NST II Psychology
NST II Neuroscience (Module 5)

Brain Mechanisms of Memory and Cognition – 3

Attention; the binding problem

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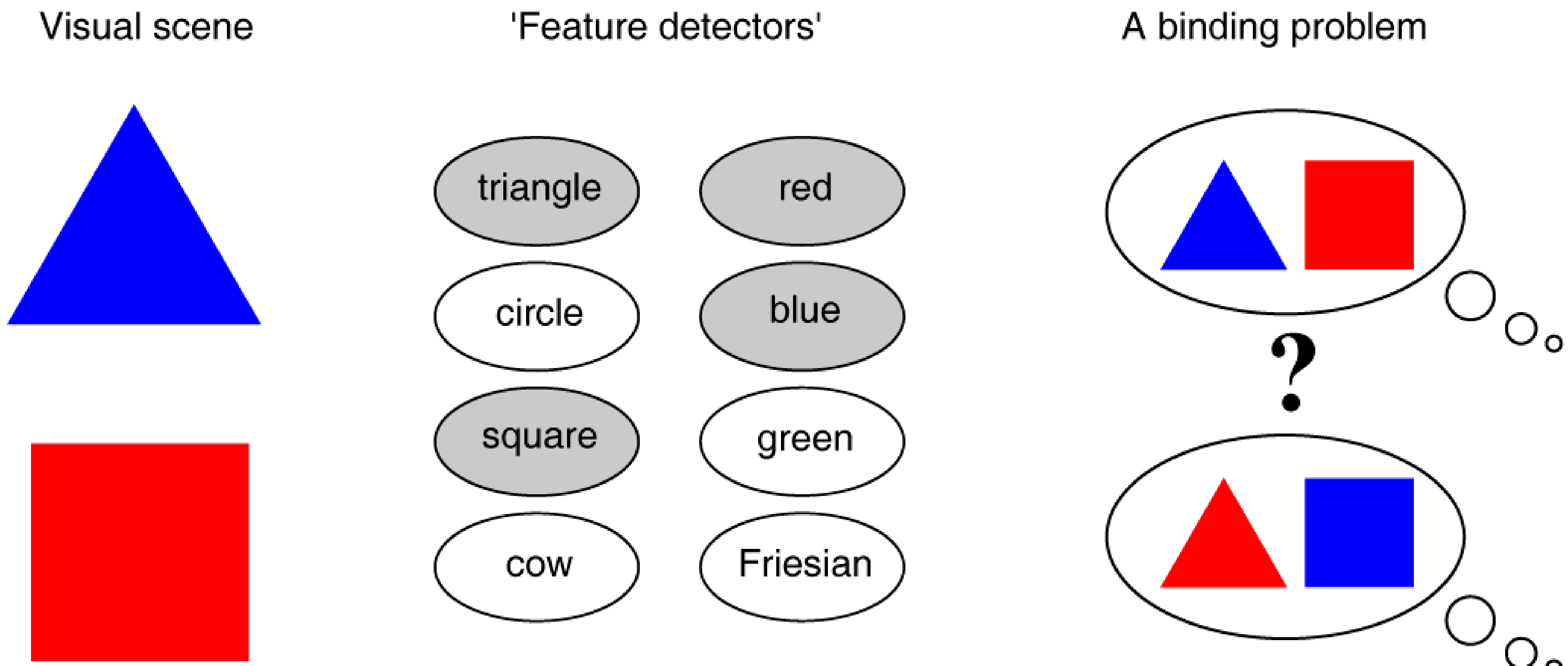
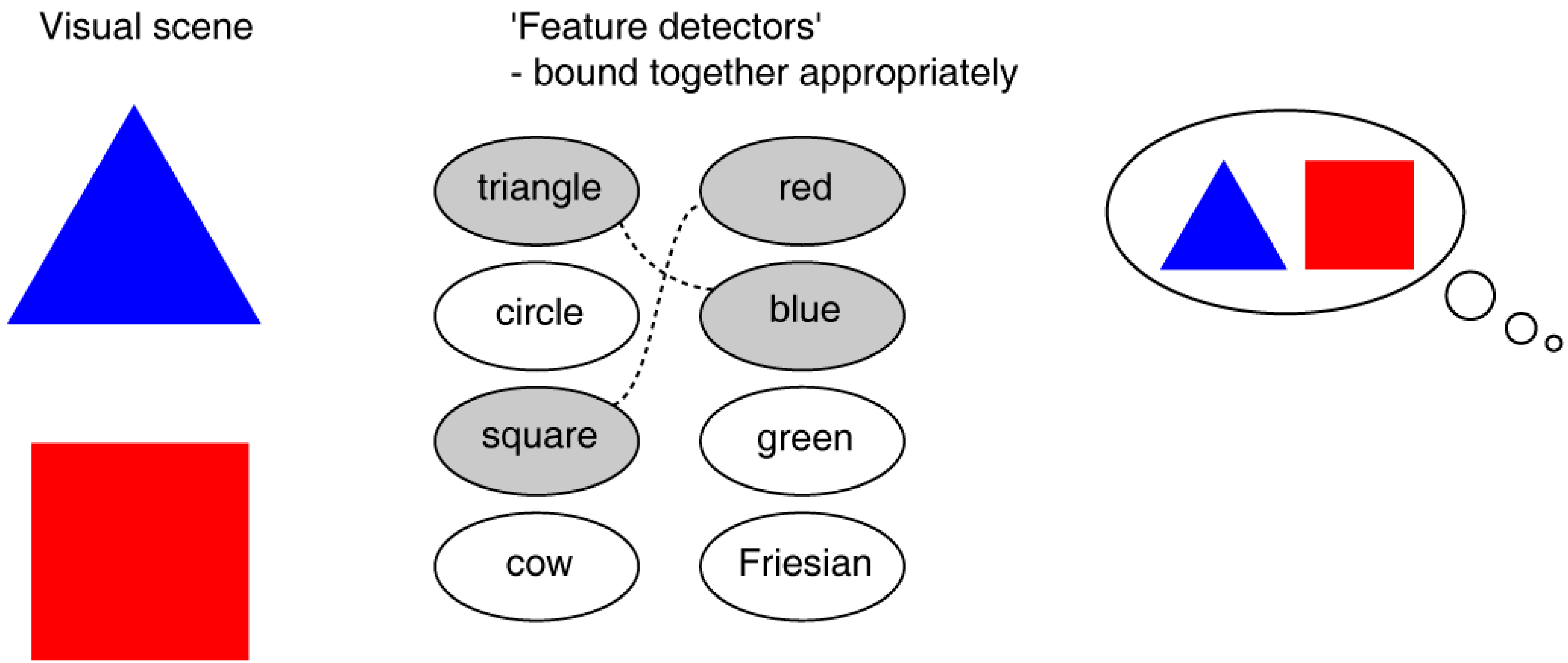
Monday 17, 24, 31 Jan; 7, 14, 28 Feb 2005; 10 am
Physiology Main Lecture Theatre
Slides will be at pobox.com/~rudolf/psychology

Binding

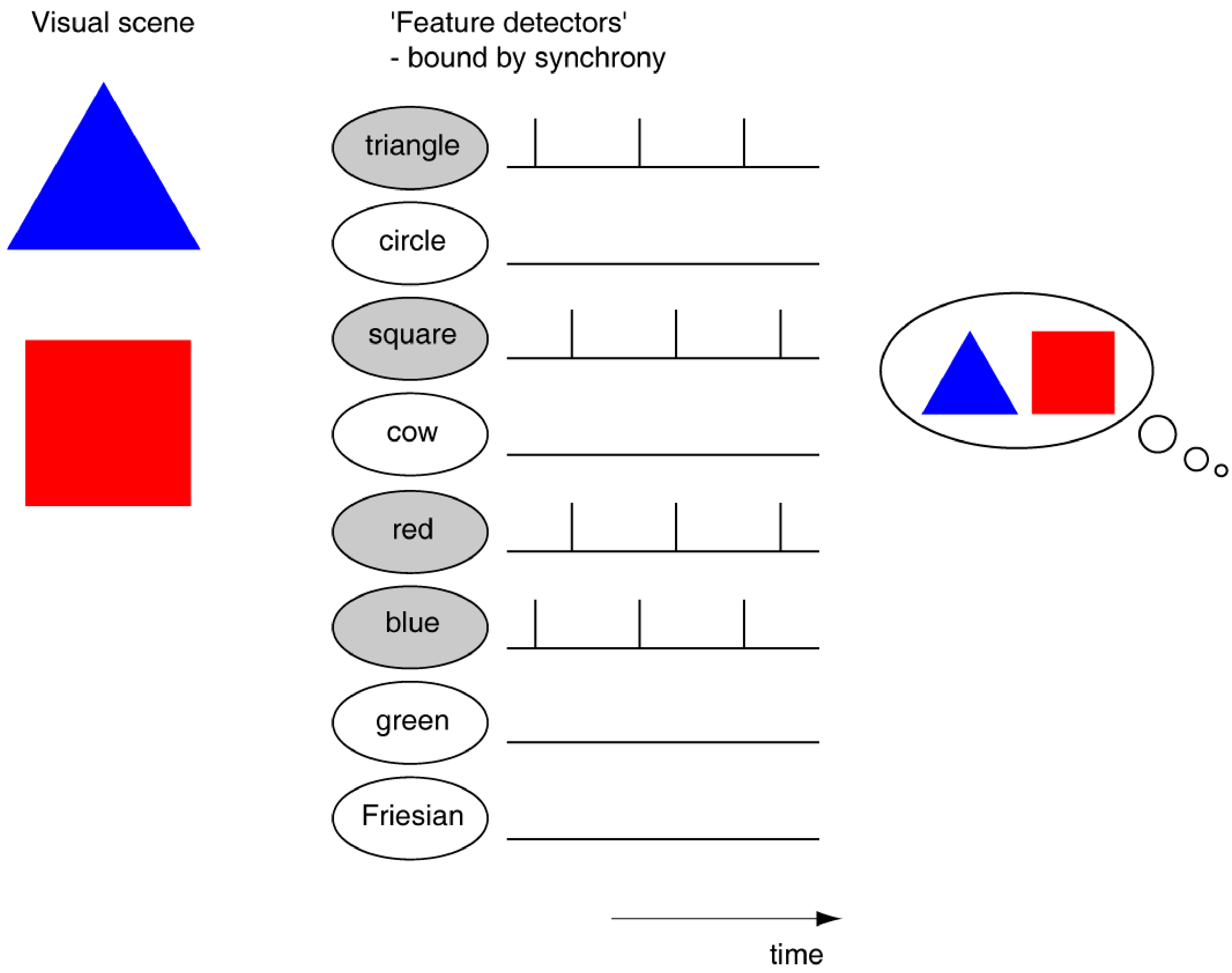
An example of a binding problem



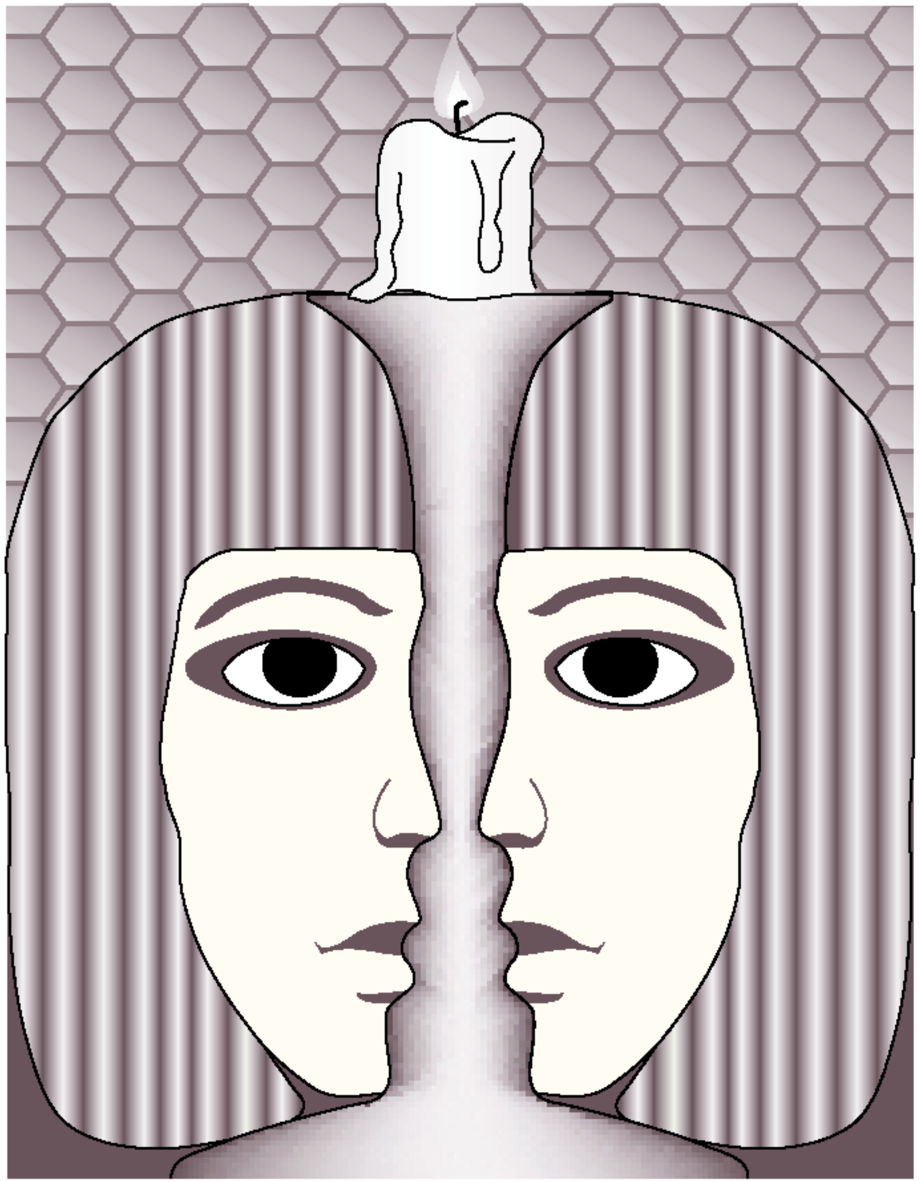
What needs to happen...



Binding by synchrony

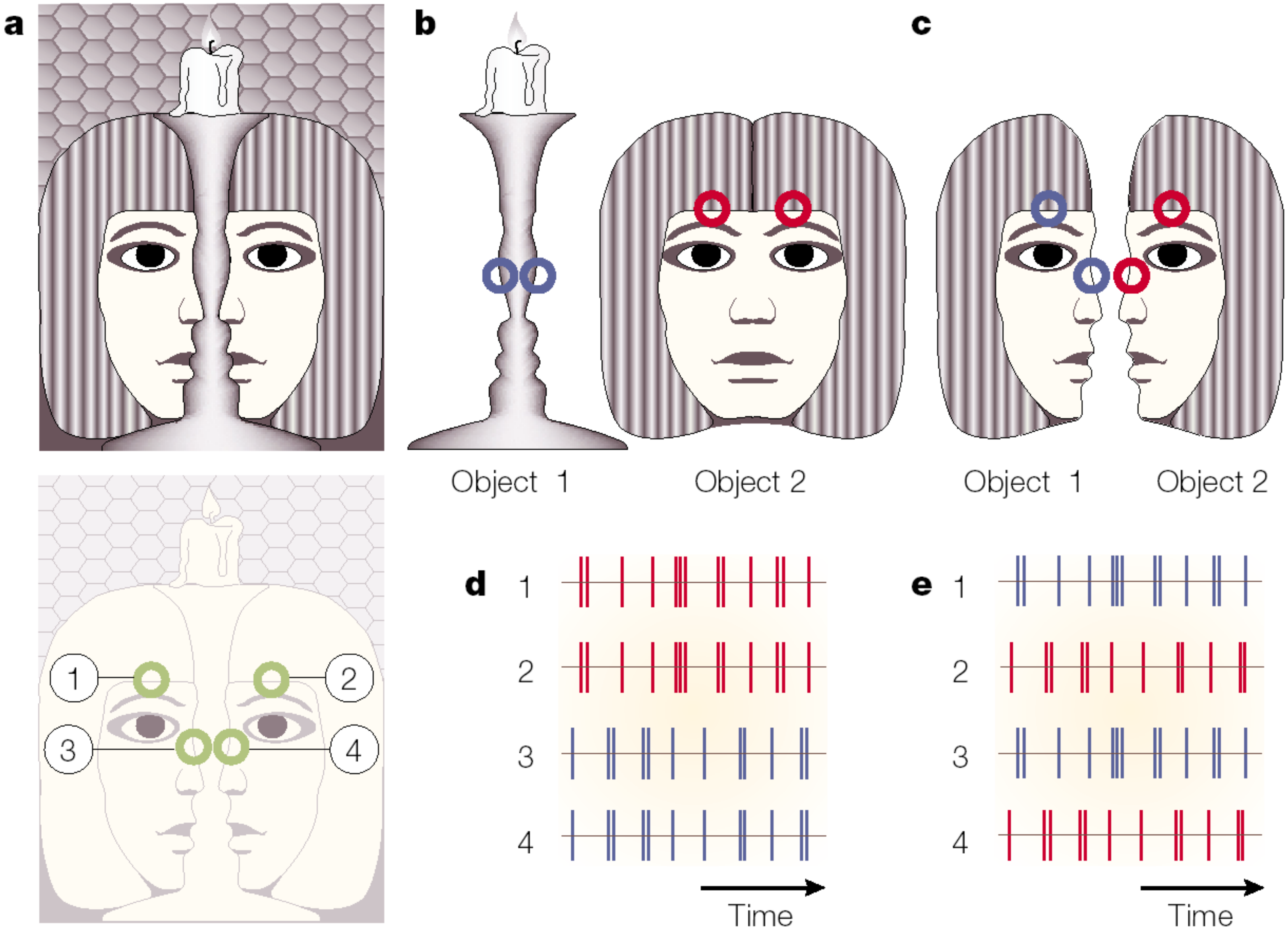


Another example: ambiguous figures (1)



Engel et al. (2001)

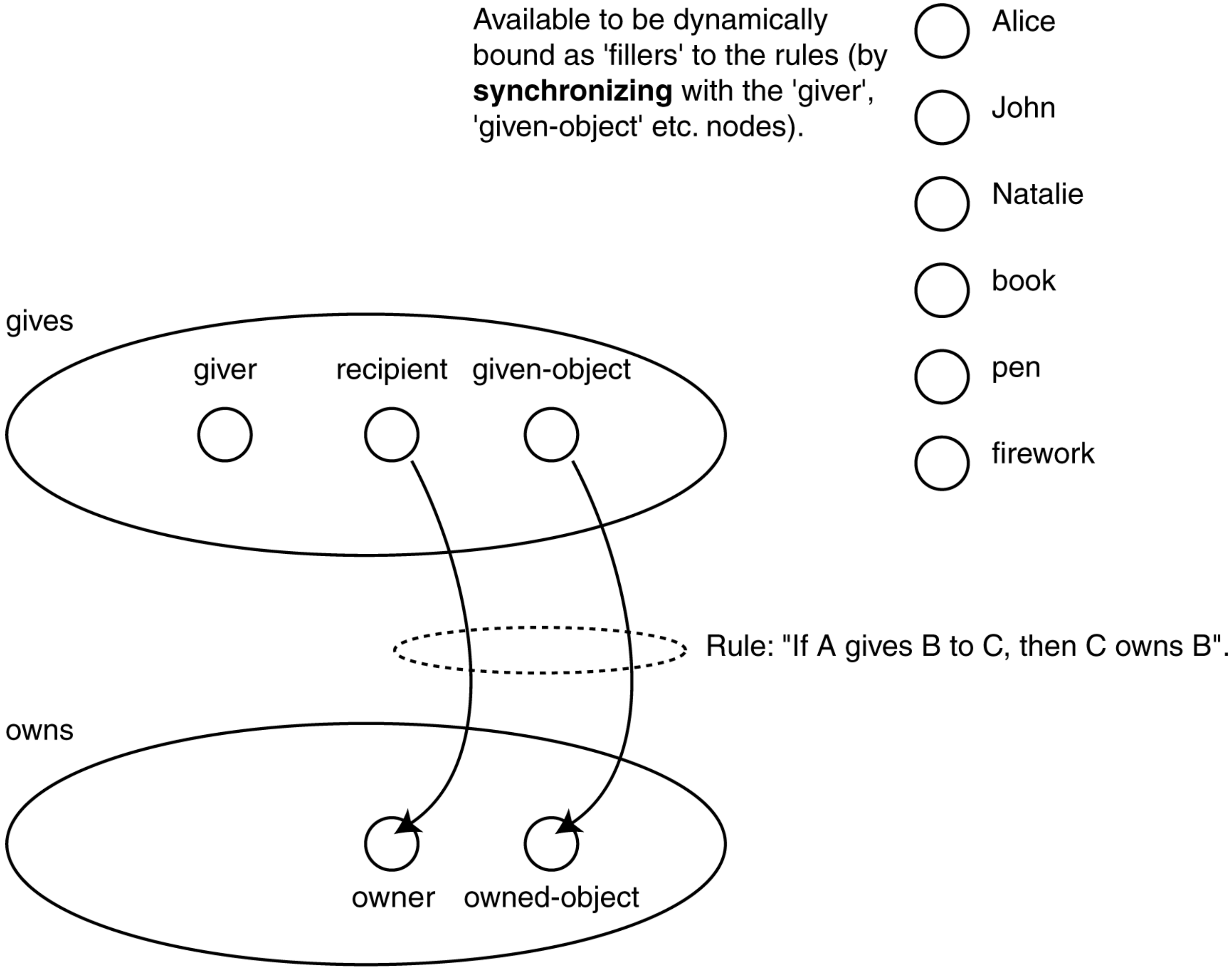
Another example: ambiguous figures (2)



Engel et al. (2001)

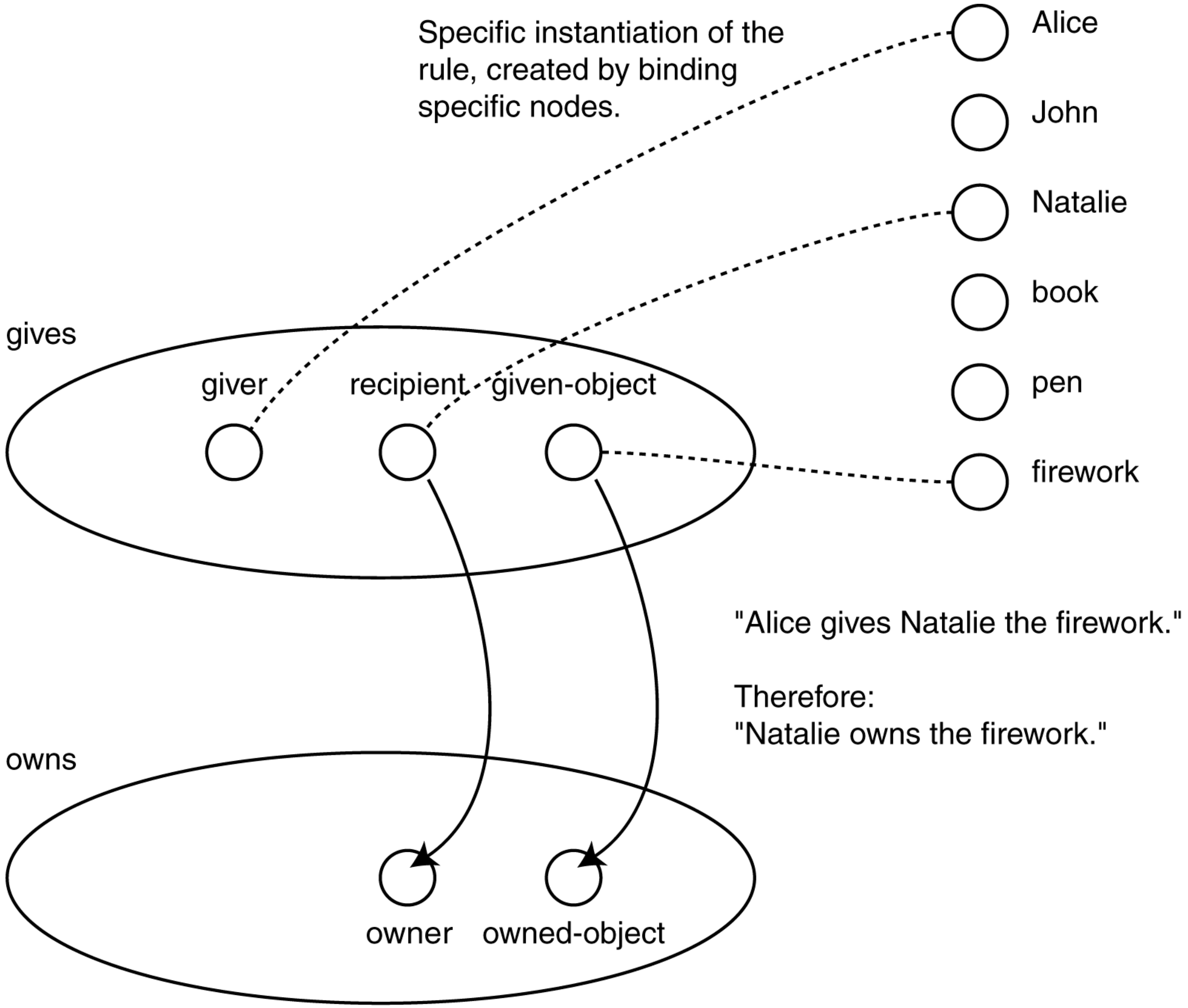
Reasoning by dynamic binding? (1 - the static bit)

Available to be dynamically bound as 'fillers' to the rules (by **synchronizing** with the 'giver', 'given-object' etc. nodes).



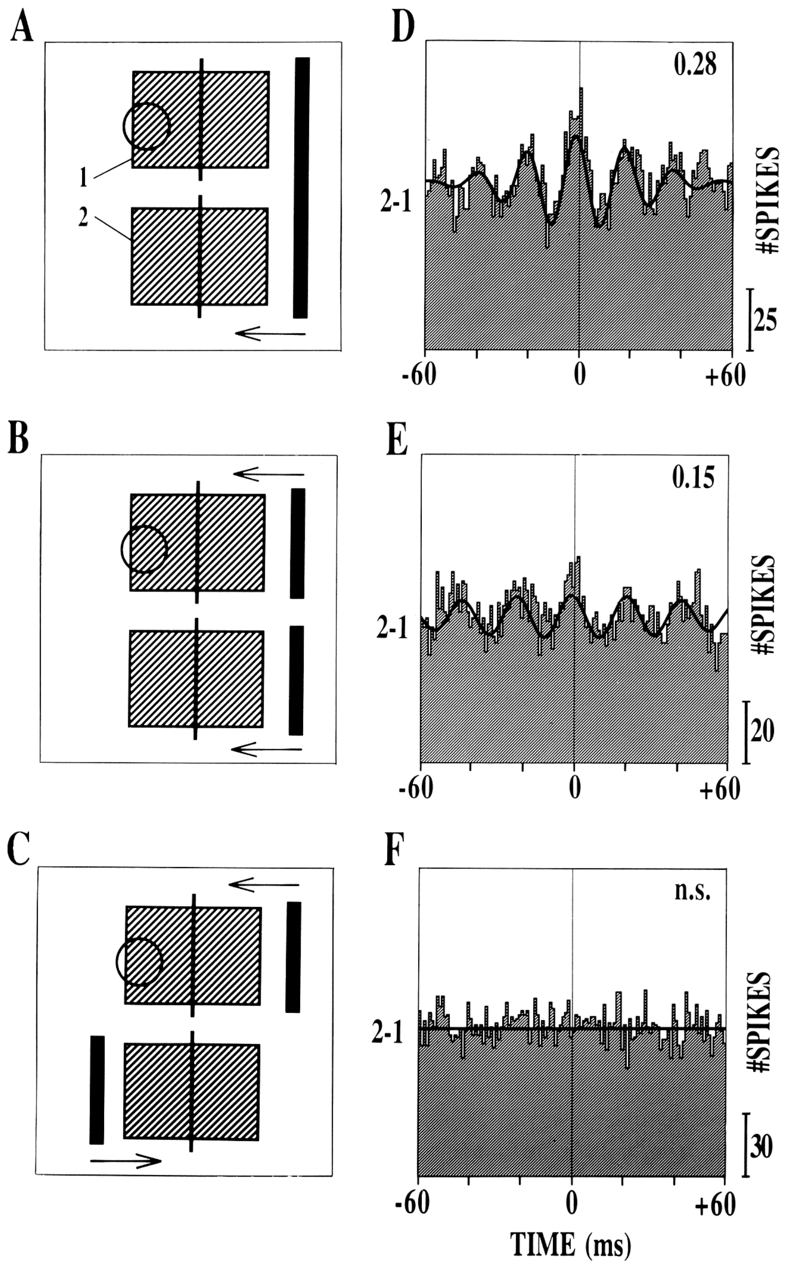
based on Shastri & Ajjanagadde (1993)

Reasoning by dynamic binding? (2 - the dynamic bit)



based on Shastri & Ajjanagadde (1993)

Evidence for synchrony: cat visual cortex (1)



• Two sites a long way (7 mm) apart in area 17 (V1).

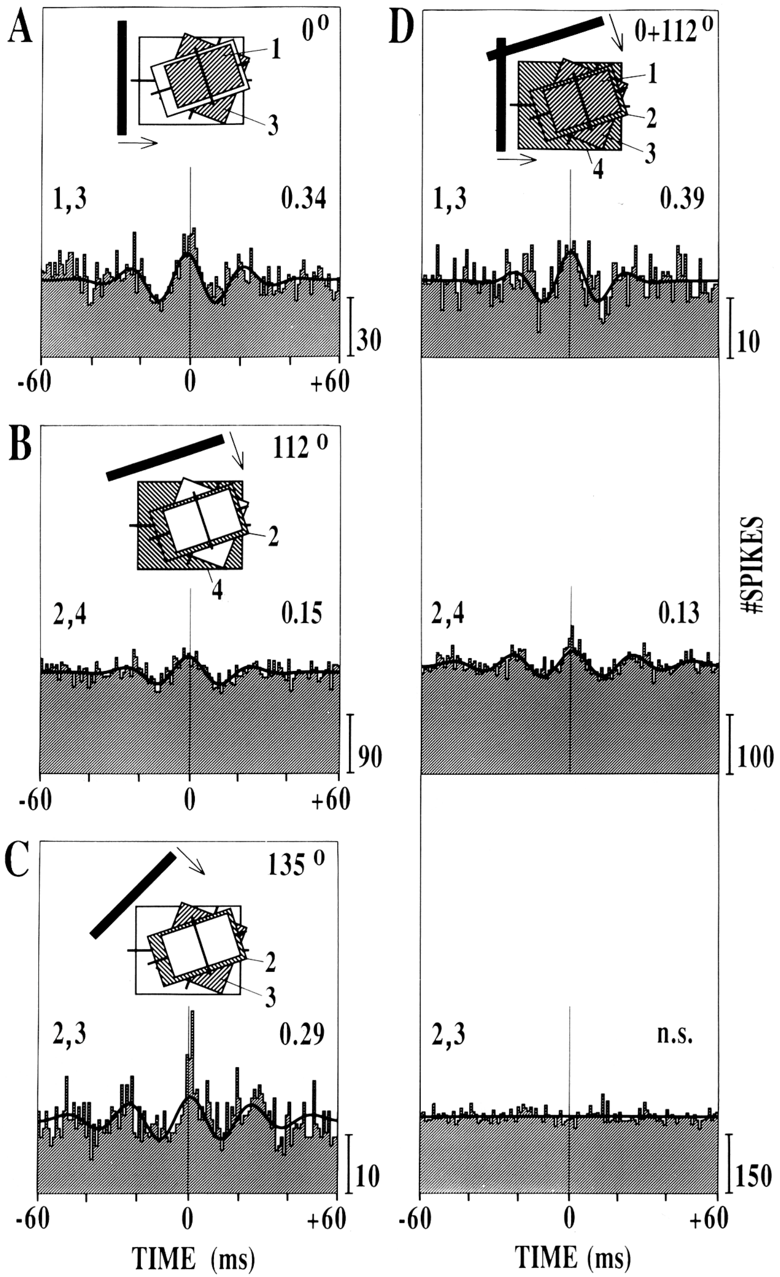
• Responses to a long bar covering both receptive fields (A), two short bars moving in the same direction across the receptive fields (B), or two short bars moving in different directions (C).

• Cross-correlation functions (right-hand side) indicate **synchrony** between the two sites in conditions A and B, but not C.

• Conditions A and B match Gestalt criteria for perceptual grouping (i.e. perceiving the bars as one object).

from Singer (1995) / Engel et al. (1992)

Evidence for synchrony: cat visual cortex (2)



• Four sites in area 17 (V1). Different groups of cells prefer different orientations (shown in insets).

• If a moving bar of light activates several cells, they synchronize (A, B, C).

• But if two bars are used, the cells **split:** some prefer one bar, some the other (D).

• In this case, cells that respond to bar 1 are mutually synchronized; cells that respond to bar 2 are mutually synchronized; but the group that respond to bar 1 are *not* synchronized with those that respond to bar 2.

• There are then **two populations, defined by synchrony,** each responding to one visual stimulus.

from Singer (1995) / Engel et al. (1991)

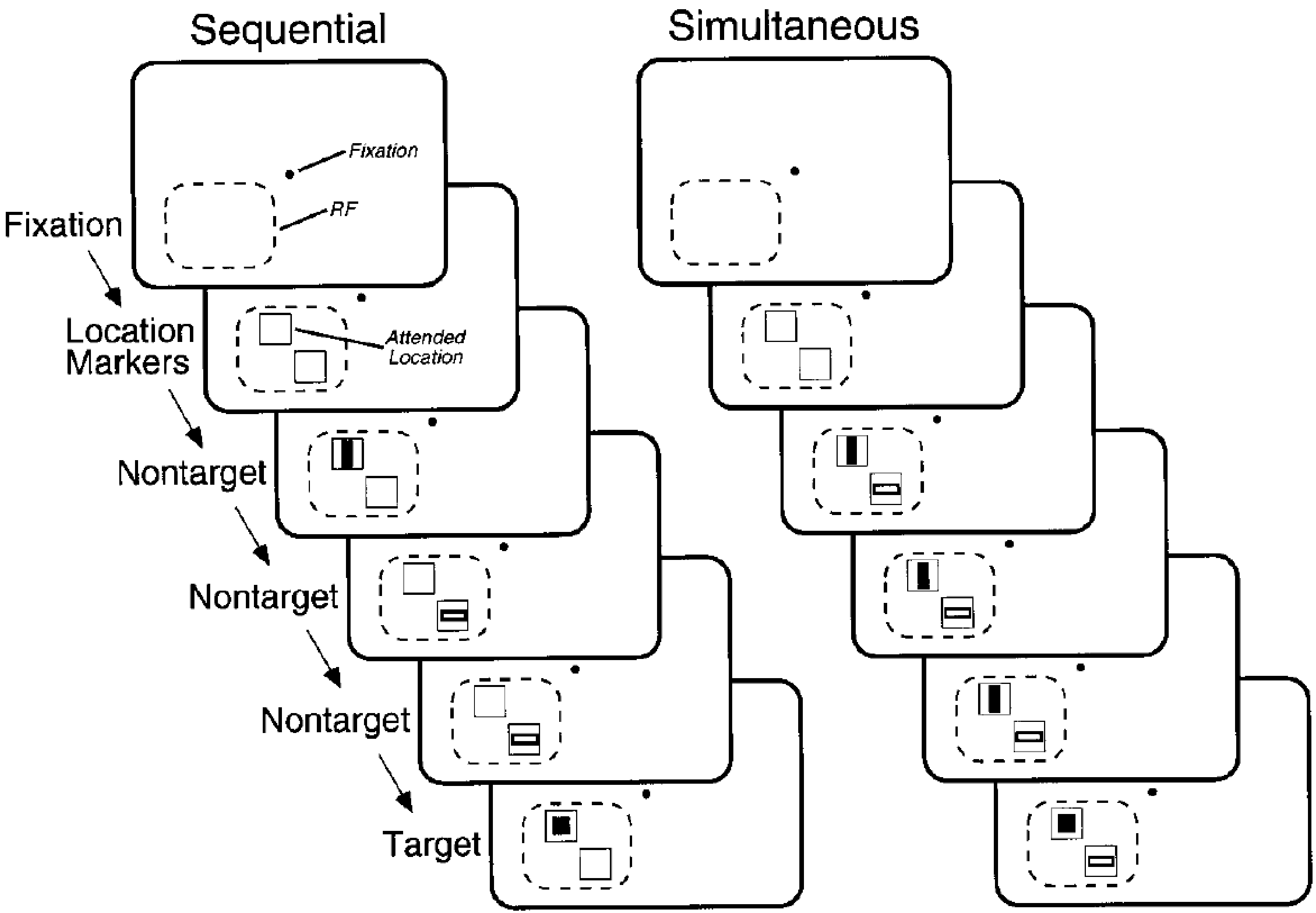
Attention:

‘The taking possession by the mind in clear and vivid form of one out of what seem several simultaneous objects or trains of thought.’

James (1890)

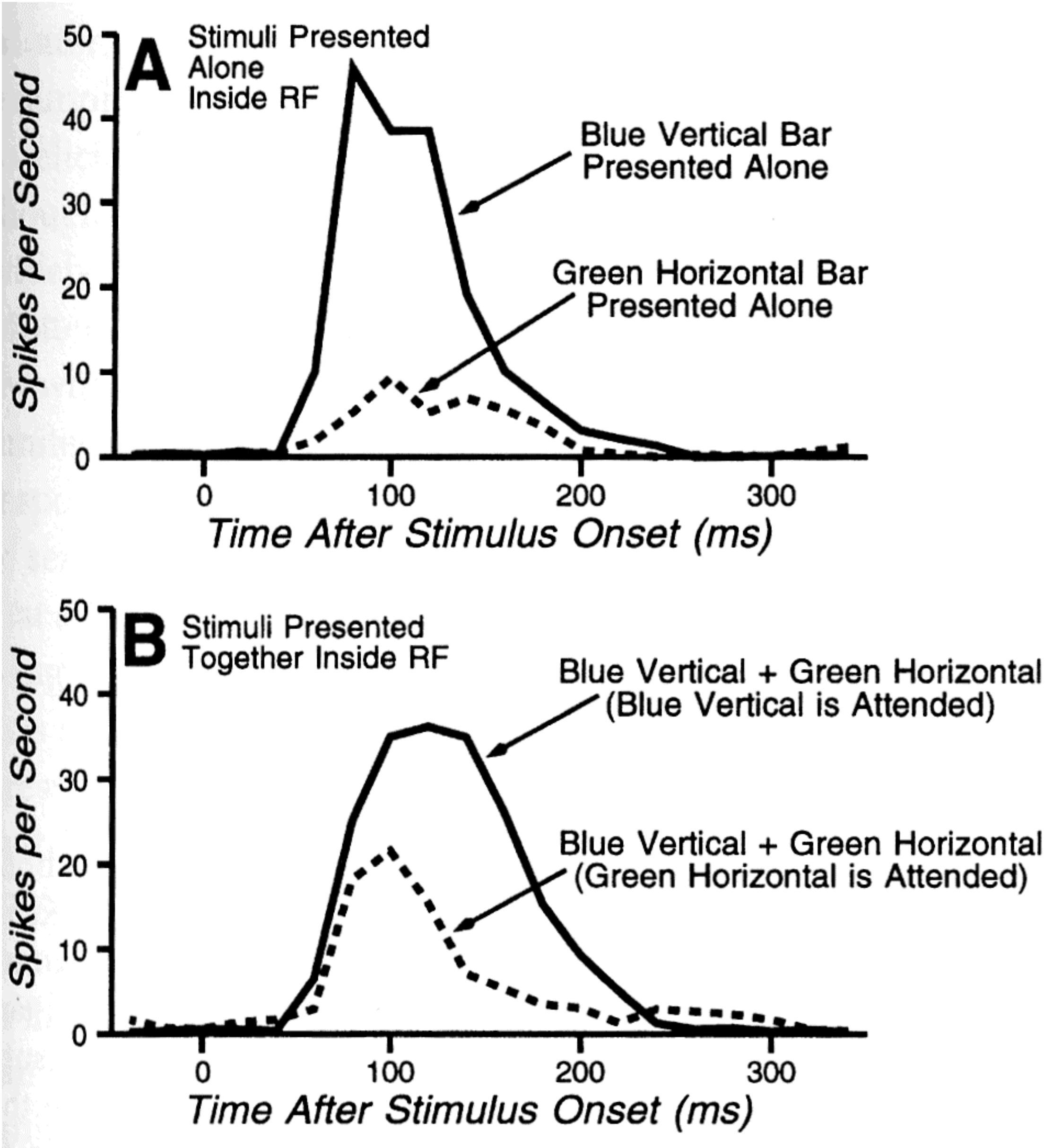
Attentional enhancement and suppression of firing

Monkeys can attend to a location in order to detect targets...



Luck et al. (1997)

Modulation of V4 responses by attention

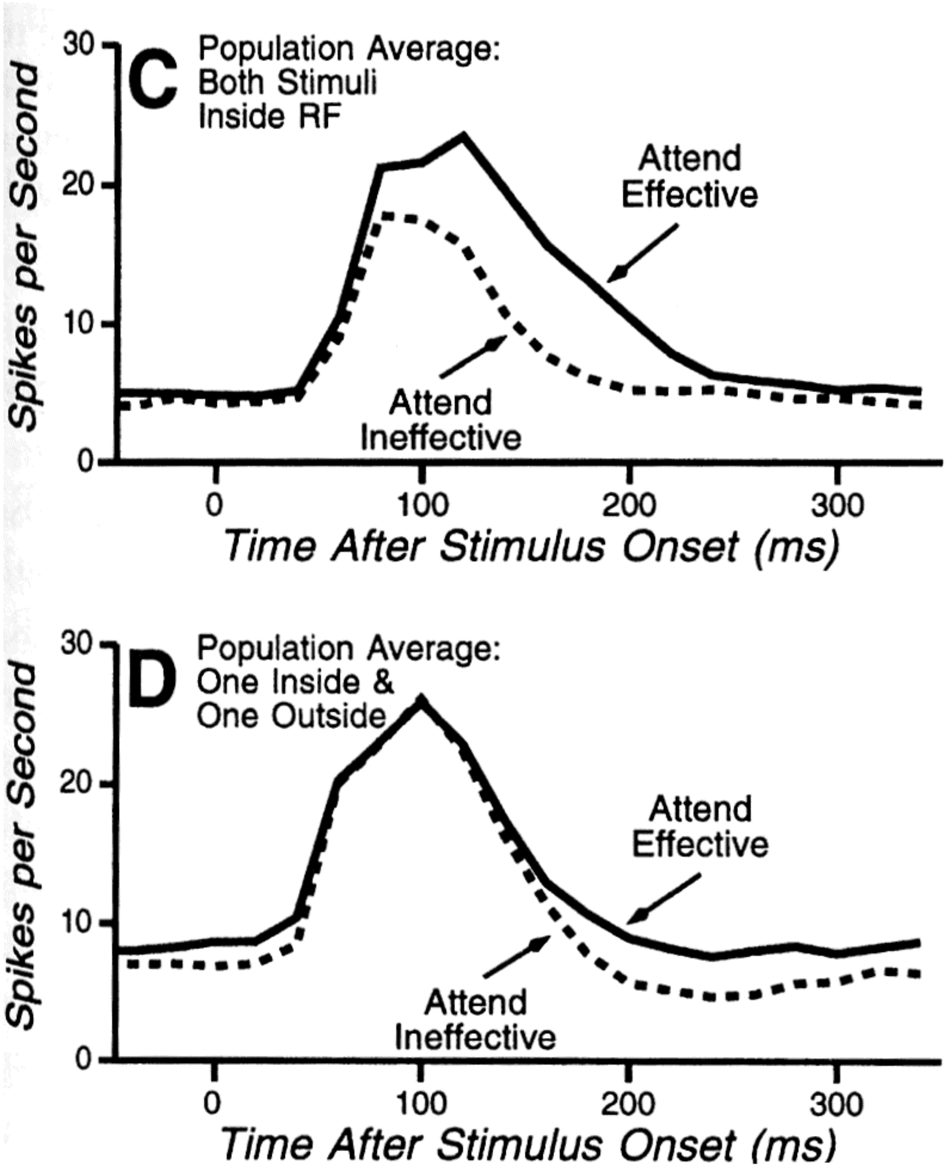


This cell prefers blue vertical bars to green horizontal bars.

When *both* a blue and a green stimulus are present, the response depends strongly on which stimulus is being attended to.

Luck et al. (1997)
J Neurophysiol 77: 24

Attentional modulation depends on competition in the RF?

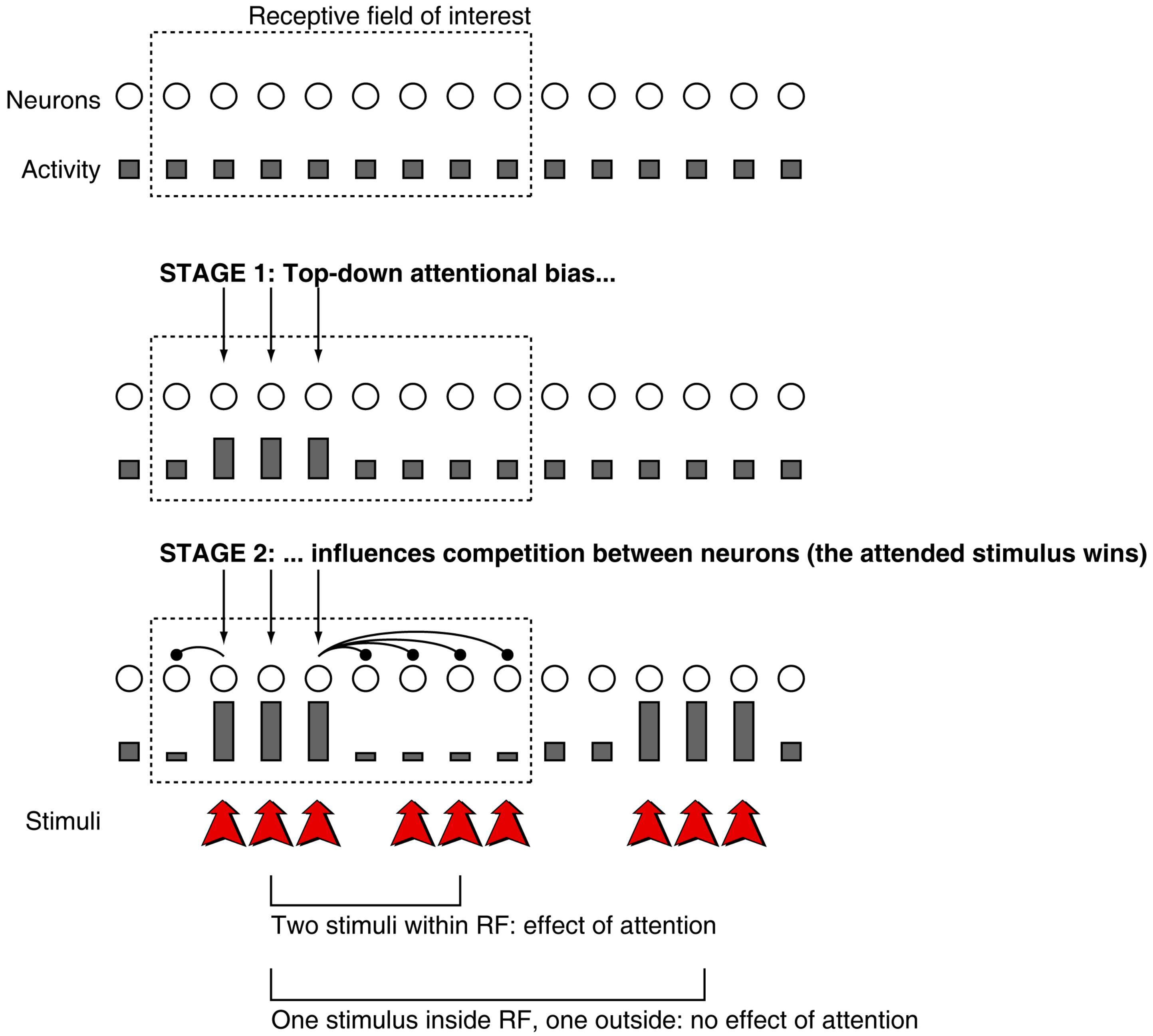


When there are *two* stimuli inside the receptive field of a cell, the response depends on which stimulus is being attended to.

If there is only one stimulus inside the RF (whichever one it is), the response *doesn't* depend on which stimulus is being attended to.

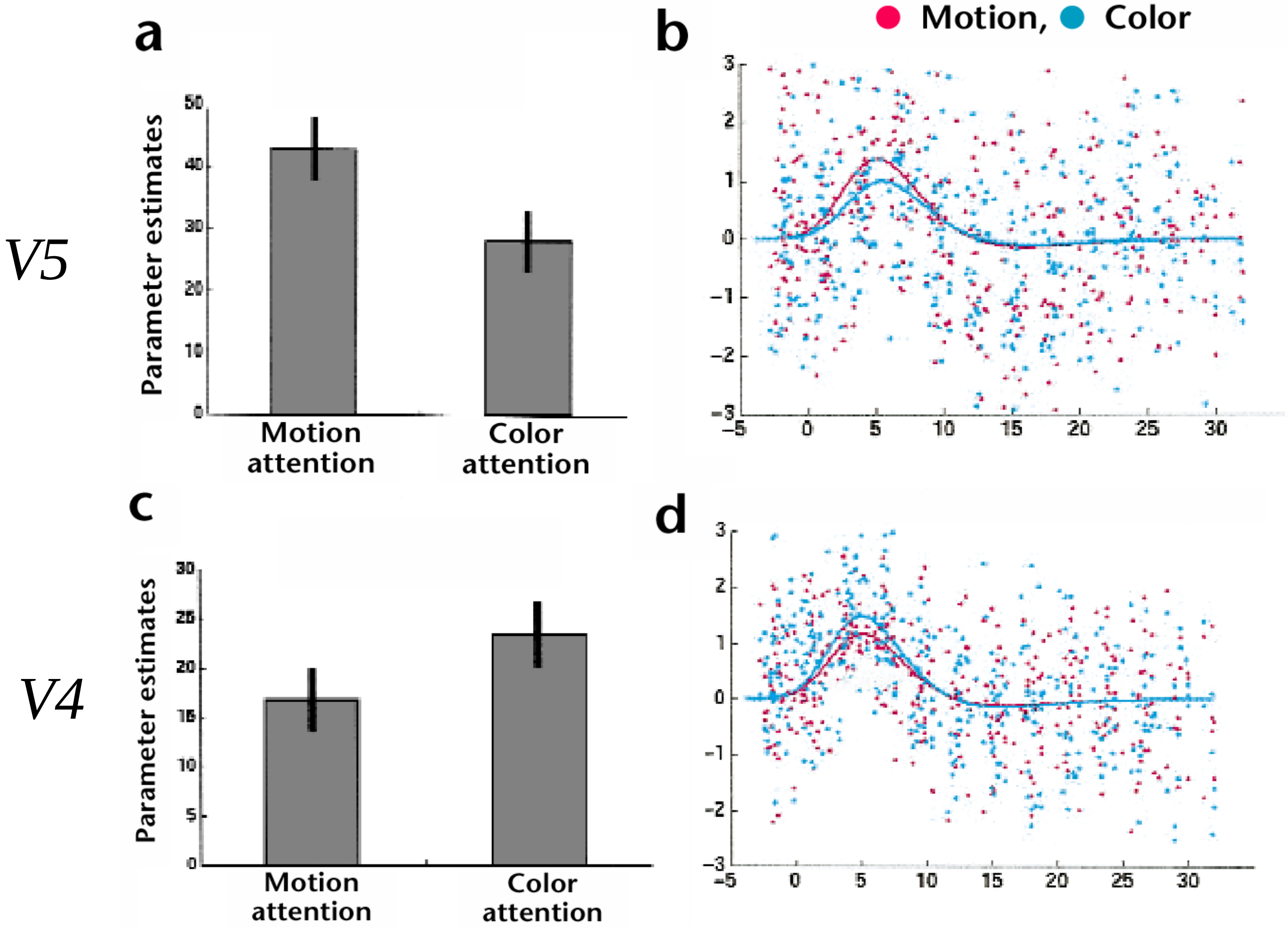
Luck et al. (1997)
J Neurophysiol 77: 24

Therefore… one view of the Luck et al. (1997) model



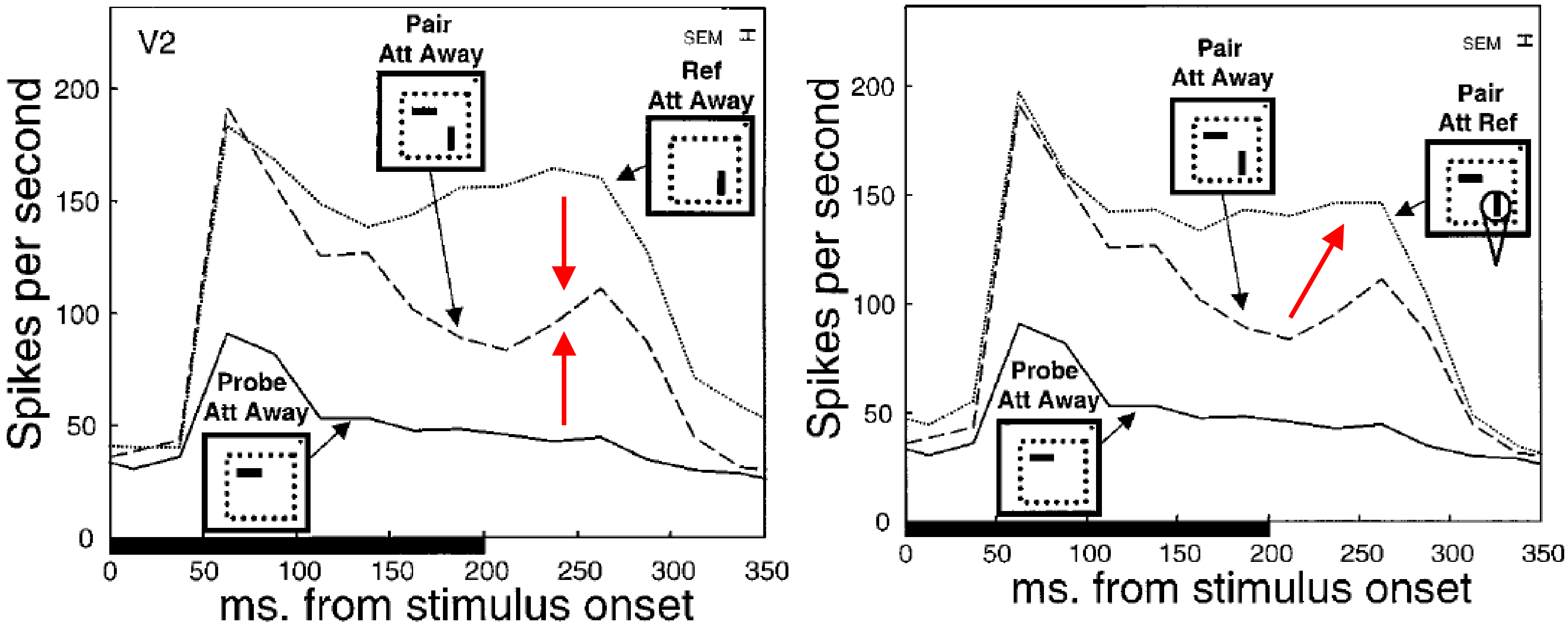
Evidence for attentional modulation in the absence of stimuli

• Monkeys: e.g. Luck *et al*. (1997) — attention increased baseline firing
• Humans: e.g. Chawla *et al*. (1999) — attention increased baseline blood flow (in V4 for attention to colour, and V5 for attention to motion)



baseline blood flow *stimulus-evoked change in blood flow*

Evidence for stimulus competition in the absence of attention

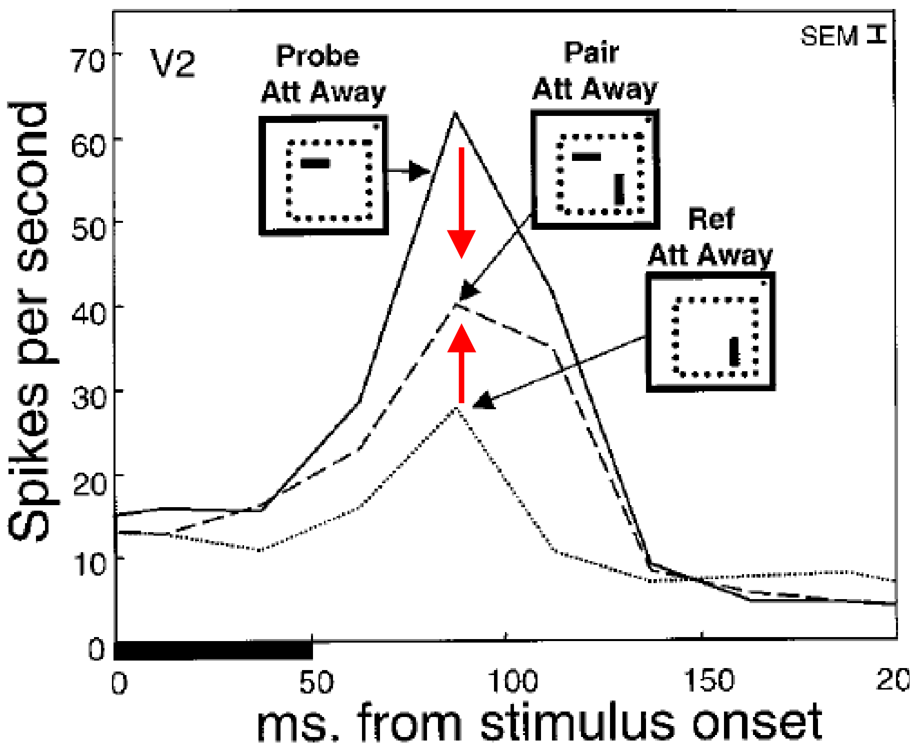


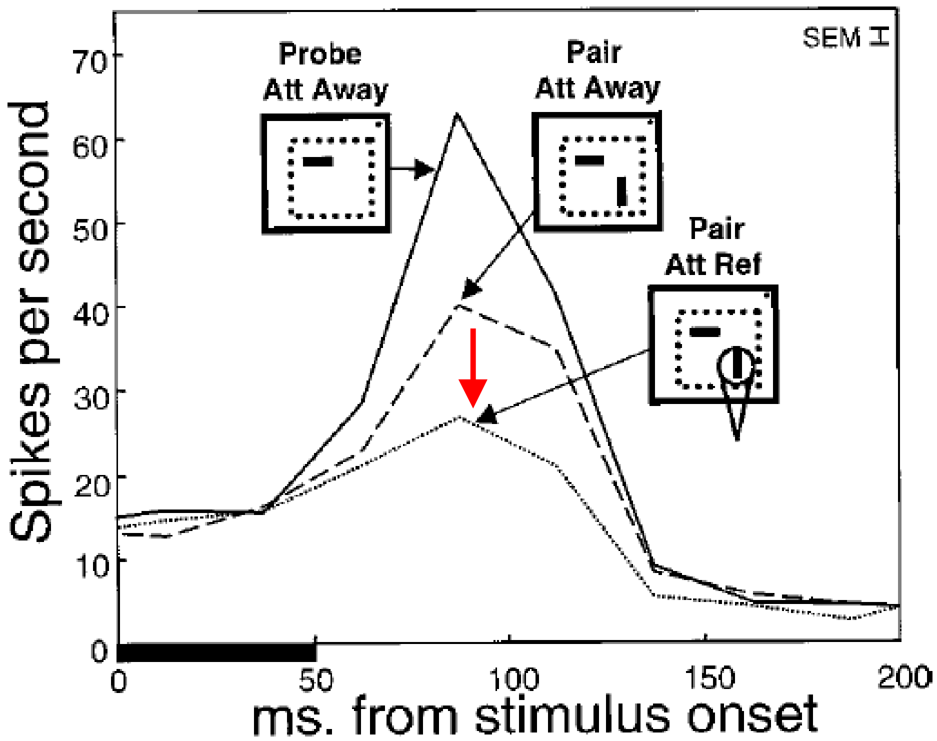
NO ATTENTION.
The response to two stimuli ('pair')
*is **not** the best of the response to*
each alone ('pair', 'ref'); it is
*intermediate, i.e. they **compete.***

If one stimulus is attended to,
the effects of competition against
that stimulus are eliminated.

Reynolds et al. (1999)

Attention increases the *influence* of stimuli (even if inhibitory)





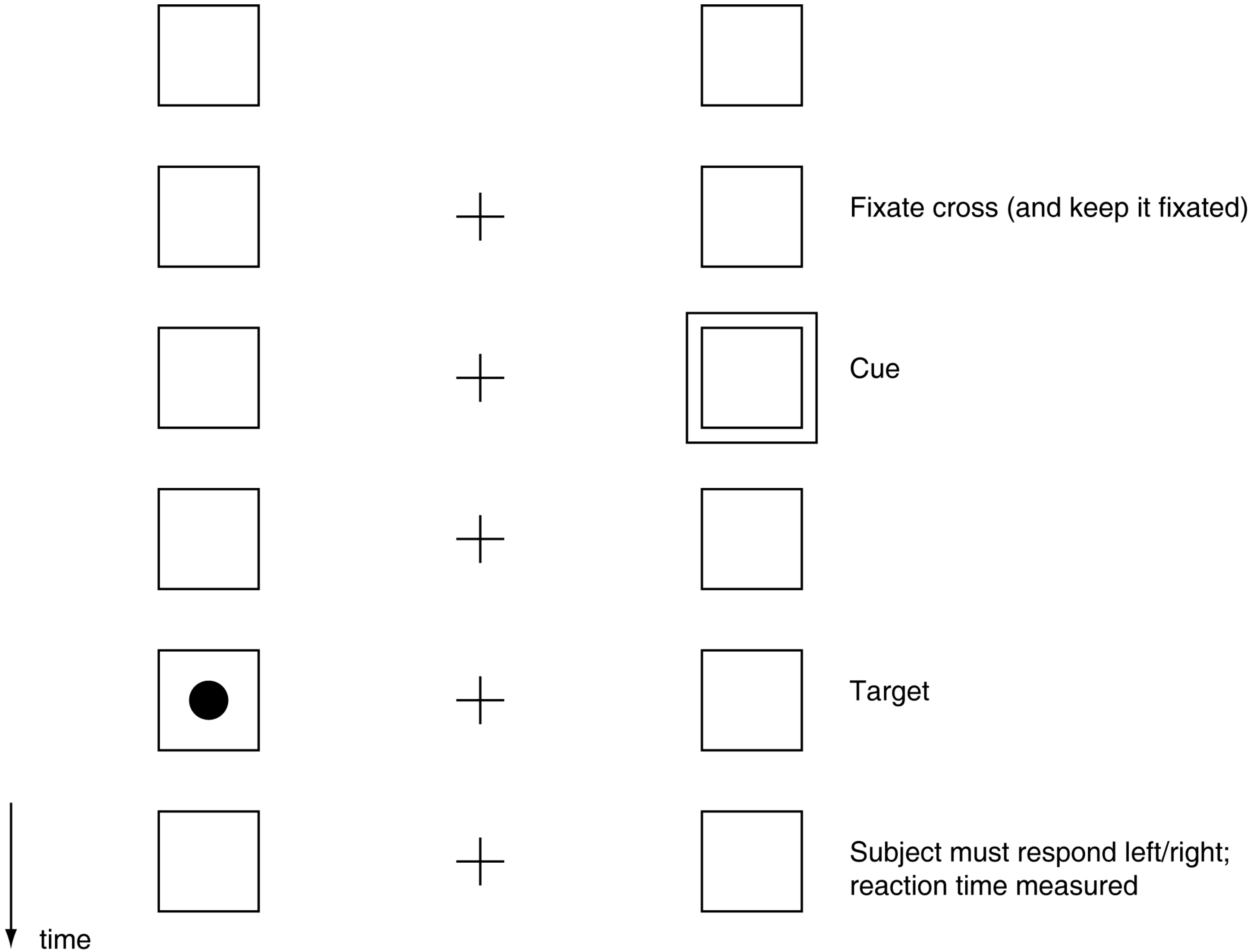
NO ATTENTION.
Again, two stimuli compete.

Again, if one stimulus is attended to,the effects of competition against that stimulus are eliminated.
*If the **less**-preferred stimulus is attended to, the neuron's response to the pair is **diminished.** Attention enhances the **influence** of the stimulus, not simply the response?*

Reynolds et al. (1999)

Networks of attentional control

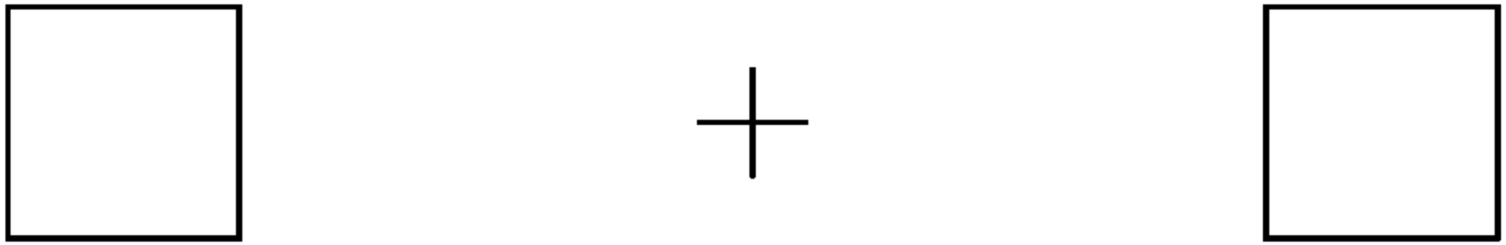
Cued spatial orienting paradigm (Posner et al. 1984)



Cue may be valid (same side as target) or invalid (opposite side, as shown here).

Cued spatial orienting paradigm (Posner et al. 1984)

Invalid - DISENGAGE, MOVE, ENGAGE



Posterior parietal lesions impair the DISENGAGE operation

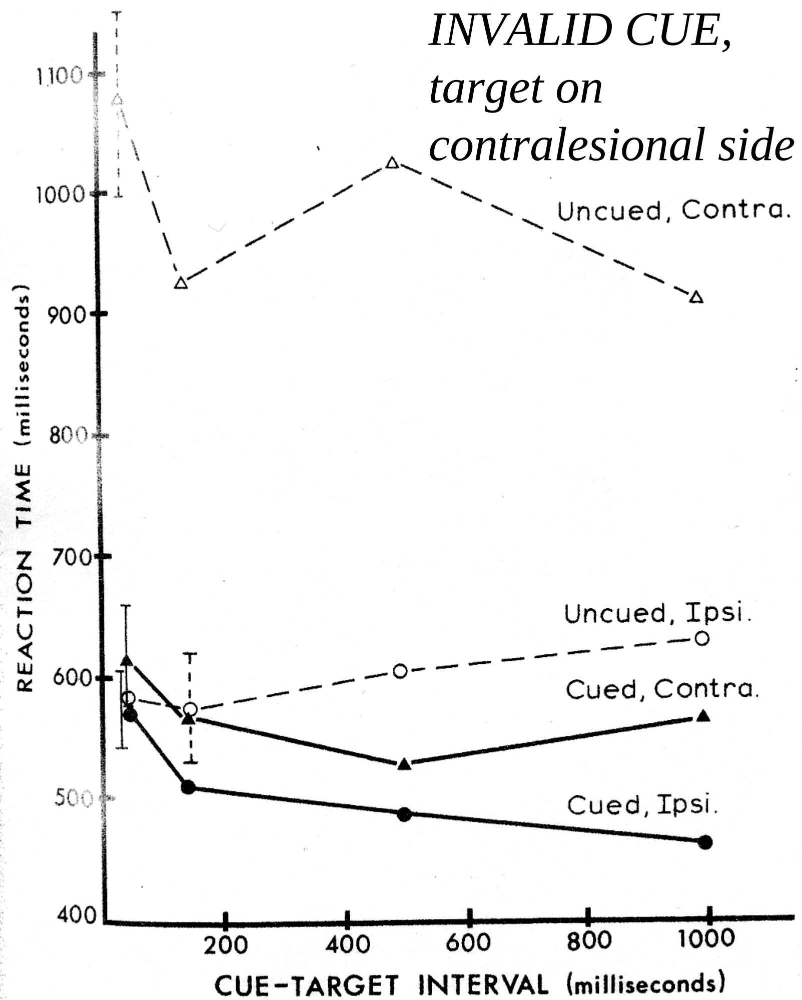


Figure 2. Reaction time for six right parietal patients in the main experiment. *Solid lines* are for targets on the cued side, and *dashed lines* are for targets on the uncued side. *Triangles* are contralateral targets, and *circles* are ipsilateral targets. *Bars* indicate ±1 SE for representative points.

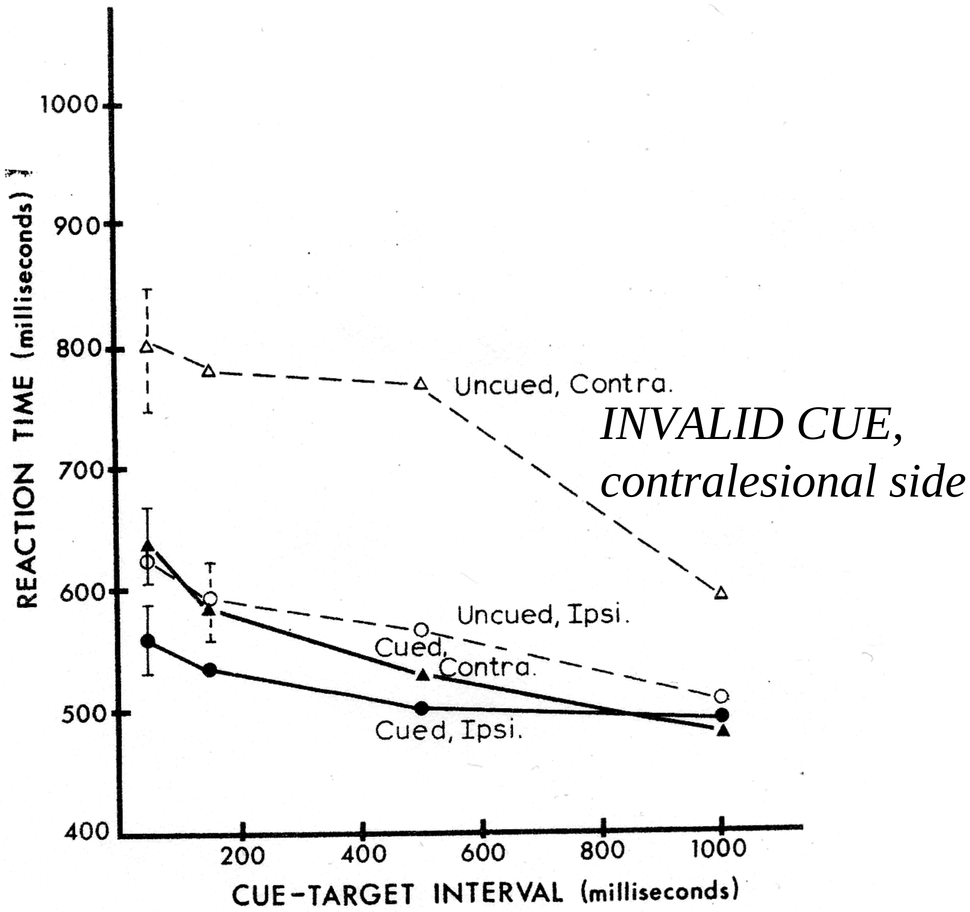


Figure 3. Reaction times for seven left parietal patients in the main experiment. *Solid lines* are targets on the cued side, and *dashed lines* are for targets on the uncued side. *Triangles* are contralateral targets, and *circles* are ipsilateral targets. *Bars* indicate ±1 SE for representative points.

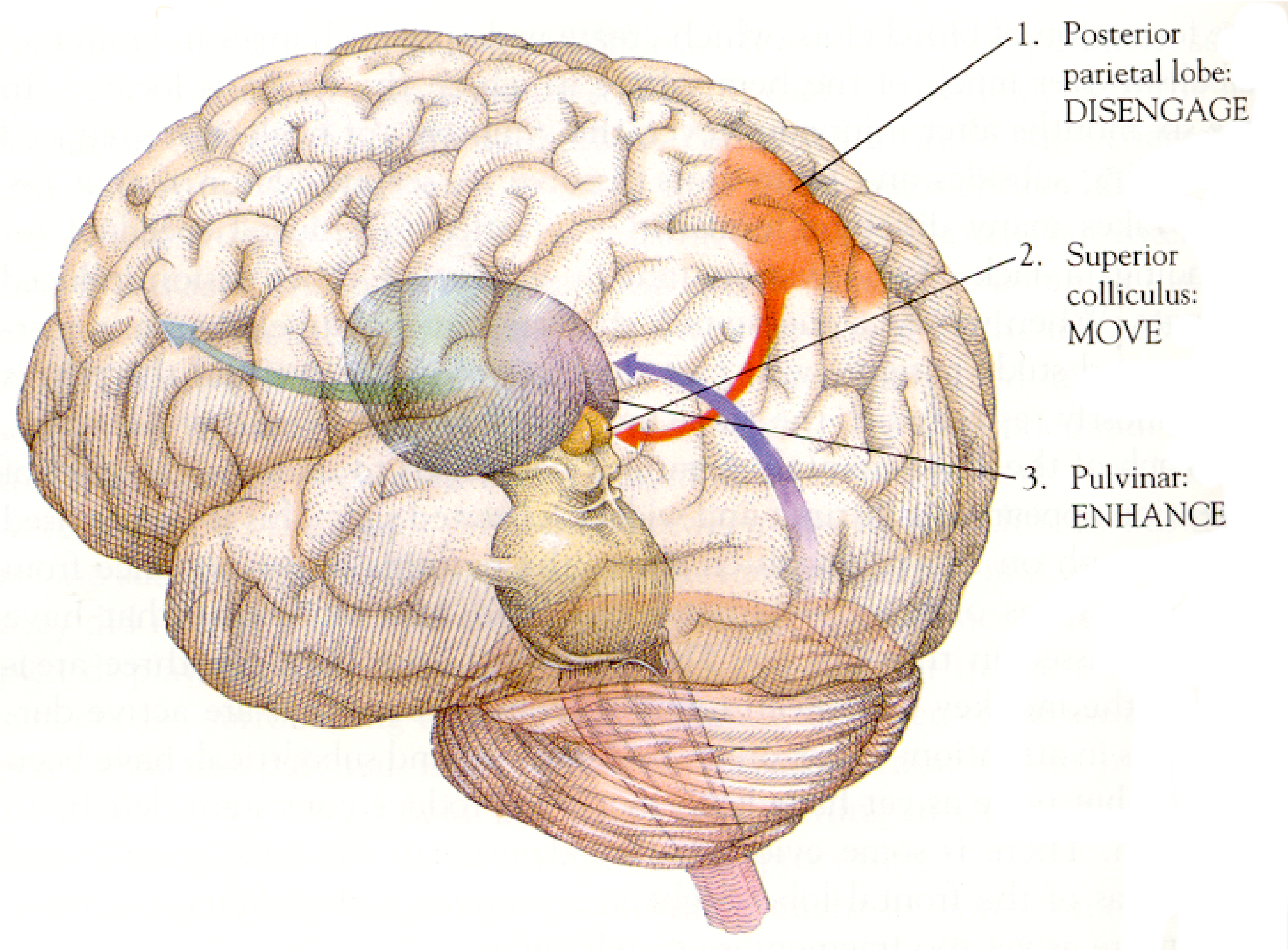
Posner et al. (1984)

The 1980s model...

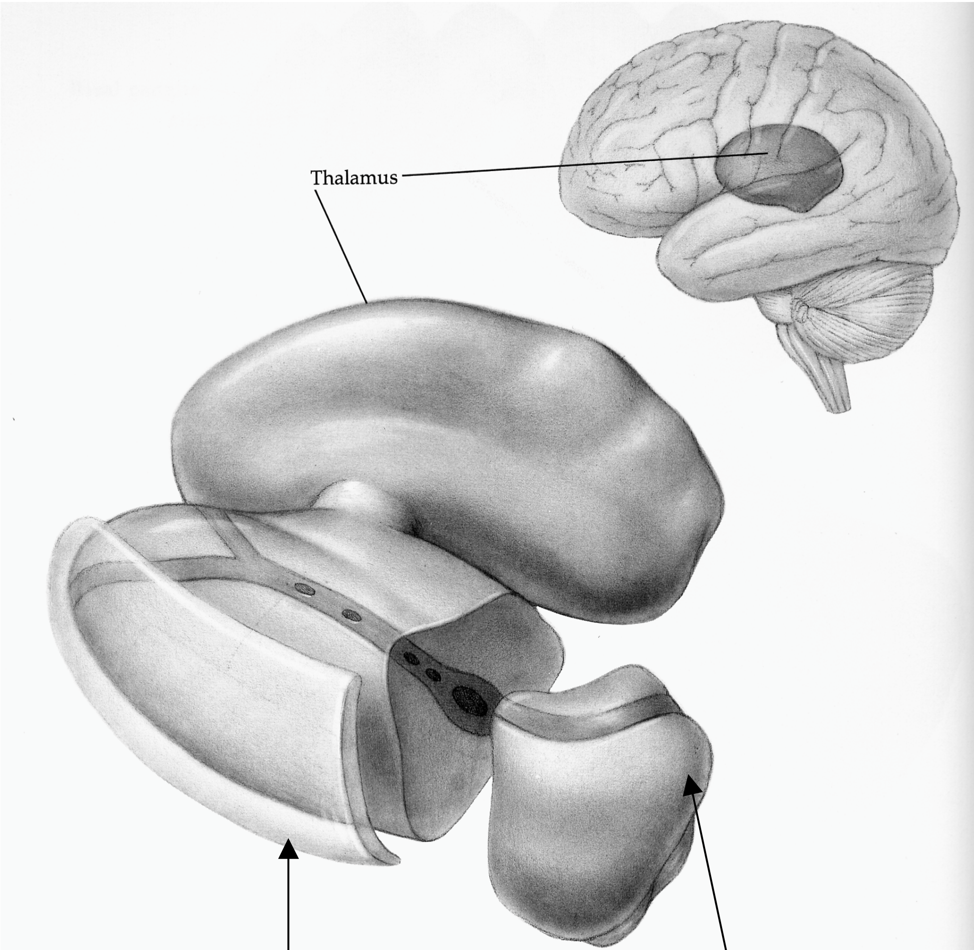
- Posterior parietal cortex: DISENGAGE. Lesioned subjects are slower if their attention was previously engaged elsewhere.
    - Relevance to **neglect** caused by lesions of posterior parietal cortex (e.g. temporo-parietal junction). Failure to disengage from targets on the ipsilesional side, and can't get attention to targets on the contralesional side.
- Superior colliculus (midbrain): MOVE. Lesioned subjects are slower for both valid and invalid cues. (The SC is known to be important for orienting and eye movement control.)
- Pulvinar (thalamus): ENGAGE. Lesions impair the ability to engage contralateral targets. Lesioned monkeys are *slow* to respond to contralesional stimuli, but are *faster* than normal following an invalid (contralateral) cue — i.e. the cues don't engage attention.

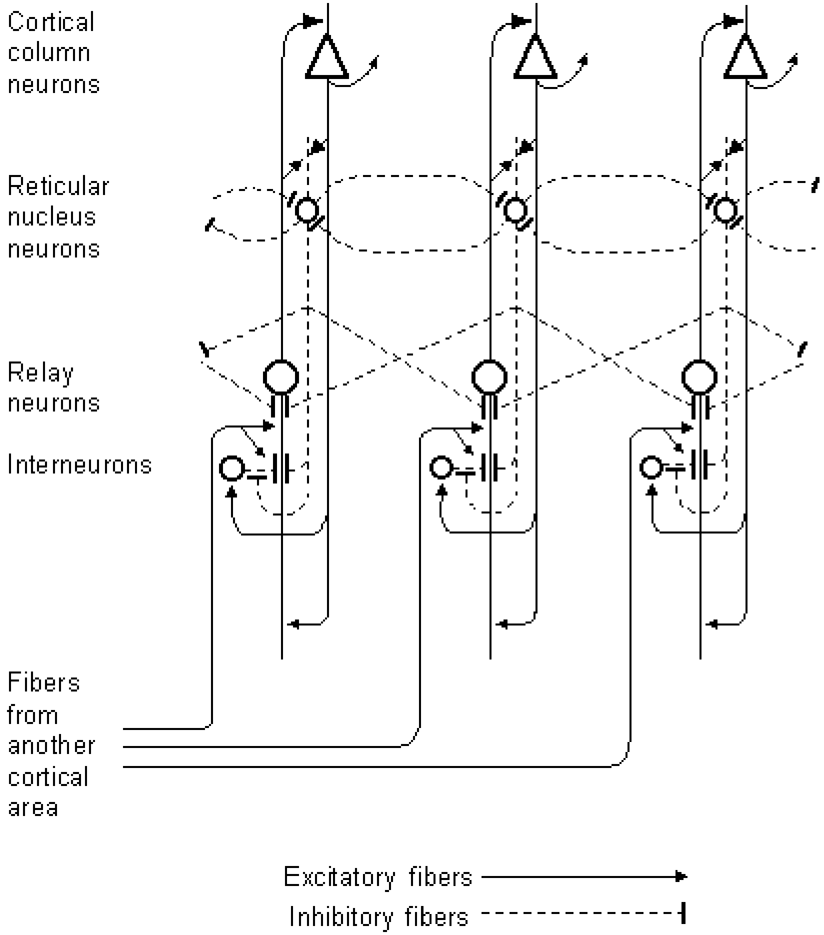
Humans: e.g. Posner & Petersen (1990)
Monkeys: e.g. Desimone et al (1990)

A network for attentional control



What does the thalamus contribute to attention?



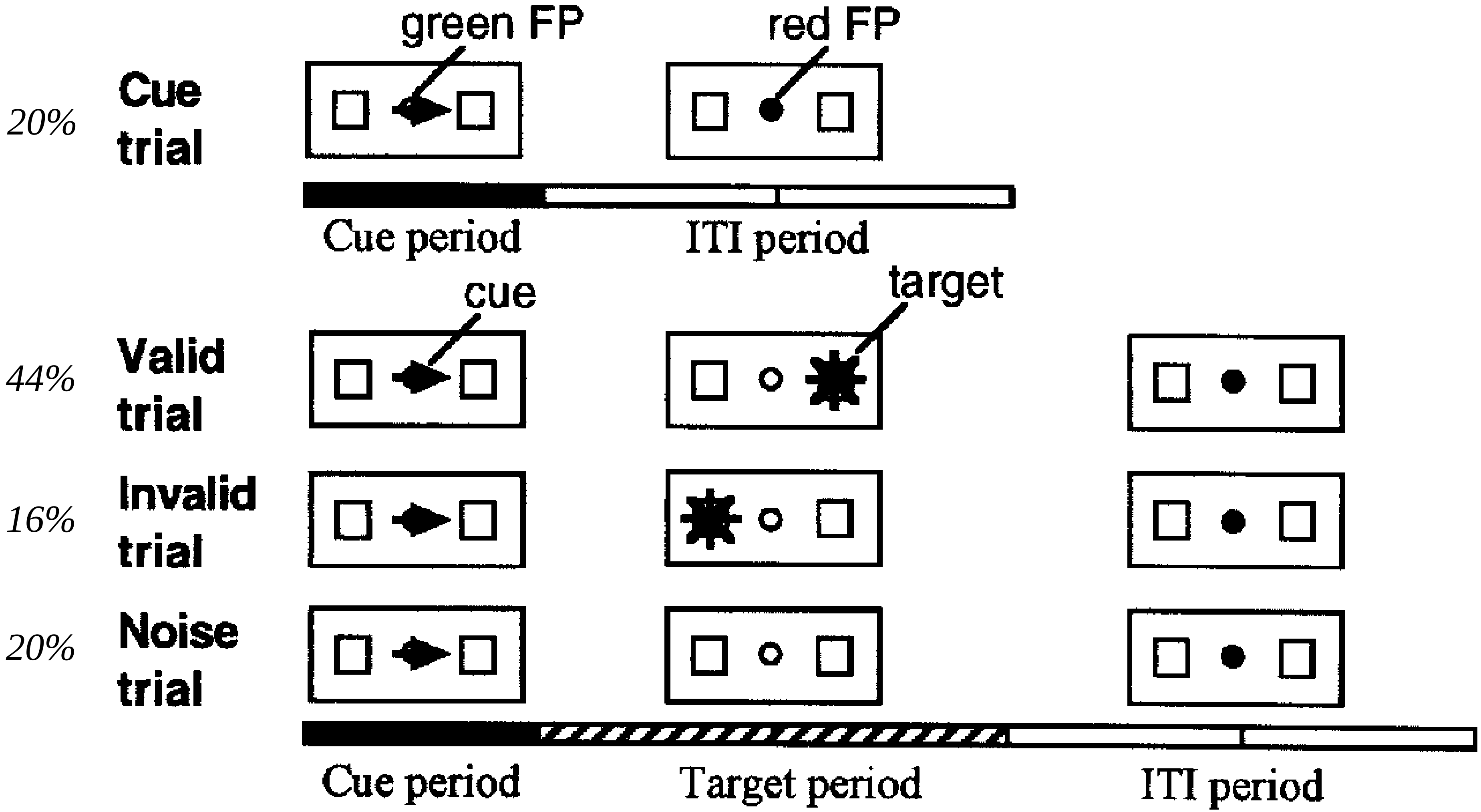


reticular nucleus (partly cut away)

pulvinar

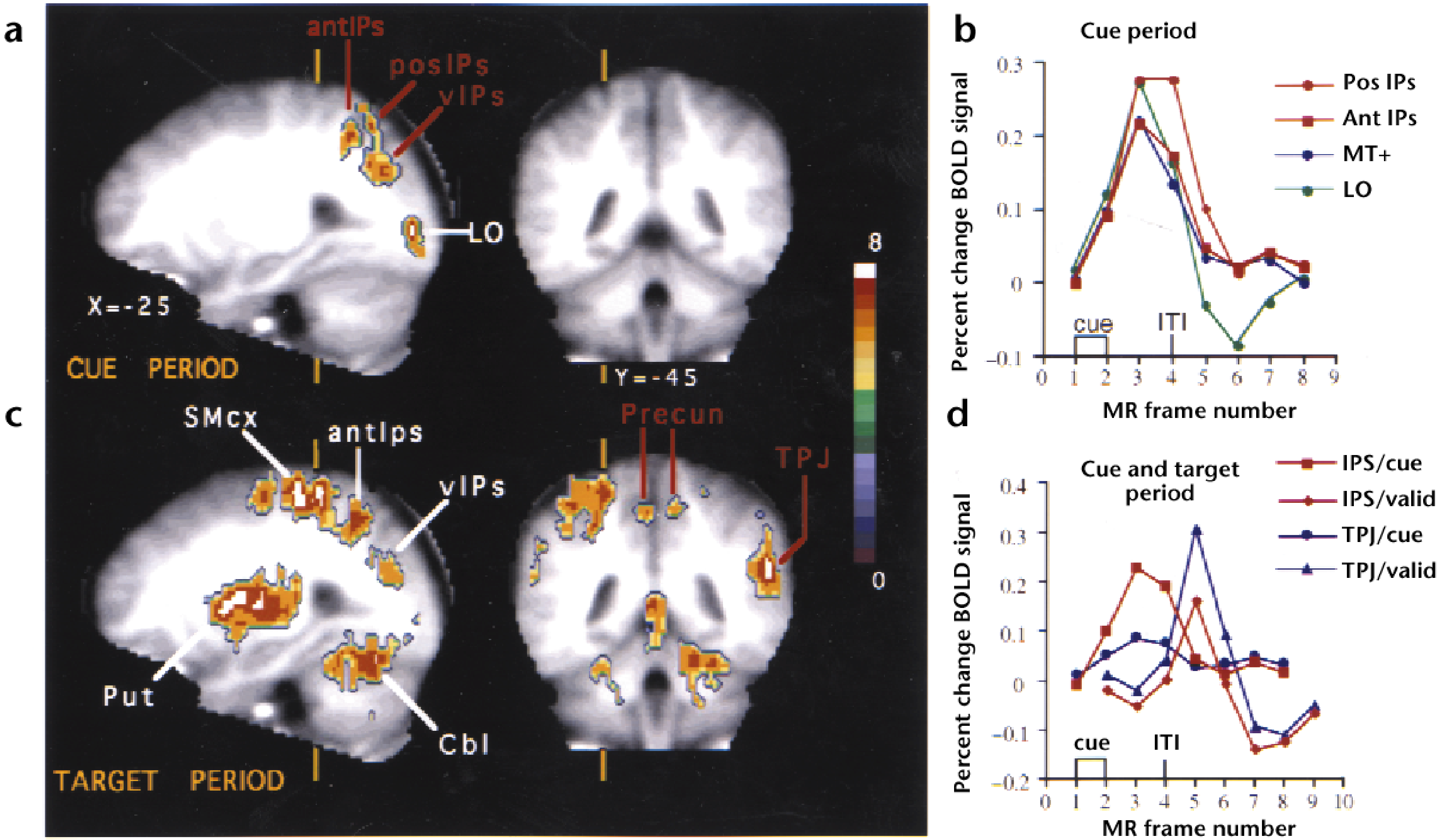
LaBerge (2000a, b)

Voluntary ('top-down') versus 'bottom-up' attention



Corbetta et al. (2000)

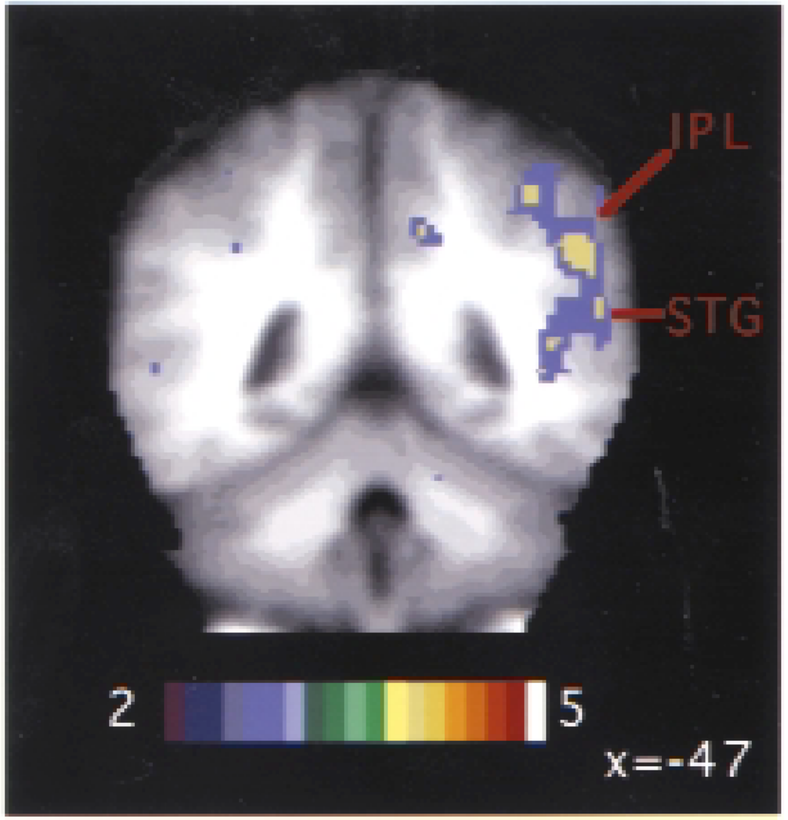
Voluntary ('top-down') attention and the IPS



The intraparietal sulcus (IPS) responds to the cue (a correlate of directing attention to a particular location). Several regions are active when the target arrives...

Corbetta et al. (2000)

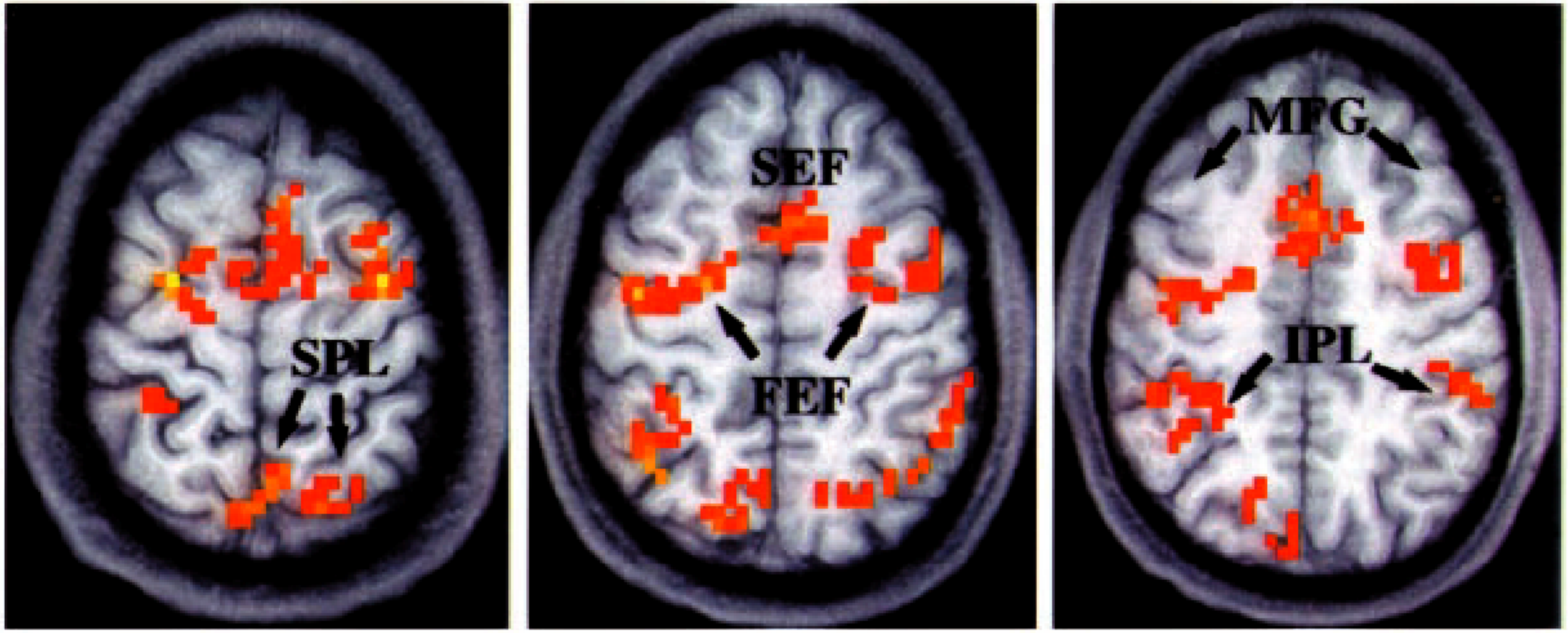
‘Bottom-up’ attention and the TPJ



… but the temporo-parietal junction (TPJ) region, including inferior parietal lobule (IPL) and superior temporal gyrus (STG), is selectively activated when unexpected targets arrive (INVALID minus VALID cue conditions).

Corbetta et al. (2000)

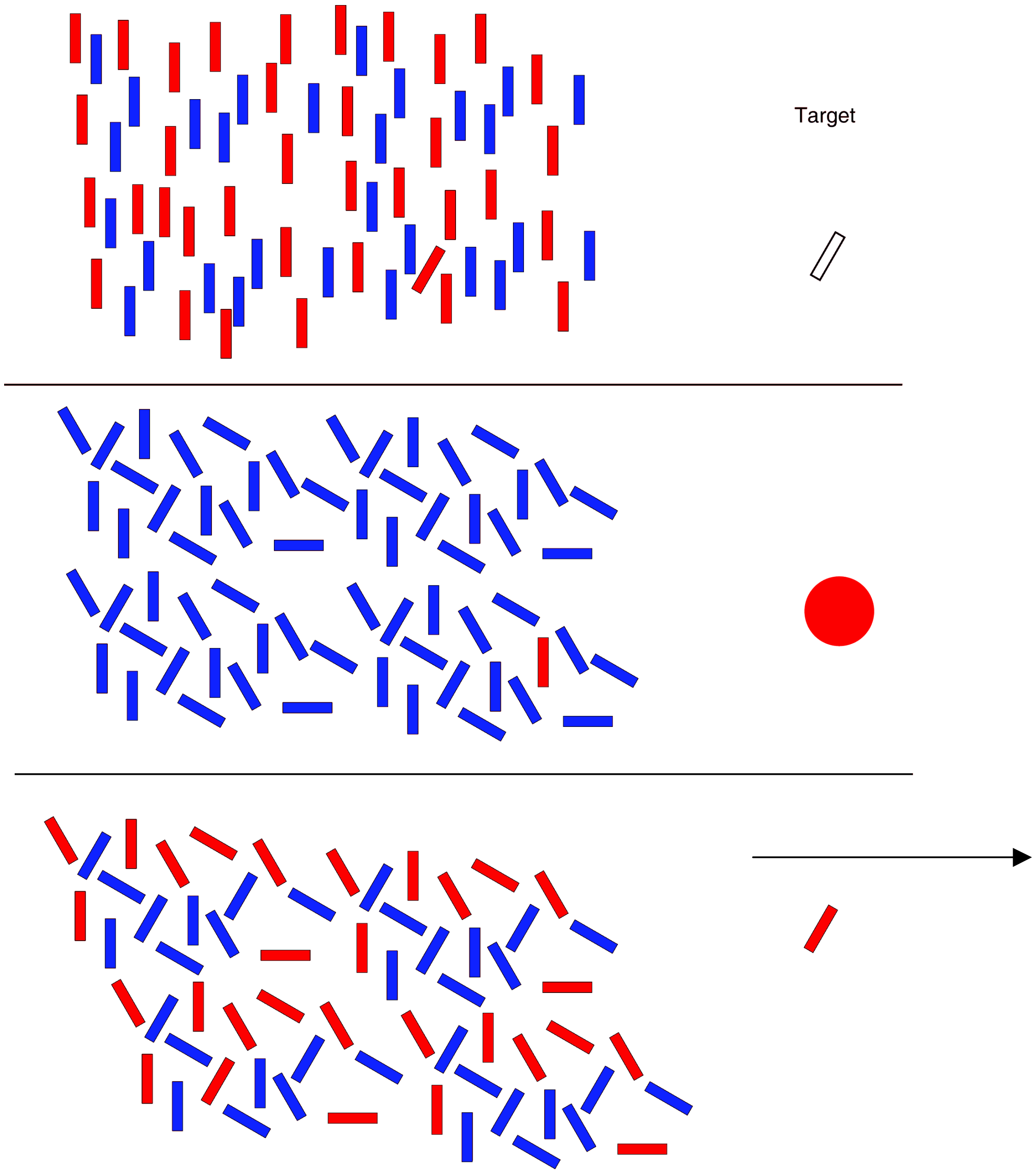
‘Top-down’ from frontal lobe: frontal eye fields, cingulate...



Attending to a peripheral stimulus (while looking at a central fixation point) MINUS looking at a central fixation point

Kastner et al (1999)

‘Top-down’ from the frontal lobe: dorsolateral PFC



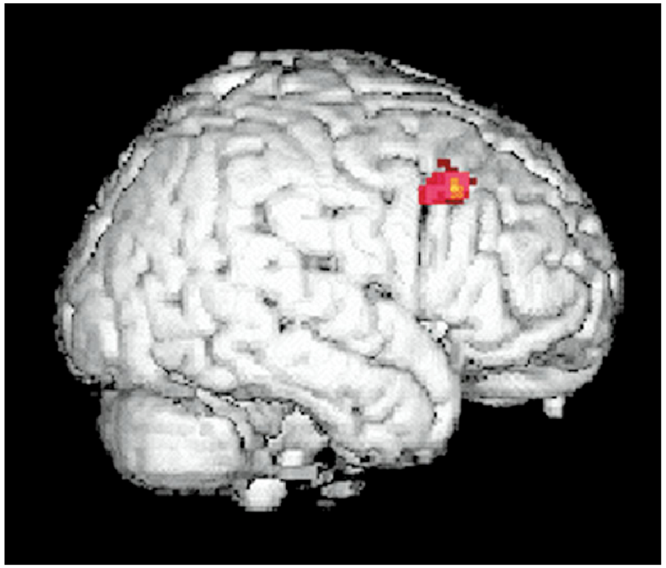


Fig. 2. The area activated by the conjunction task relative to the feature tasks shows no effect of stimulus presentation rate and is located in right BA 8 [Talairach coordinates are (42 22 40), and the *Z* score is 4.22].

Rees et al. (1997)