Experimental Design II: Design, Timing & Efficiency

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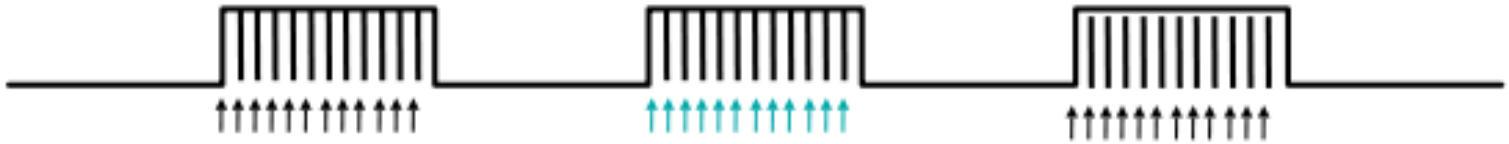
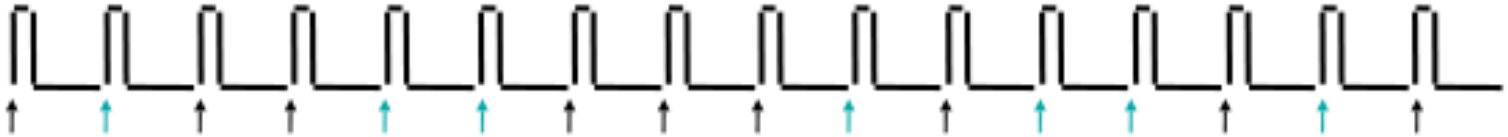
Blocks v Event-Related Designs

BLOCKED:

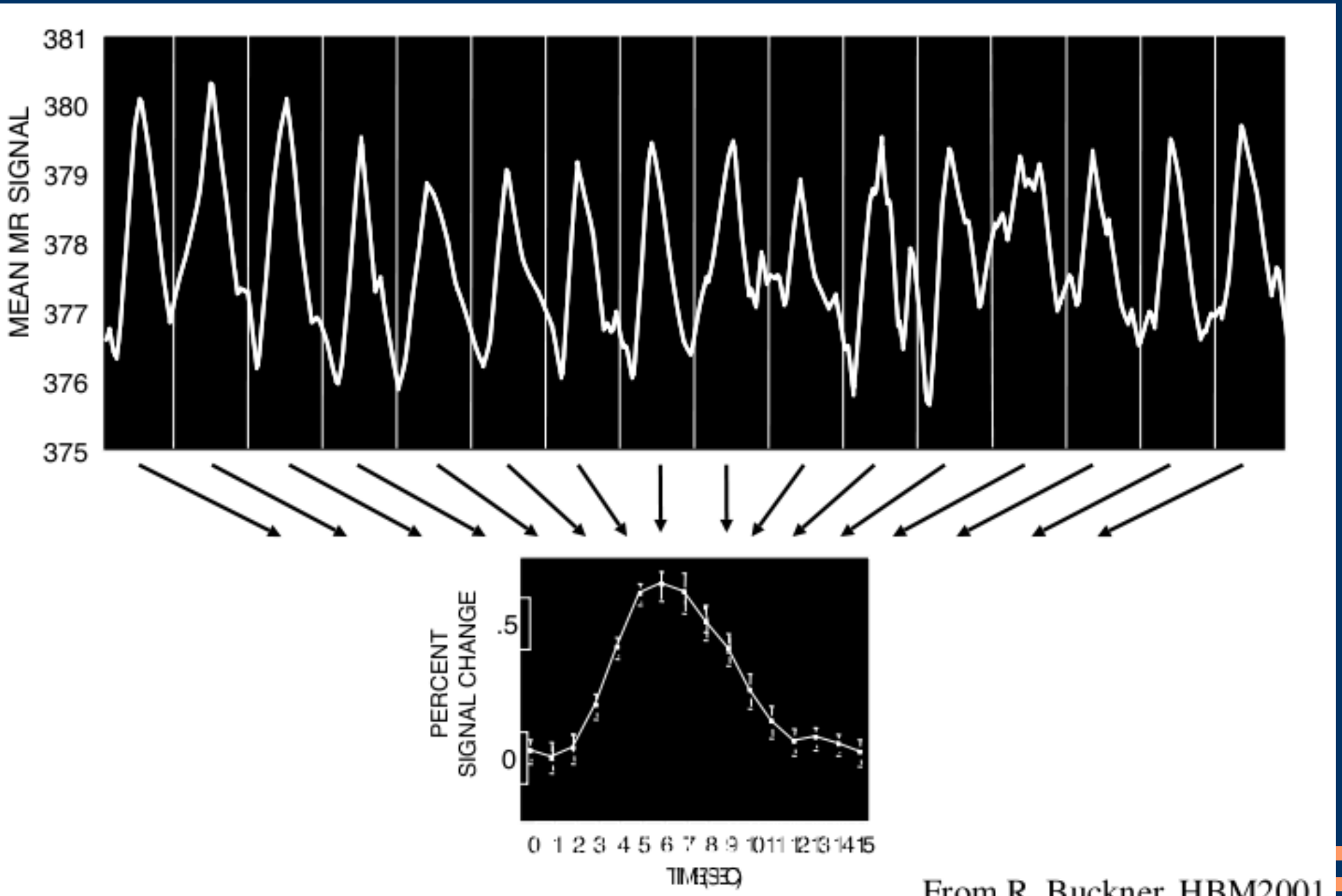


SPACED MIXED TRIAL:



From R. Buckner, HBM2001

Language Event-Related Design



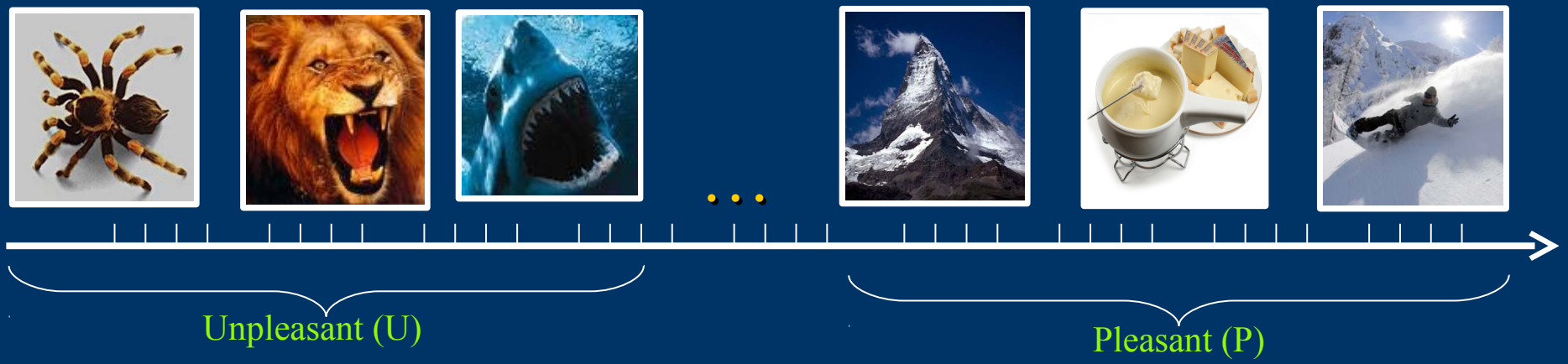
From R. Buckner, HBM2001

Why Event related Designs?

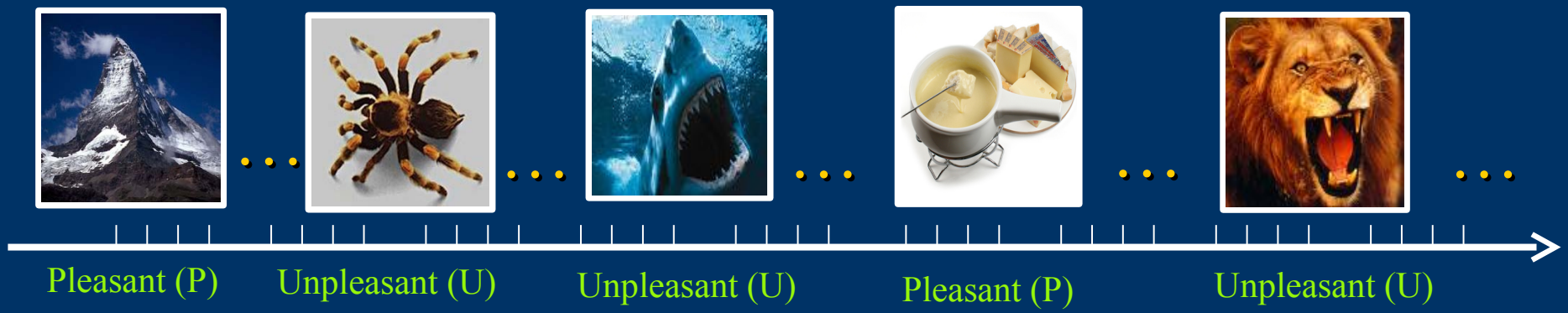
1. Randomised trial order
   c.f. confounds of blocked designs (Johnson et al 1997)

Why Event related Designs?

Blocked designs may trigger expectations and cognitive sets



Intermixed designs can minimise this by stimulus randomisation



From C. Ruff

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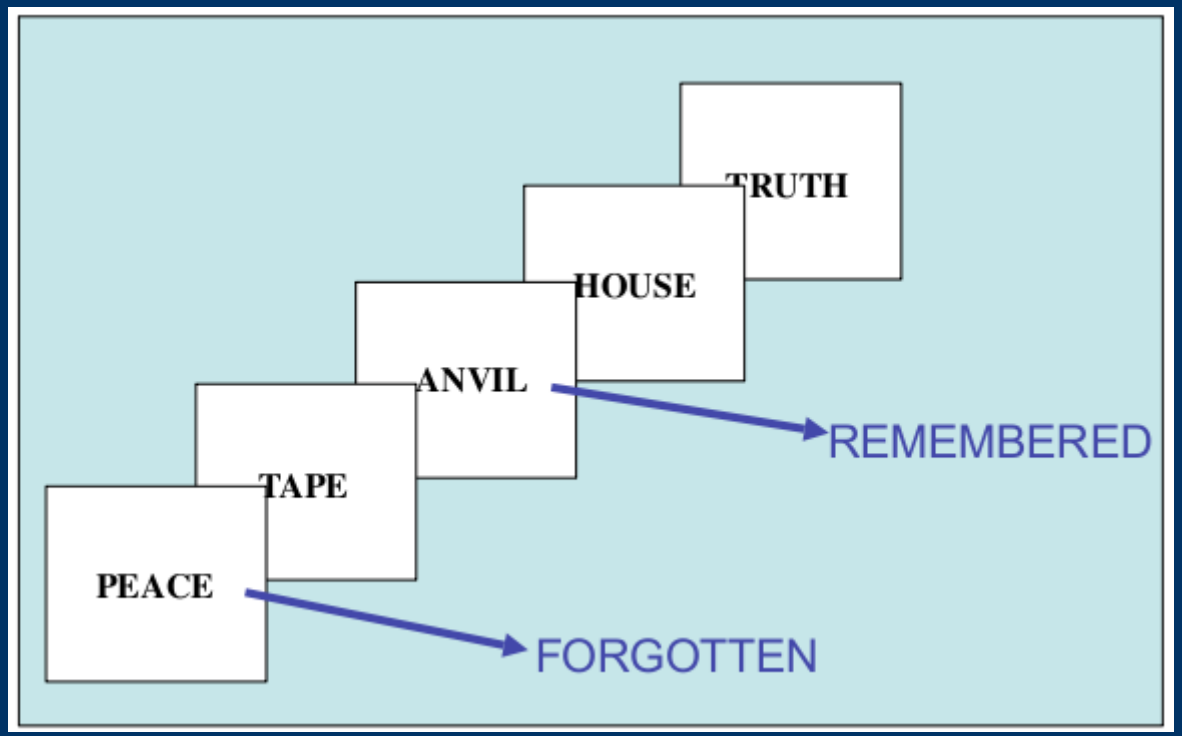
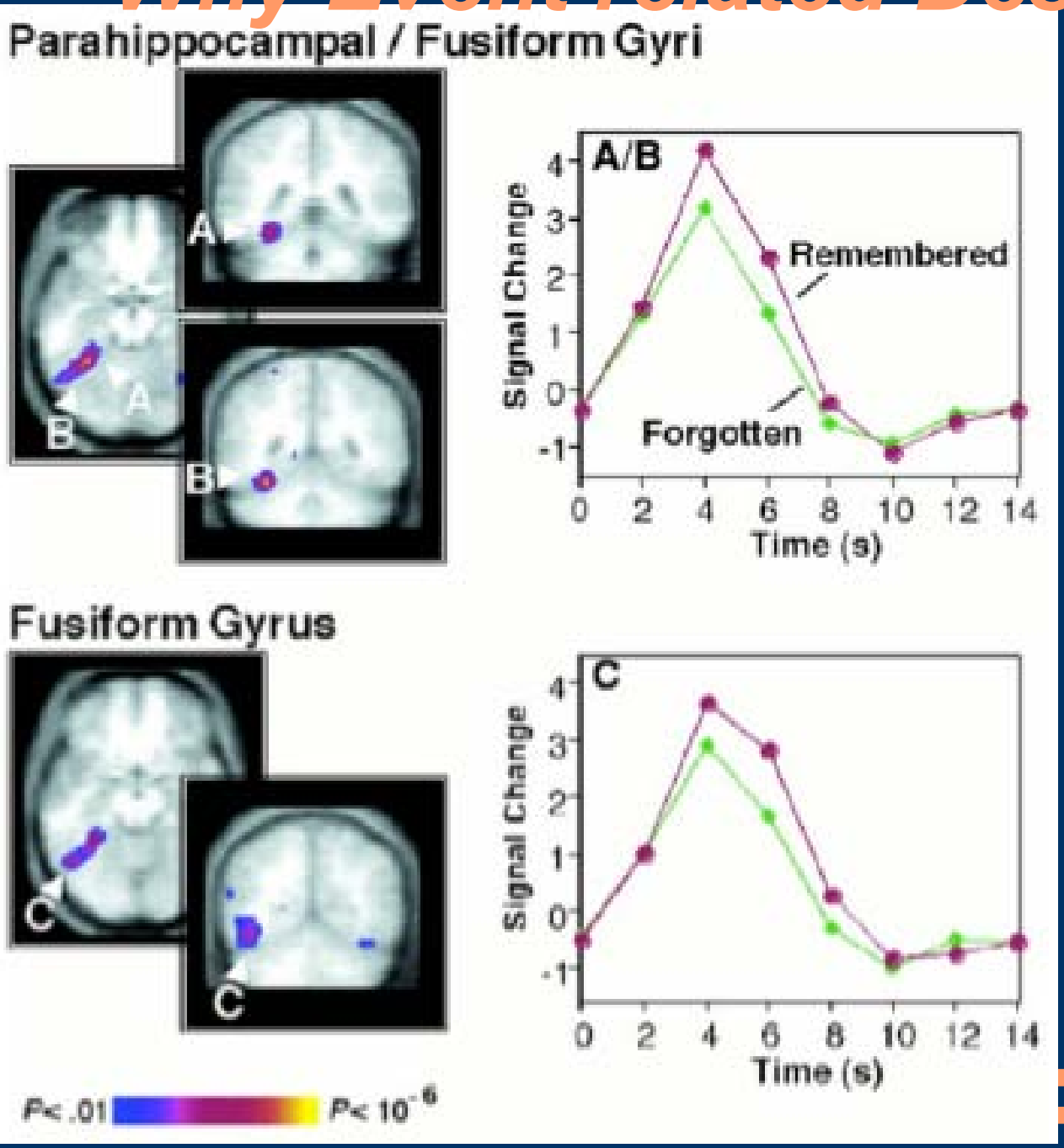
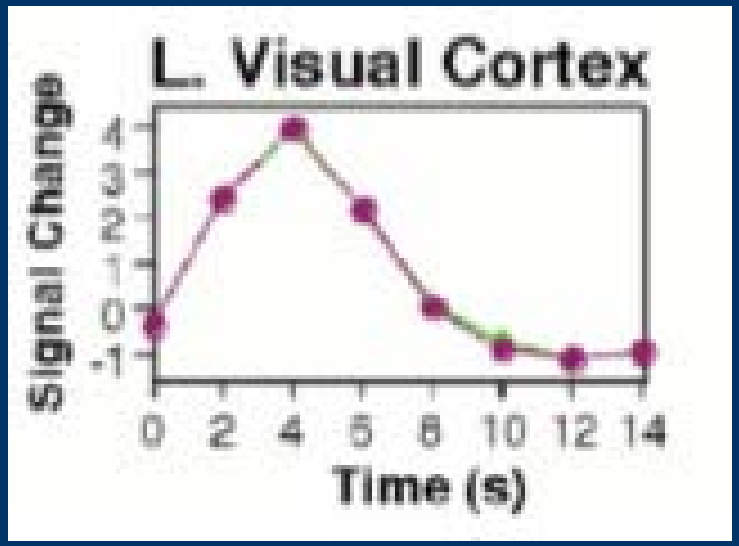


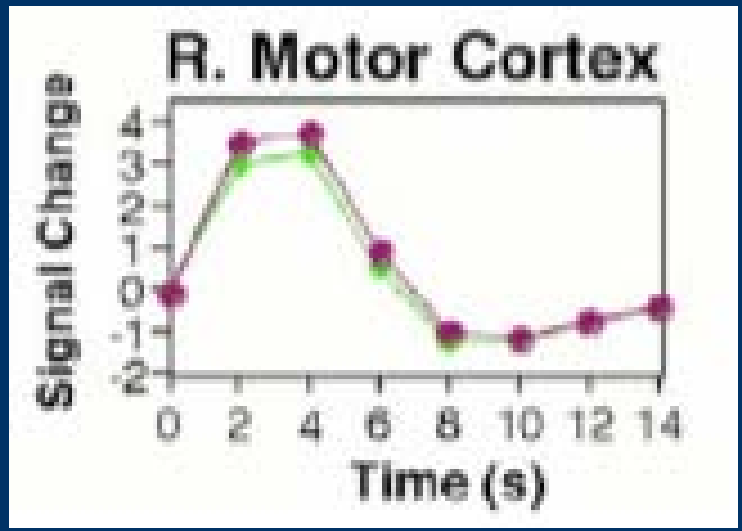
- Task: abstract/concrete
- After scanning, recognition memory test
- FMRI Data Analysis: Sort trials: hit (remembered) v miss (forgotten)

Wagner et al., Science, 1998

Why Event related Designs?







Wagner et al., Science, 1998

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e.g, spontaneous perceptual changes (Tong et al 1998)

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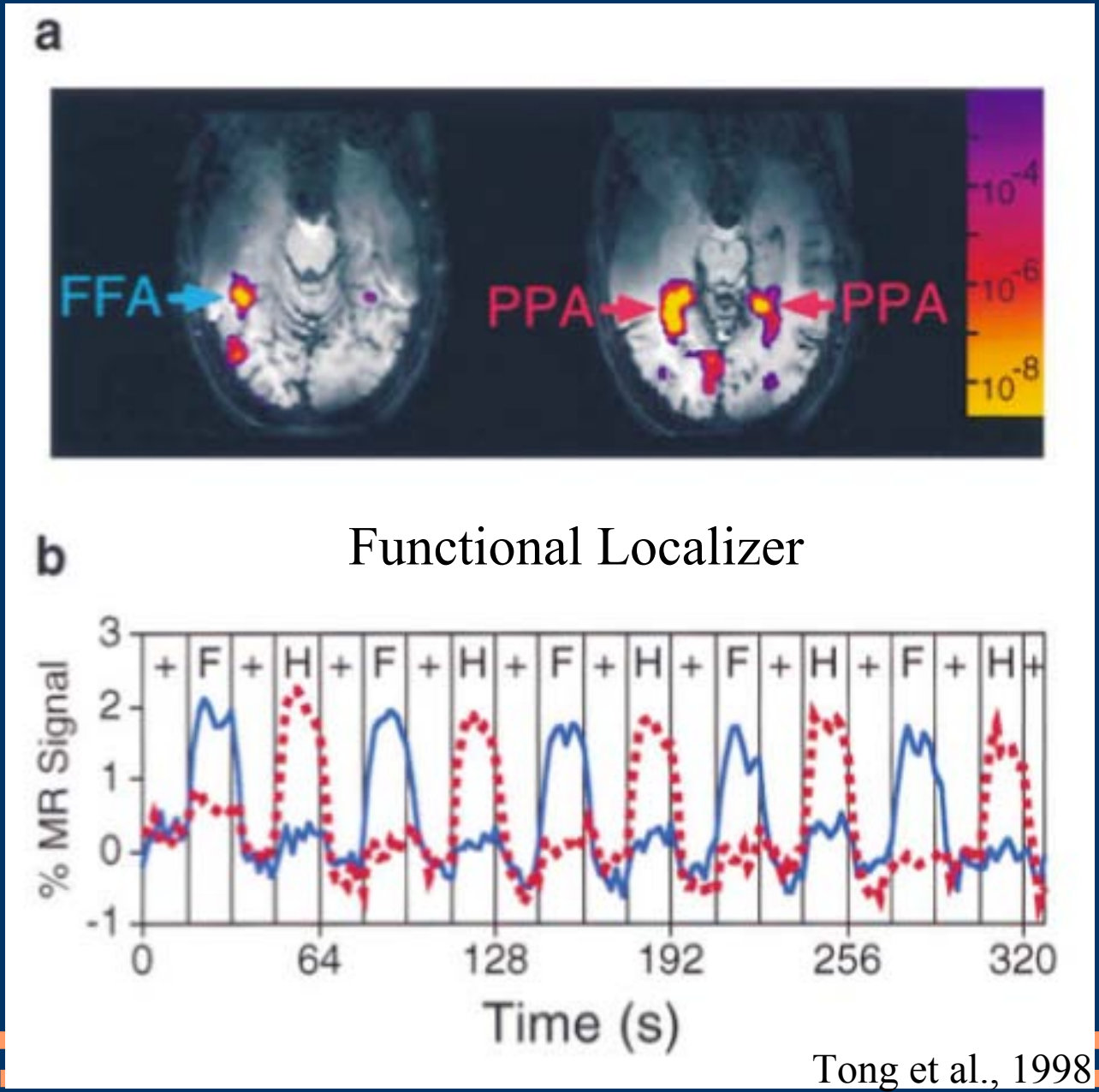

Tong et al., 1998

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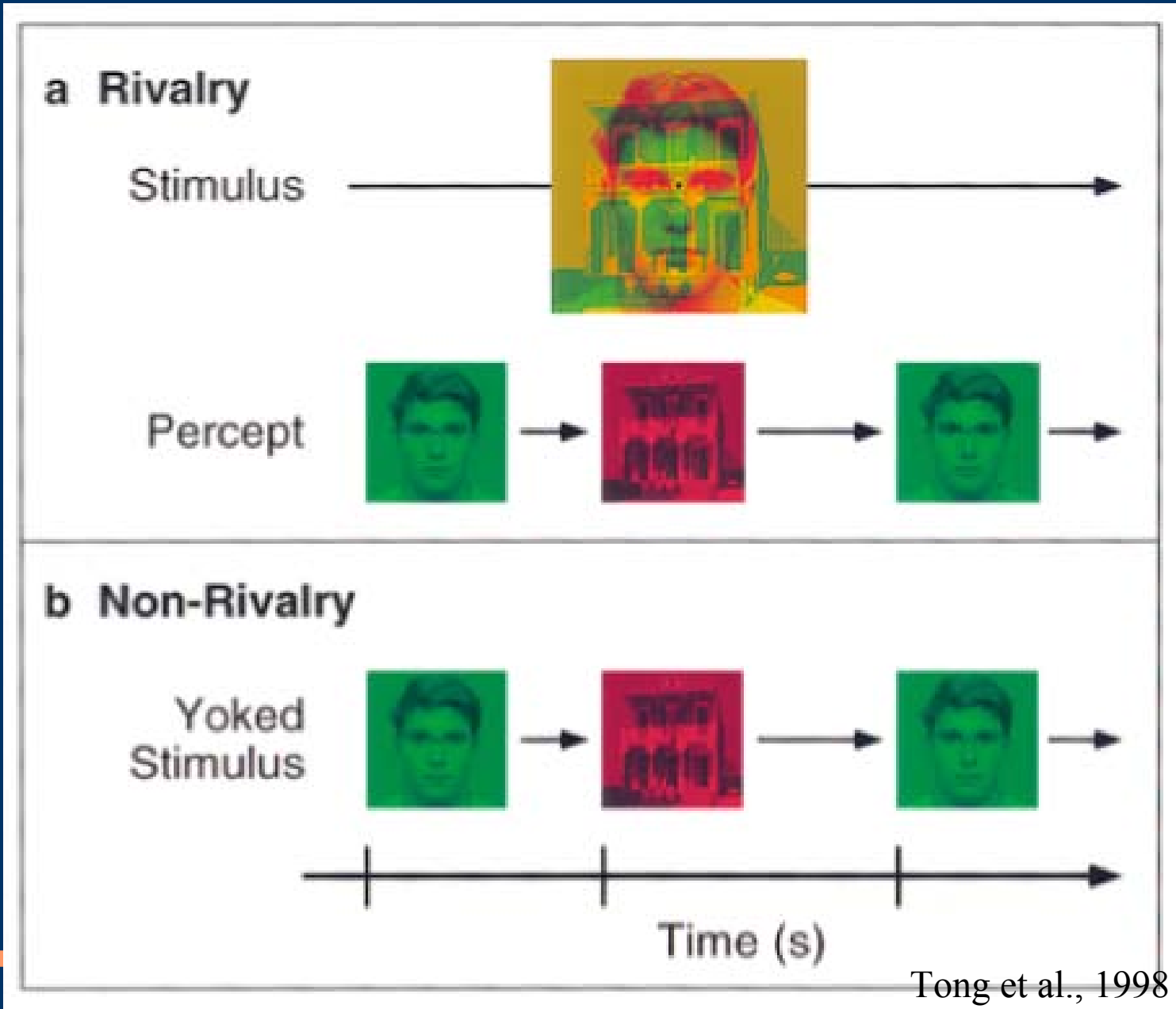

Tong et al., 1998

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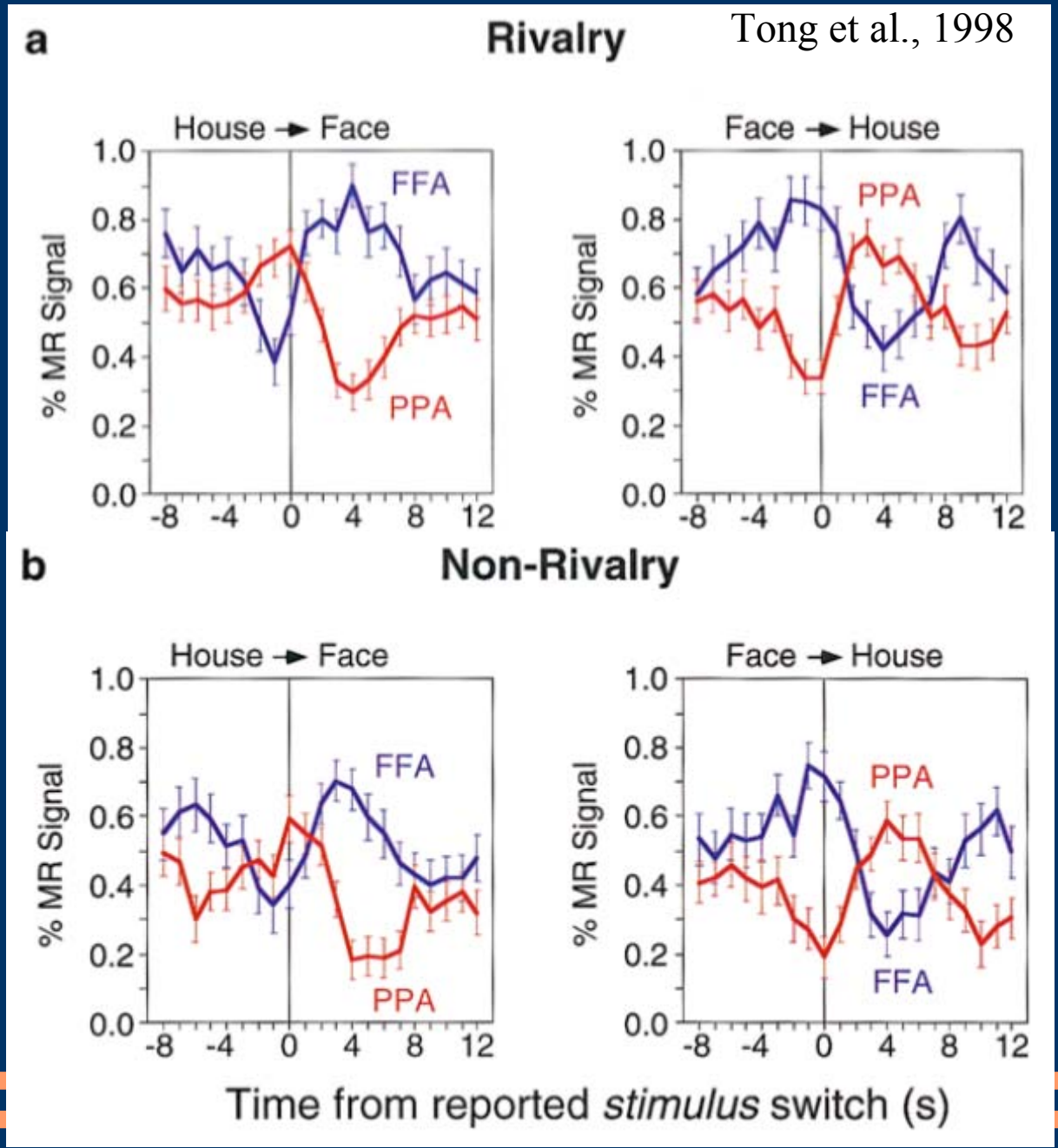

Tong et al., 1998

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4. Some trials cannot be blocked due to stimulus context or interactions
   e.g, "oddball" designs (Clark et al., 2000)

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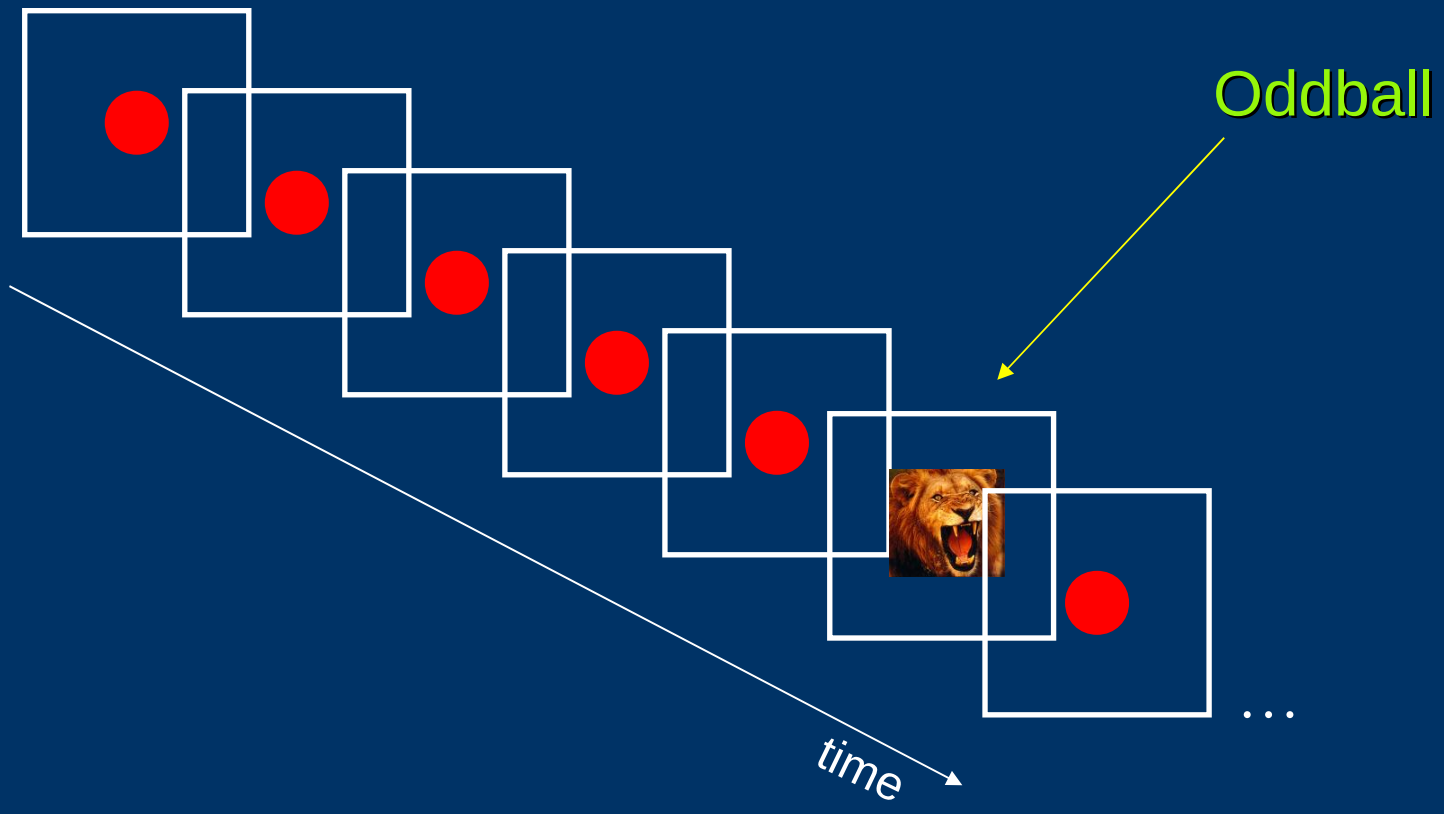

From C. Ruff

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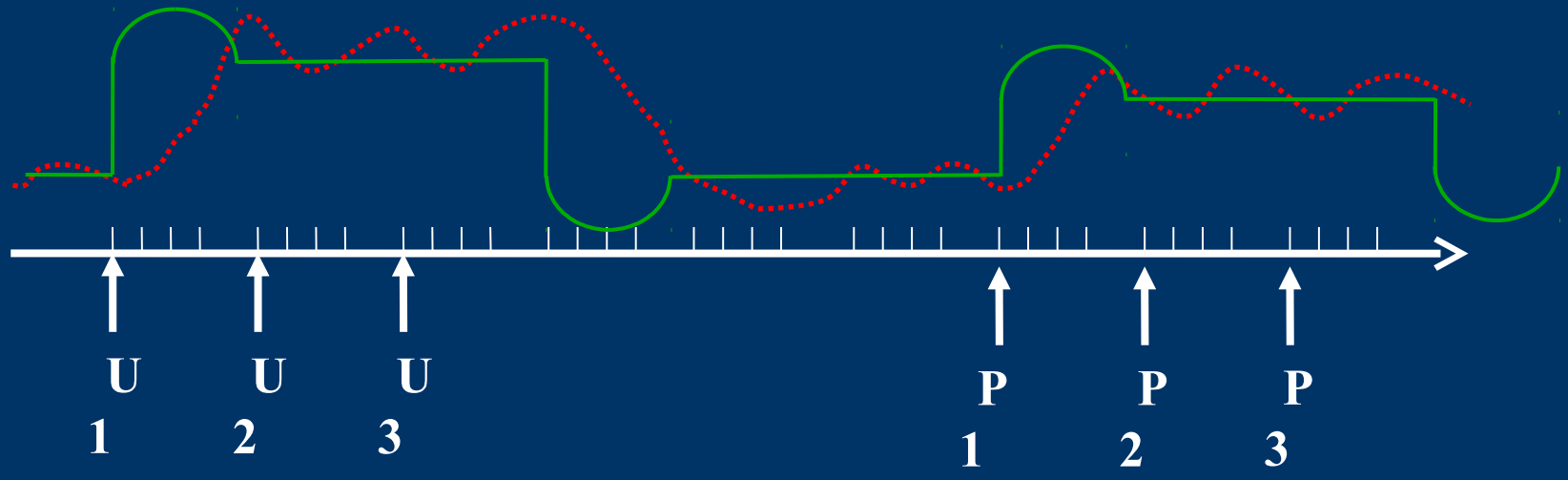
5. More accurate models even for blocked designs?
e.g., "state-item" interactions (Chawla et al, 1999)

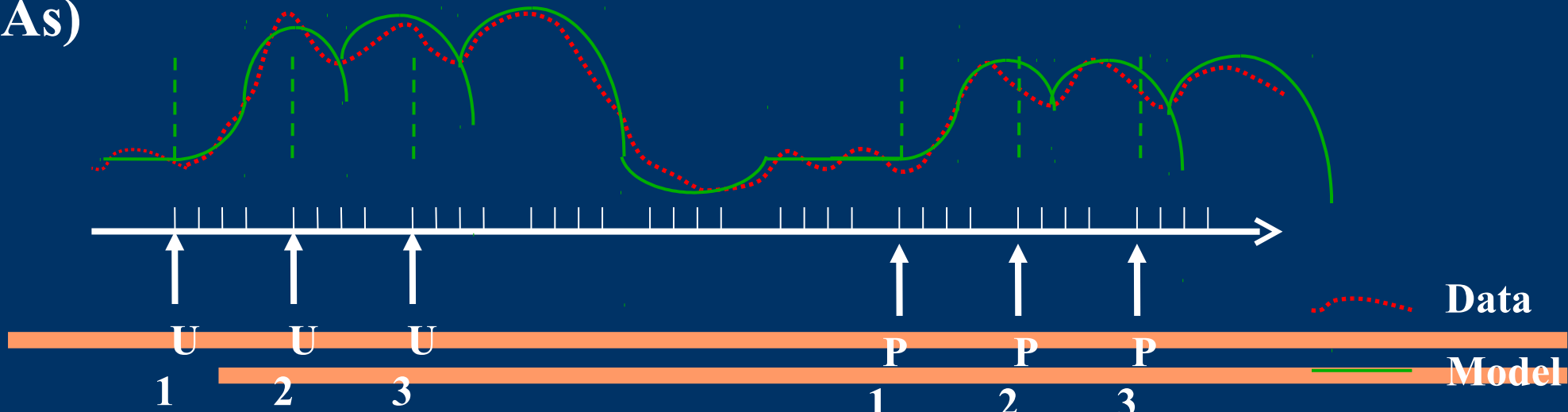
From C. Ruff

ER Models of Block Designs

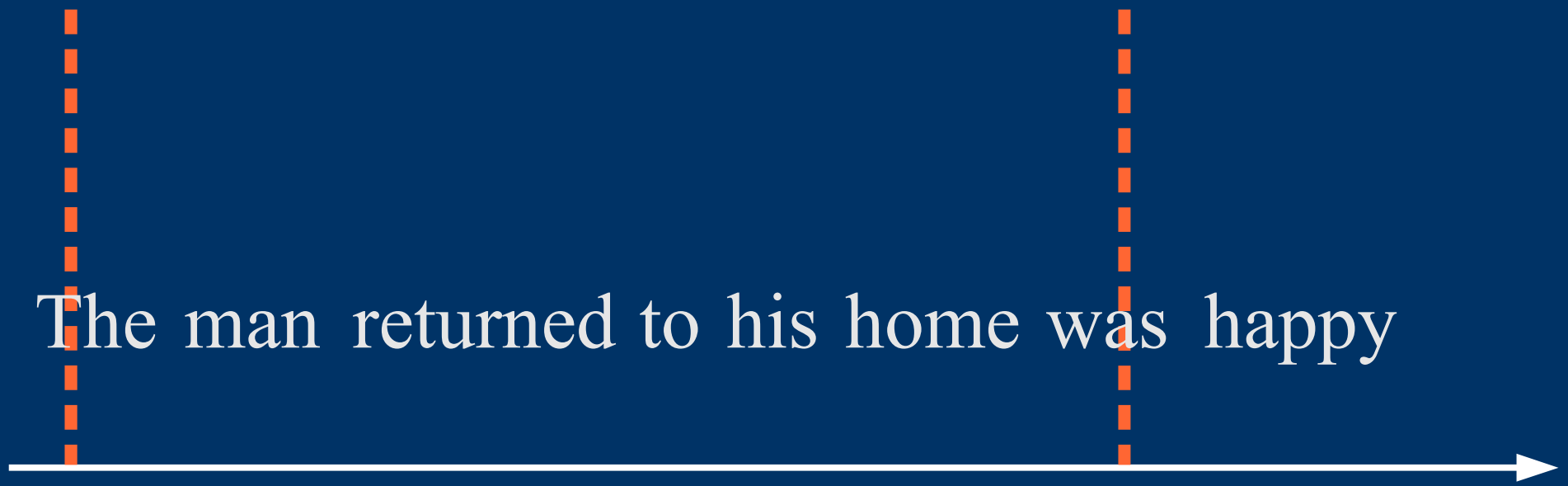
"Epoch" model assumes constant neural processes throughout block



"Event" model may capture state-item interactions (with longer SOAs)



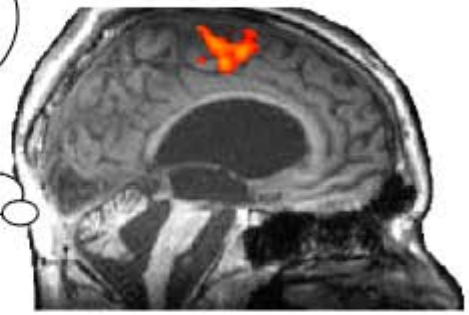
What/Where/When is your event?

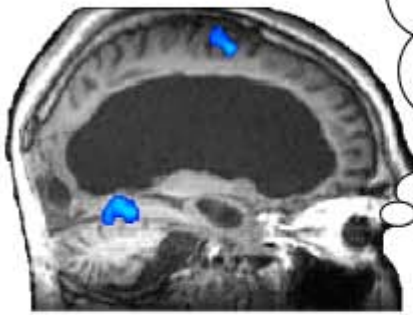


Why NOT Event related Designs?

1. Less efficient for detecting effects than are blocked designs
   (see later…)
2. Some psychological processes have to/may be better blocked
   (e.g., if difficult to switch between states, or to reduce surprise effects)

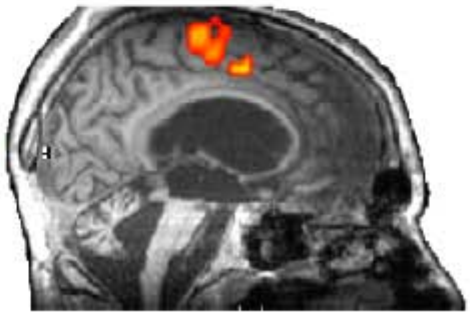
Communicating thoughts with rt-fMRI





Is your father's name Alexander?

'Yes'

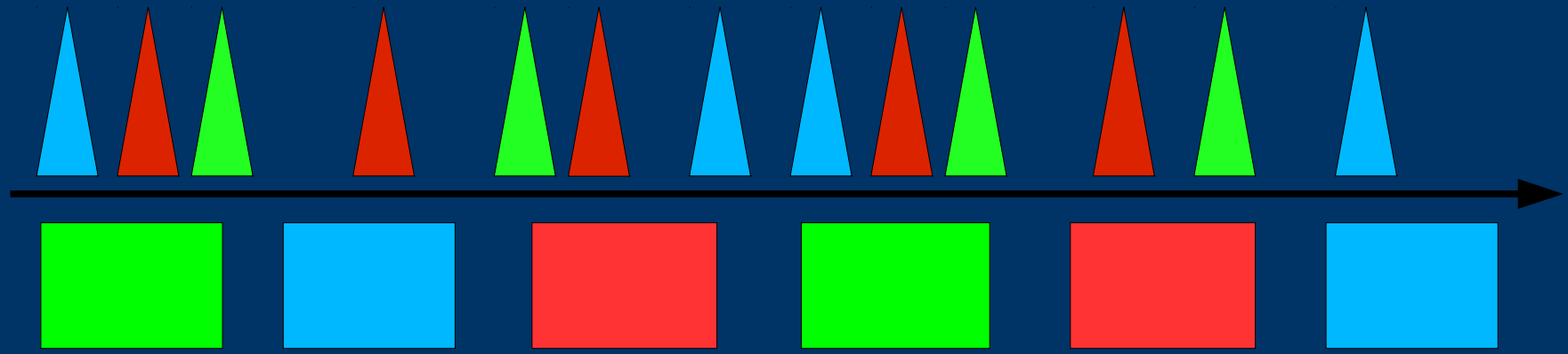


'No'

Why NOT Event related Designs?

1. Less efficient for detecting effects than are blocked designs
   (see later…)
2. Some psychological processes have to/may be better blocked
   (e.g., if difficult to switch between states, or to reduce surprise effects)
3. Role of strategy, expectations, selective attention, …

Selective Attention



Blocks v Event-Related Designs

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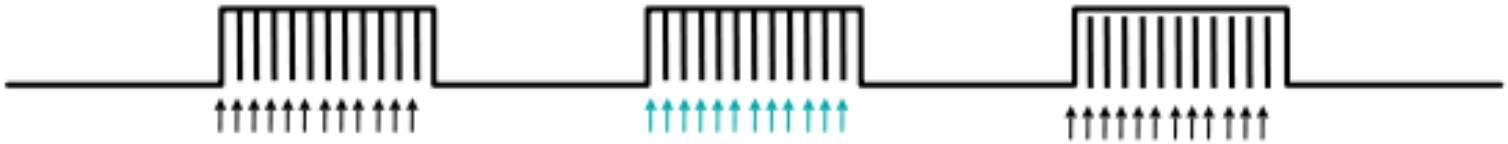
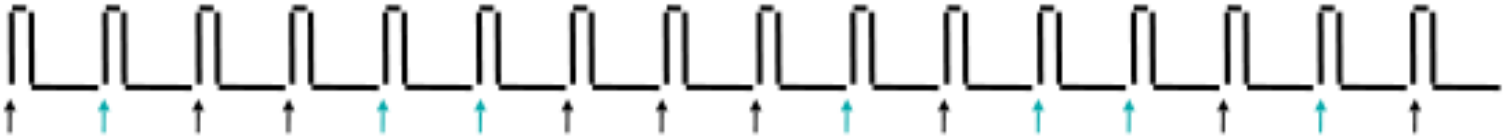


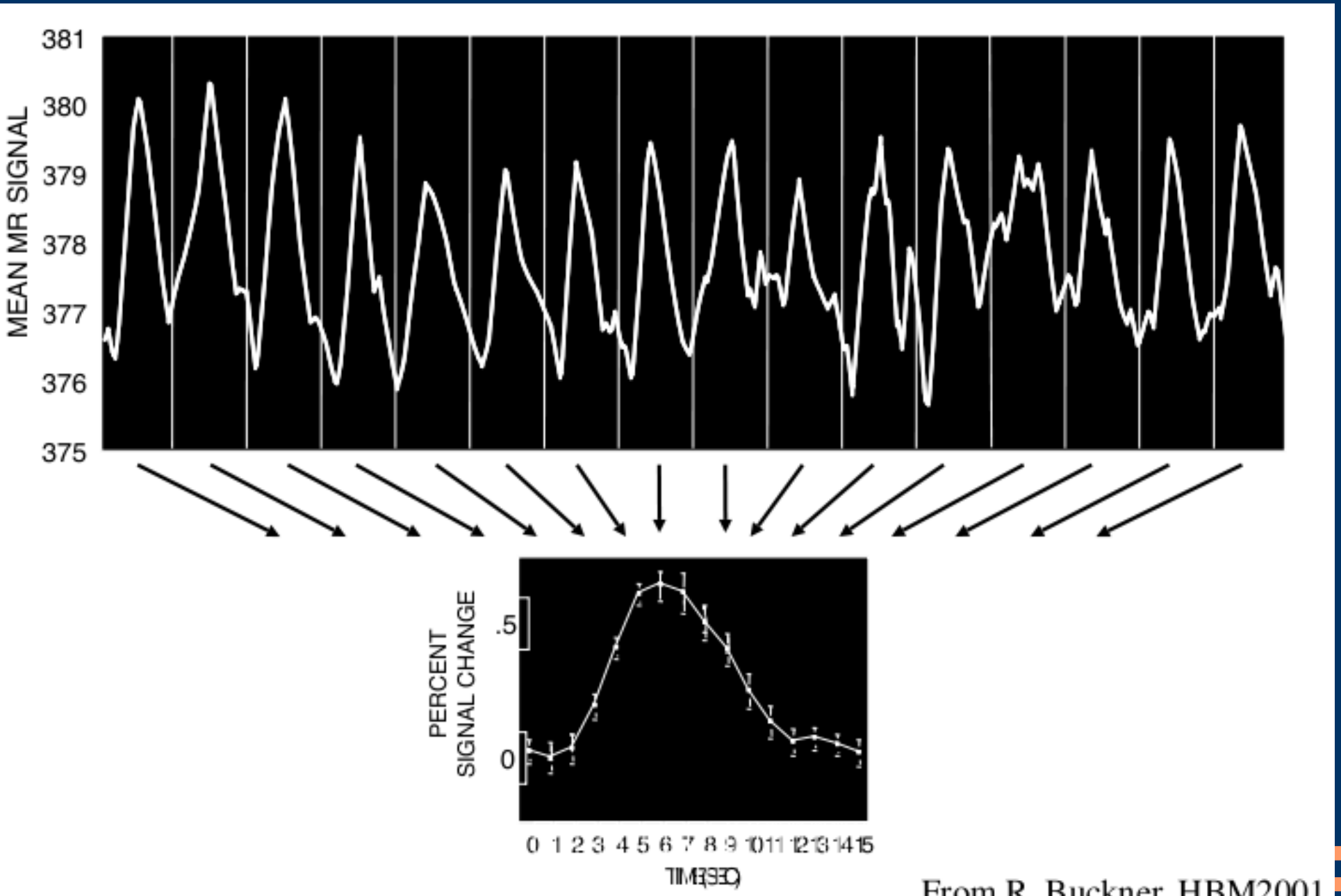
SPACED MIXED TRIAL:



RAPID MIXED TRIAL:

From R. Buckner, HBM2001

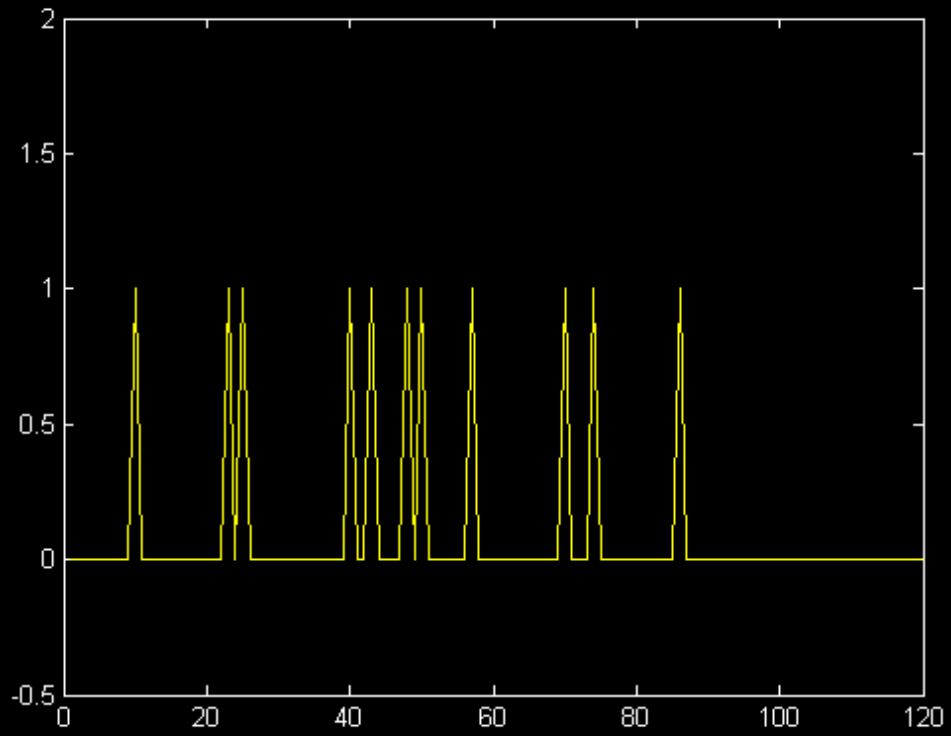
Slow Event-Related Design

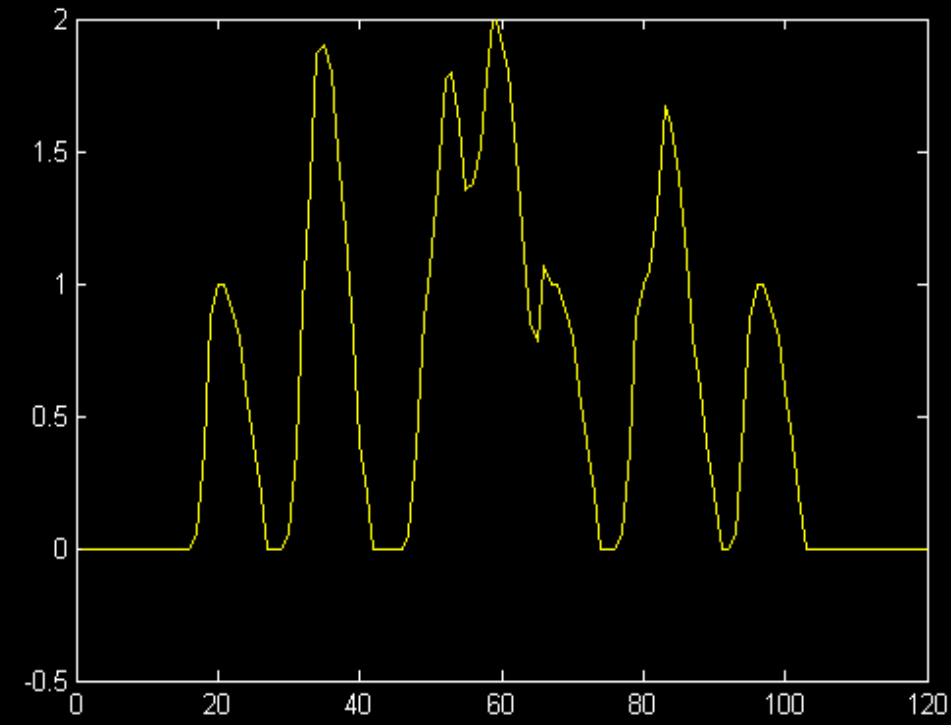


From R. Buckner, HBM2001

Fast ER

- More trials, same experiment length!
- Overlapping events
- How to tease apart which part of the response comes from which event?





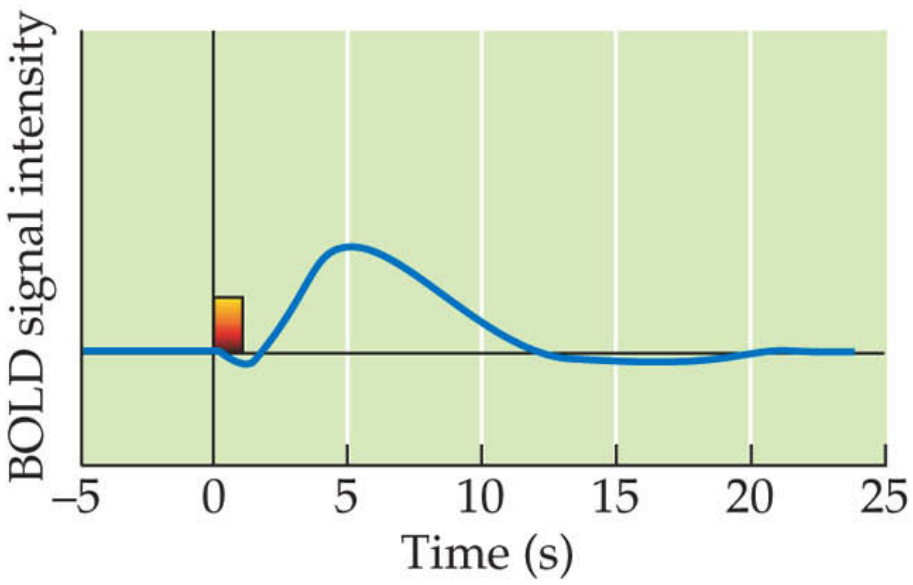
Assumption: Linear System

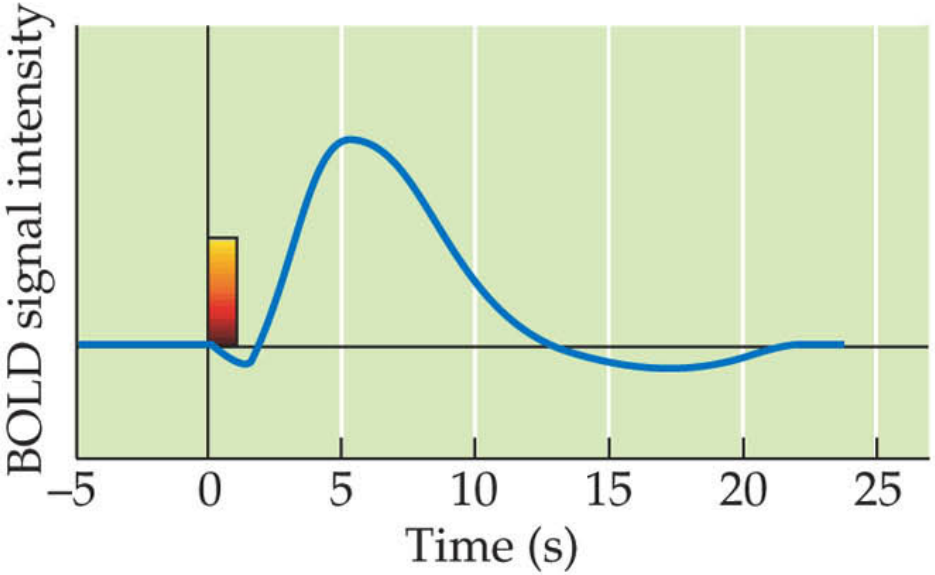
- System = input --> output
  - Neural activity --> fMRI signal
- System is linear if it has two features:
  - Scaling & Superposition
- If it passes these two tests,

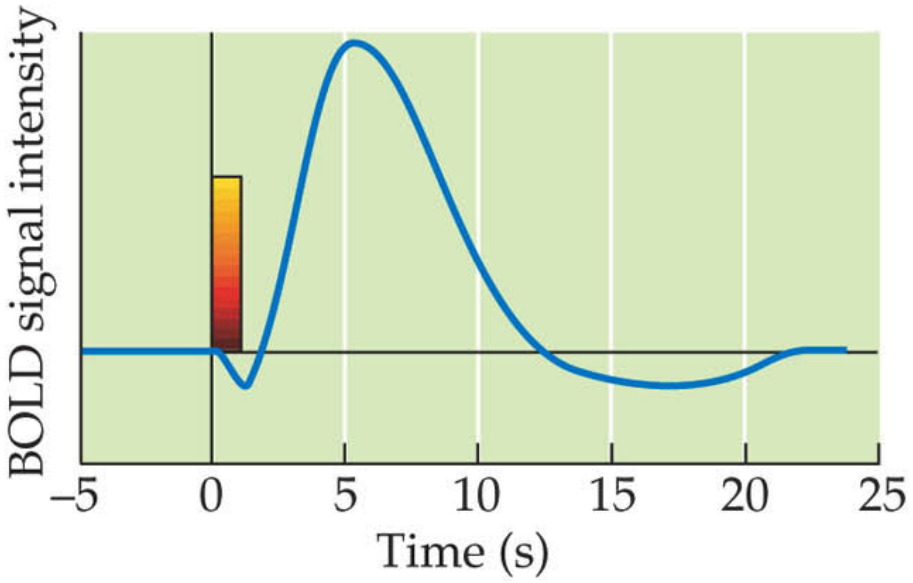
  then we can add and subtract responses

Assumption I: Scaling

(A)

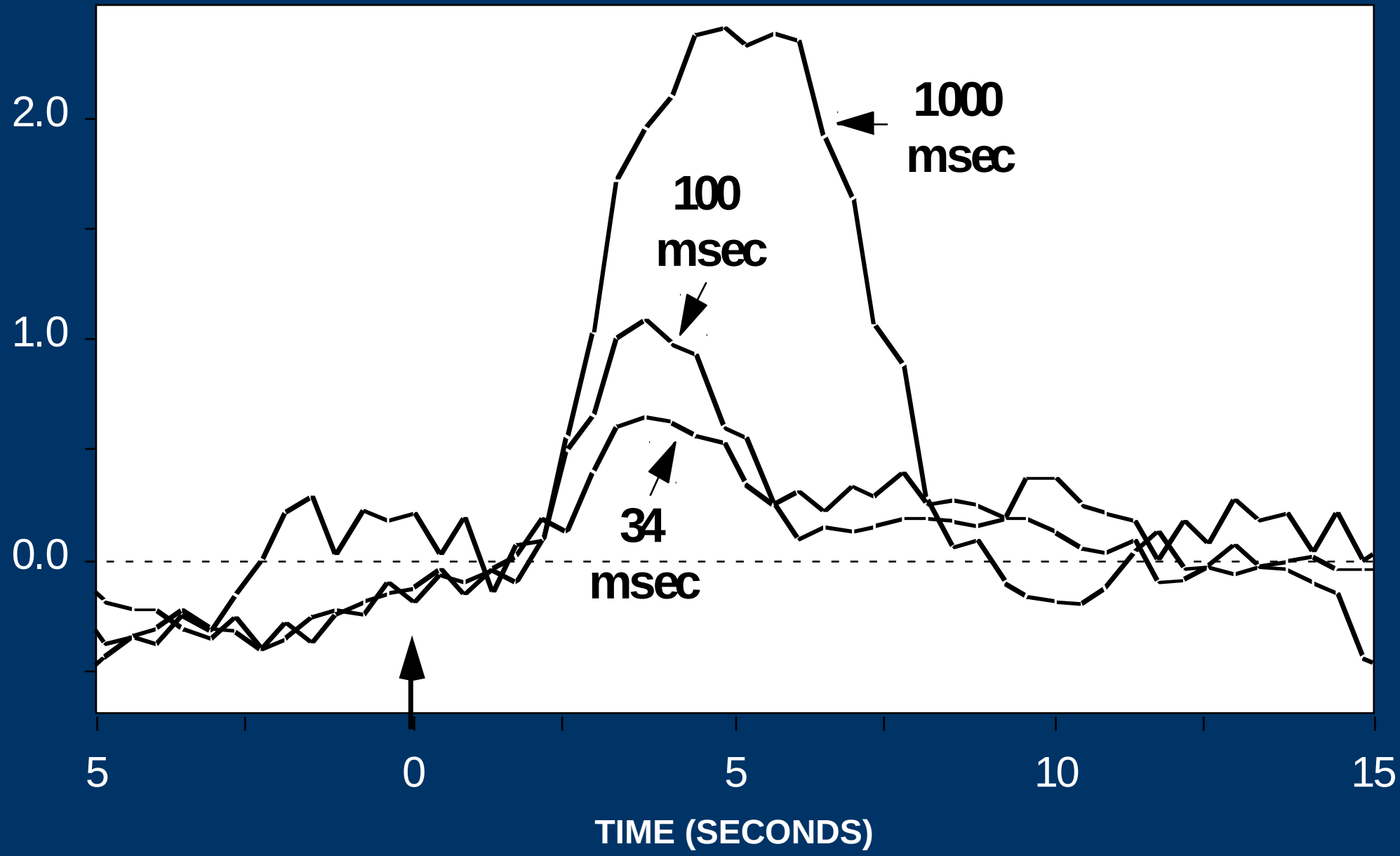




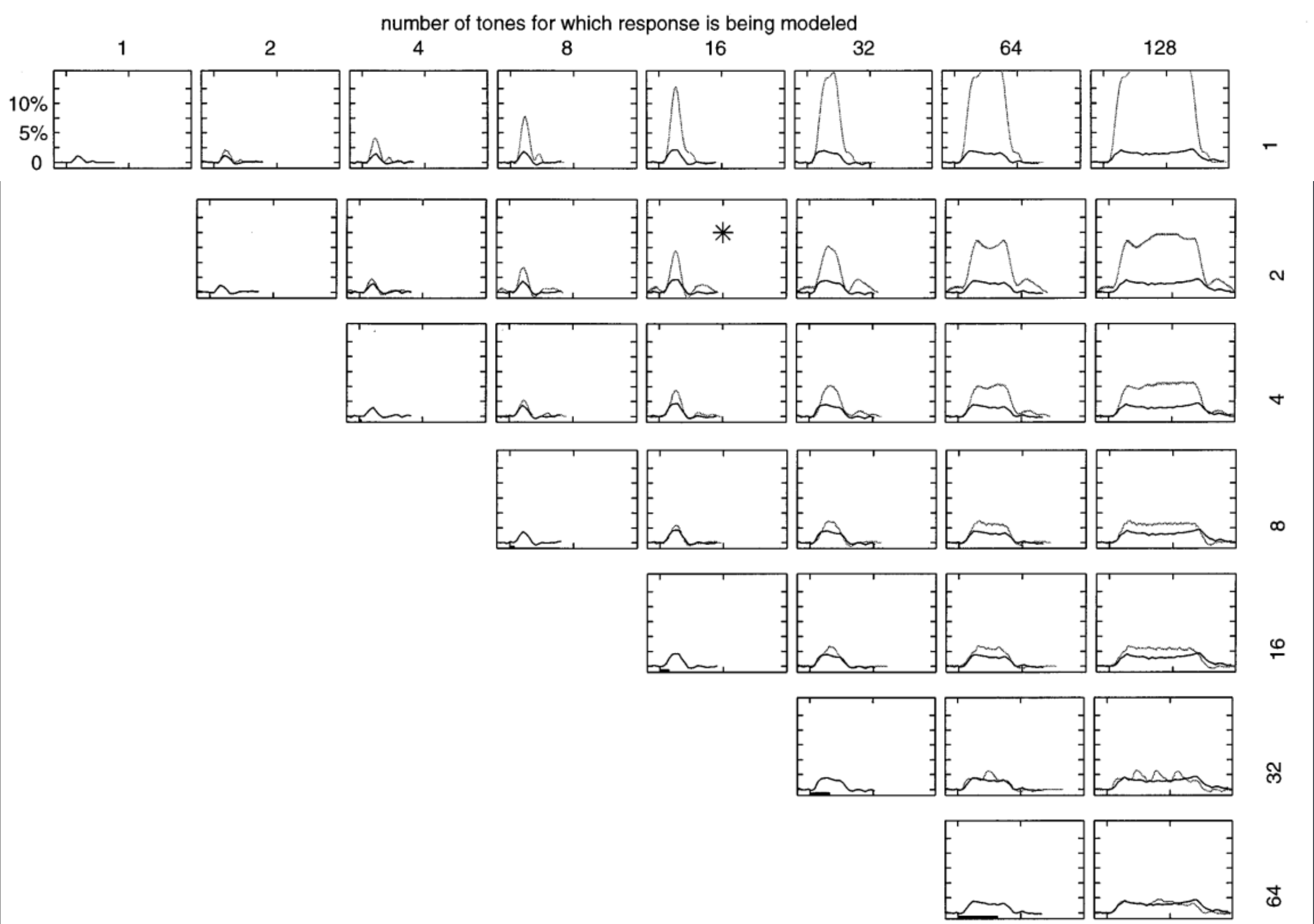


FUNCTIONAL MAGNETIC RESONANCE IMAGING, **Figure 8.18 (Part 1)**

Response of Visual Cortex to Stimuli

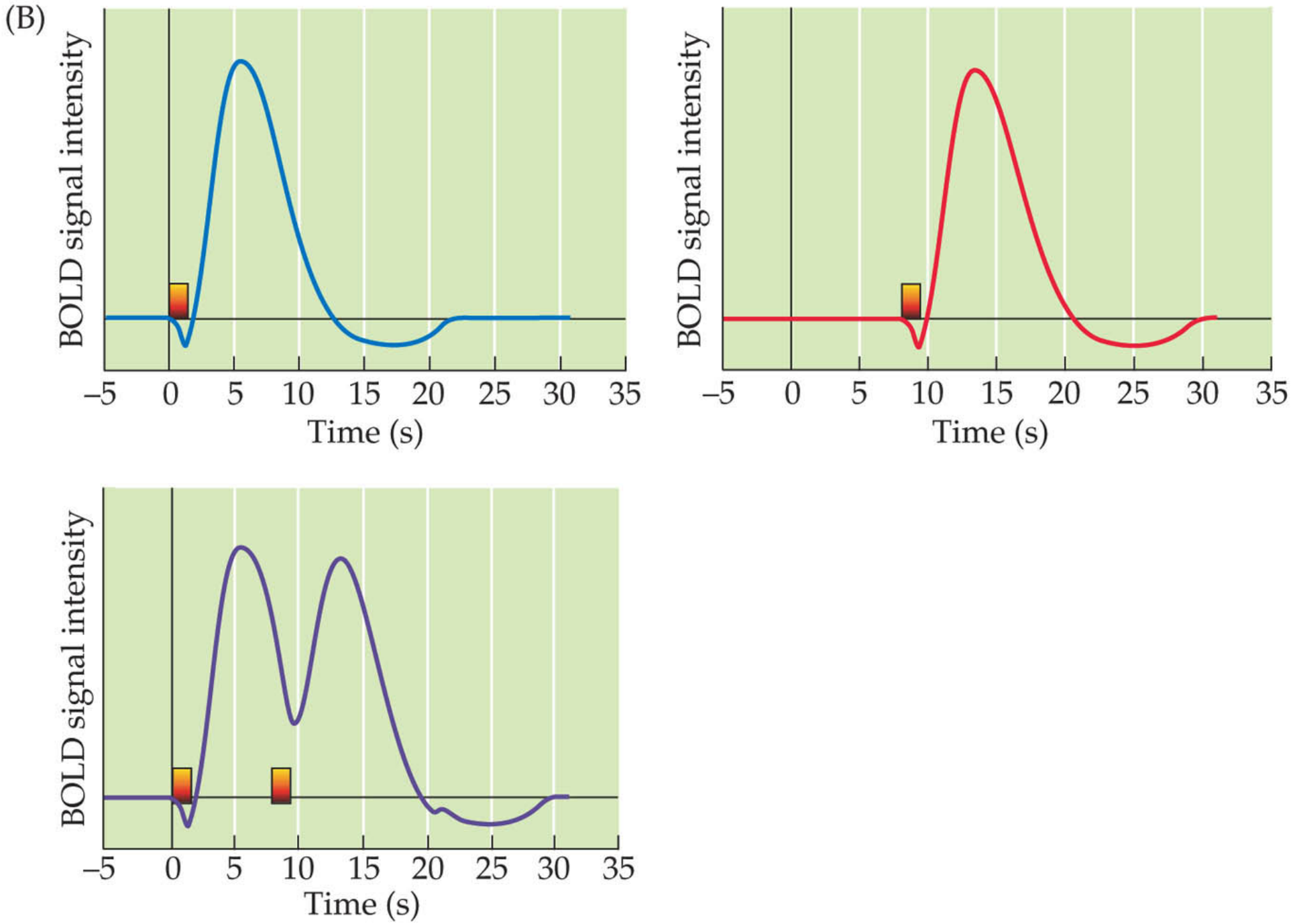


Courtesy of Robert Savoy, Kathleen O'Craven MGH-NMR Center



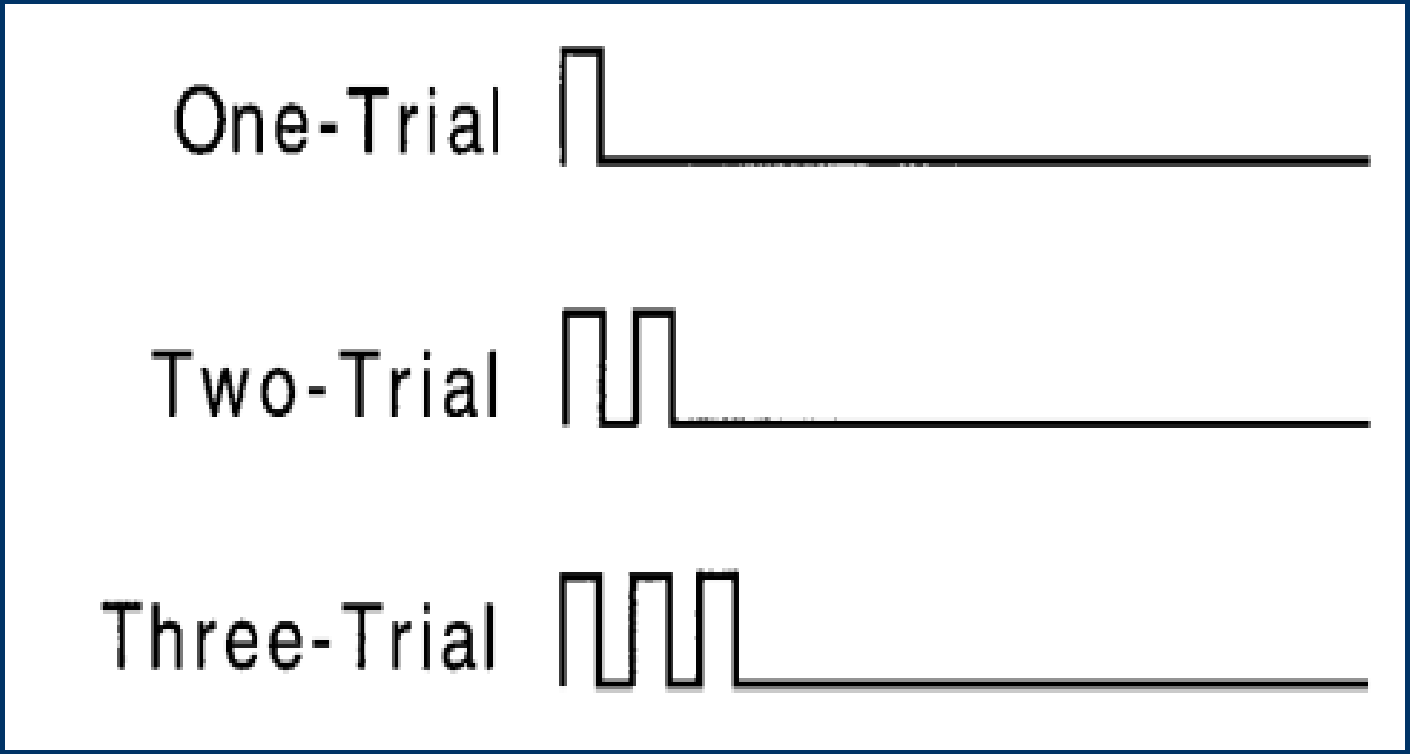
Robson et al., 1998

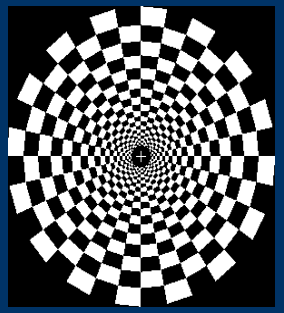
Assumption II: Superposition



FUNCTIONAL MAGNETIC RESONANCE IMAGING, **Figure 8.18 (Part 2)**

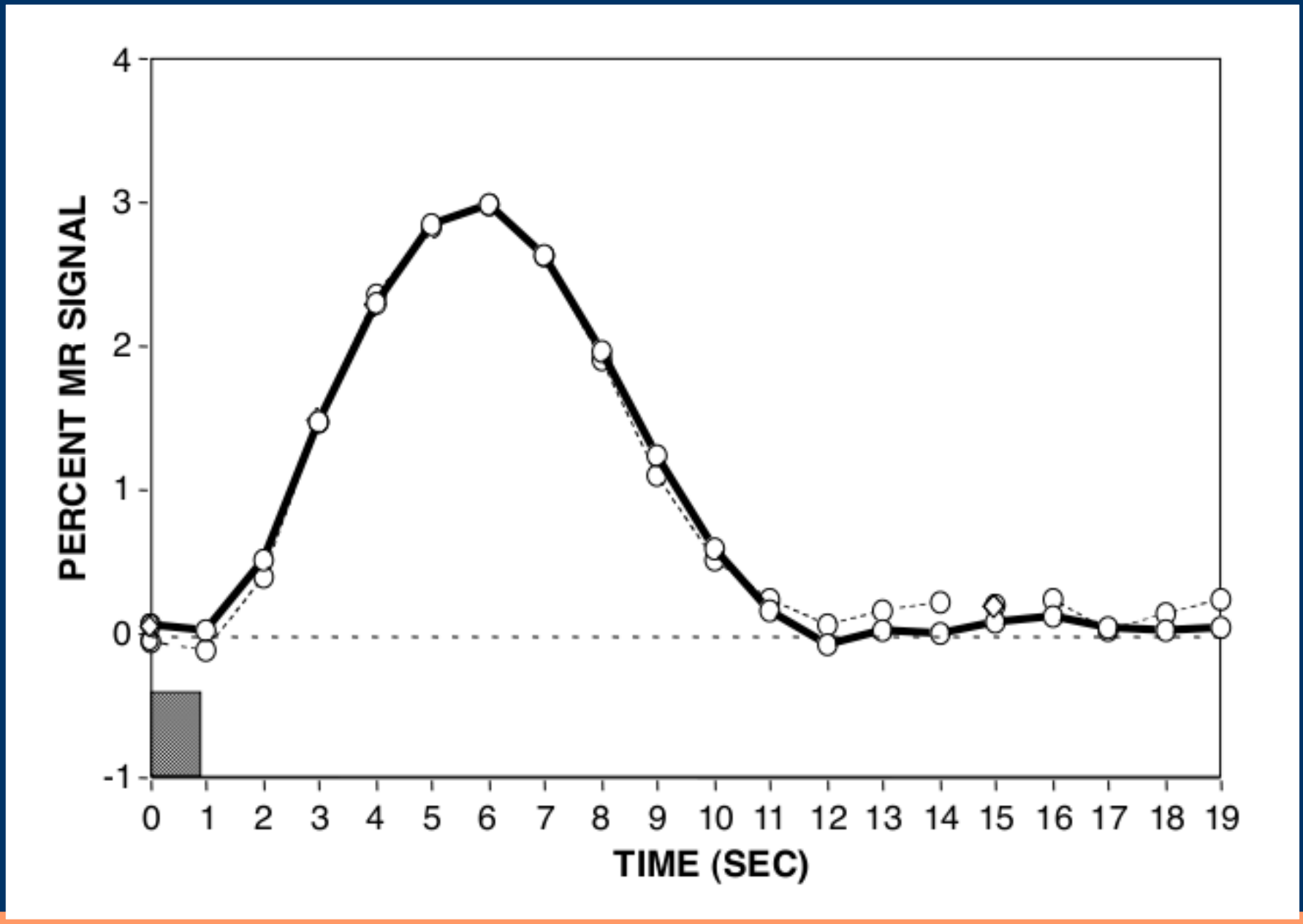
Linearity II: Superposition





Dale and Buckner, *Hum. Brain Map.*, 1997

Linearity II: Superposition



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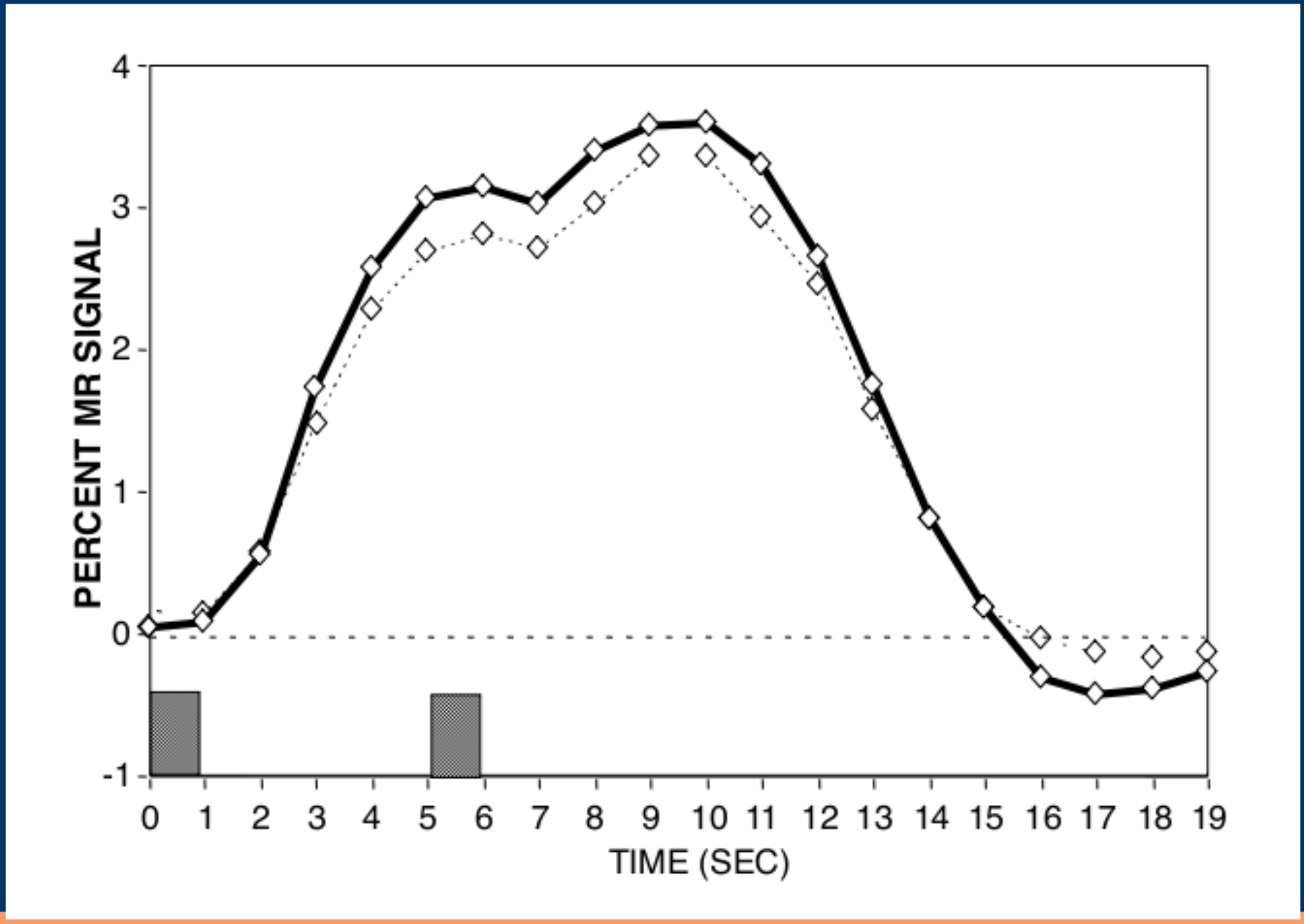

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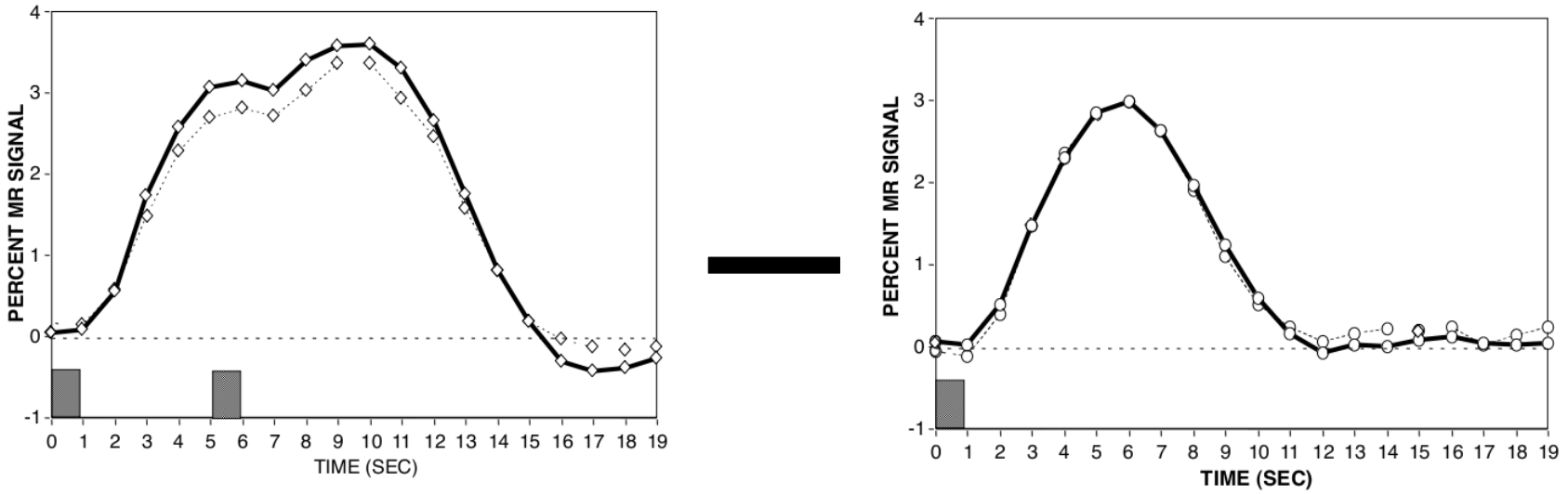

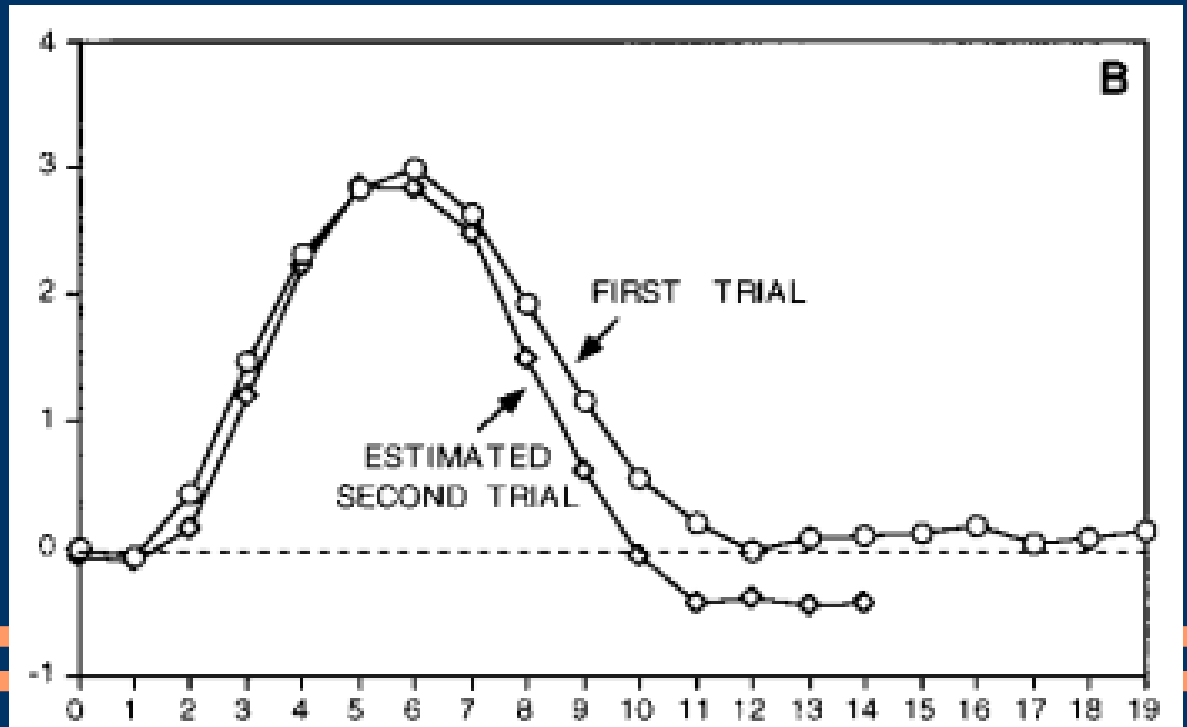

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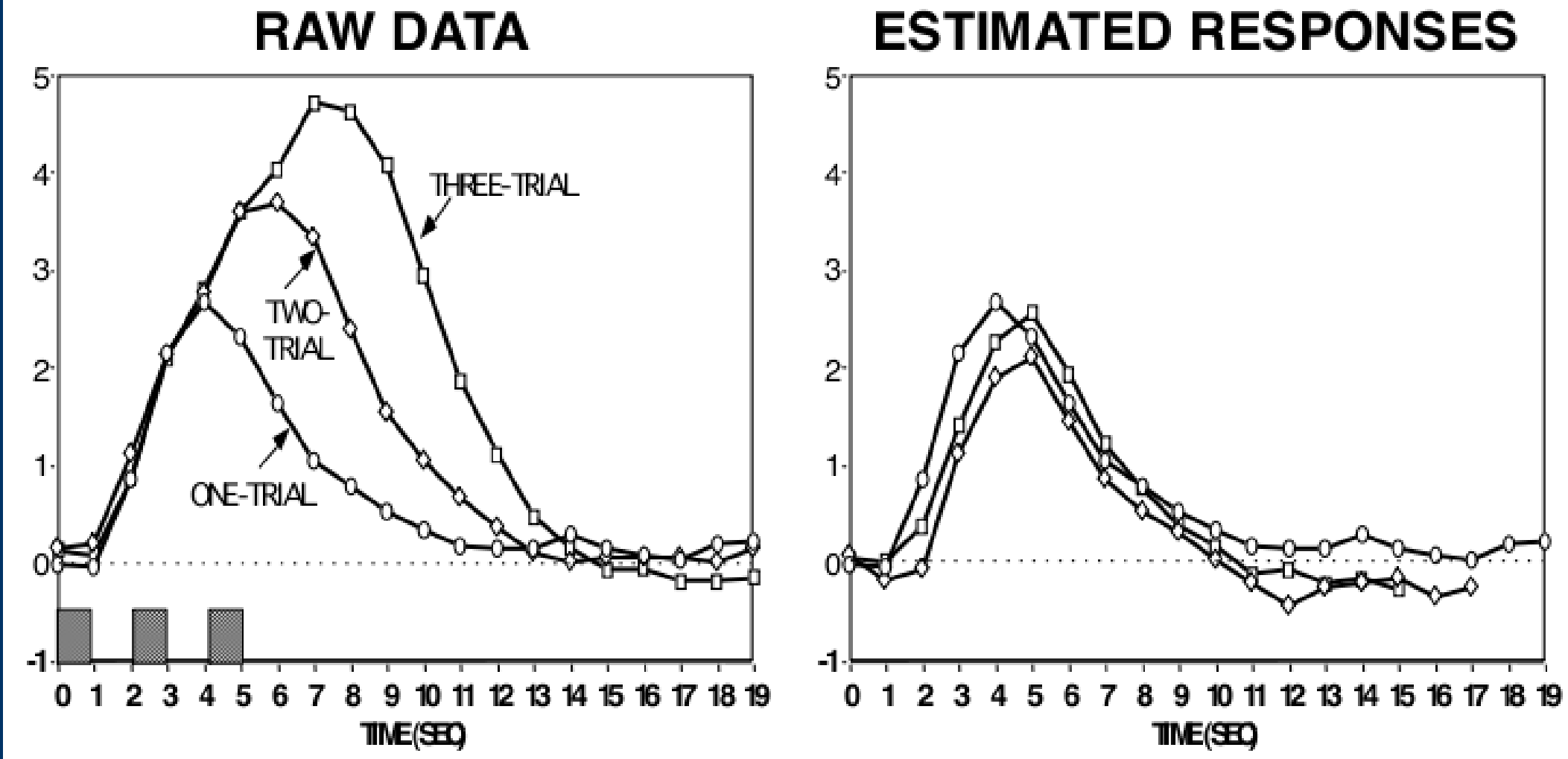
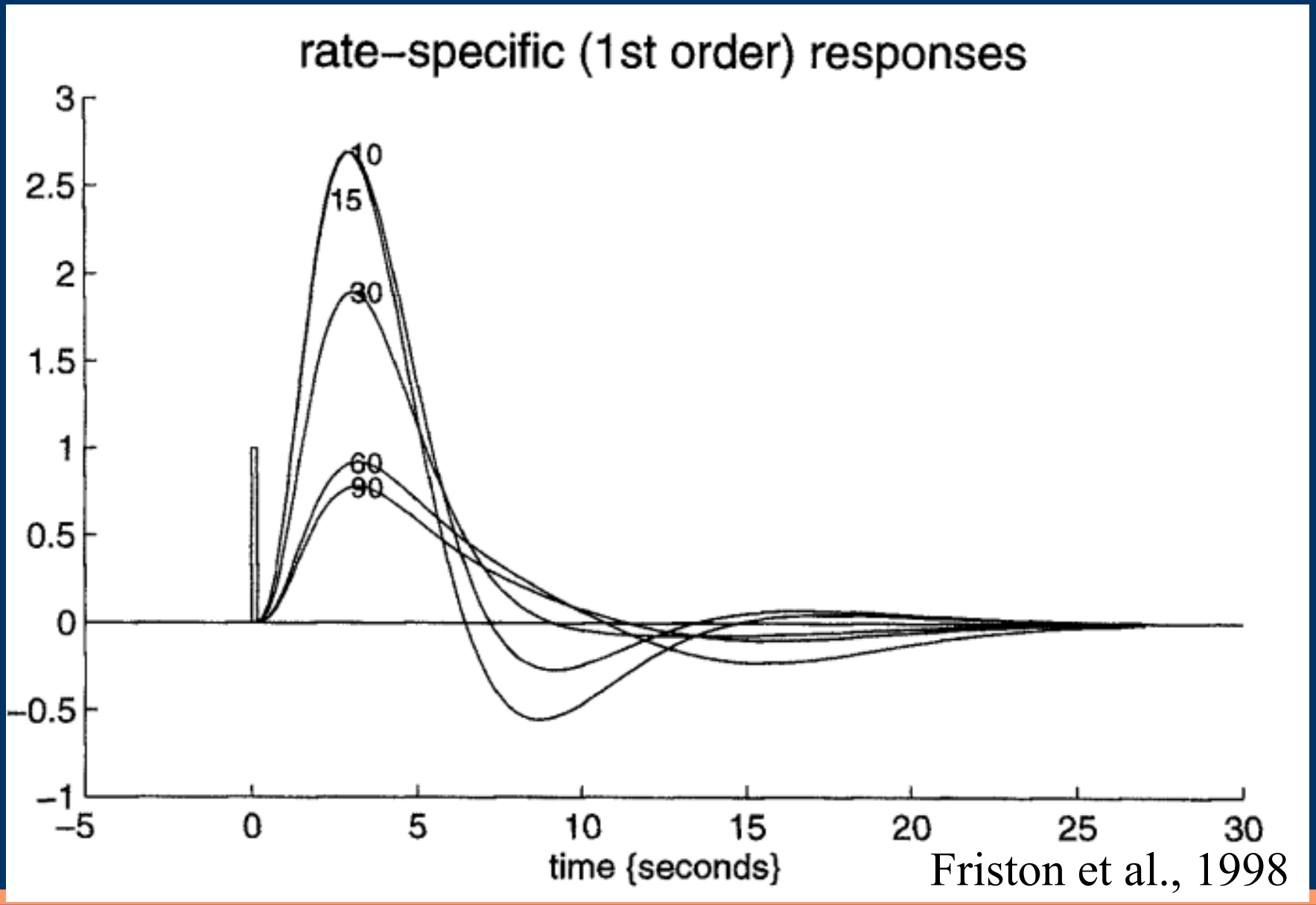
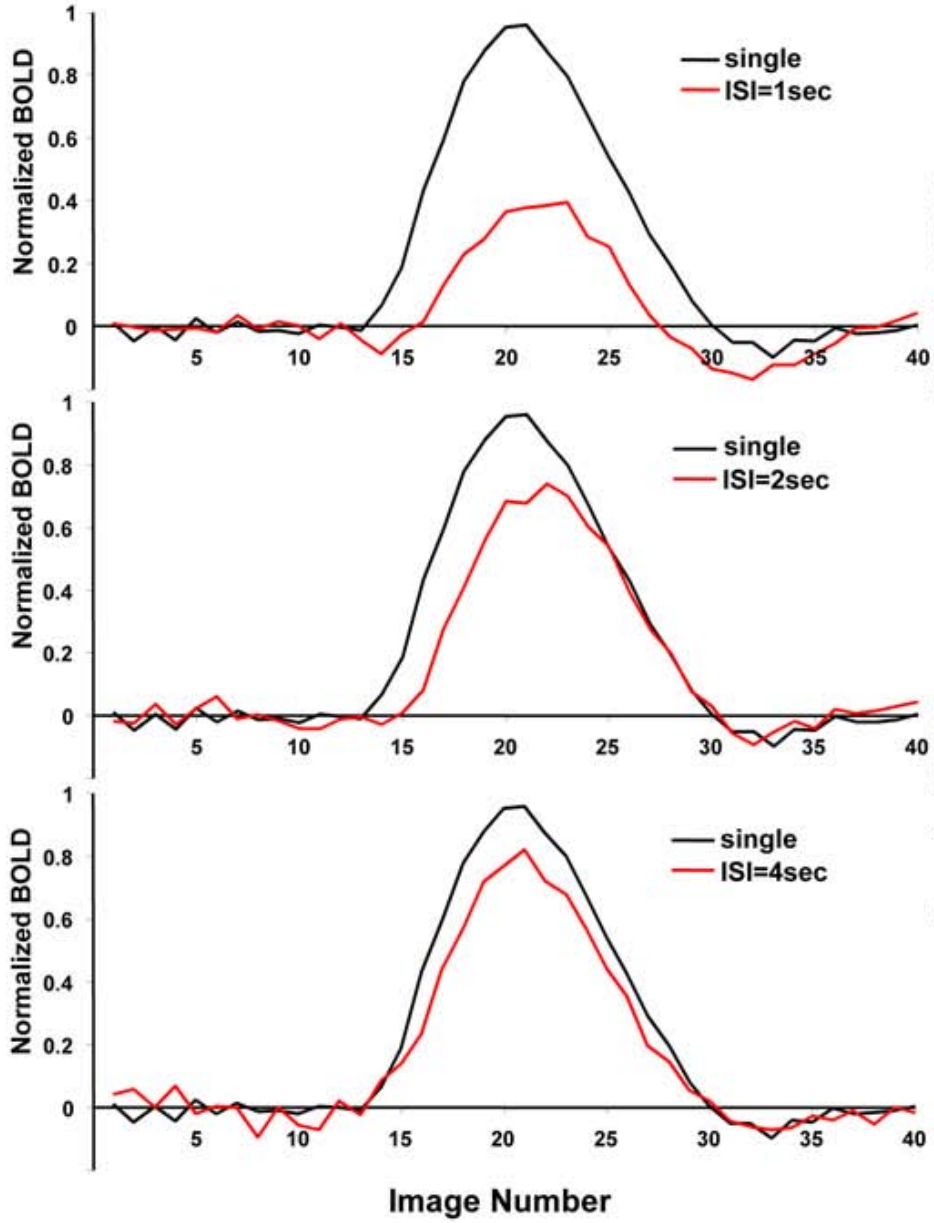


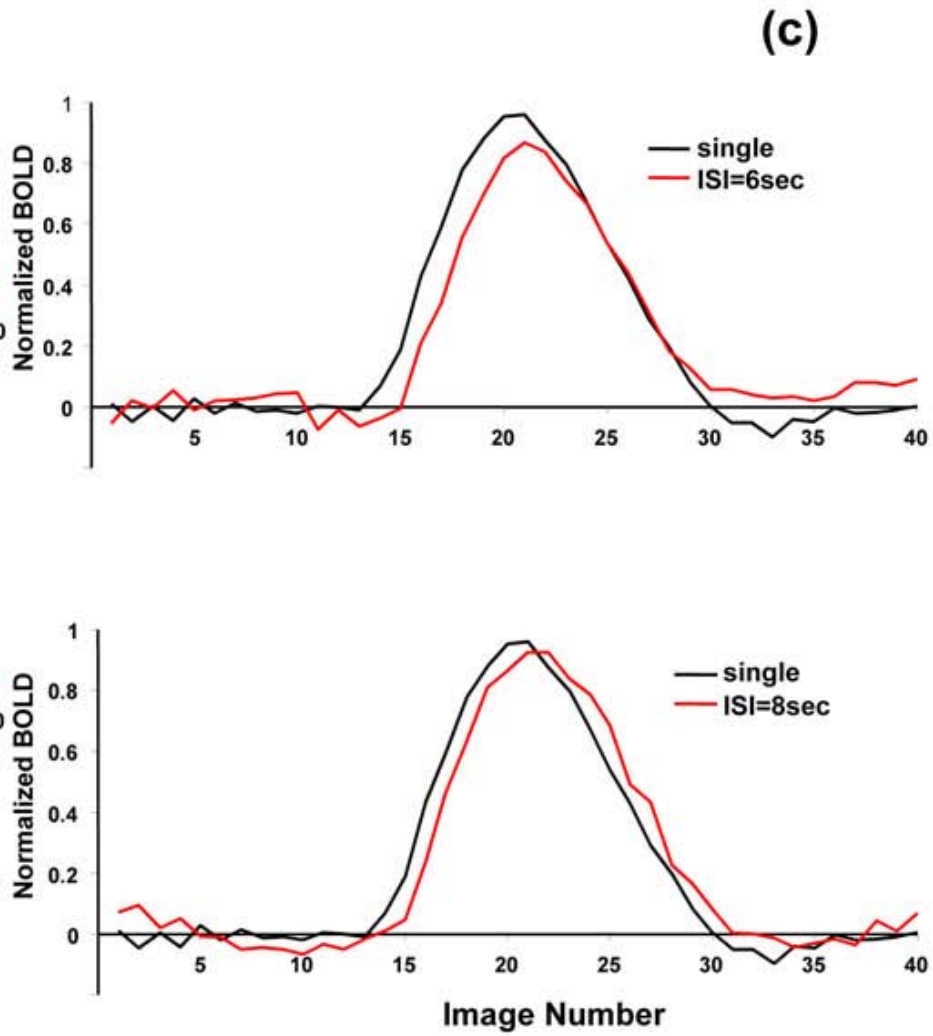
Linearity II: Superposition (stim rate)



Friston et al., 1998

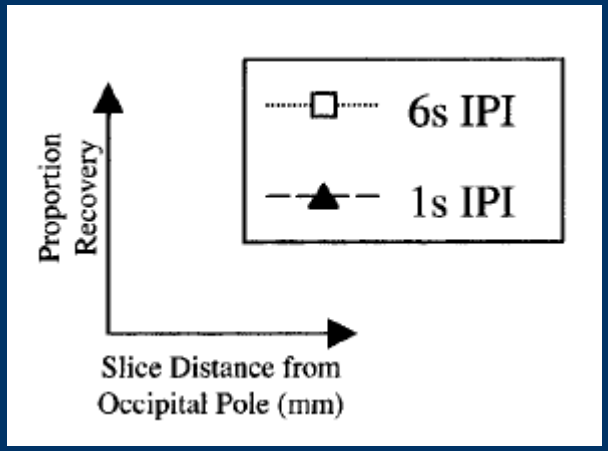
Linearity II: Superposition (ISI)

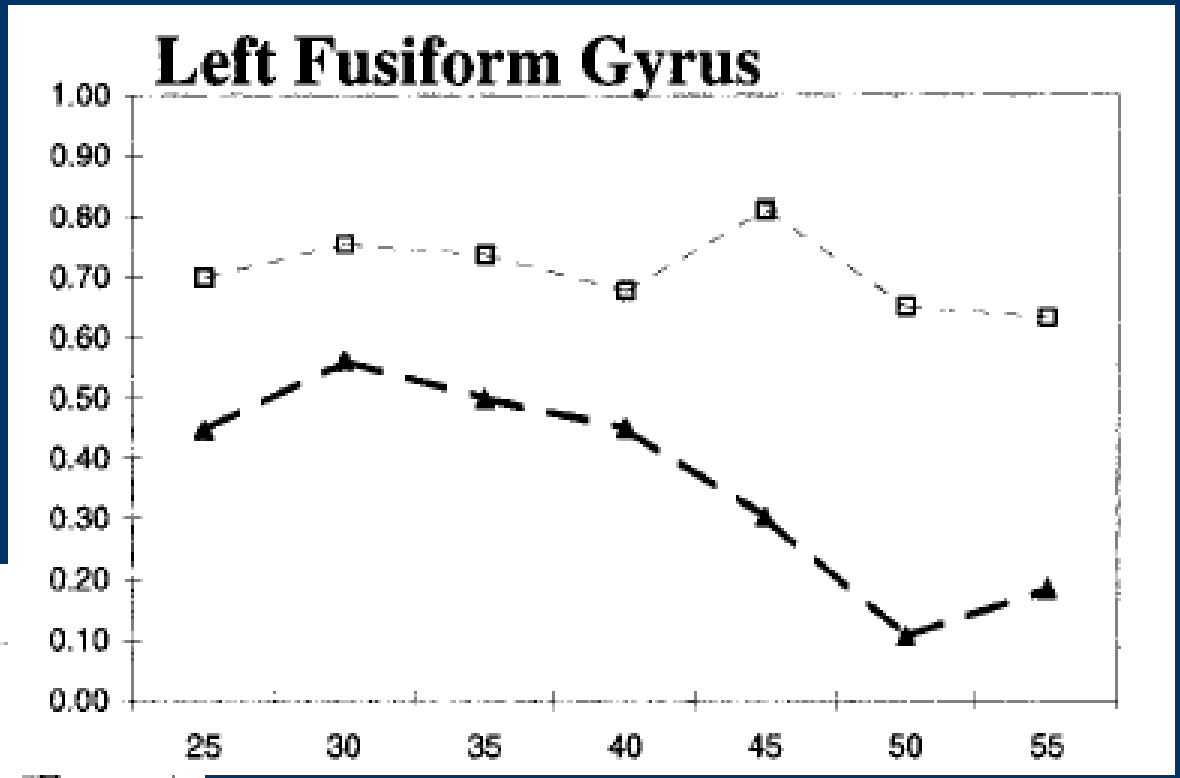


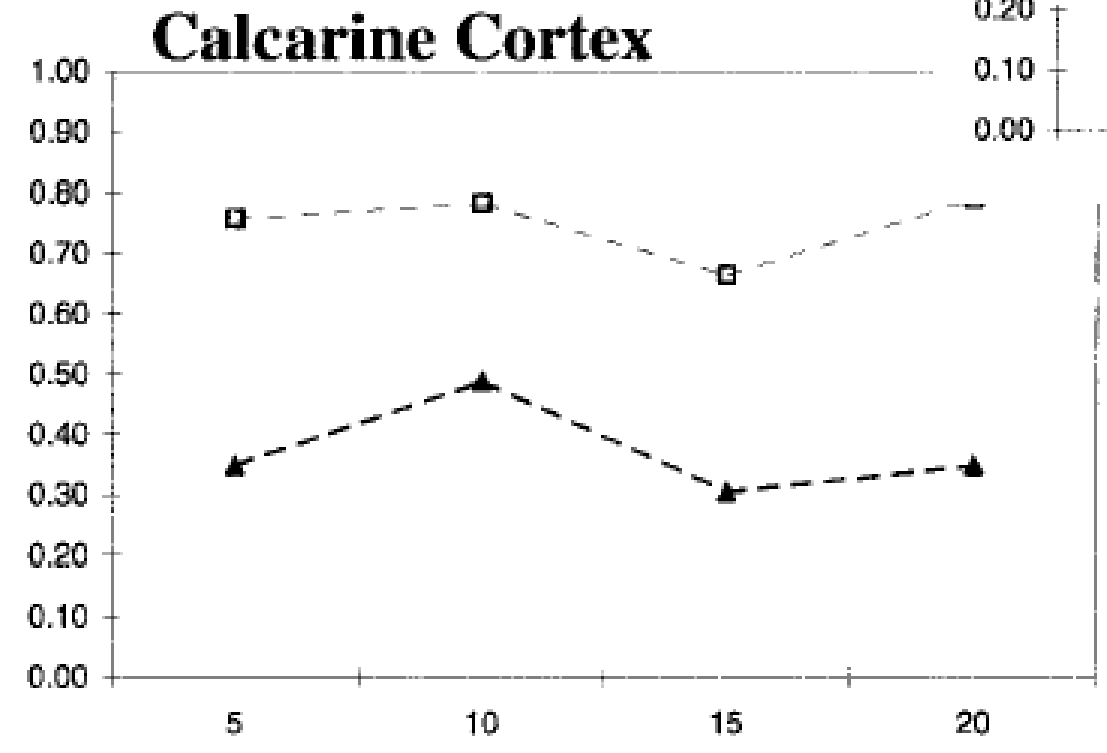


Zhang et al., 2008

Different area, different non-linearity...







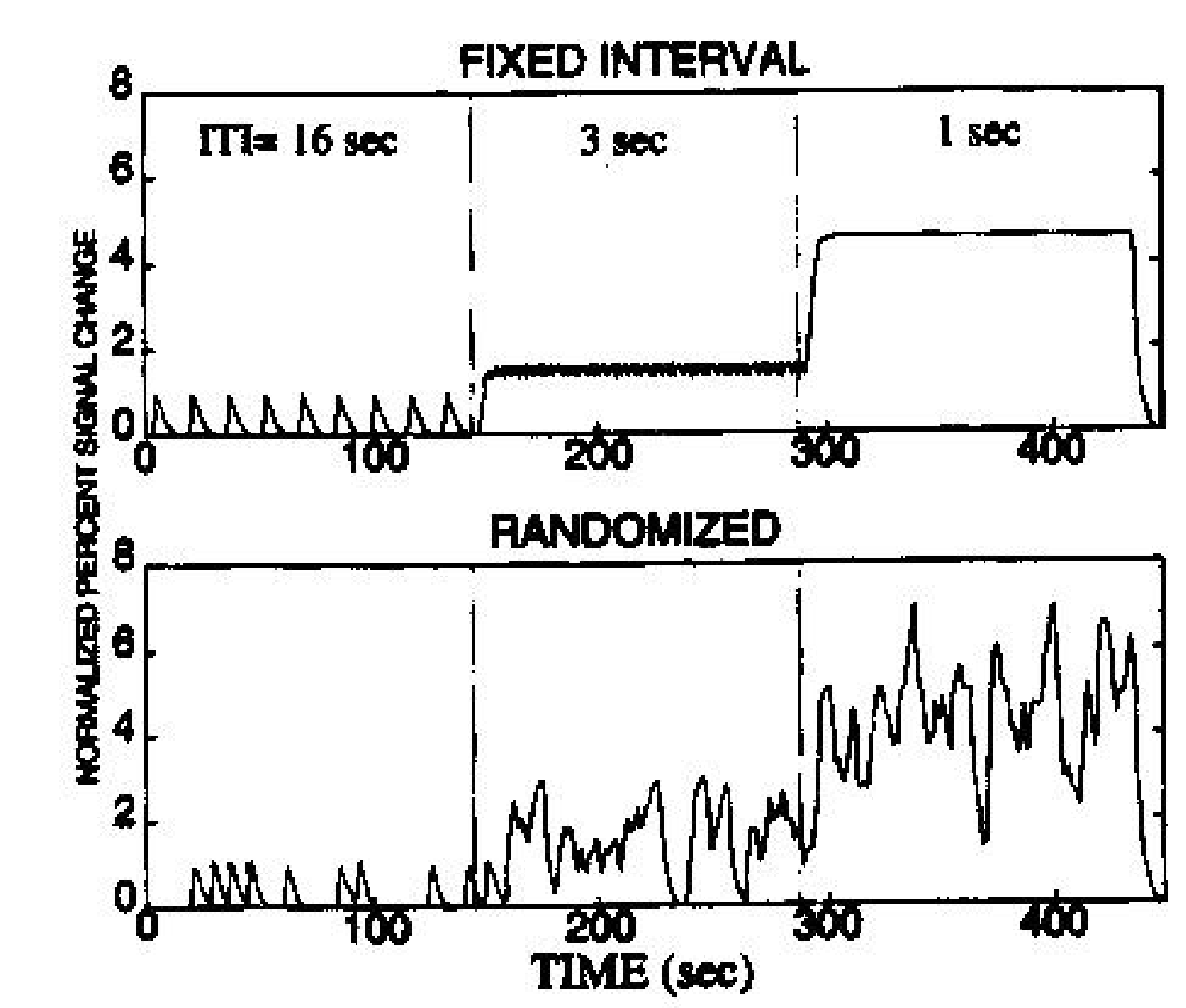
Huettel & McCarthy 2001

How to tease apart overlapping responses?

1. Trial order: shuffle things around

- With rapid ER-fMRI, it is important that different trial types follow each other equally
  - Statistical (multicollinearity) & psychological reasons
- Early studies used counterbalancing
  - Must be done to several orders depending upon trial length
- Recent studies have used randomization (full/pseudo)
  - Works fine with large enough # of trials

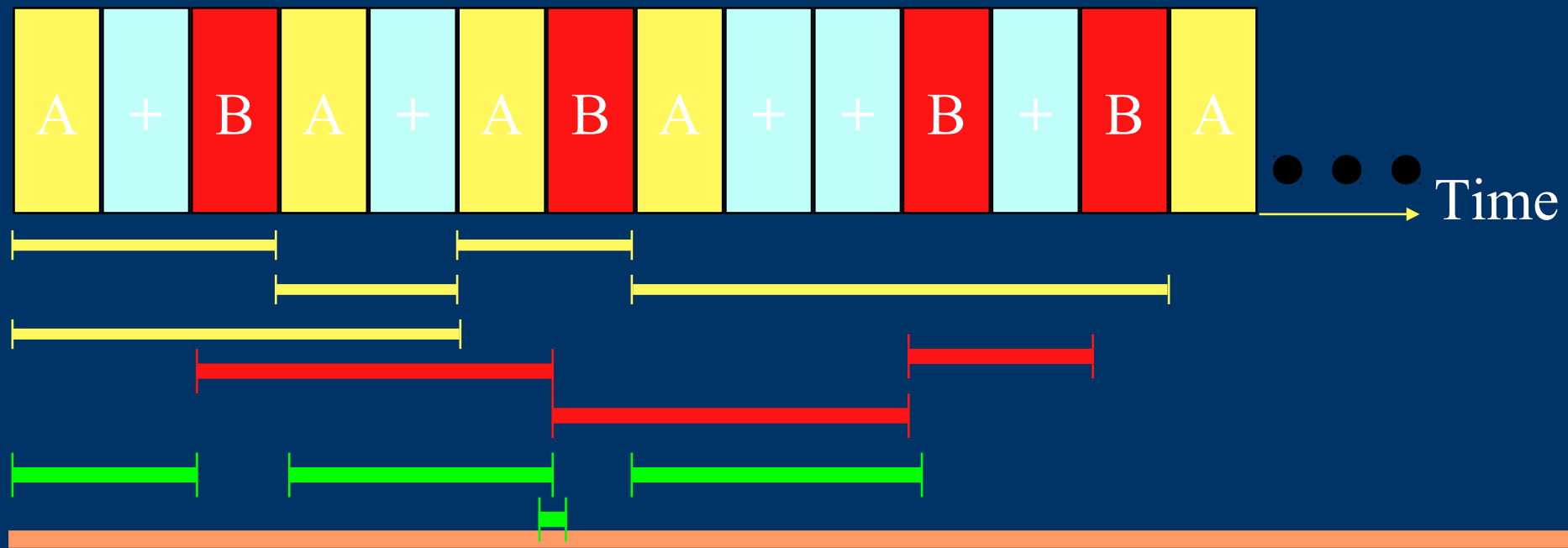
2. Inter-Stimulus Interval (ISI) Jitter (a)



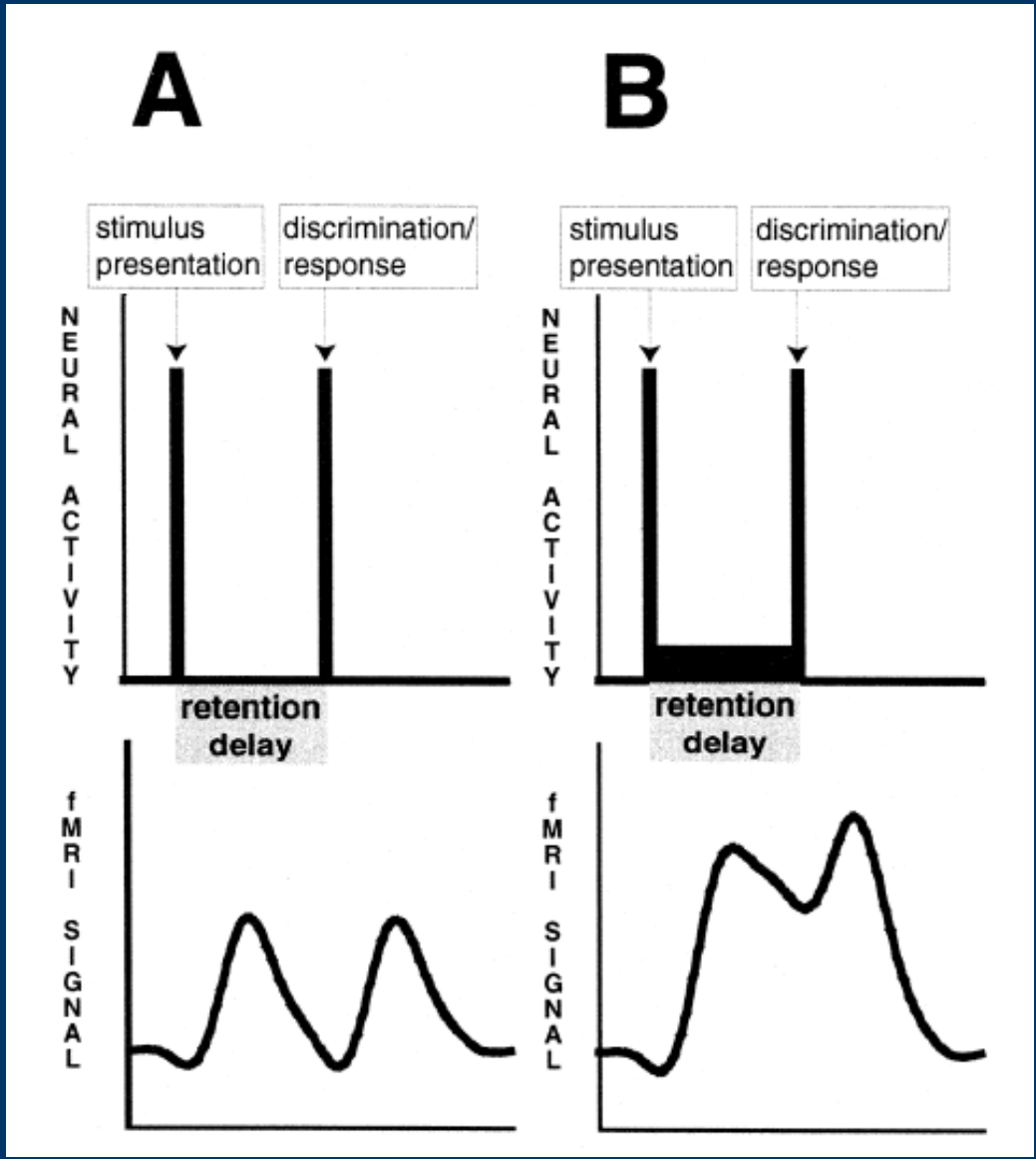
Burock et al., 1998

2. Inter-Stimulus Interval (ISI) Jitter (b)

- "Null" event – fixation cross or dot
  - Reflects baseline
- Insert random amounts of null between task conditions
- Differential ISI = Differential Overlap



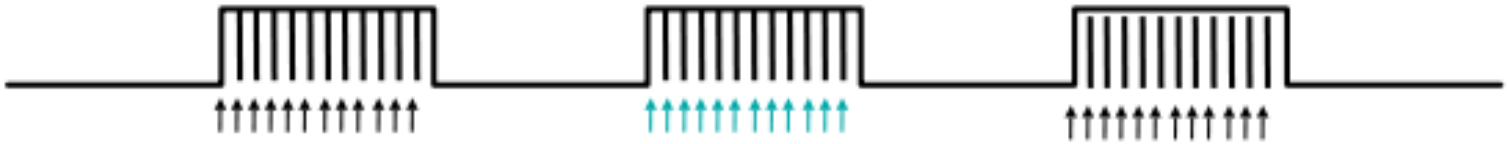
Teasing apart sequential processes



D'Esposito et al.

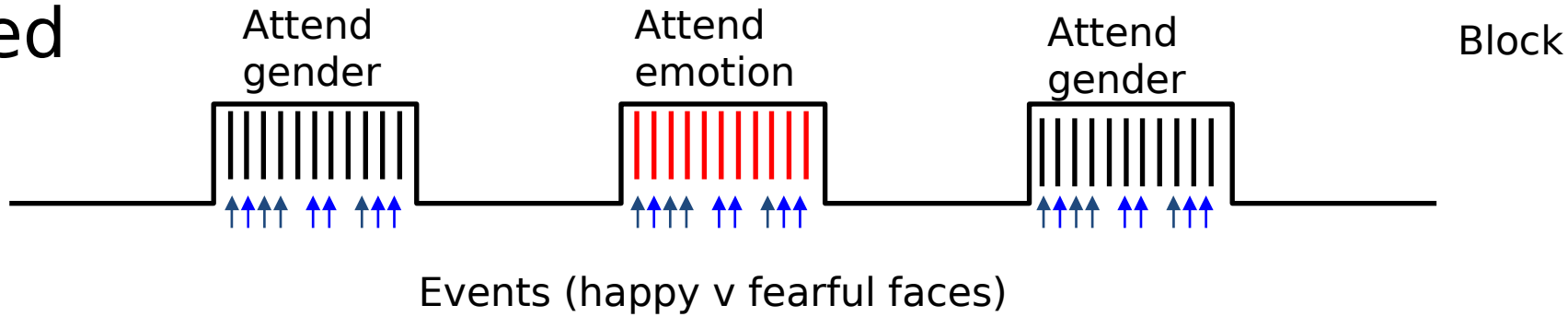
Nested/Mixed designs

BLOCKED:



RAPID MIXED TRIAL:

Nested



Teasing apart sequential processes

Stimulus/response

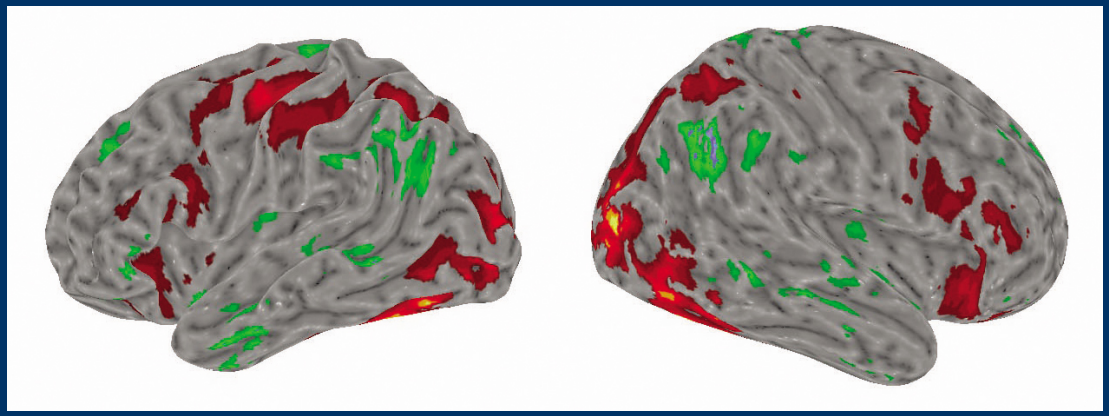
Variable interval

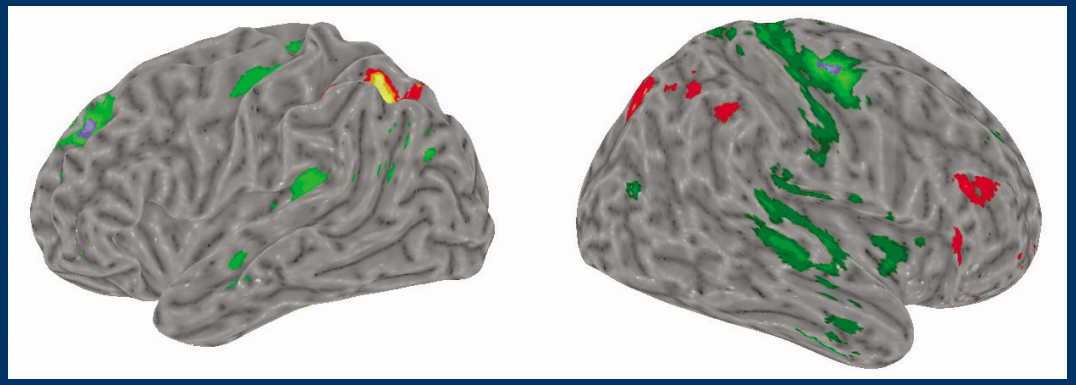
Feedback

Does he like vanilla or

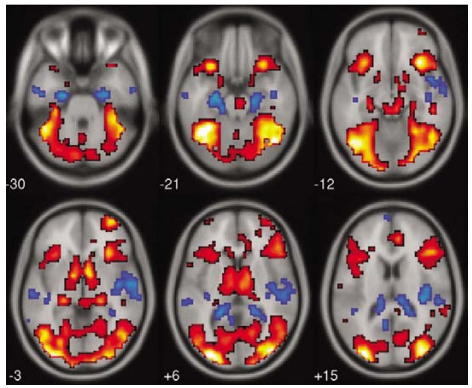
chocolate ice cream?

Stimulus & Response; Delay; Feedback

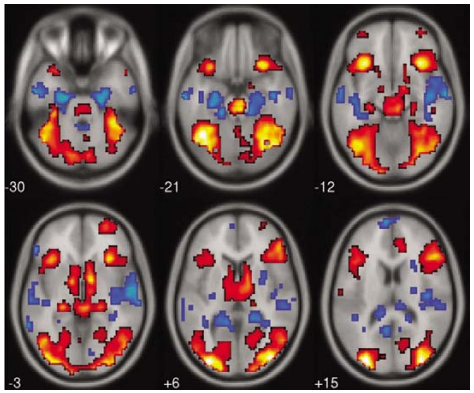




Positive



Negative



Aron et al., 2004, *J. Neurophys.*

Efficiency

- A numerical value that captures the relative ability of a design to detect an effect of interest.
- Say you are interested in the difference between two tasks, A & B.

$$t \propto \frac{estimate(A\,v.\,B)}{\sqrt{var\,estimate(A\,v.\,B)}}$$

Contrast of interest

Noise

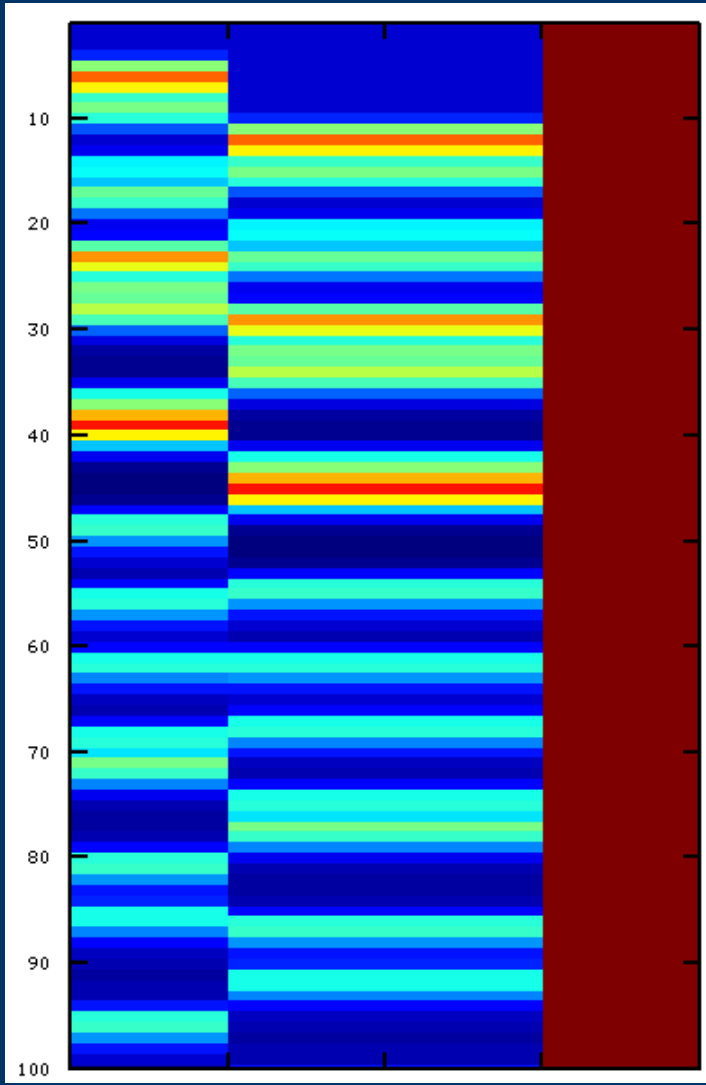
Experimental design

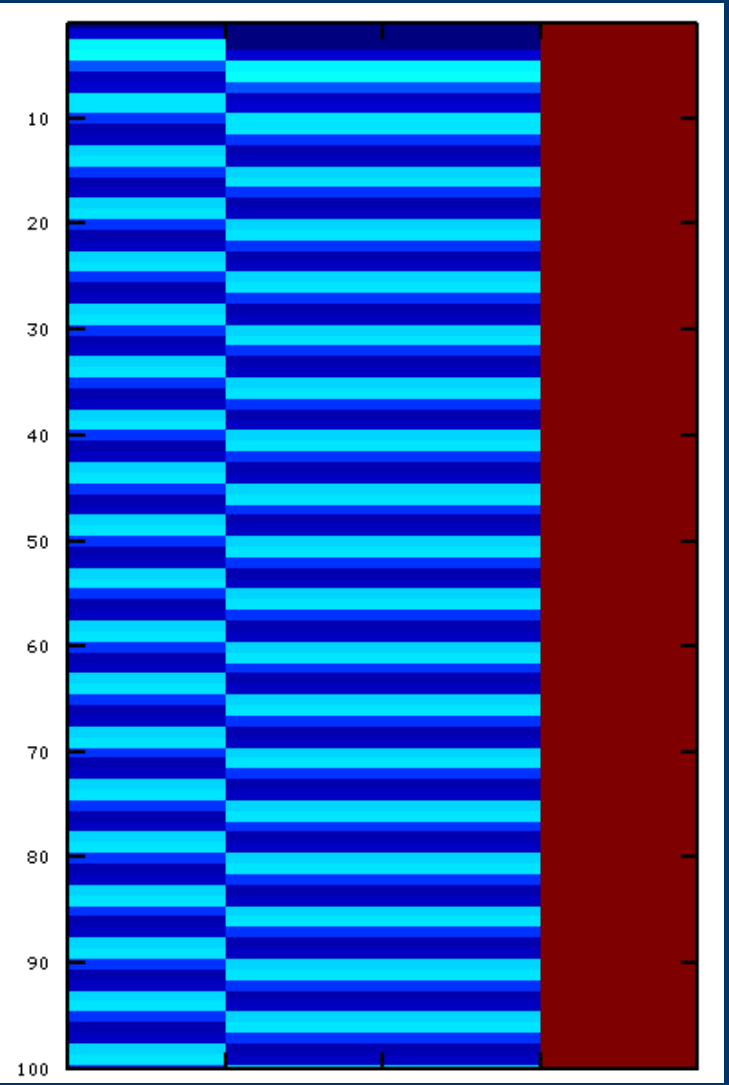
$$e(c, X) \propto \frac{1}{var\,estimate(A\,v.\,B)} = \frac{1}{Var(\hat{c}^T \beta)} = \frac{1}{\hat{\sigma}^2 [c^T (X^T X) c]^{-1}}$$

Efficiency: Examples

- X Matrix: Task A, Task B, Mean
- Contrasts of interest:
  i. Direct comparison [1 -1 0]
  ii. Estimation of each effect against baseline [1 0 0], [0 1 0]
- Randomize or not?
- Event related or block?
- Use rest periods in between blocks?

RANDOMIZED

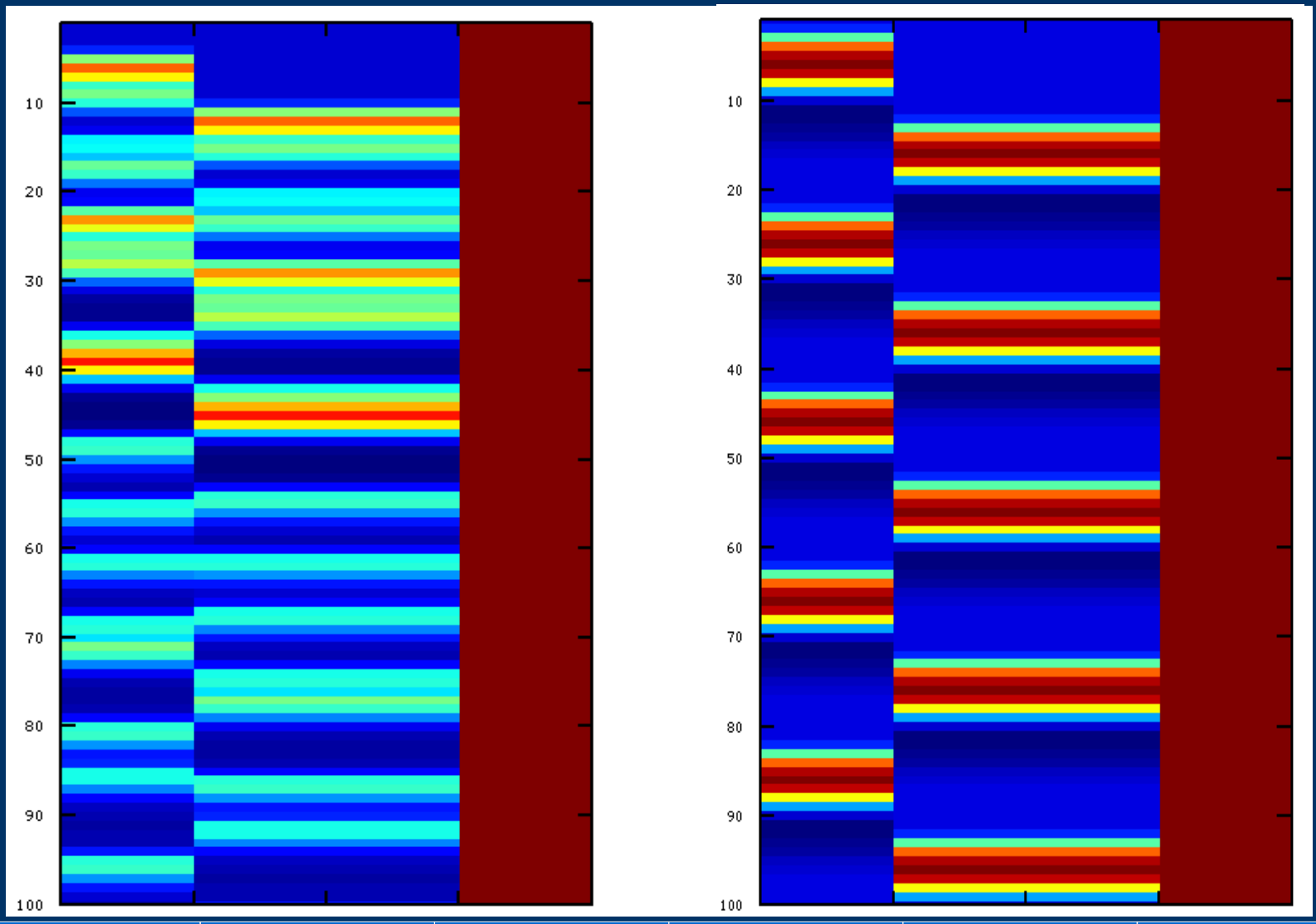




FIXED

Design	df	e(c,X)	1 -1 0	1 0 0	0 1 0
Fix	100-1	0.31	1.35	0.80	0.83
Rdm	100-1	1.32	3.05	4.47	4.84

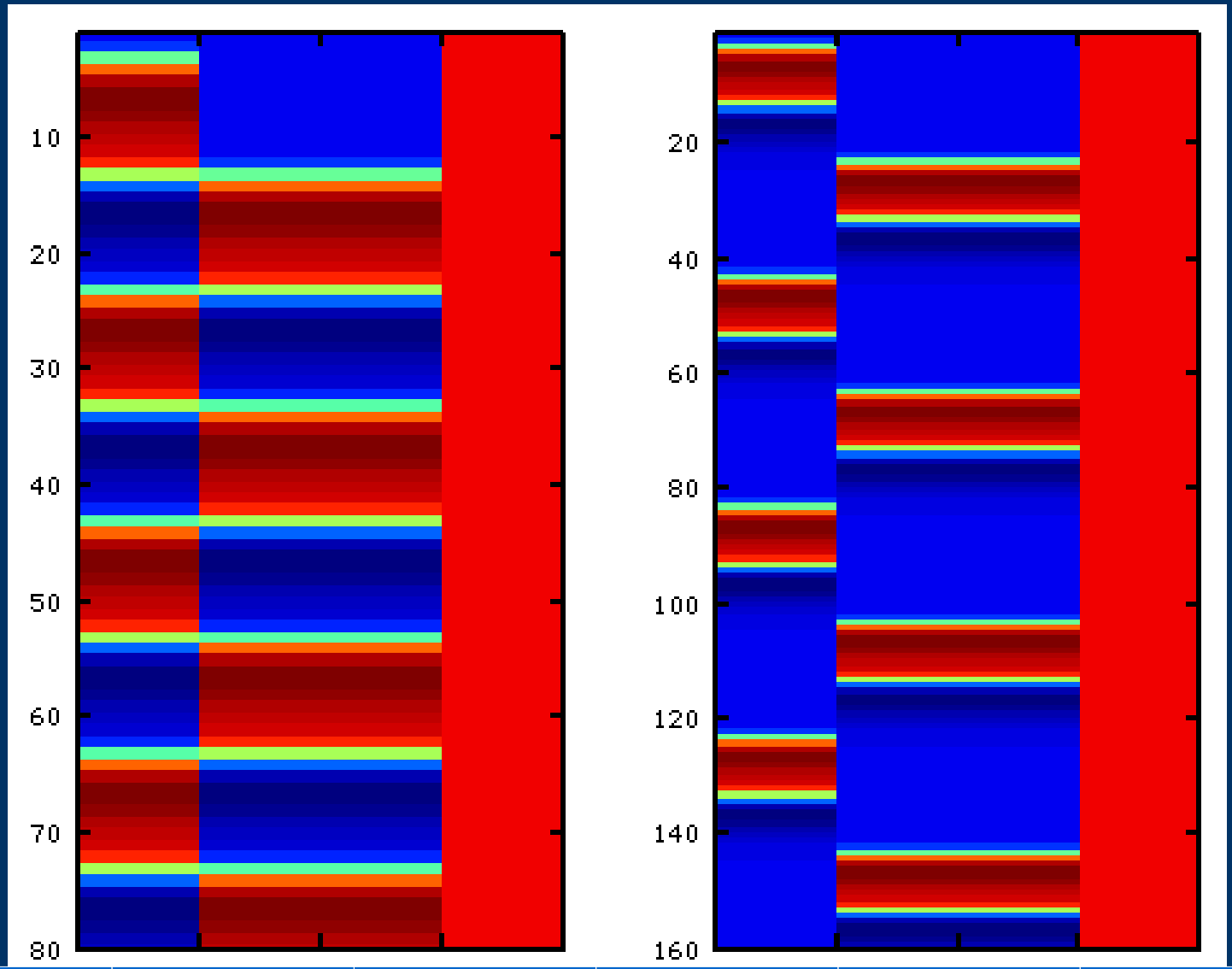
RANDOMIZED



BLOCK

Design	df	e(c,X)	1 -1 0	1 0 0	0 1 0
Block	100-1	4.80	13.39	15.09	14.84
Rdm	100-1	1.32	3.05	4.47	4.84

NO REST



REST

Design	df	e(c,X)	1 -1 0	1 0 0	0 1 0
No Rest	80-1	1.00	20.92	2.12	2.09
Rest	160-1	8.46	20.85	28.47	28.45

Good practices (but your experiment may differ …)

- Bigger IS better: more trials, more TRs, more Ss.

- What's the best design for my cog process of interest?
- What's the best design for my task(s)?
- What psychological factors might be at play?
- What comparison(s) are you interested in?

- For how long do you think you can get ***good*** data out of a volunteer?

Good practices (but your experiment may differ …)

- **Trial order**: ALWAYS vary the order. Counterbalance, randomize, pseudo-randomize (make multiple pseudo-randomizations), intersperse null events, jitter each trial's ISI (random or exponential), ...
- **Trial timing**: ISI > 2 sec (and randomize!)
- Offset TR and task.
- ***Maximize efficiency for your contrast(s) of interest, compare multiple designs, simulate.***