENT AND INCONGRUENT STIMULI



Position of the recording chambers



Single cells (n=152) were recorded from dorsal area V4 of 2 adult male macaques (*Macaca mulatta*)

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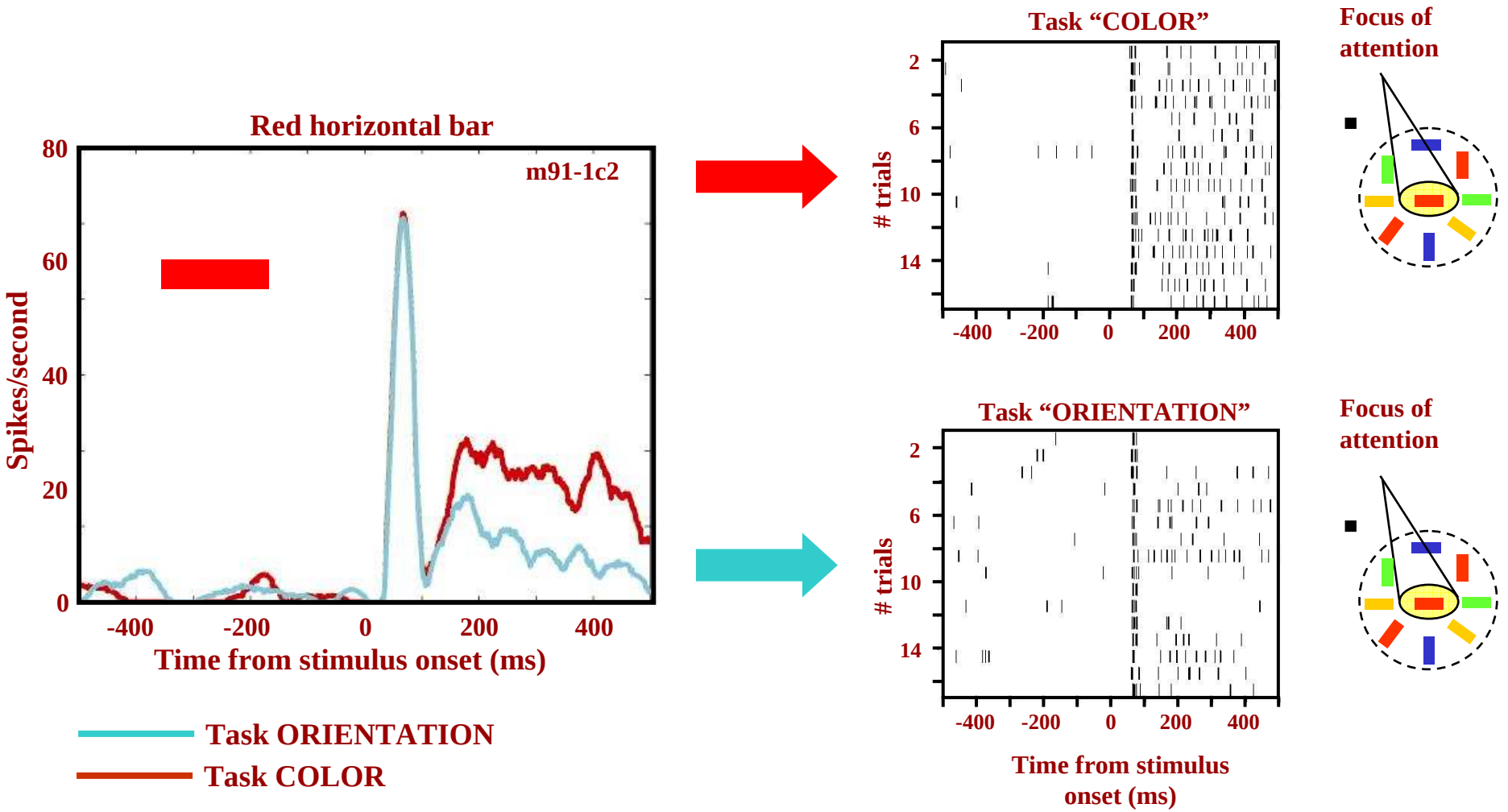
Feature-selective modulation of responses: an example cell



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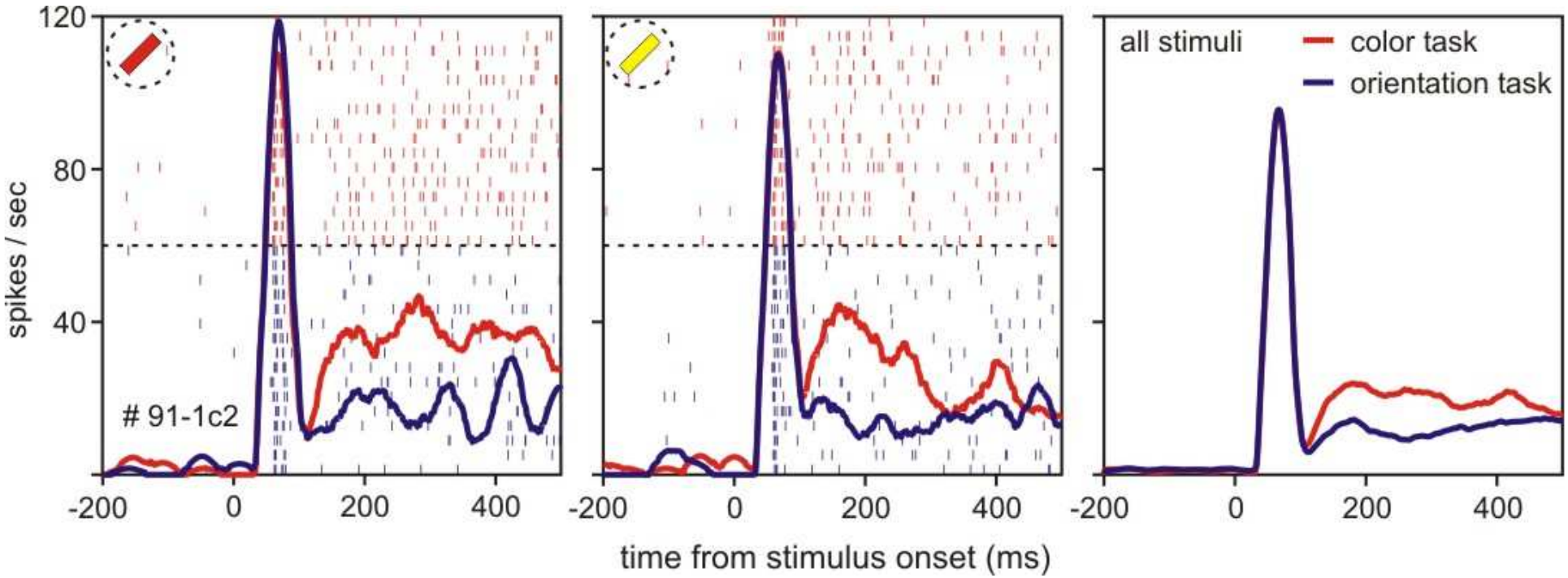
Two more example stimuli and the average effect



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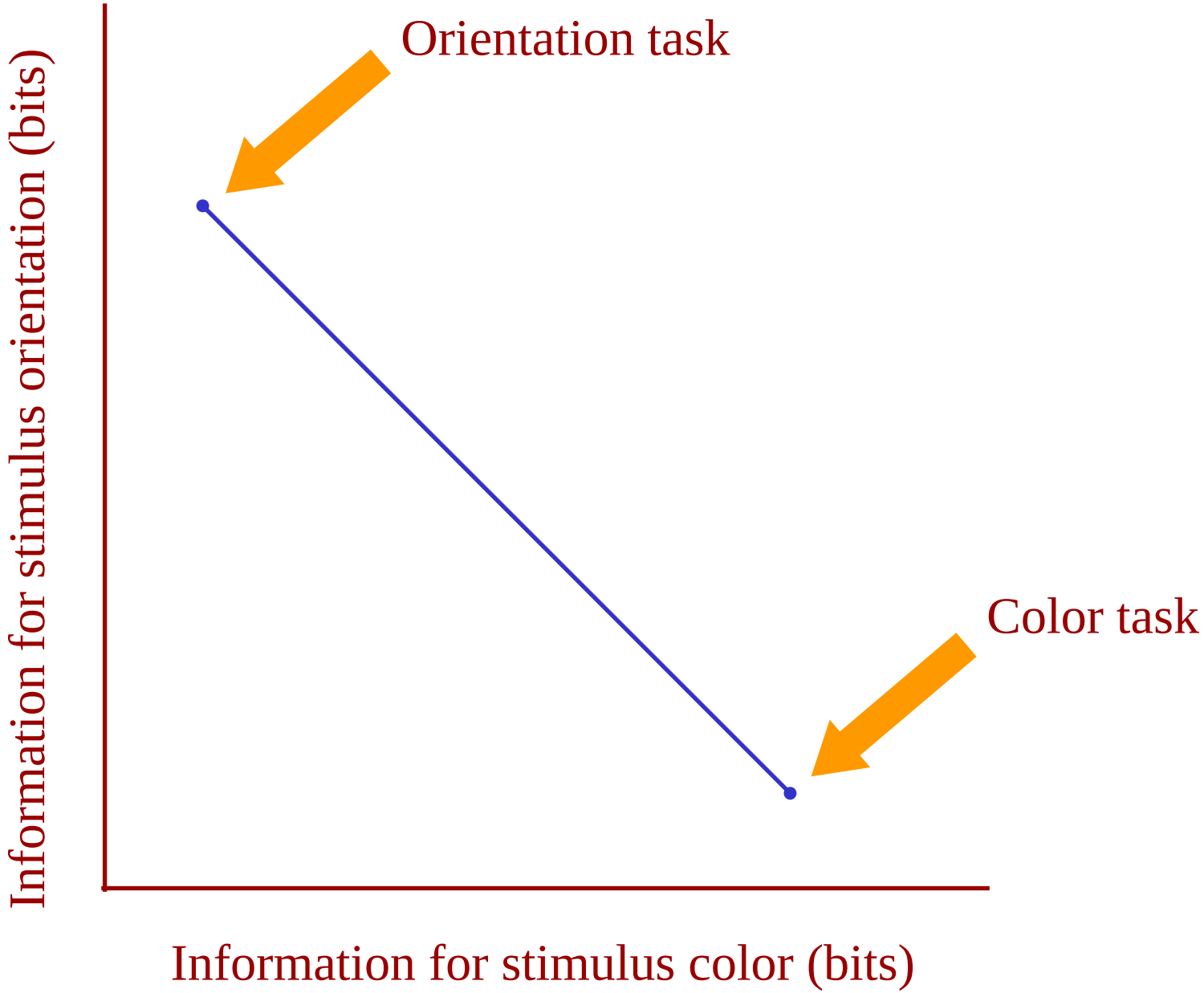
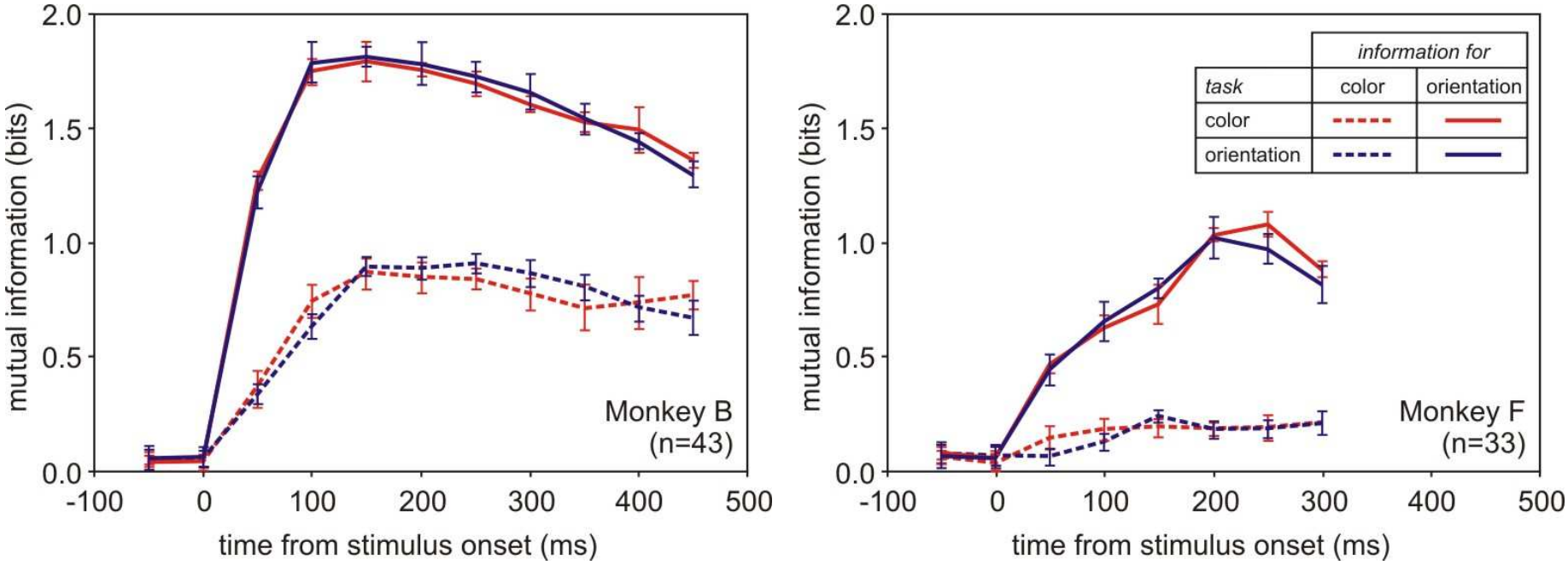
Our initial prediction



Selectivity for COLOR and ORIENTATION depending on task



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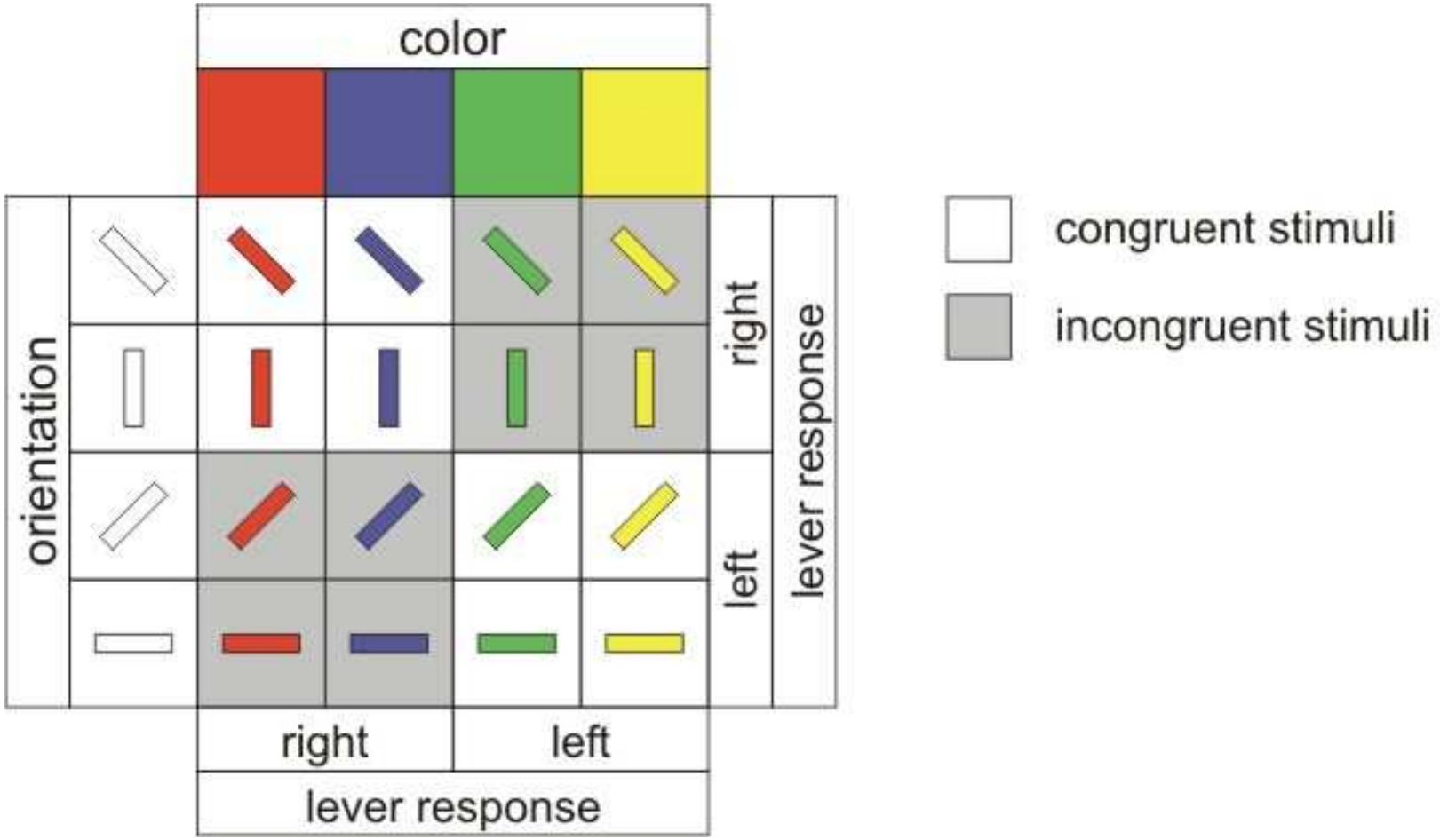
Incongruent stimuli are special



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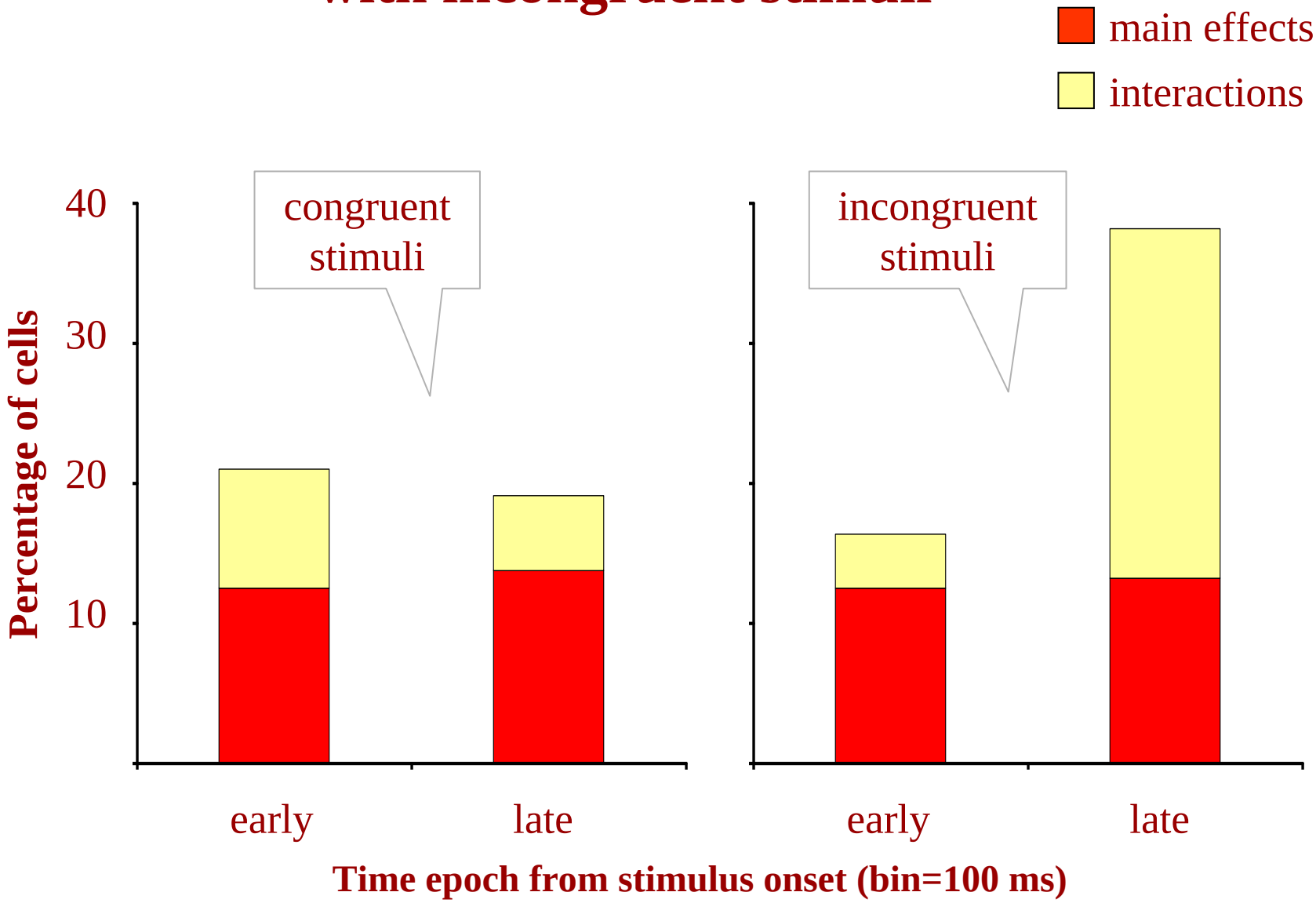
TASK-related effects were observed more often with incongruent stimuli



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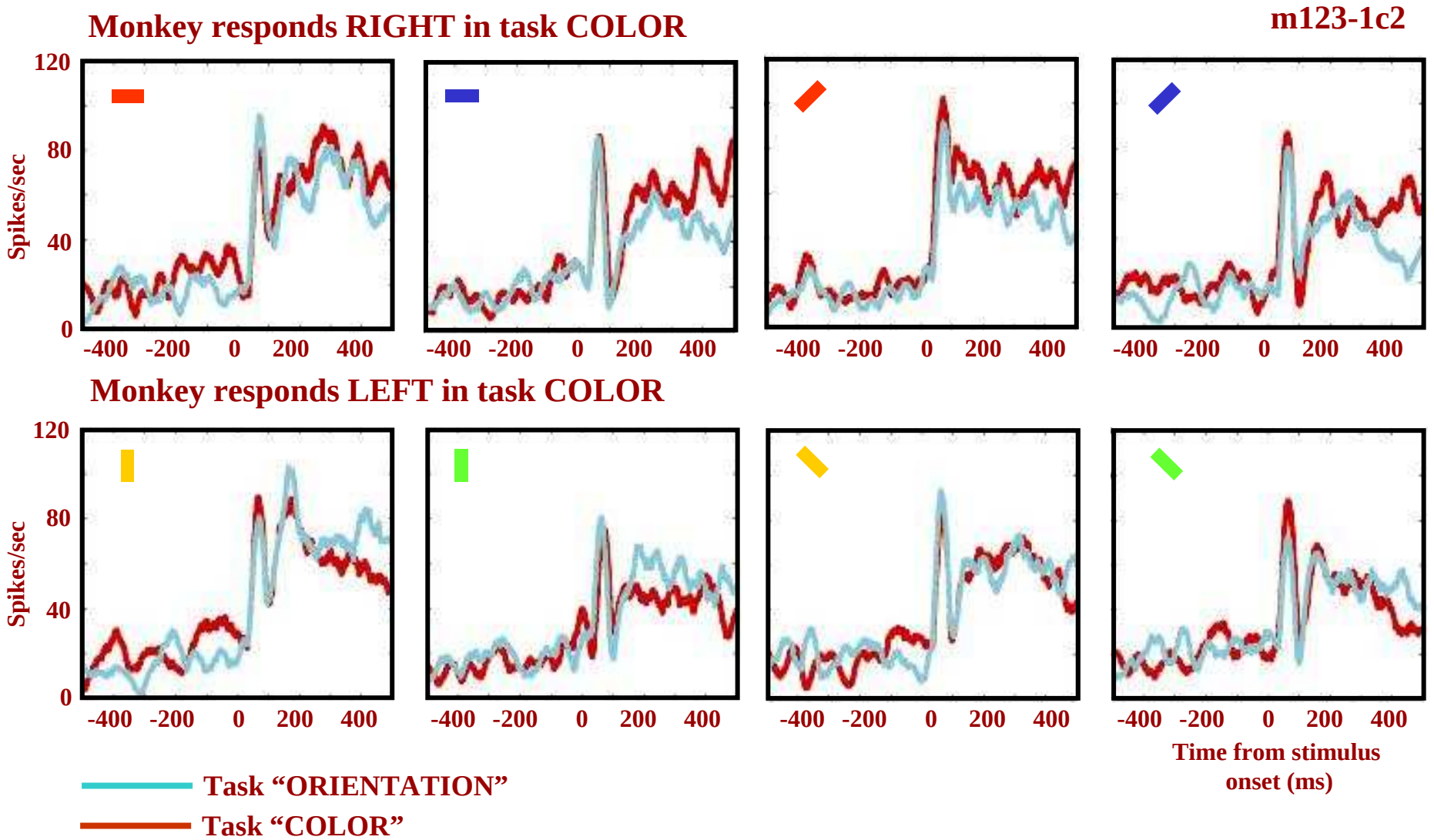
Single-cell example (INCONGRUENT STIMULI)



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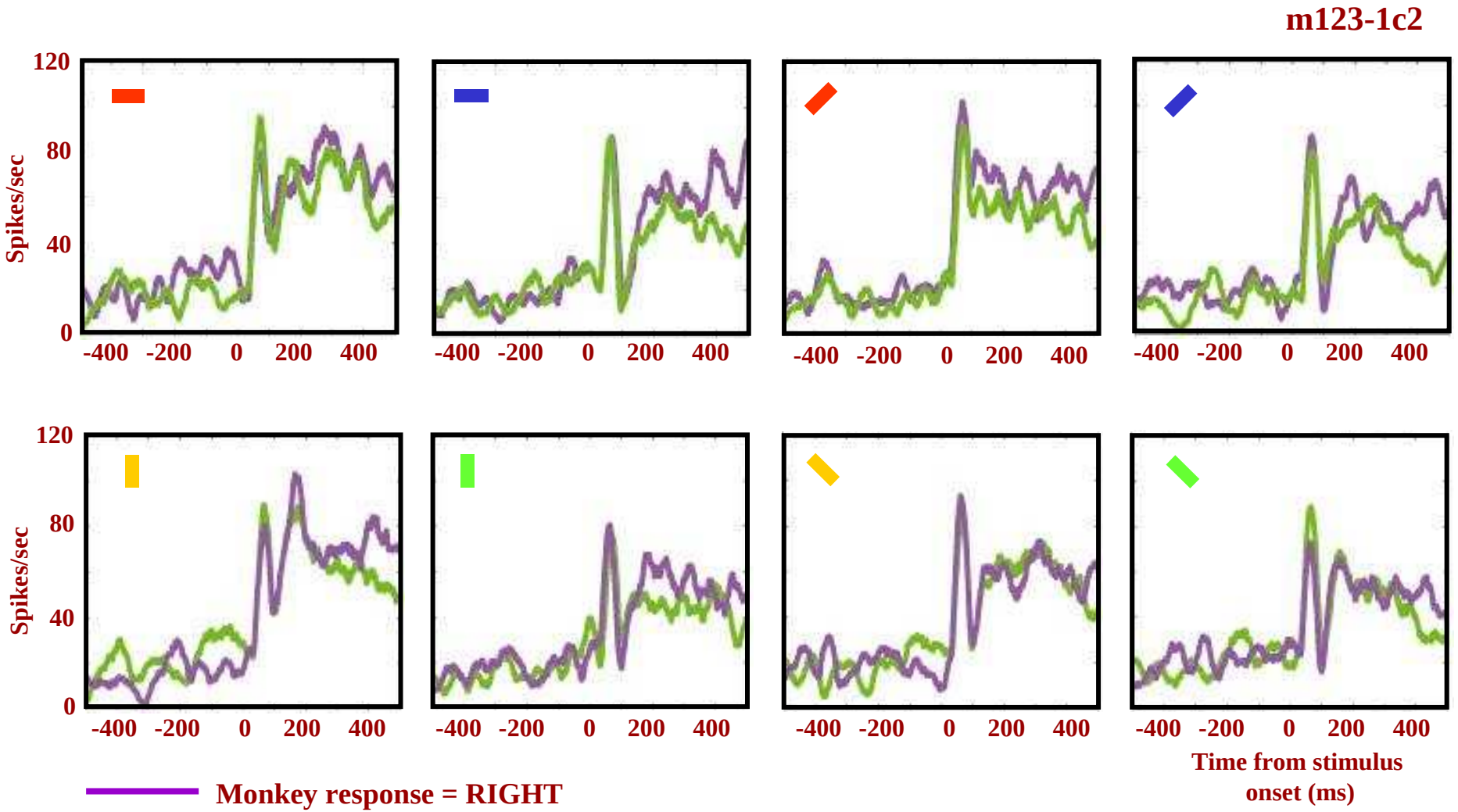
Single-cell example (INCONGRUENT STIMULI)



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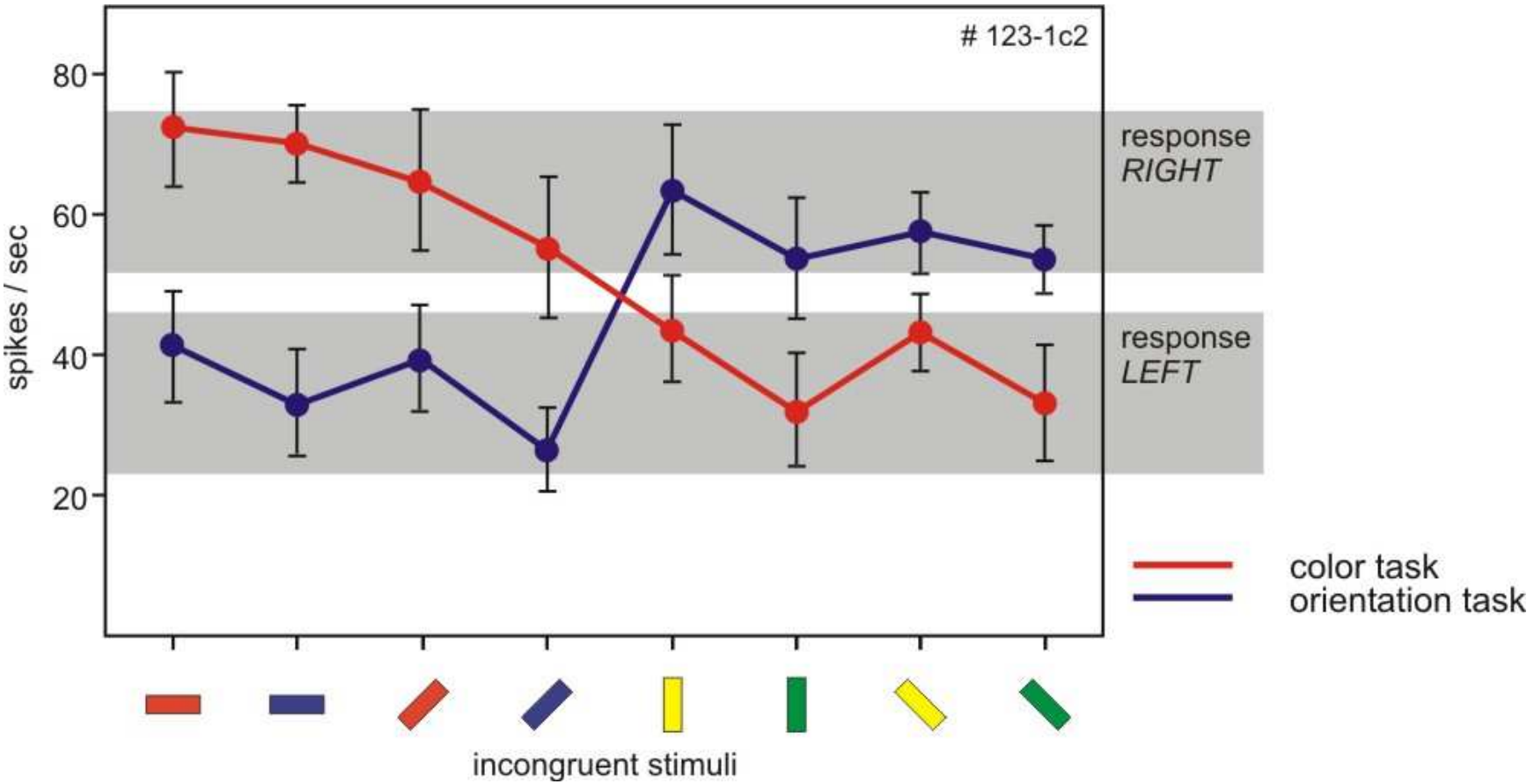
single-cell example (incongruent stimuli only)



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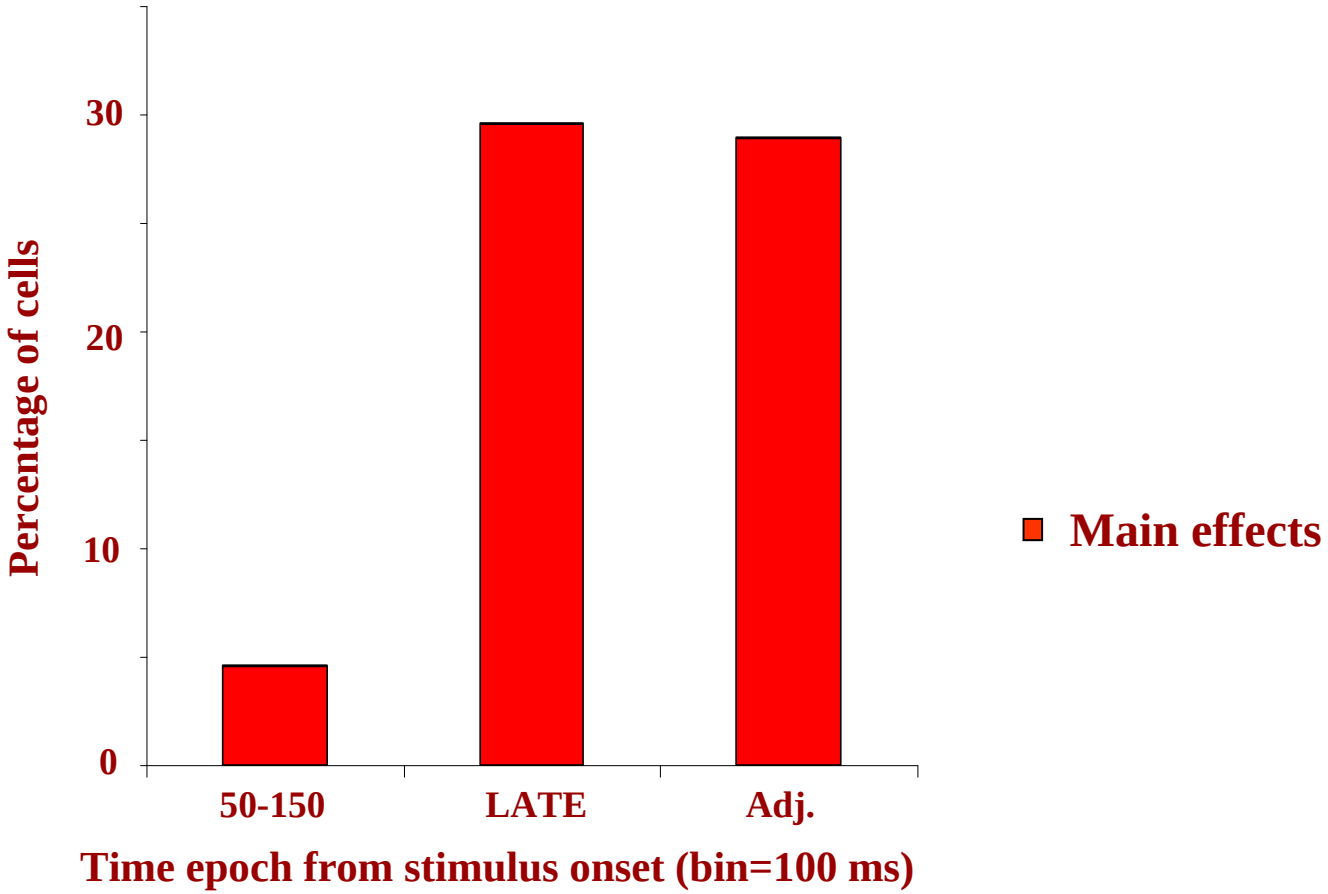
RESPONSE-RELATED EFFECTS

INCONGRUENT STIMULI

(2-WAY ANOVA - factors: 8 Stimuli, Right vs. Left response)



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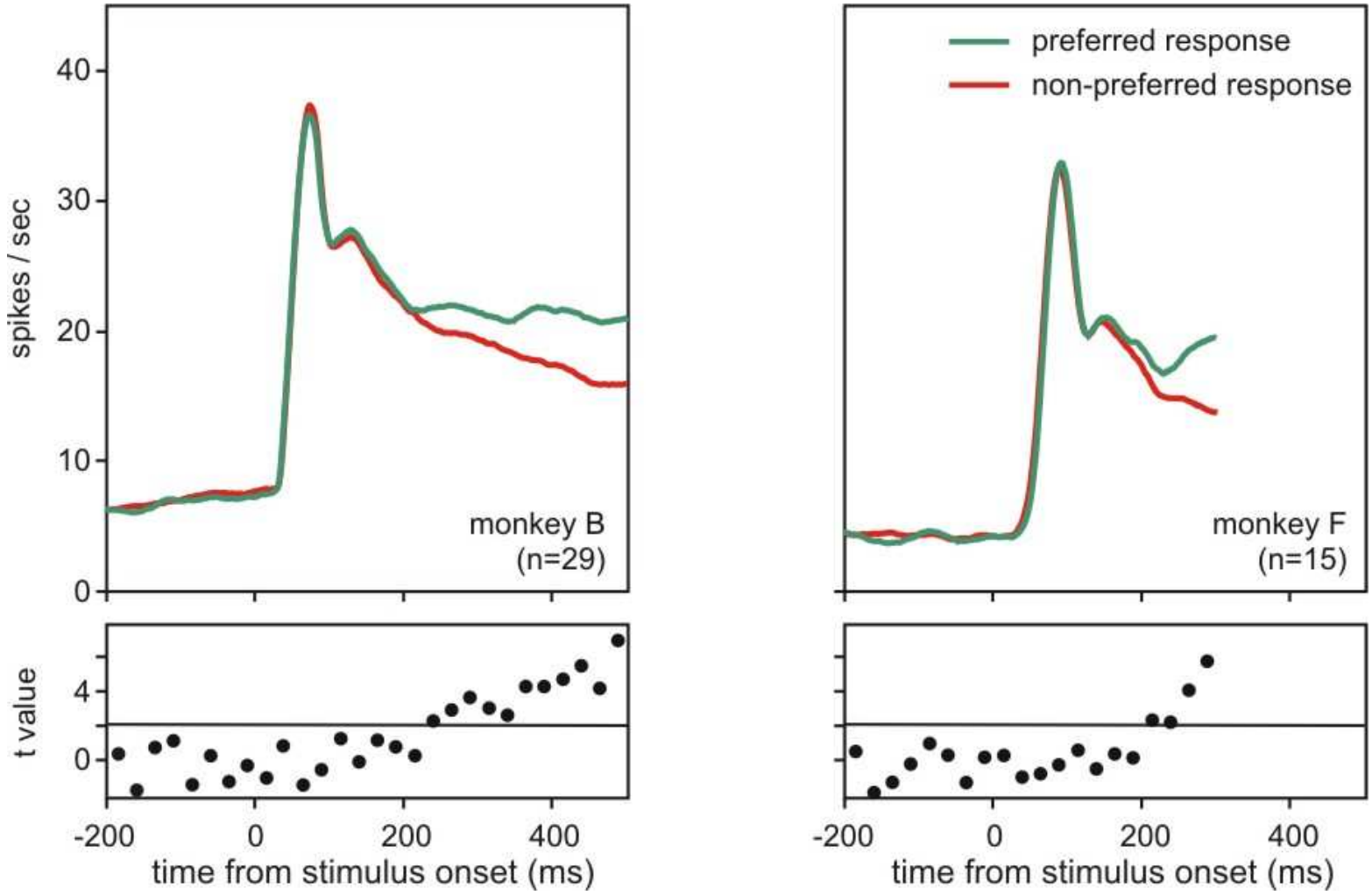
Response-related effect across the neuronal population



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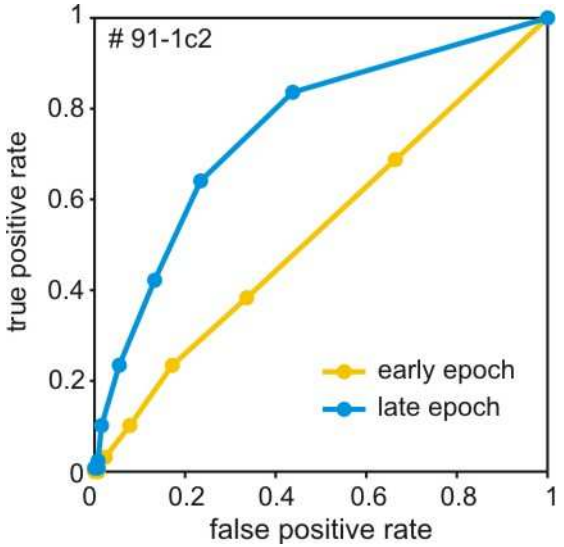
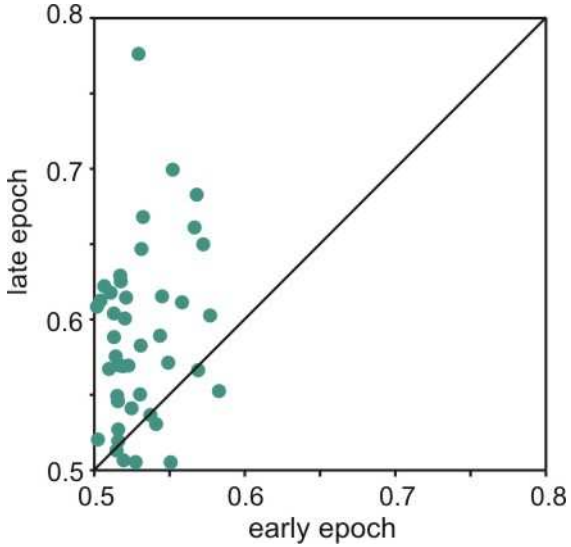
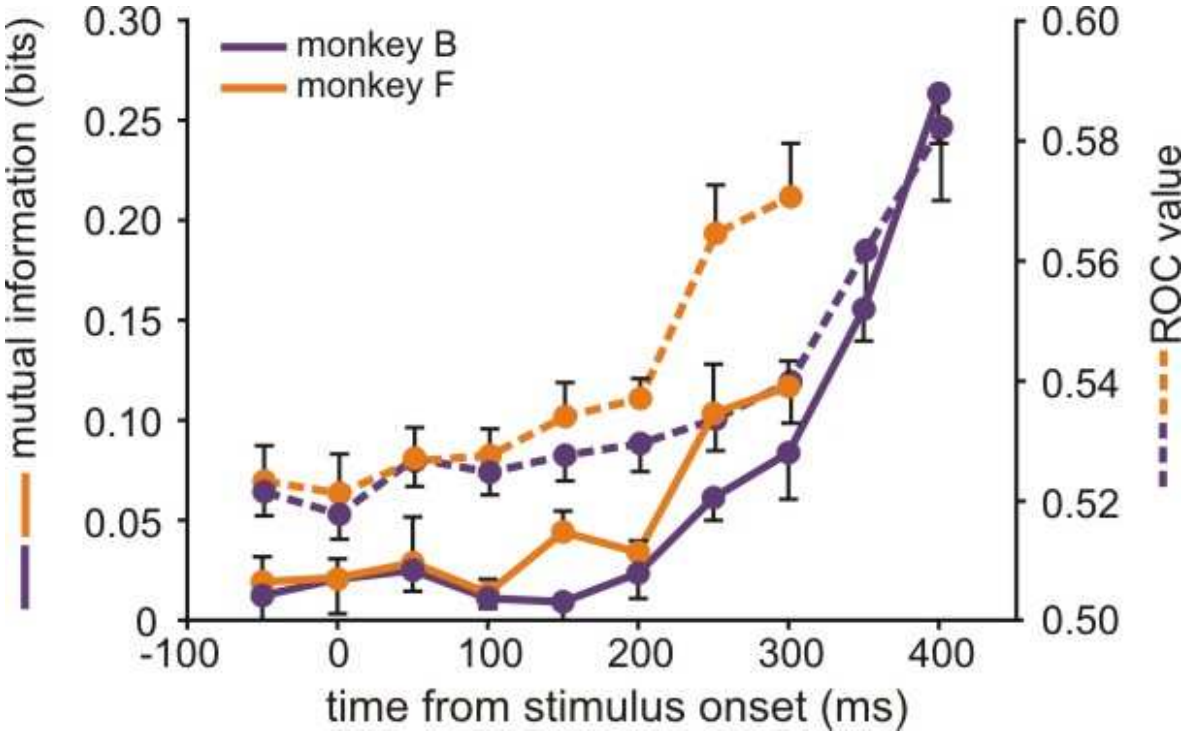




Time course of information and choice probability



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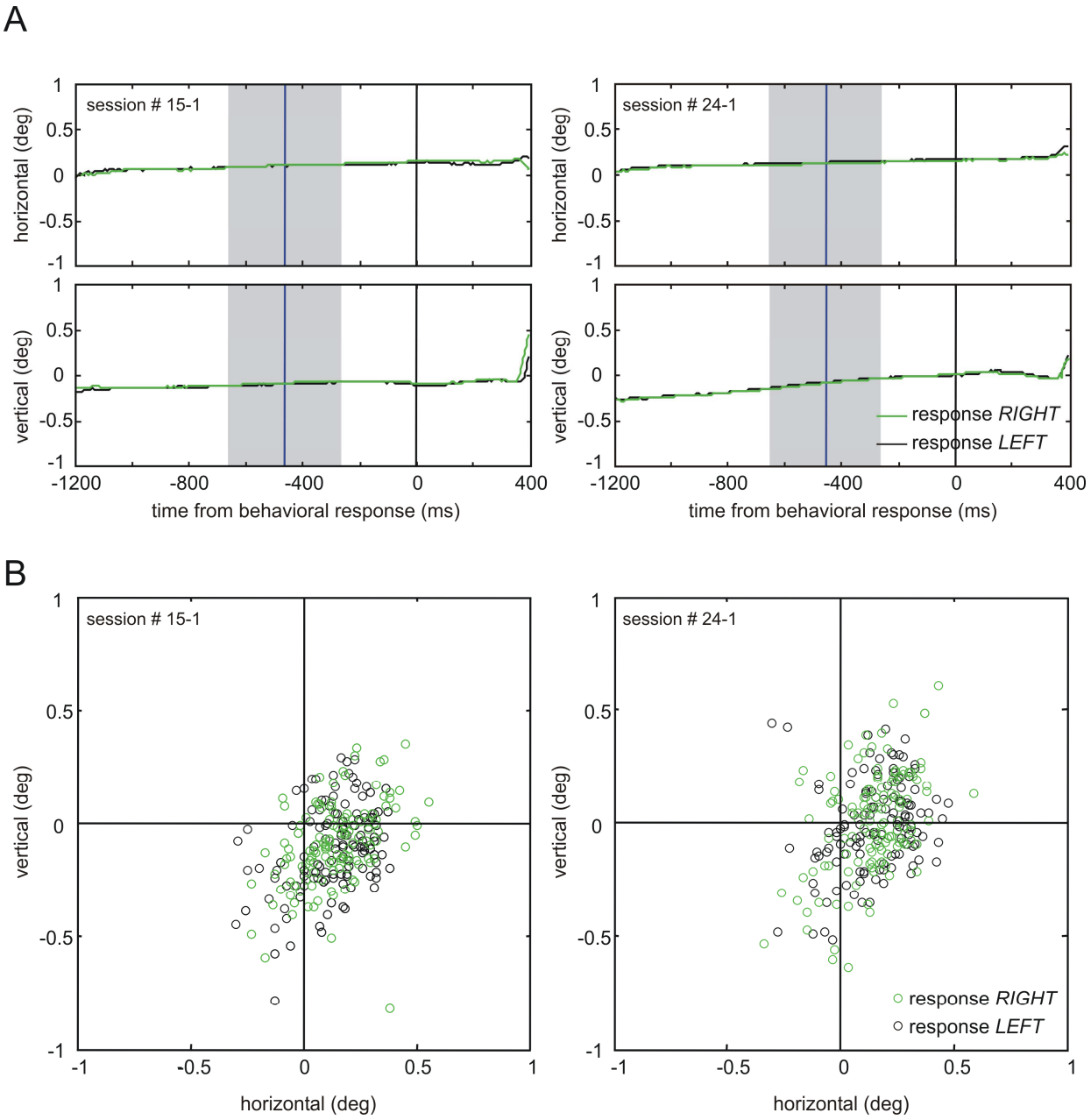
The effect is not due to differences in eye position depending on the direction of the impending lever response



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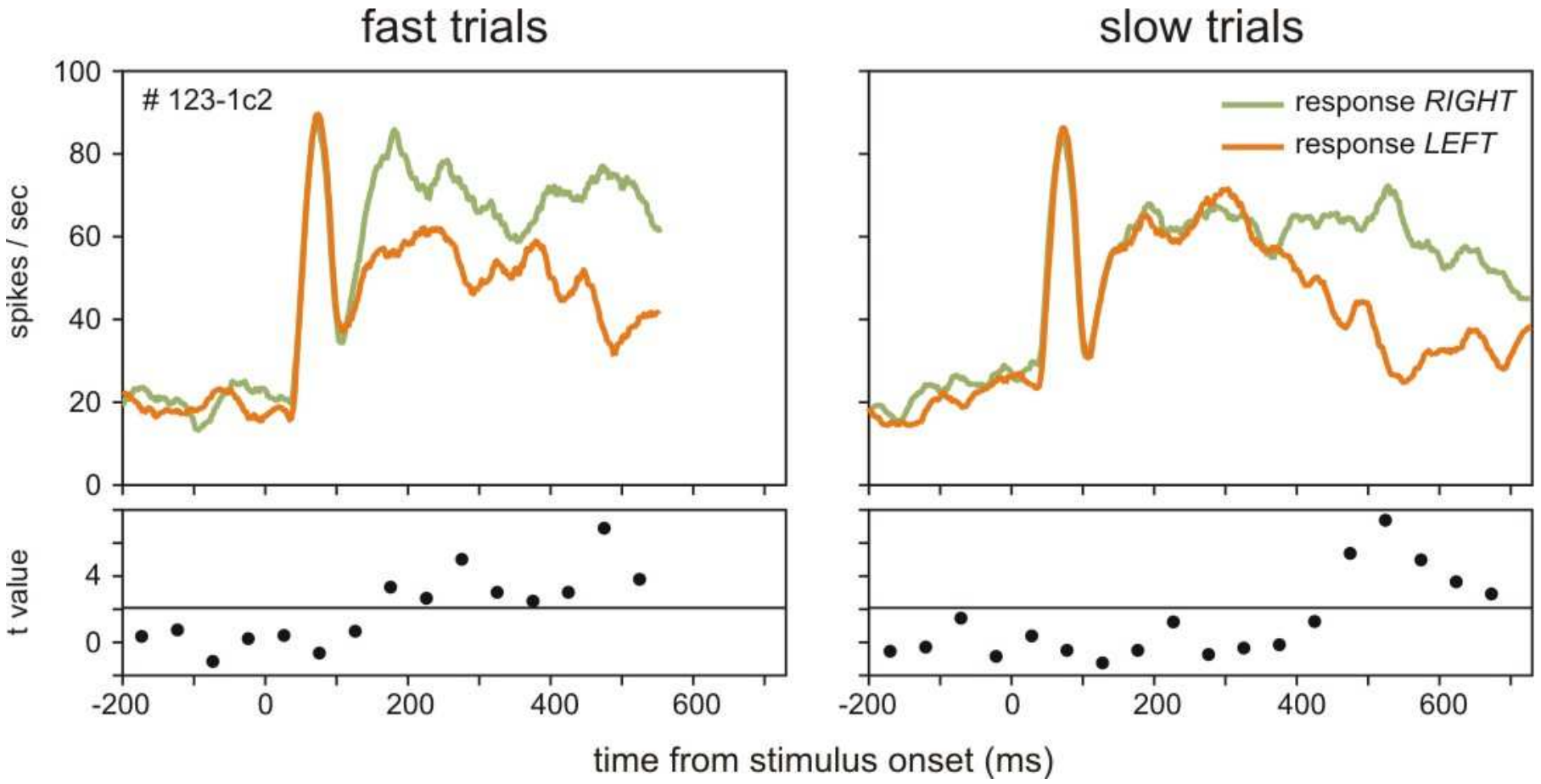
To what extent is the effect linked to the actual behavior of the animal?

Comparing fast vs. slow trials (single cell example)



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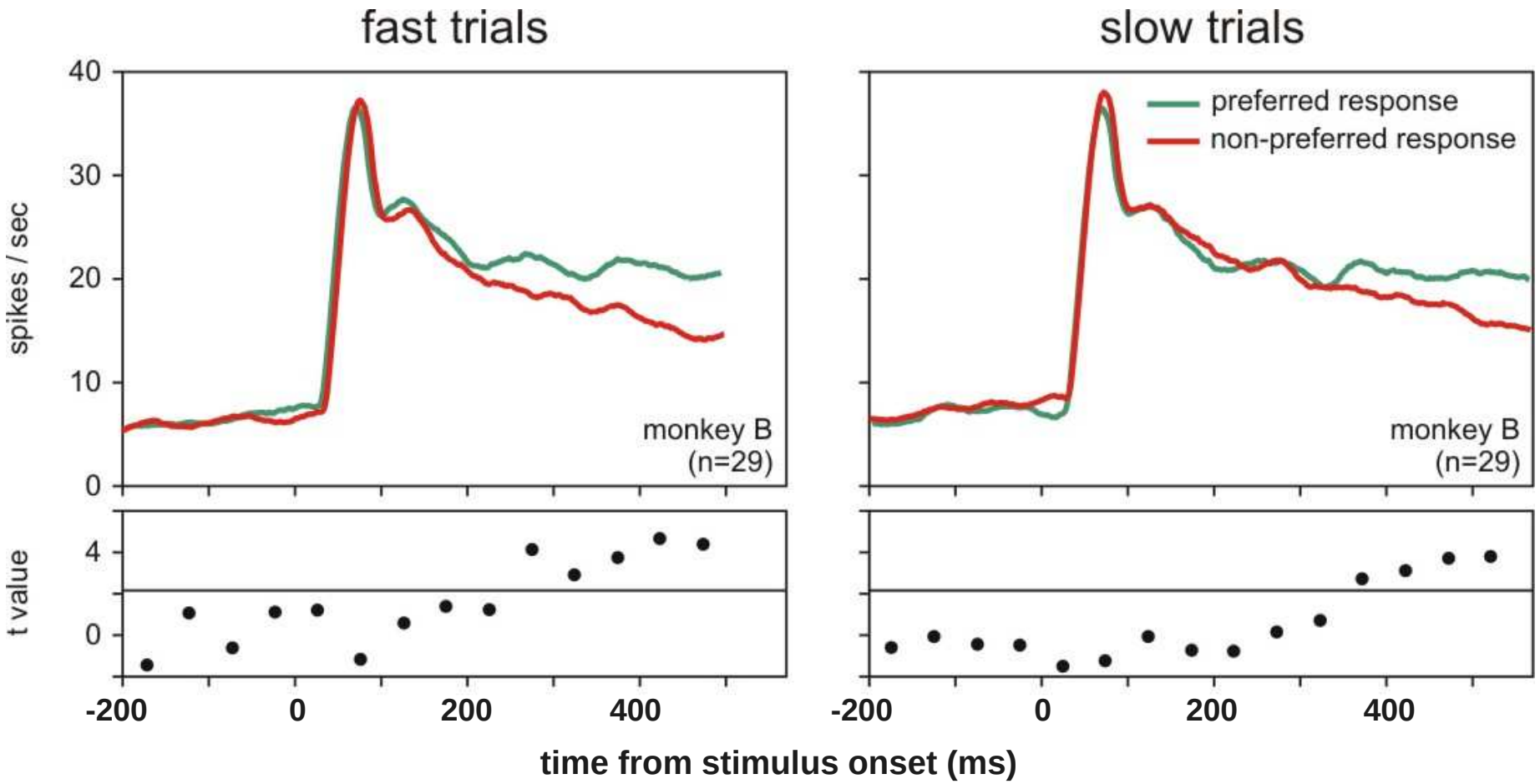
Comparing fast vs. slow trials (population analysis)



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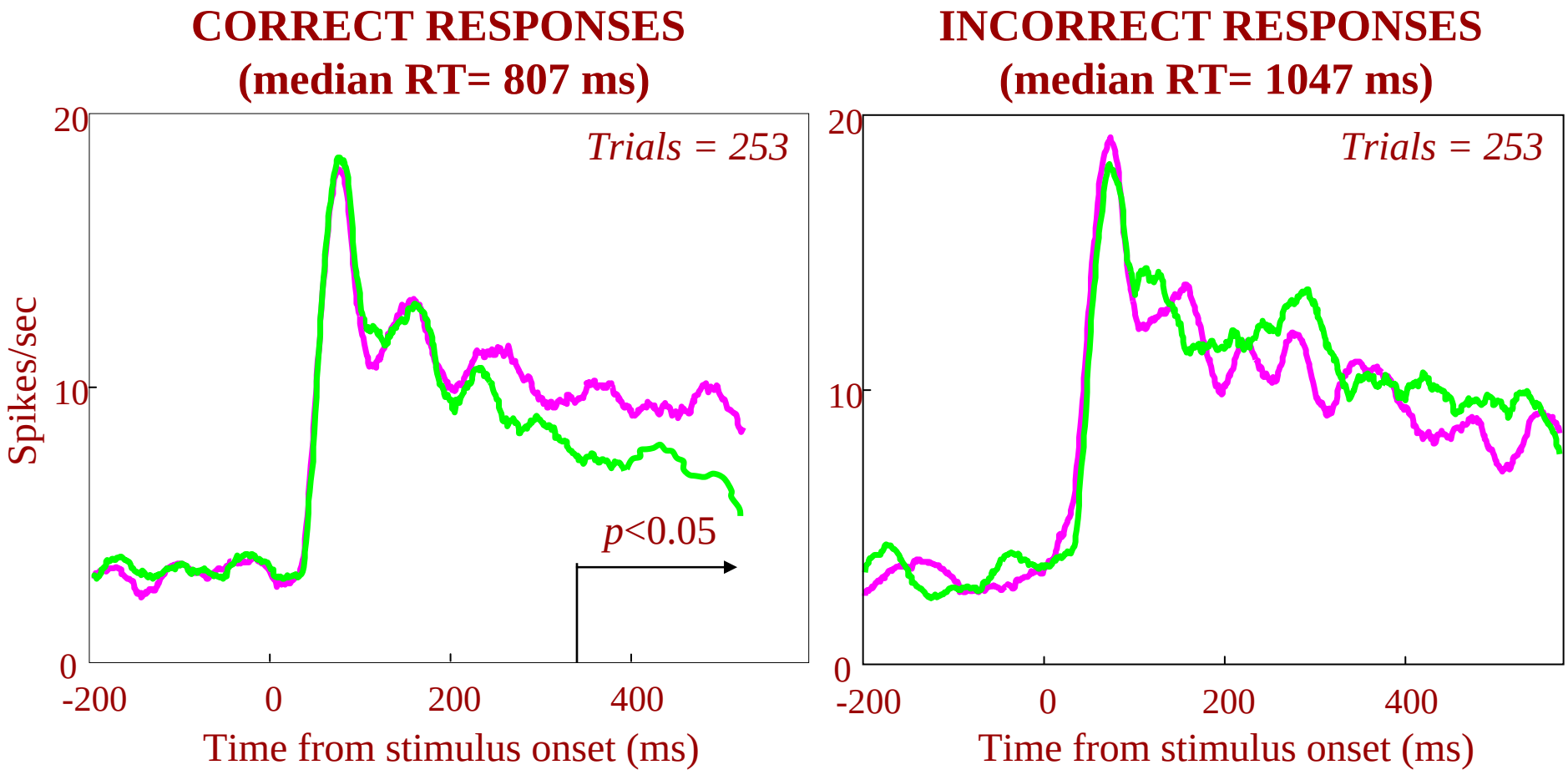
CORRECT vs. INCORRECT RESPONSES (MONKEY 1, n=29)



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Control experiments have also shown that the response-related modulation is eliminated when the monkey delivers one or the other motor response in relation to a visual stimulus presented outside the receptive field of the recorded neuron

CONCLUSIONS

- **Responses of many V4 neurons appear to be gated by feature-selective attention**
- **At least under our task conditions, effects of feature-selective attention did not take the form of consistent changes in selectivity (tuning) as a function of task**
- **Instead, about one third of the studied neurons were able to "translate" the attended stimulus feature into a *categorical* code for the required behavioral response**
- **This suggests that V4 plays a role at the level of decision stages of processing, i.e. in linking perception to action**

Thank you!