

Assessing intrinsic “blind spots” in attention to dynamic streams of sensory events.

Derek N. Eder

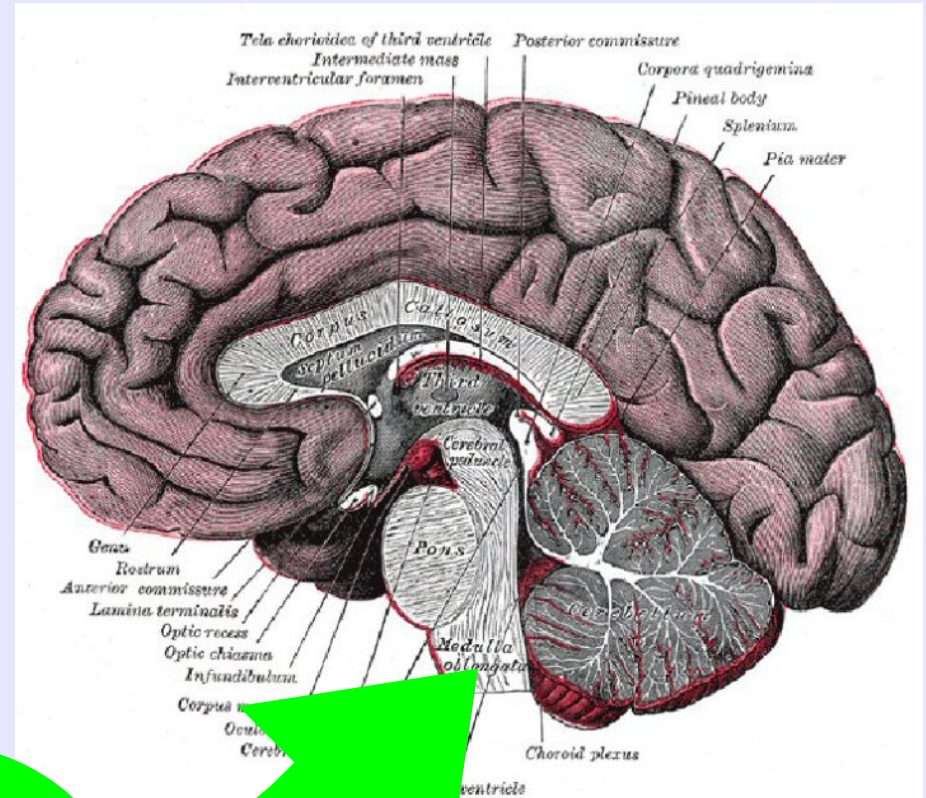
University of Gothenburg,
Vigilance and Neurocognition Laboratory
SAFER

Brain bombarded by a stream of raw sensory signals

Sensitive
male



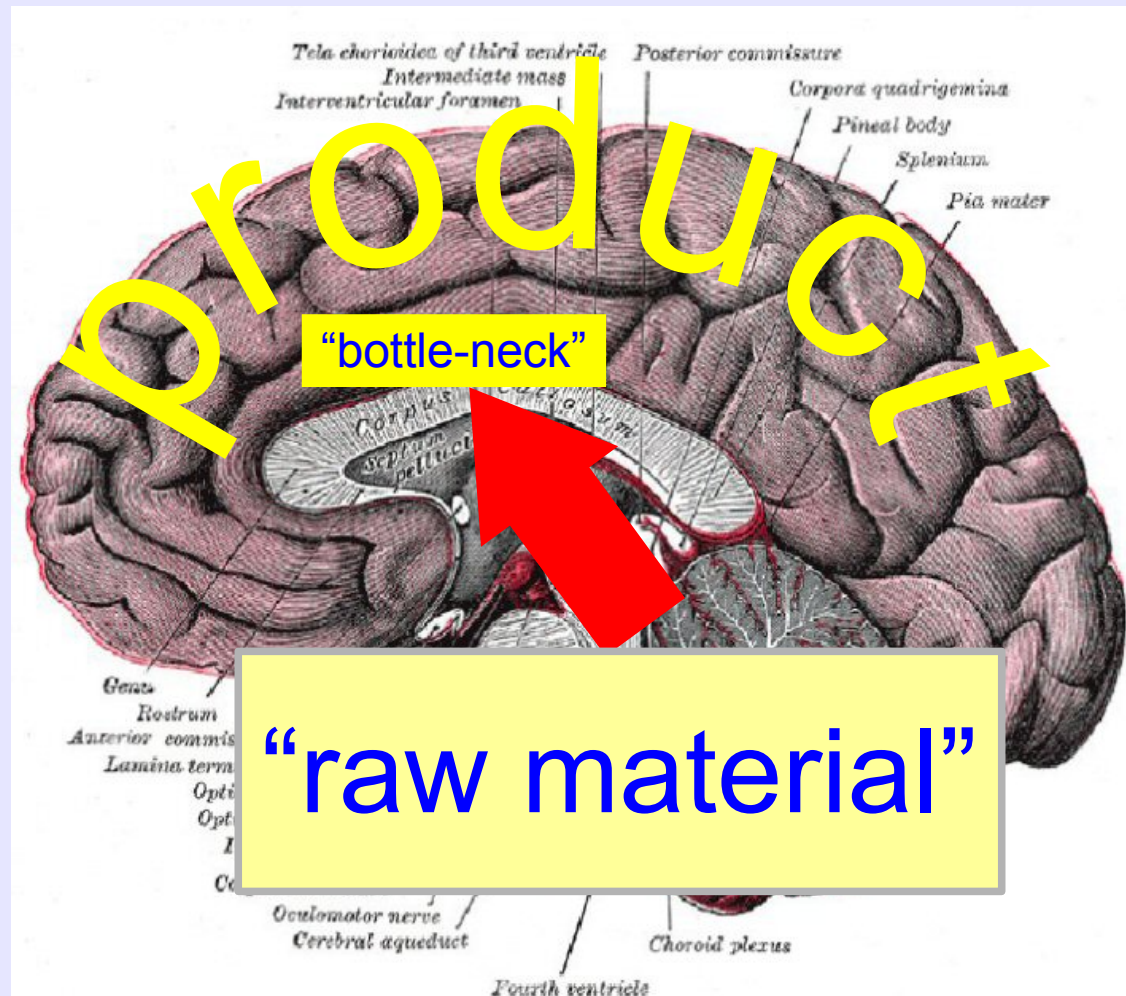
*Penfield's Homunculus
Body scaled according to sensory
representation in CNS*



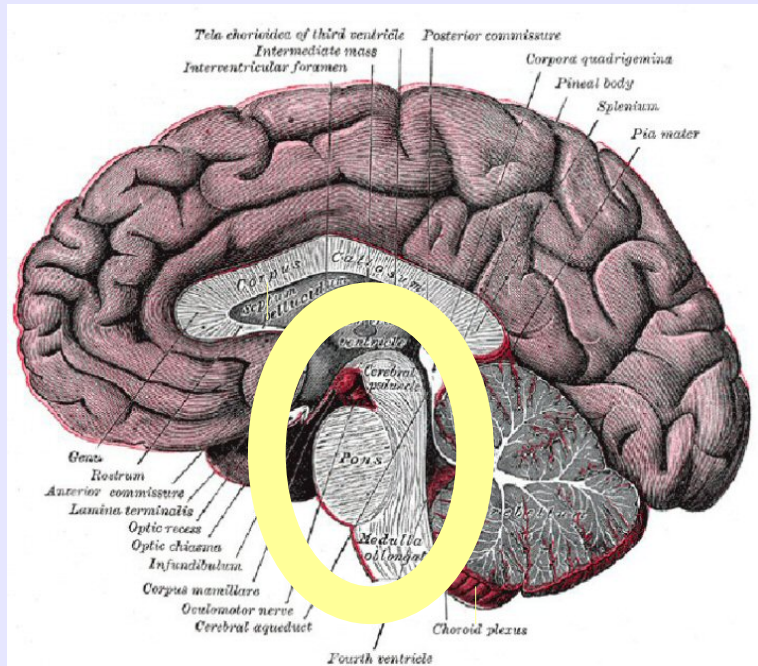
dynamic stream of sensory signals

Limited processing capability

- processing speed (“throughput”)
- simultaneous attention
- attention is resource intensive - subject to depletion



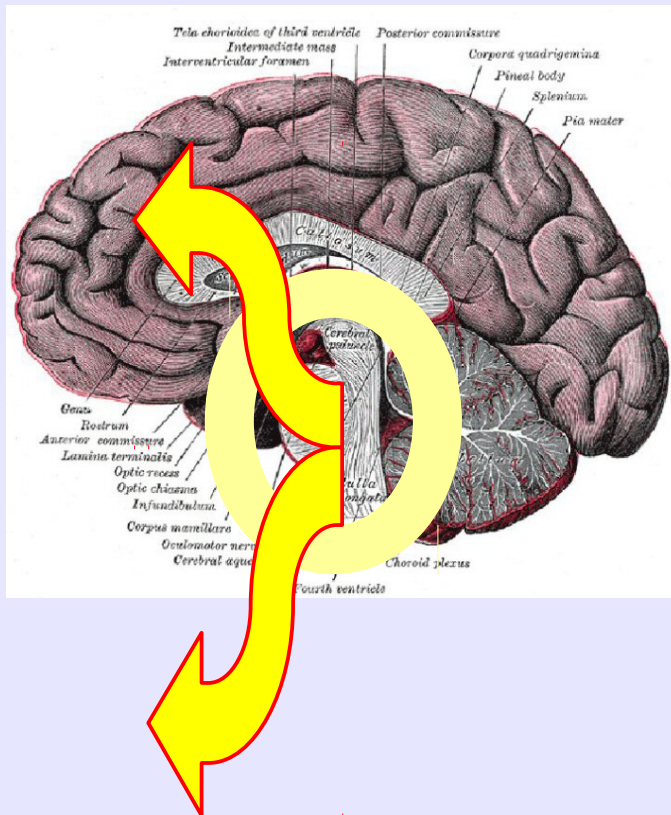
Optimization of information intake: Preprocessing in brainstem



Fast, non-specific detectors select targets for “higher” attention and initiate reflexive preparations for action

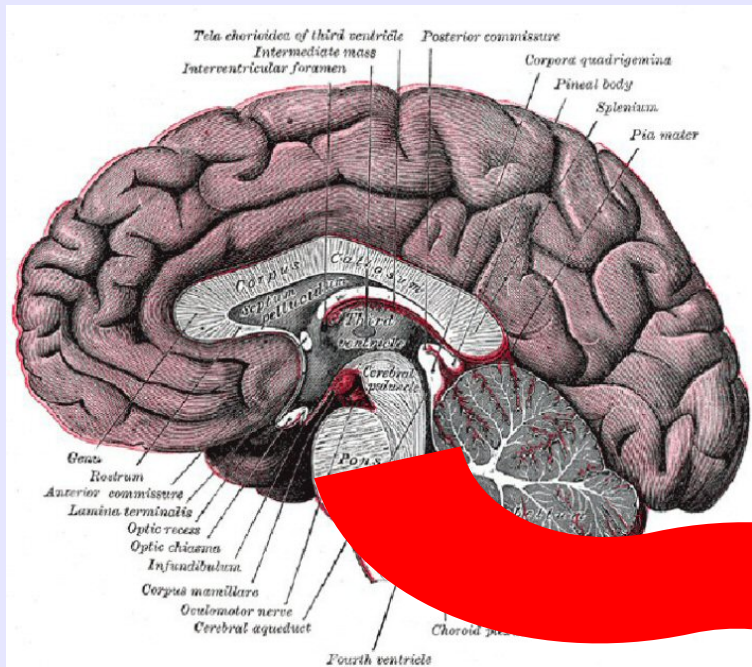
- *Novelty*
- *Change*
- *Learned*
- *“Instinct”*

Engagement of sensory events: Widespread preparation for action (and possible reaction)



- Activation of “alertness”
- Re-orienting attentional focus
- Disengage ongoing attention focus
- Prepare for behavioral response

“Irrelevant” sensory input is effectively ignored



As far as
consciousness
is concerned . . .



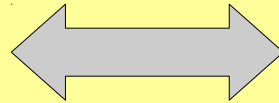
But as attention is engaged, information gathering and processing needs to be protected!



Balancing competing interests:

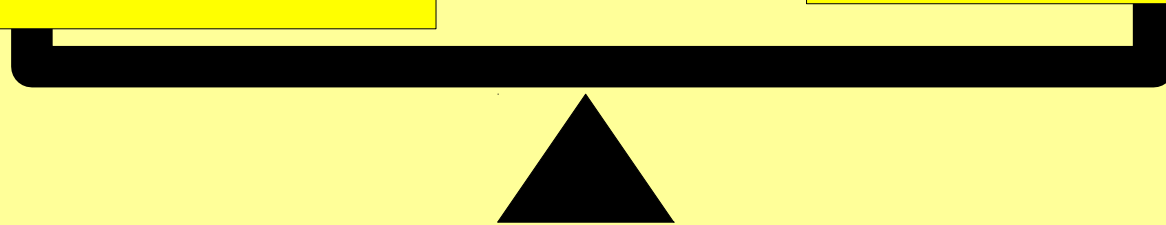
Maintaining focus:

- holding attention on target
- preventing interruptions



Maintaining flexibility:

- facilitating exploration



... In dynamic sensory streams “juggling” incoming information can create “blind spots” to new incoming information

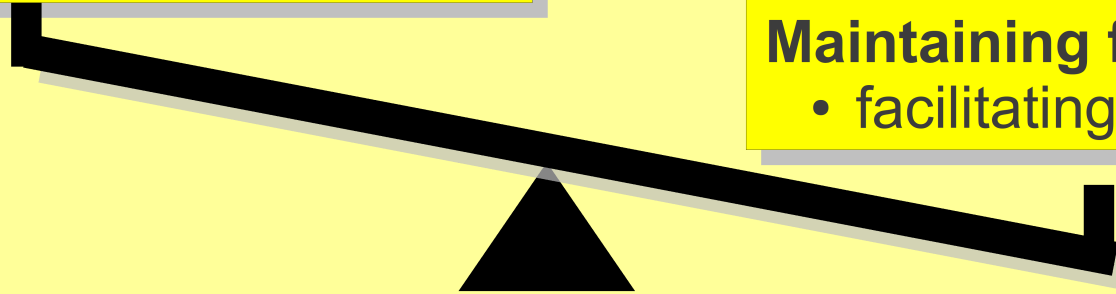
Competing interests:

Maintaining focus:

- holding attention on target
- preventing interruptions

Maintaining flexibility:

- facilitating exploration



Aim: Examine interactions in serial information processing using paired events

How can attention to one sensory event affect attention to the next sensory event when ...

- 1. first event signals the arrival of the next ?*
- 2. first event signals location of the next ?*
- 3. time between events varies ?*

Method overview

Visual stimuli “events” are presented in closely timed pairs:

cue . . . target

Method overview

Events are presented in pairs: **cue ... target**

Outcomes derived from response times to target

“press a button when target appears”

Method overview

Events are presented in pairs: **cue ... target**

Outcomes derived from response times to target

Cues predict either the onset or location of target.

Method overview

Events are presented in pairs: **cue ... target**

Outcomes derived from response times to target

Cues predict the onset or location of target.

Manipulation of time between cue and target:
Stimulus Onset Asynchrony (SOA)

cue . . . target

cue target

Method overview

Events are presented in pairs: **cue ... target**

Effects of attention derived from response times to target

Cues predict the onset or location of target.

Manipulation of time between cue and target

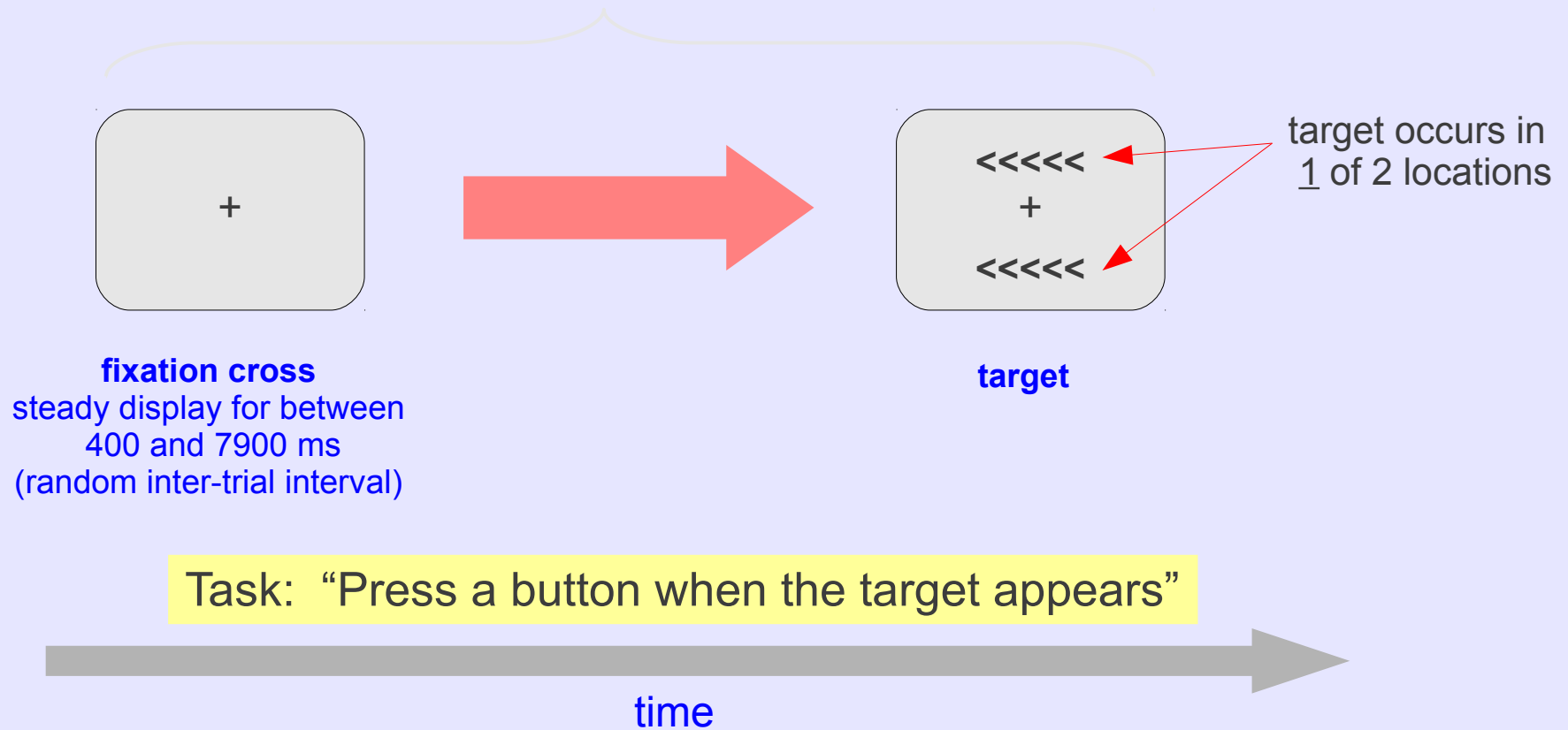
Based on Posner's Covert Orienting of Attention
and derived from a subset of Posner and Fan's Attention
Network Test (ANT)

Method

4 types of trials

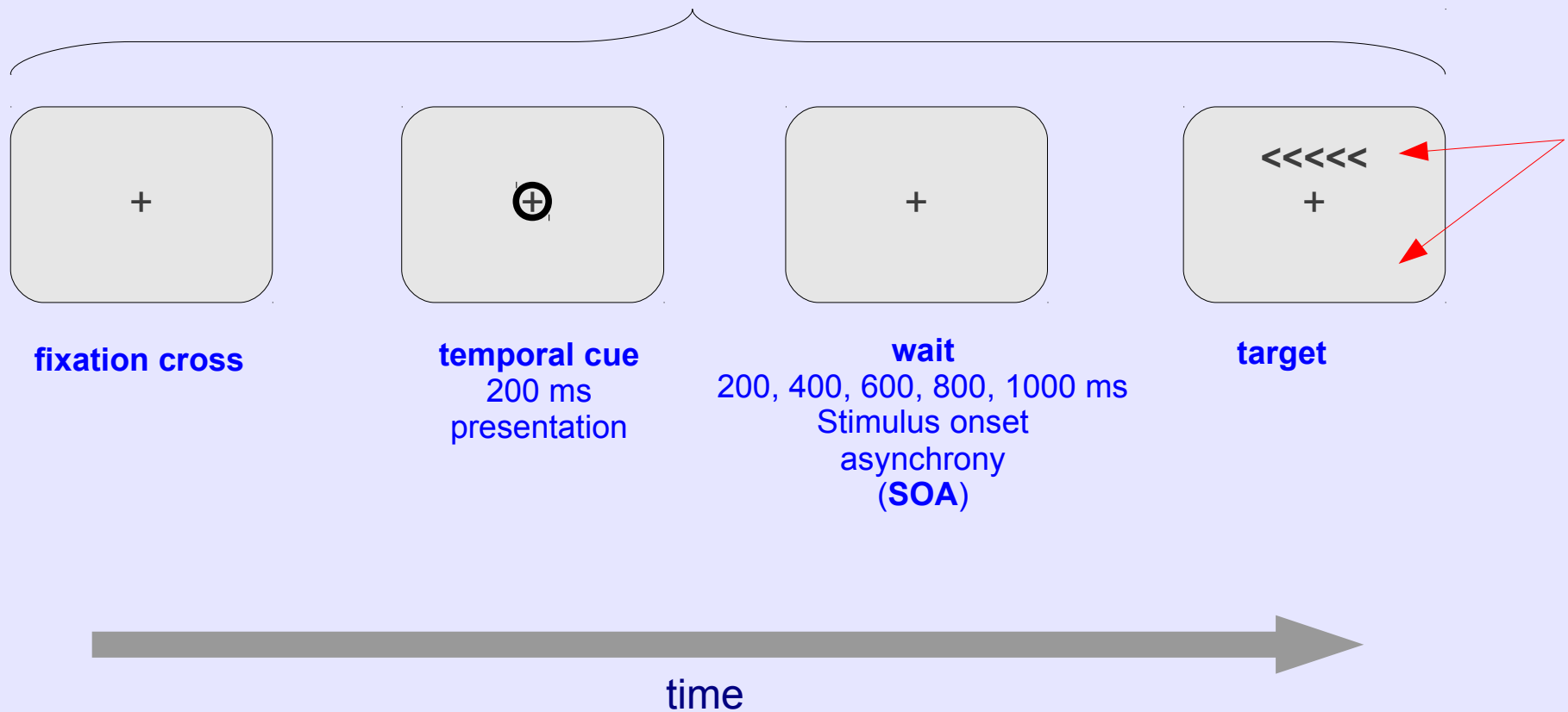
(1) “Simple” uncued trial

target appears at random intervals

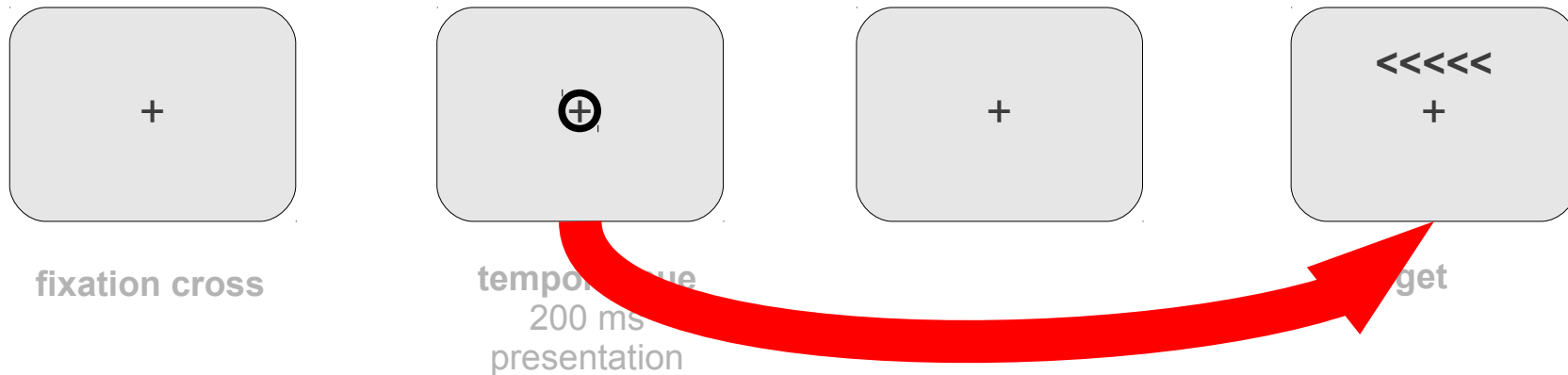


(2) Temporal cued trial

cue predicts imminent onset of target



A key concept !



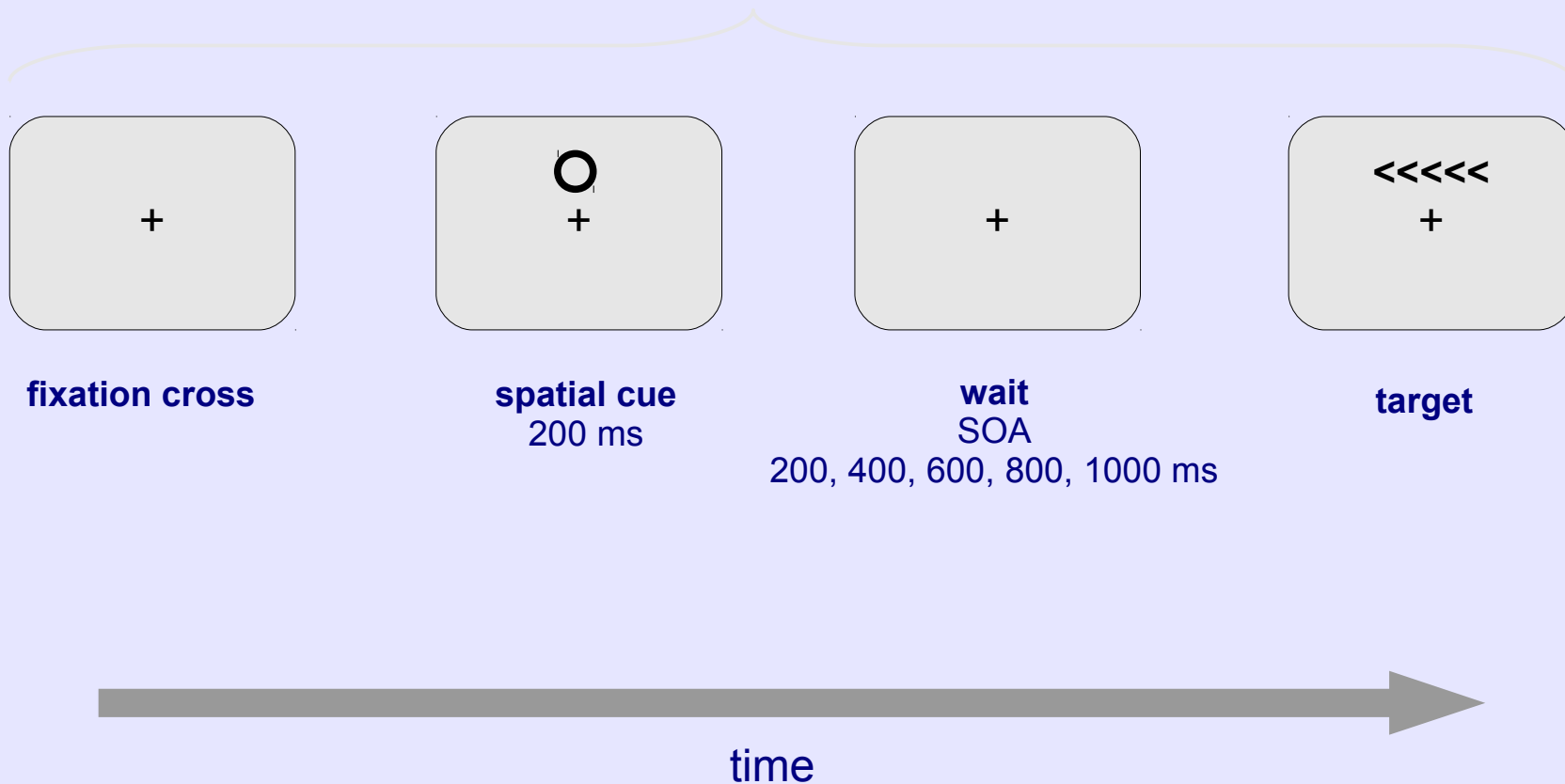
***5 different time intervals
between onsets of
cue and target***

**Stimulus onset asynchrony
(SOA)**

200, 400, 600, 800, or 1000 ms

(3) Spatial cued trial

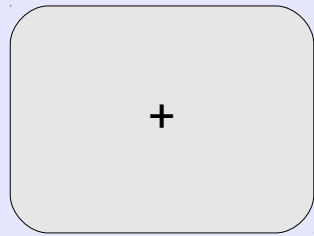
cue predicts location of target



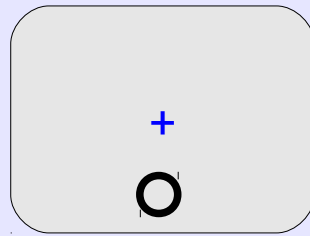
“Distance” between fixation cross and cue / target is 1.06°

Re-orienting of attention to target is “covert” -- no eye movements are required !

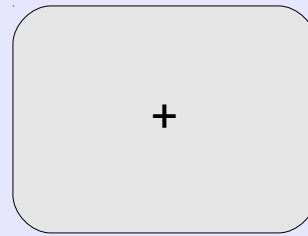
(4) Invalid spatial cued trial
cue misleads location of target
rare -- 14%



fixation cross

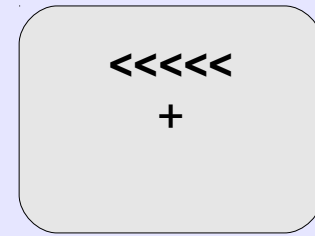


spatial cue
200 ms

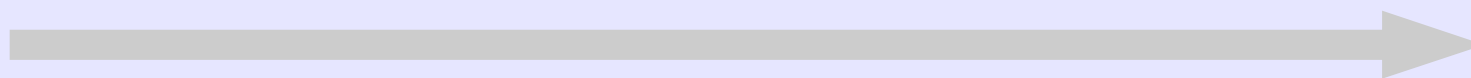


wait
SOA

200, 400, 600, 800, 1000 ms

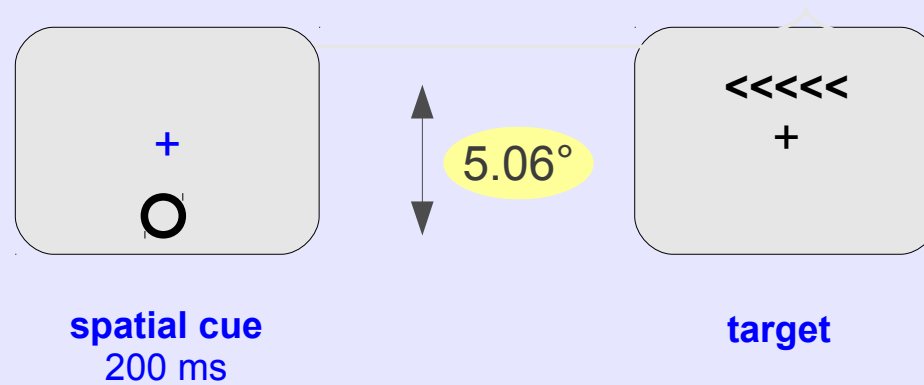


target



time

(4) Invalid spatial cued trial
cue misleads location of target
rare -- 14%



Outcome measures

Trial outcomes (*effects*) are computed as differences between uncued RT* and each cued trial (at each SOA):

Alerting: How does temporal cue affect response efficiency?

Alerting effect = Uncued RT - temporal cued RT

* RT = “reaction time” (milliseconds)
speed of target detection (button press)

Outcome measures

Trial outcomes (*effects*) are computed as differences between uncued RT and each cued trial (at each SOA):

Alerting: How does temporal cuing affect response efficiency?

Alerting effect = Uncued RT - Temporal cued RT

Orienting: How does spatial cuing affect response efficiency?

Orienting effect = Uncued RT - Spatial cued RT

* RT = “reaction time” (milliseconds)
speed of target detection (button press)

Outcome measures

Trial outcomes (*effects*) are computed as differences between uncued RT and each cued trial (**at each SOA**):

Alerting: How does temporal cueing affect response efficiency?

Alerting effect = Uncued RT - temporal cued RT

Orienting: How does spatial cueing affect response efficiency?

Orienting effect = Uncued RT - spatial cued RT

Validity: How does invalid spatial cueing affect response efficiency?

Validity effect = Uncued RT - Invalid cued RT

Method

4 types of trials

280 trials in 20 minutes over 4 blocks

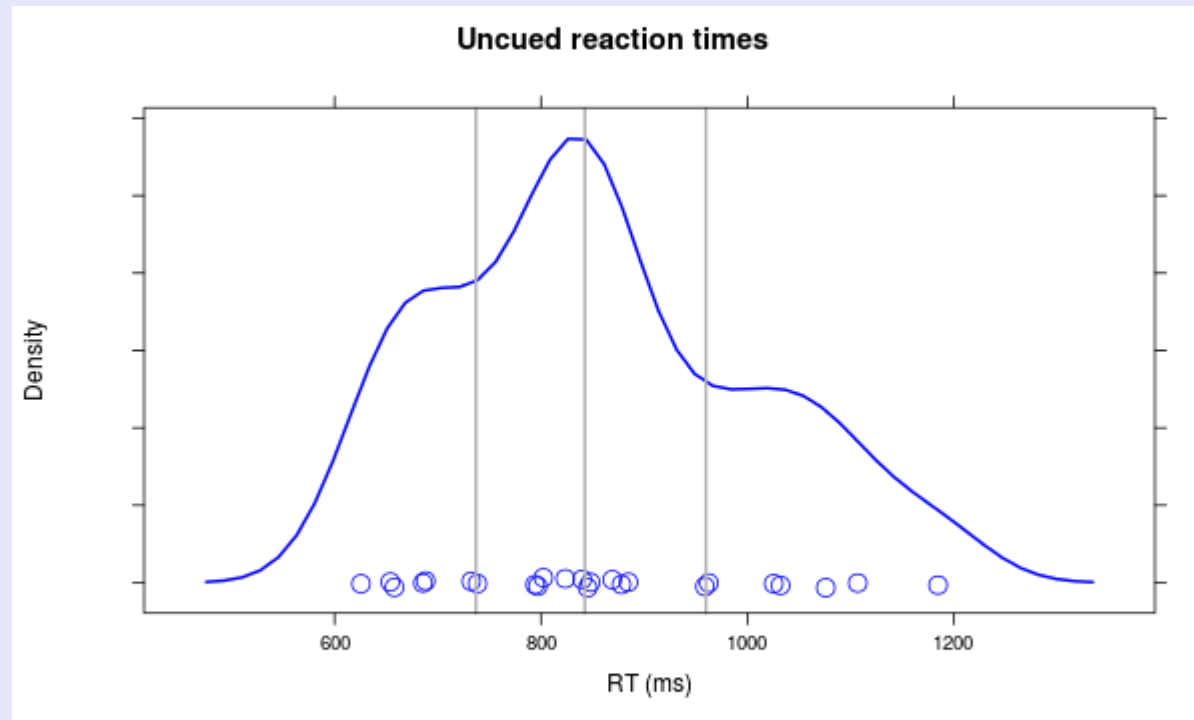
Full randomization of trials within block

Linear Mixed Effects statistical models of effects

Data from 24 healthy subjects between 27 and 74 years old (quartiles: $_{46}^{63}_{68}$)

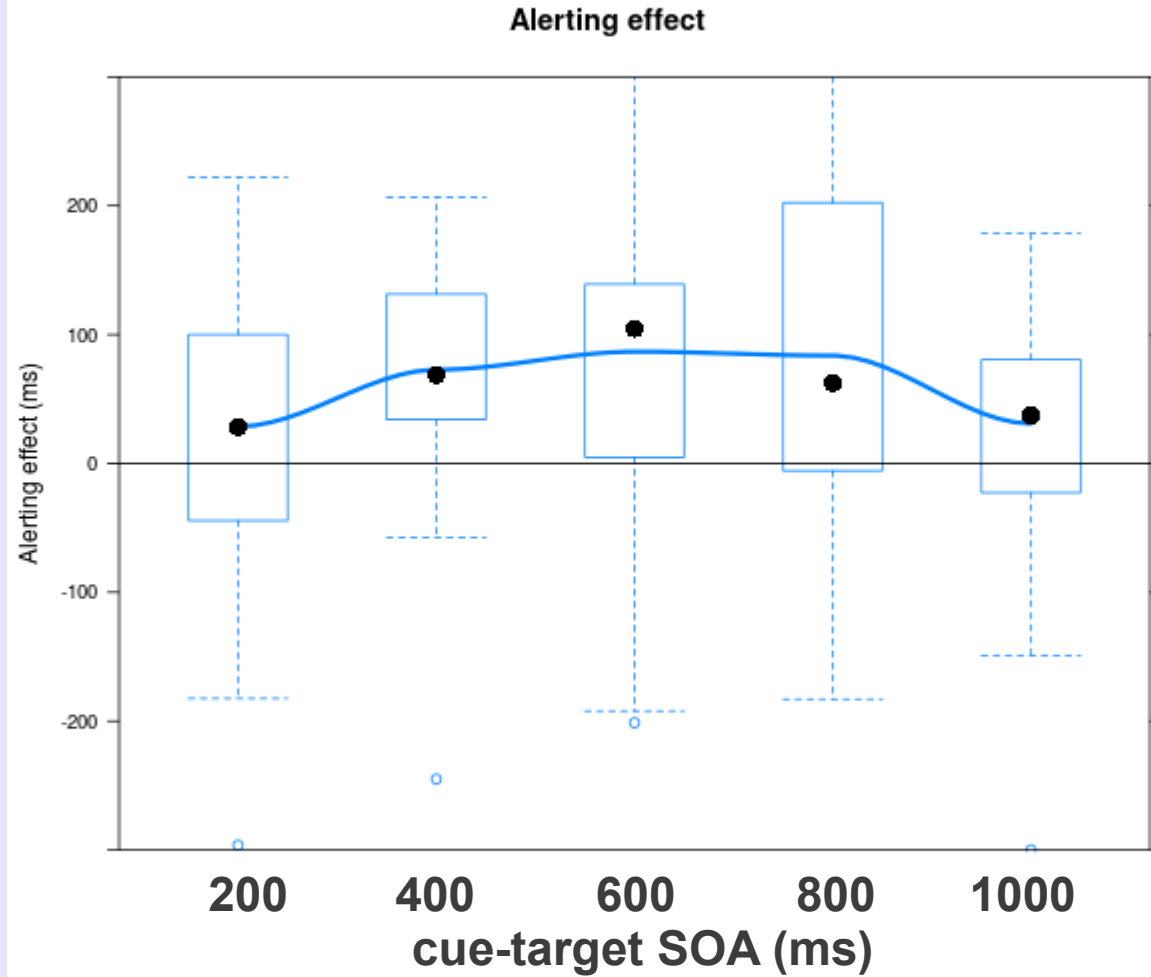
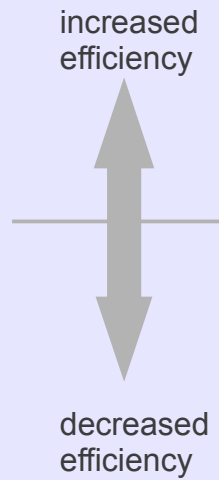
Results

Simple reaction time



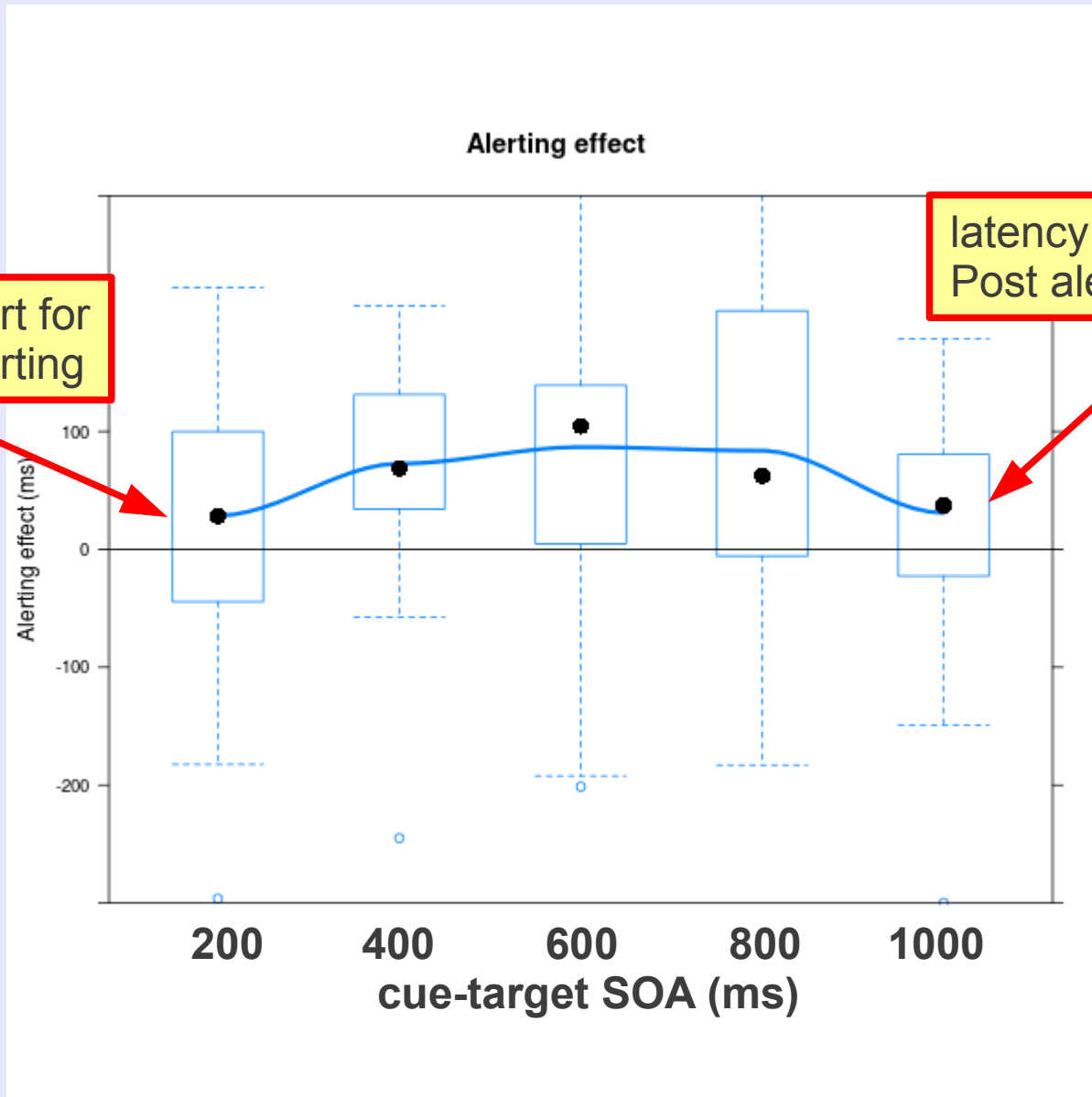
Kernel density plot of reaction times (RT) to uncued targets. Grey horizontal lines denote quartile limits ($_{25\%}^{50\%75\%}$ quartiles: $_{737}^{842^{970}}$ ms).

Effects of Temporal cuing: Alerting



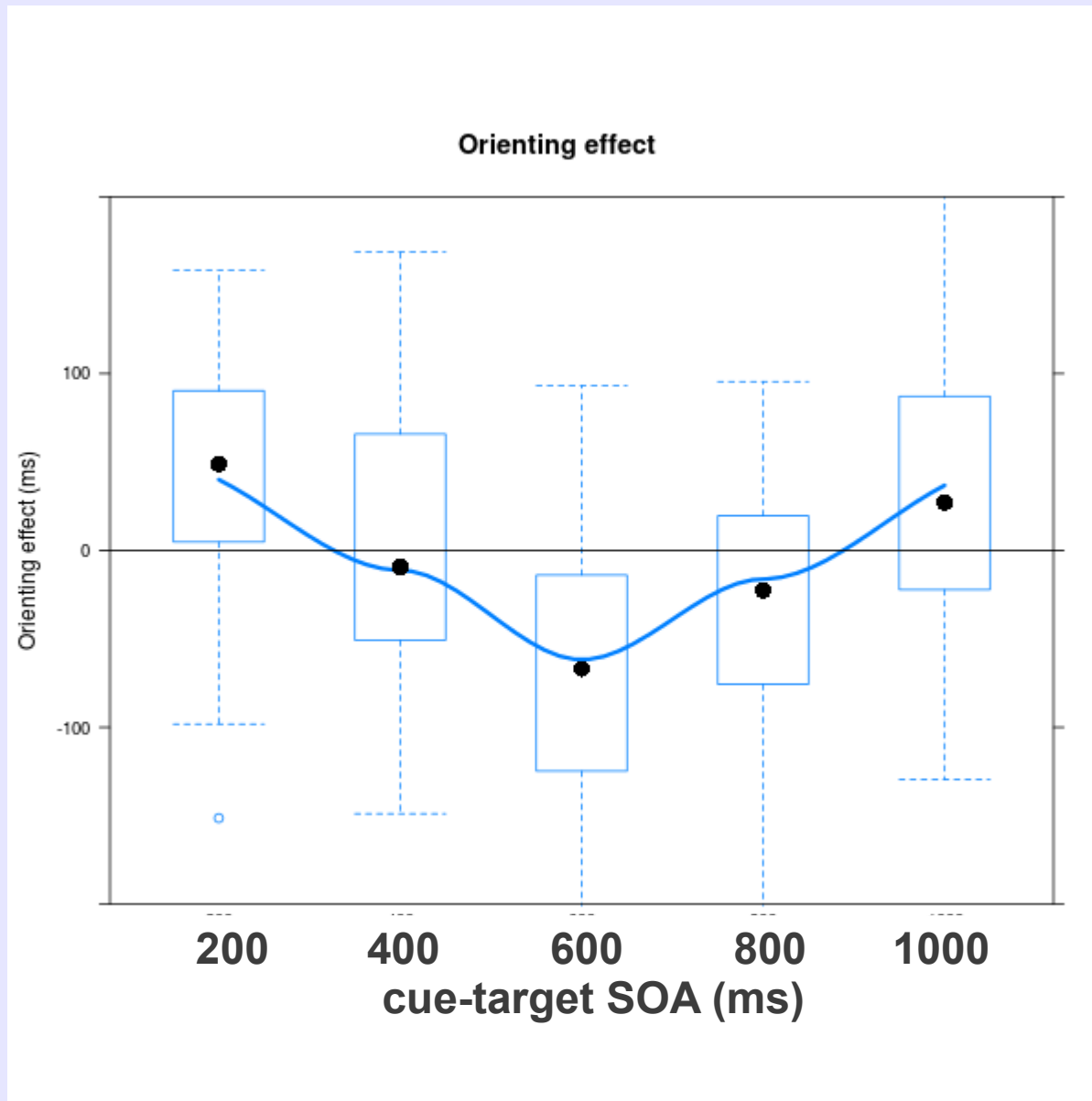
| SOA | alerting (ms) | t ₍₉₂₎ | p |
|------|---------------|-------------------|-------|
| 200 | 18 | 0.7 | 0.4 |
| 400 | 63 | 2.6 | 0.01 |
| 600 | 80 | 3.2 | 0.001 |
| 800 | 83 | 3.4 | 0.001 |
| 1000 | 19 | 0.8 | 0.4 |

Effects of Temporal cuing: Alerting



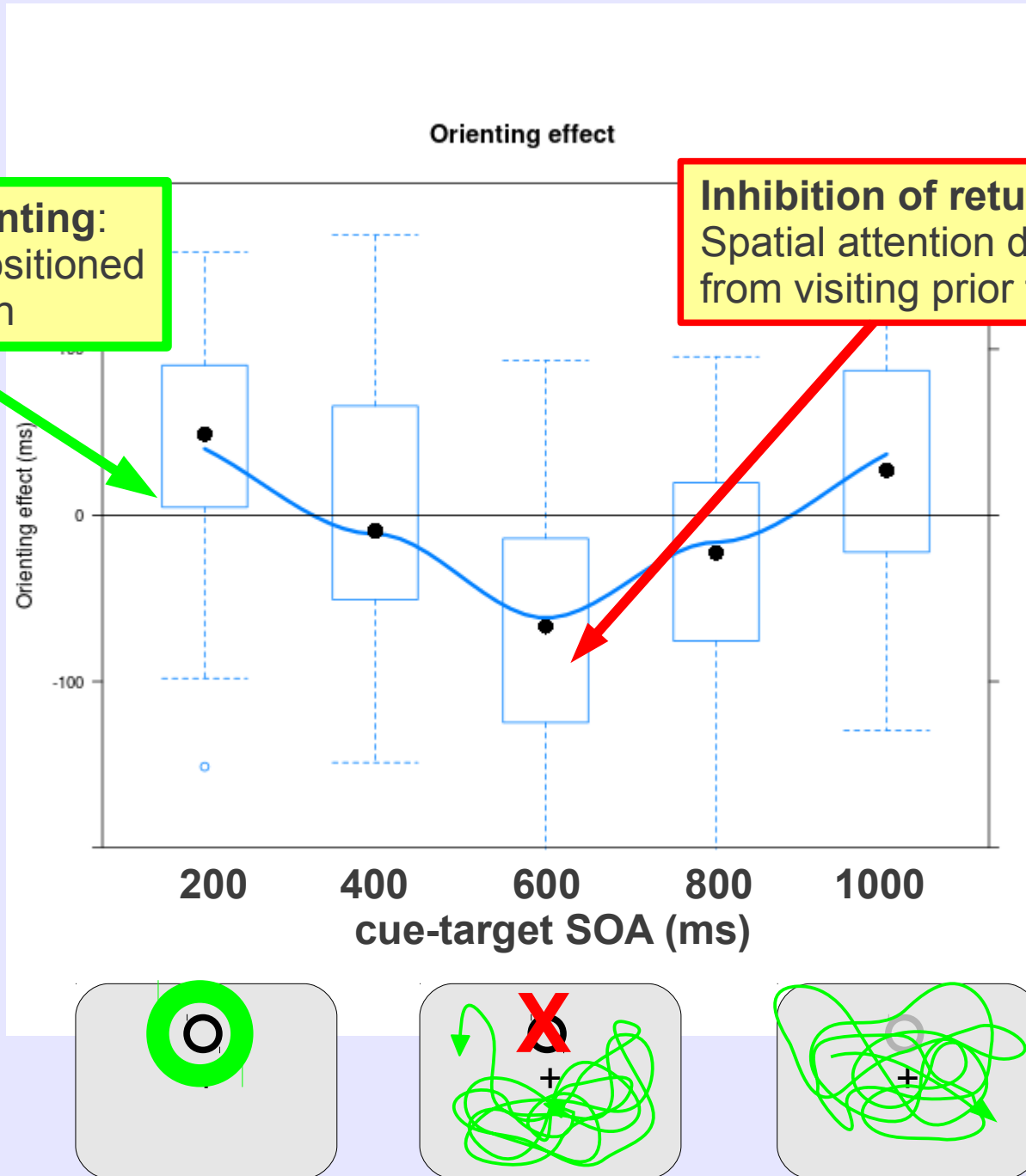
| SOA | alerting (ms) | t ₍₉₂₎ | p |
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Effects of spatial cuing: Orienting



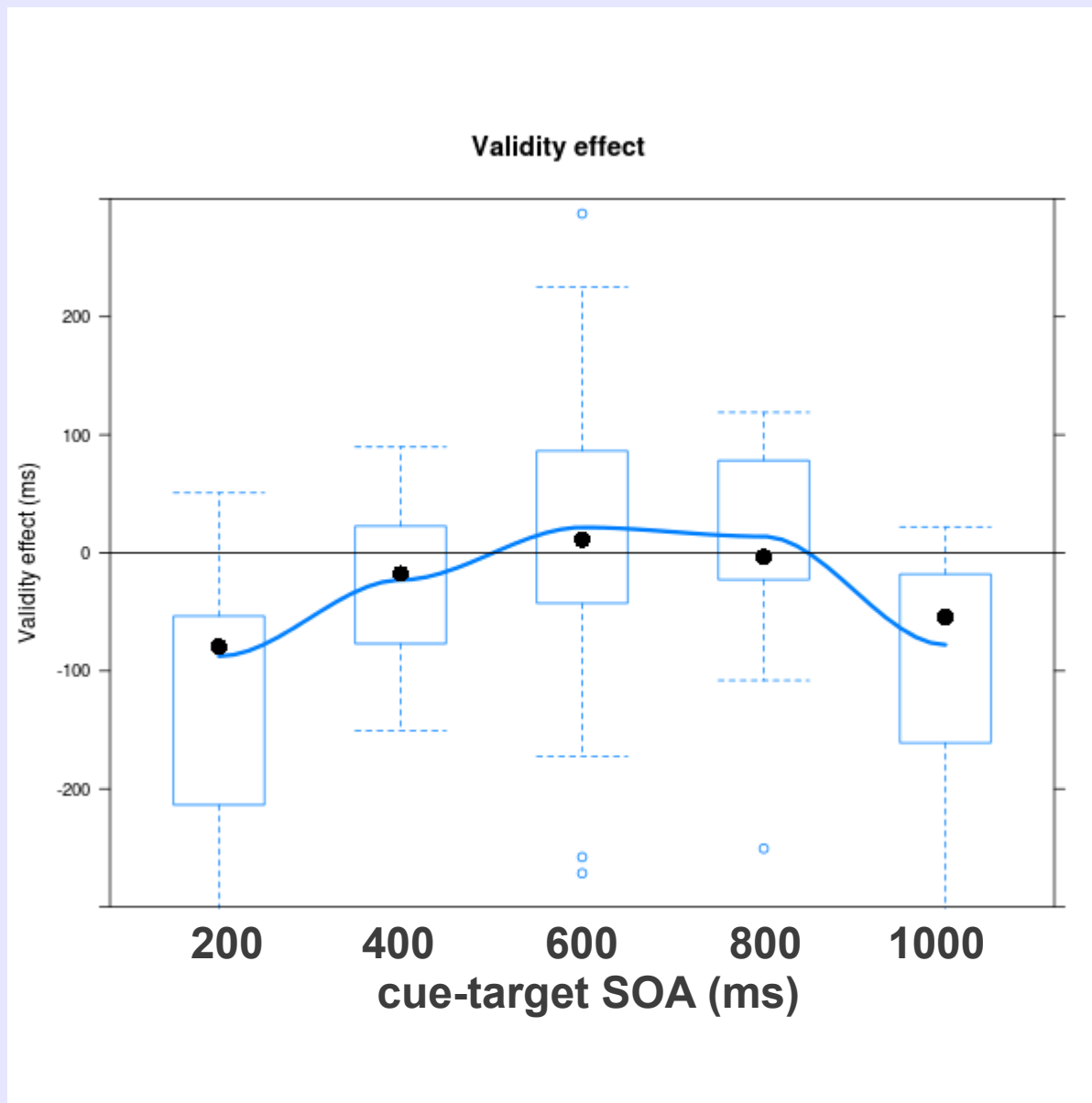
| SOA | orienting (ms) | t ₍₉₂₎ | p |
|------|----------------|-------------------|-------|
| 200 | 44 | 1.9 | 0.05 |
| 400 | 3 | 0.1 | 0.9 |
| 600 | -76 | 3.3 | 0.001 |
| 800 | -47 | 2.1 | 0.04 |
| 1000 | 37 | 1.6 | 0.1 |

Effects of spatial cuing: Orienting



| SOA | orienting (ms) | t ₍₉₂₎ | p |
|------|----------------|-------------------|-------|
| 200 | 44 | 1.9 | 0.05 |
| 400 | 3 | 0.1 | 0.9 |
| 600 | -76 | 3.3 | 0.001 |
| 800 | -47 | 2.1 | 0.04 |
| 1000 | 37 | 1.6 | 0.1 |

Effects of “false” spatial cuing: Validity



| SOA | validity (ms) | t ₍₉₂₎ | p |
|------|---------------|-------------------|-------|
| 200 | -115 | 4.5 | ~0 |
| 400 | -24 | 0.9 | 0.3 |
| 600 | -16 | 0.6 | 0.5 |
| 800 | 6 | 0.2 | 0.8 |
| 1000 | -74 | 2.8 | 0.005 |

Effects of “false” spatial cuing: Validity

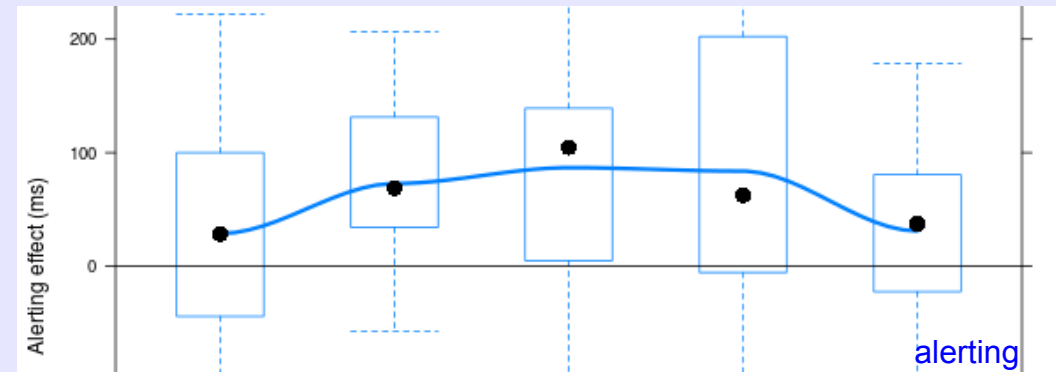


| SOA | validity (ms) | t ₍₉₂₎ | p |
|------|---------------|-------------------|-------|
| 200 | -115 | 4.5 | ~0 |
| 400 | -24 | 0.9 | 0.3 |
| 600 | -16 | 0.6 | 0.5 |
| 800 | 6 | 0.2 | 0.8 |
| 1000 | -74 | 2.8 | 0.005 |

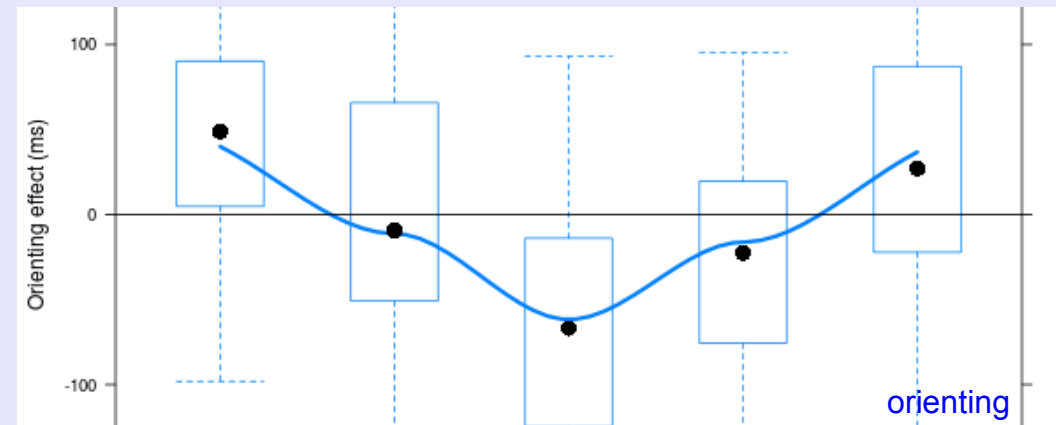
Discussion

Sensitive detection of effects of serial attention capture

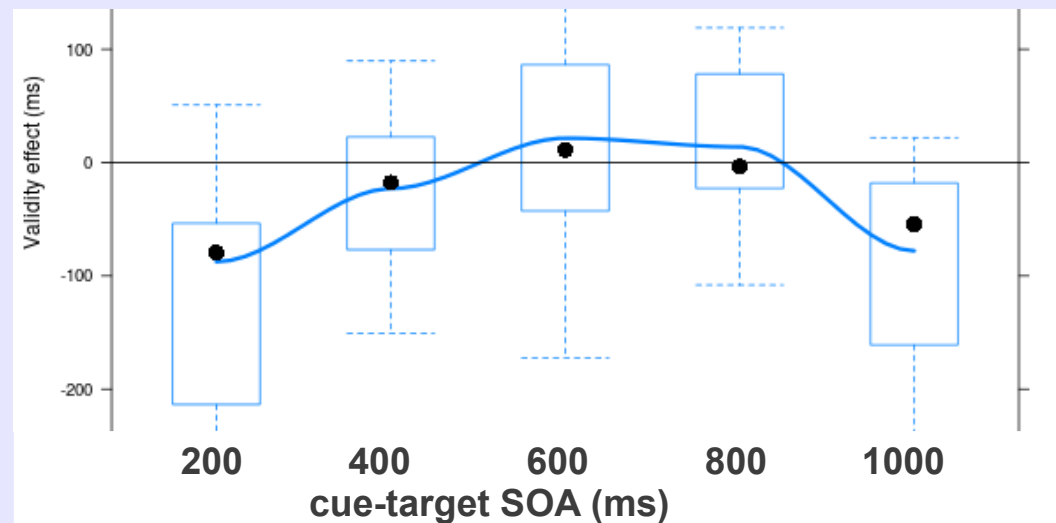
Phasic arousal peaks at ~ 600ms
Transient, < 1 second



Covert spatial orienting:
Fast onset targeting followed by
active inhibition (IOR)



IOR protects information gathering
during overt “distraction”



Implications?

(1) Inform HMI design by predicting effects of information demands on driver/operator

Implications?

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(2) Inform safe driver behavior regarding “multi tasking”

Implications?

(1) Inform HMI design by predicting effects of information demands on driver/operator

(2) Inform safe driver behavior regarding “dual tasking”

(3) Reveal effects on attention processing:

- **Drowsiness**

Subjective drowsiness associated with impaired alerting

Attention slow to disengage from warning cue (“distraction”)

Response to target worse than uncued performance !

Implications?

(1) Inform HMI design by predicting effects of information demands on driver/operator

(2) Inform safe driver behavior regarding “dual tasking”

(3) Reveal effects on attention processing:

- Drowsiness
- Mental fatigue ?
- Boredom / motivation ?
- Age ?
- Disease ?
- Chemical (medication, alcohol, drugs) ?
- Time of day ?

Thank you!

Derek N. Eder

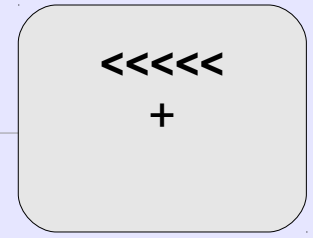
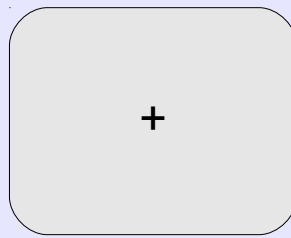


The wise protect attention as the greatest treasure

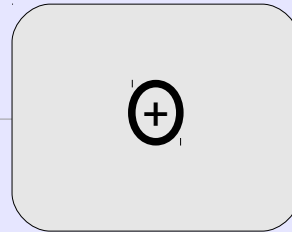
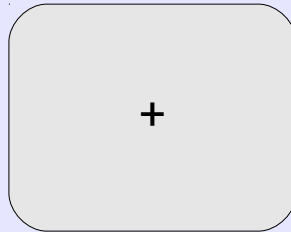
Dhammapada 26



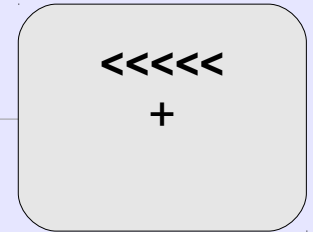
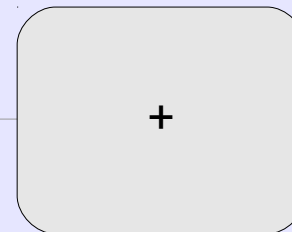
(1) Uncued trial



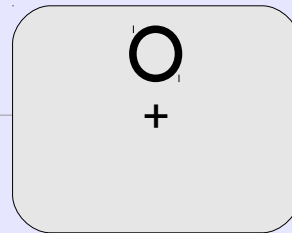
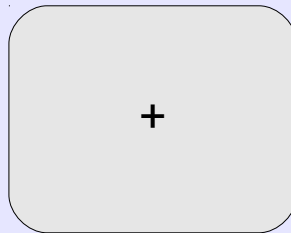
**(2) Temporal cued trial
(alerting)**



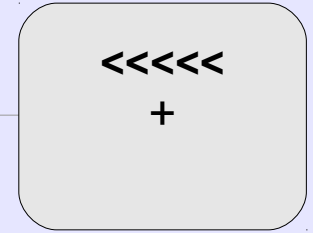
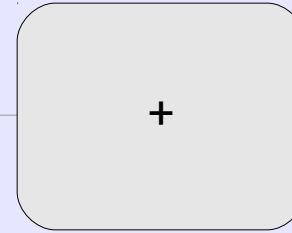
temporal cue



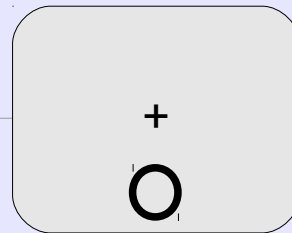
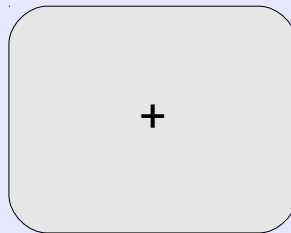
**(3) Spatial cued trial
(orienting)**



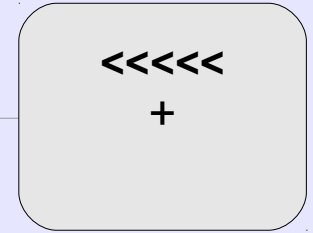
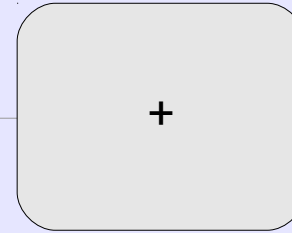
spatial cue



**(4) Invalid spatial cued trial
(validity)**



invalid spatial cue



Fixation cross

Cue

Wait

Target

Stimulus Onset Asynchrony
(SOA)

200, 400, 600, 800, 1000 ms

time

