# Progress in the search for the neural correlates of visual awareness


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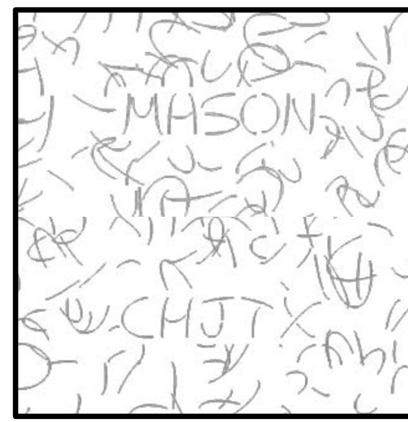
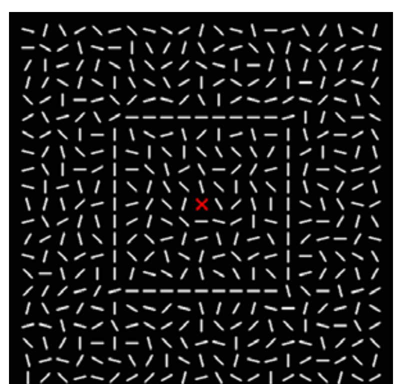
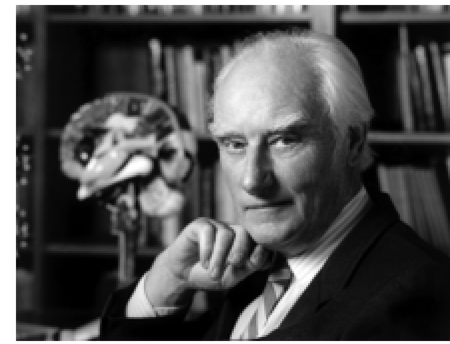


# Neural correlates of consciousness (NCC)

"Most of the processing that goes on in your brain is unconscious. Some of the results of that processing, you become conscious of. What's the difference between the two?"

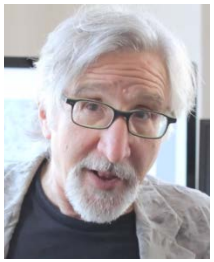


Francis Crick (1999)

Christof Koch (2004)

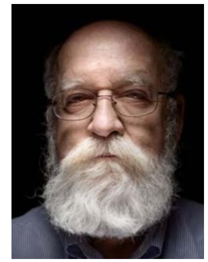
NCC = "The minimal set of neuronal events jointly sufficient for a specific conscious percept"

# Theories of consciousness



N. Block

V. Lamme



D. Dennett

S. Dehaene

**Sensory Theories**

e.g. recurrent processing theory

- phenomenal vs. access
- “rich” awareness
- **NCC: early (< 300ms)**
- **NCC: localized “flicker”**
- **attention & awareness fully dissociable**

**Cognitive Theories**

e.g. global neuronal workspace theory

- access-only
- “sparse” awareness
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*Research Article*

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pss.sagepub.com

# We See More Than We Can Report: "Cost Free" Color Phenomenality Outside Focal Attention

**Zohar Z. Bronfman[1,2], Noam Brezis[1], Hilla Jacobson[3], and Marius Usher[1,4,5,6]**
[1]School of Psychology, Tel Aviv University; [2]The Cohn Institute for the History and Philosophy of Science and Ideas, Tel Aviv University; [3]Cognitive and Brain Sciences, Ben-Gurion University of the Negev; [4]Sagol School of Neuroscience, Tel Aviv University; [5]Wadham College, University of Oxford; and [6]Department of Experimental Psychology, University of Oxford

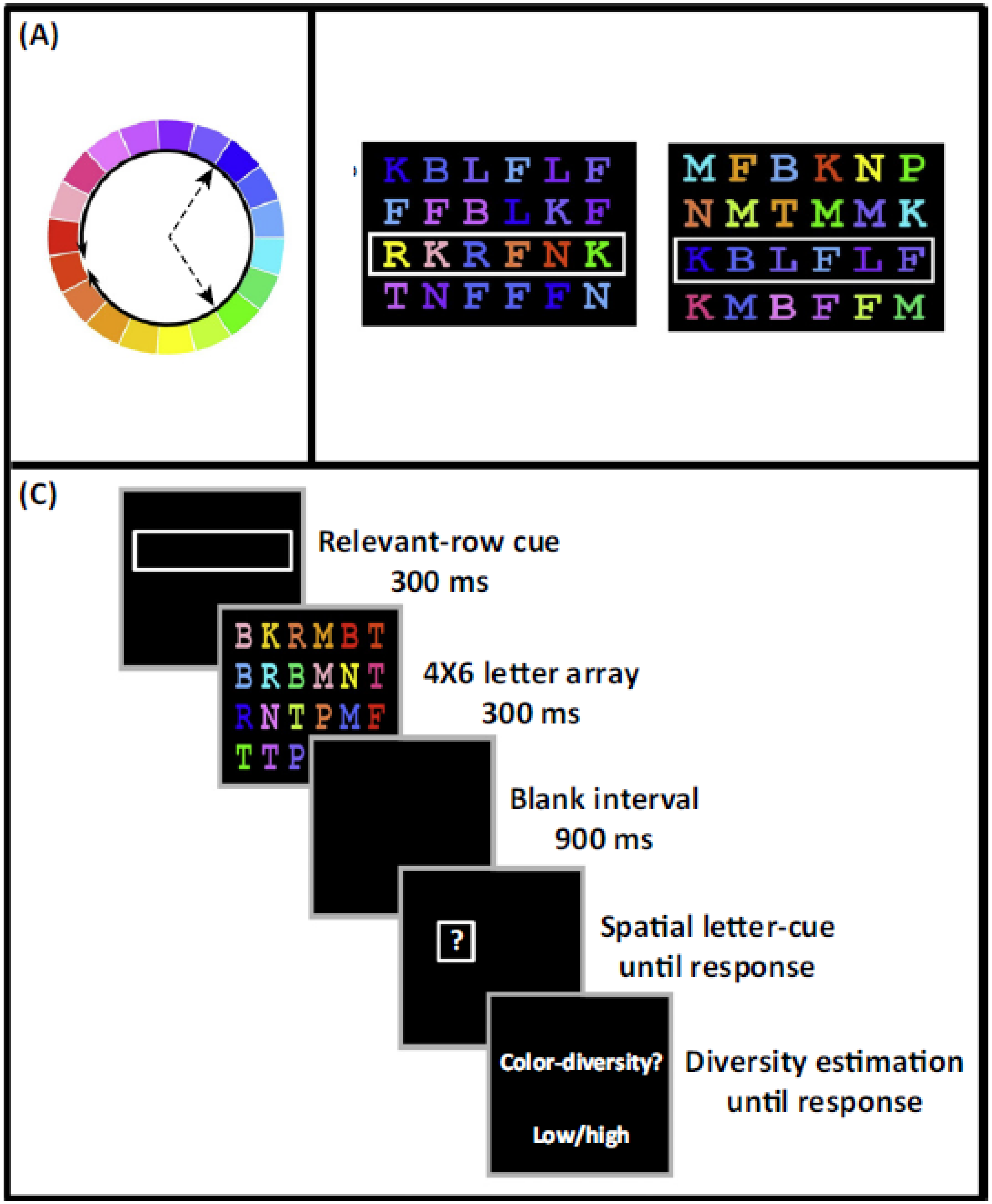
Spotlights

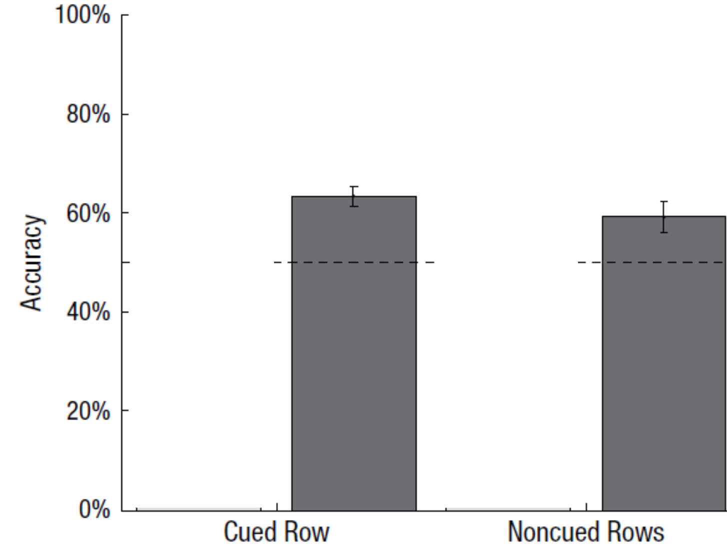
# Rich conscious perception outside focal attention

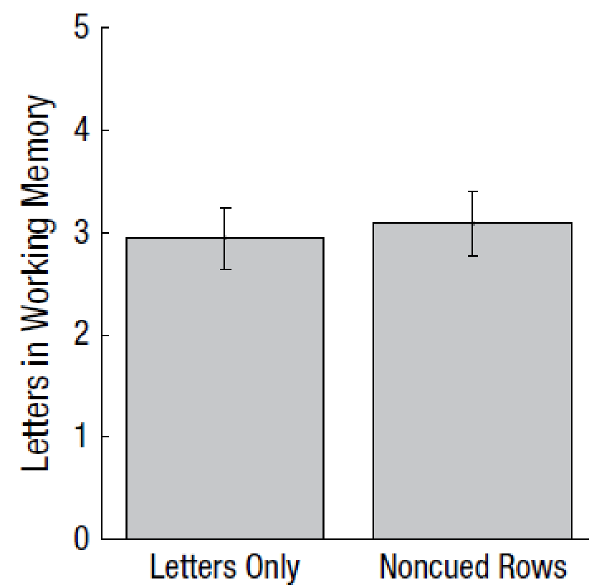
**Ned Block**

New York University, New York, NY, USA

Bronfman et al. (2014)



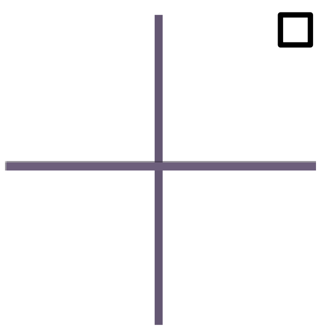



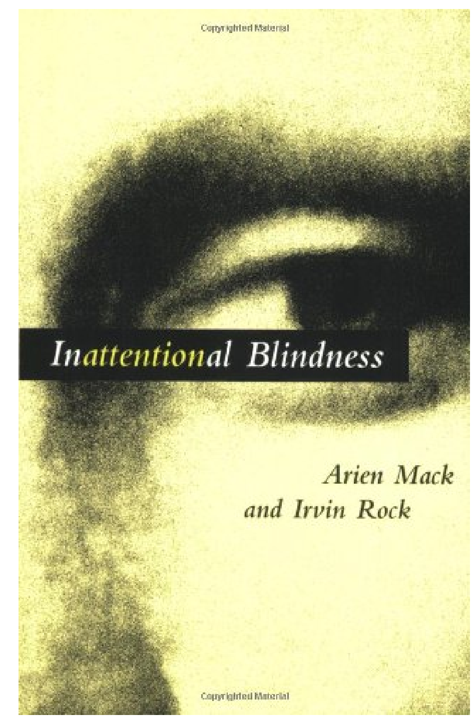
# awareness without attention… *really*?

**Inattentional Blindness**

“Failure to perceive unexpected objects or events because attention is focused on another task”

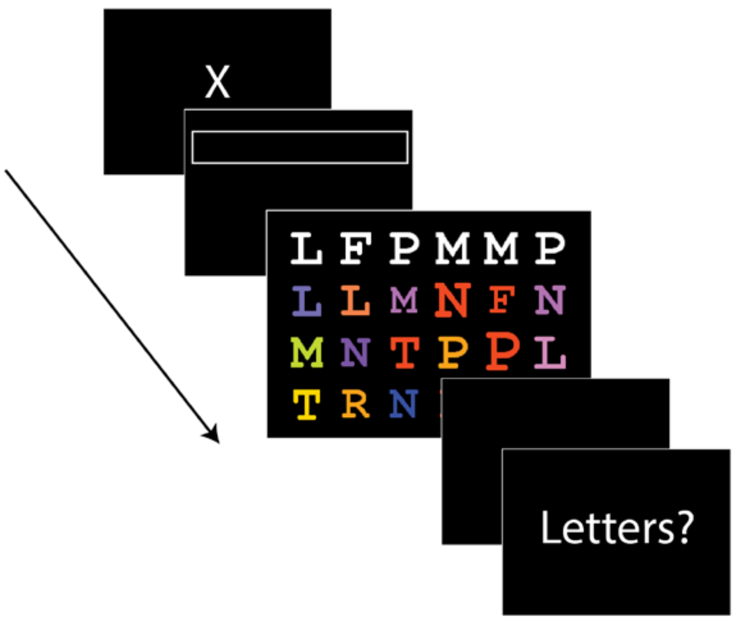
Mack & Rock (1998); Simons & Chabris (1999)



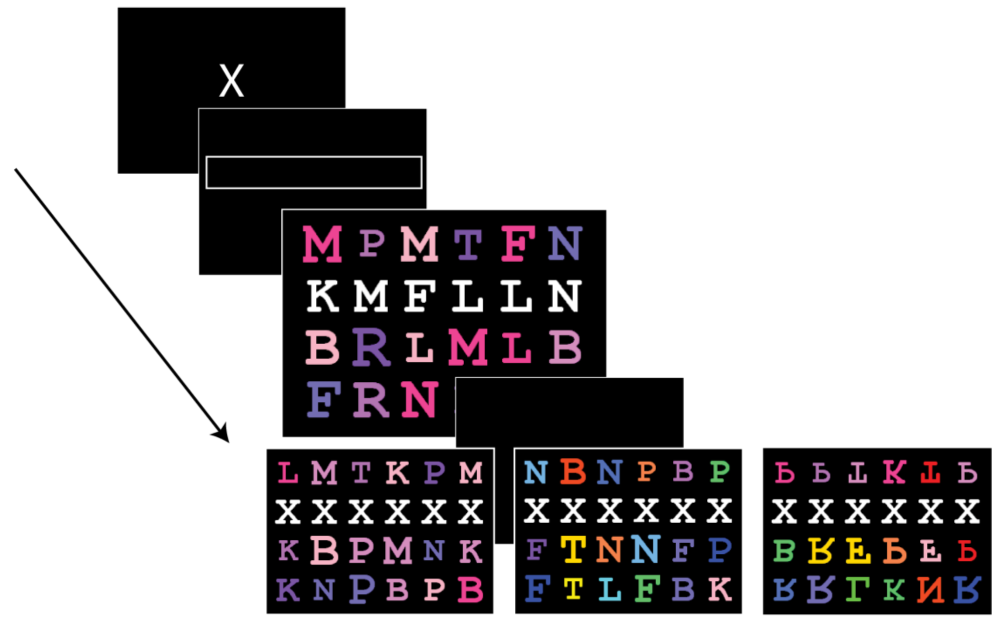


# Methods: single task

Single task
(report cued row)




Critical trial
(change in color variance)

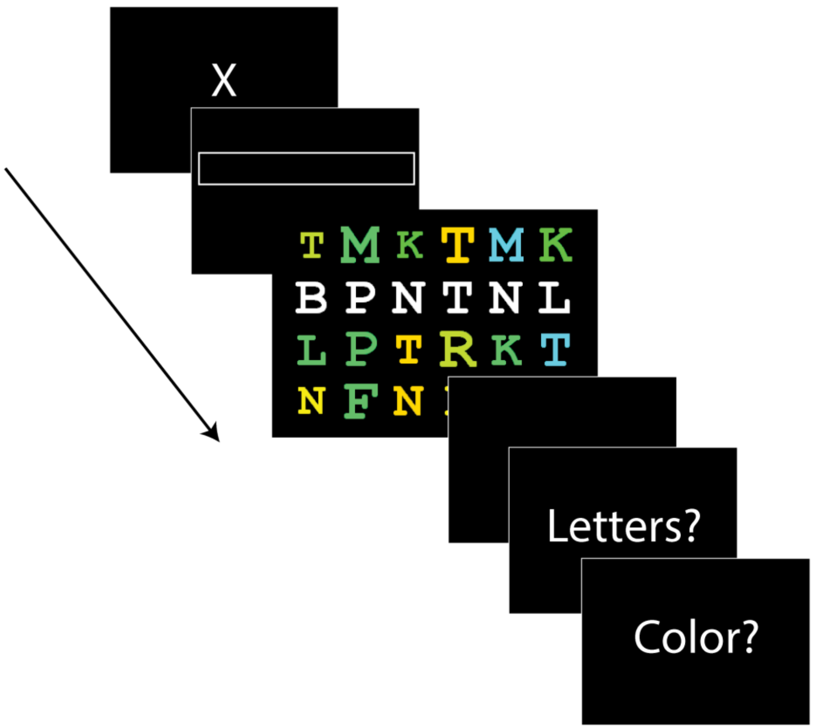



3-AFC: Which looks most like what you just saw?

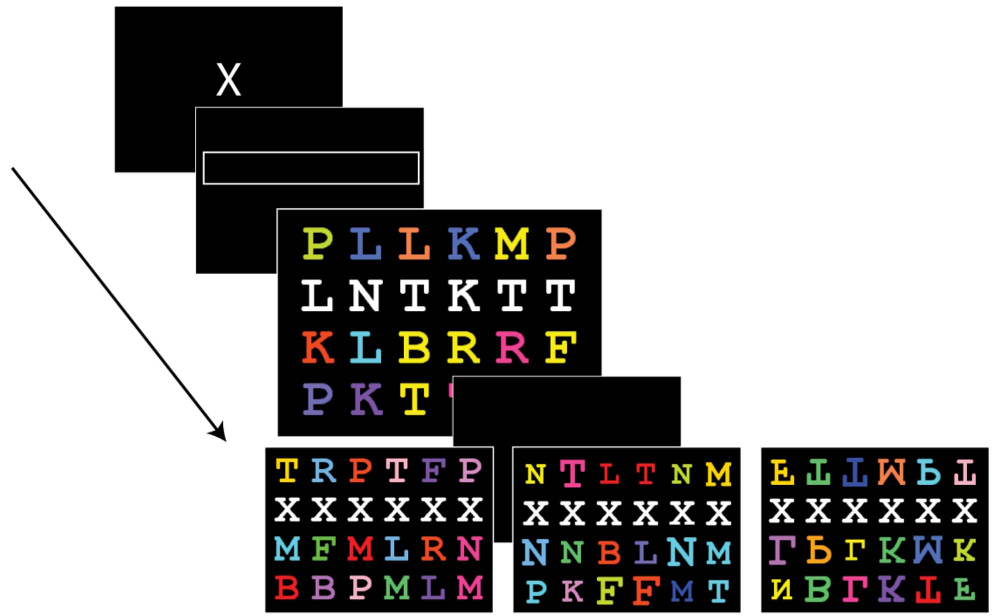
Jackson-Nielsen, Cohen, & Pitts (under review)

# Methods: dual task (color)

Dual task
(cued row + color)



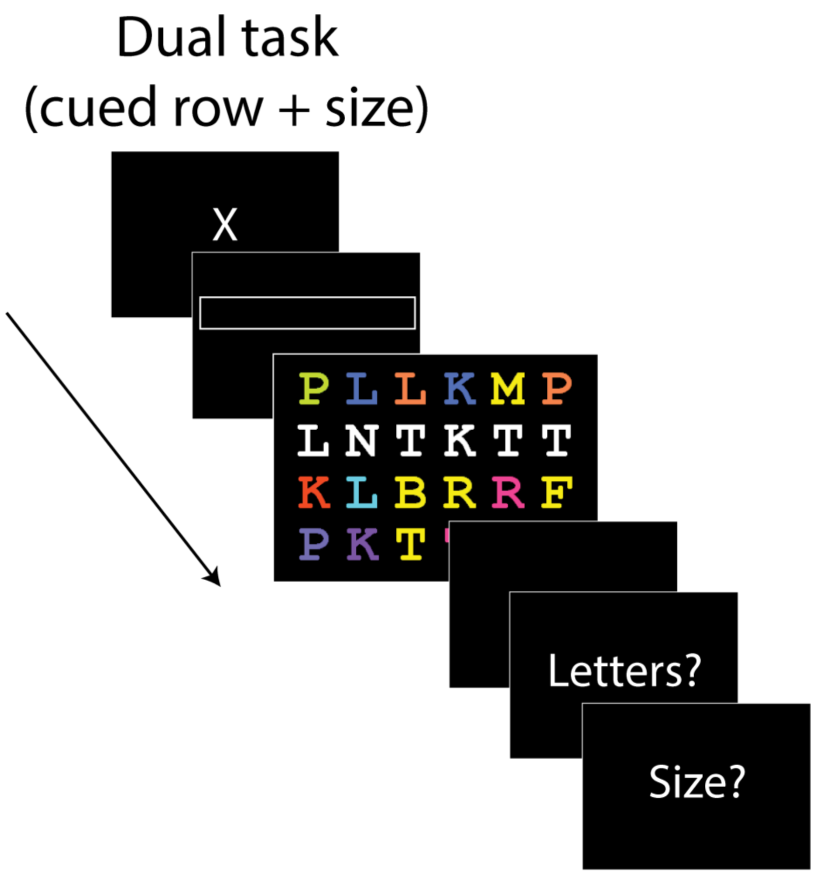

Critical trial
(change in size variance)




3-AFC: Which looks most like what you just saw?

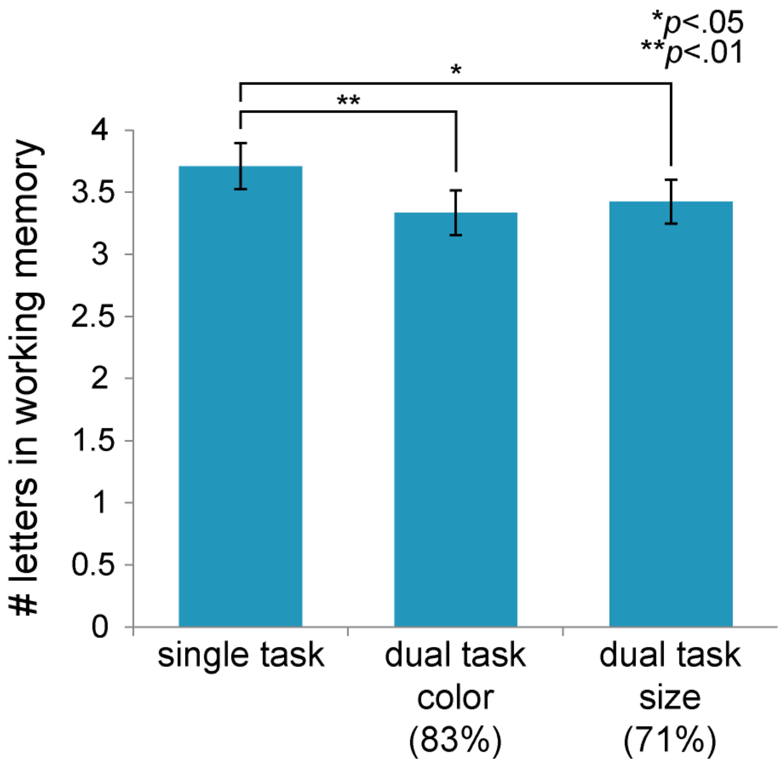
Jackson-Nielsen, Cohen, & Pitts (under review)

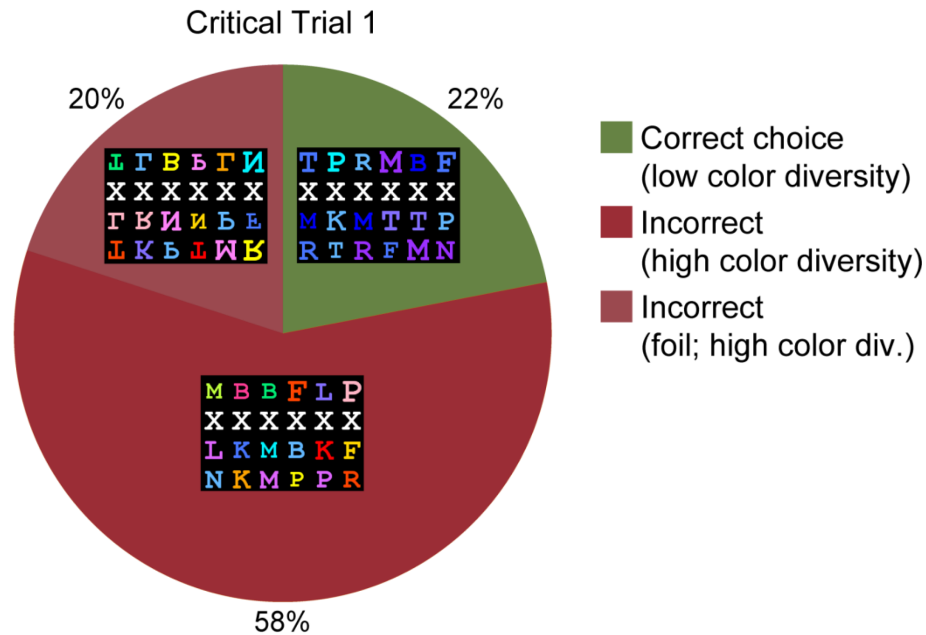
# Methods: dual task (size)

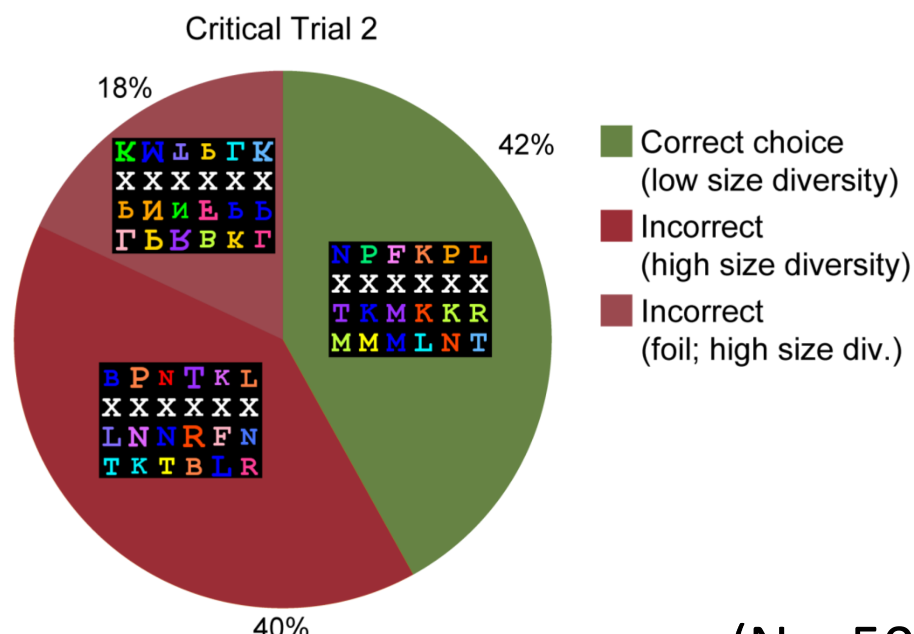



Jackson-Nielsen, Cohen, & Pitts (under review)

# Results



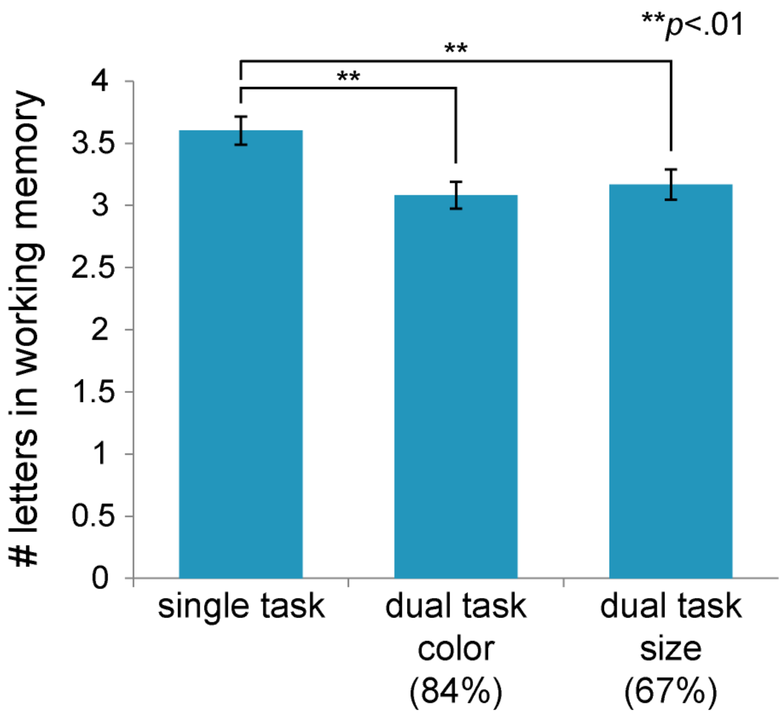



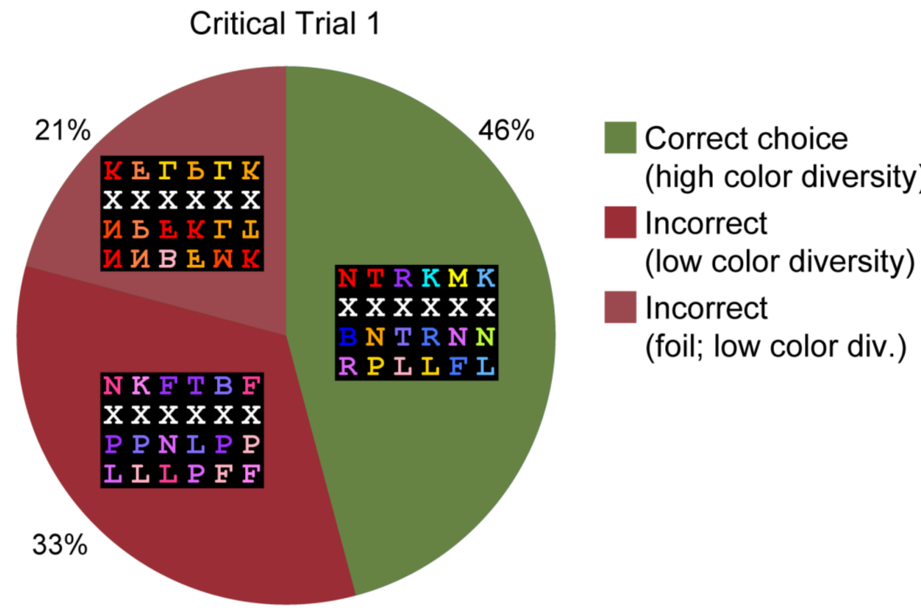



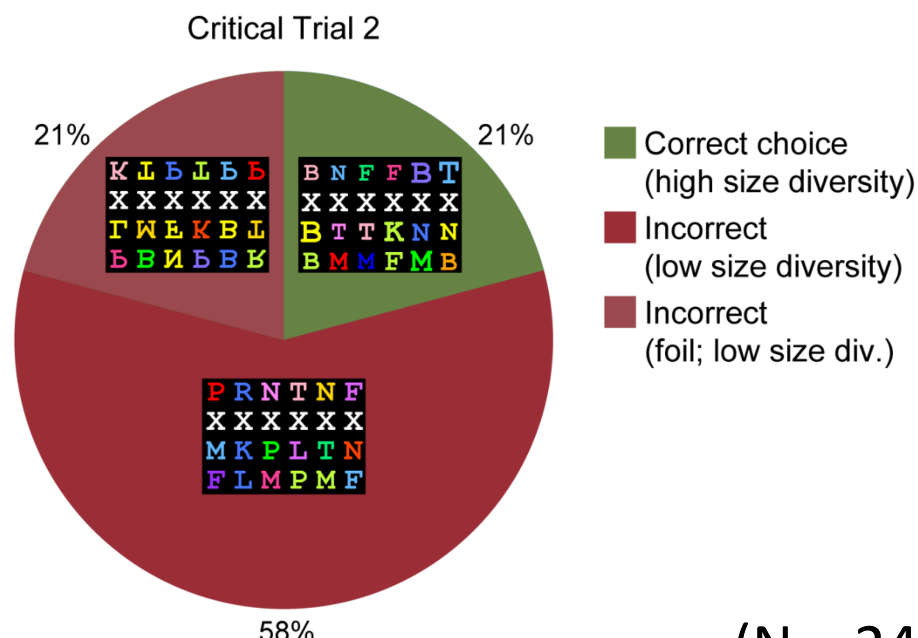

Jackson-Nielsen, Cohen, & Pitts (under review)

(N = 50)

# Results Exp 2: low-to-high




Jackson-Nielsen, Cohen, & Pitts (under review)

(N = 24)

# awareness without attention… *really*?

**No**

- attention is necessary for awareness (single dissociation)

Why the discrepancy between our results and Bronfman et al.’s?

- subjects learned over 100’s of trials to distribute a small (non-zero) amount of attention to non-cued rows to perceive color diversity


# Theories of consciousness

**Sensory Theories**

e.g. recurrent processing theory

- phenomenal vs. access
- “rich” awareness
- NCC: early (< 300ms)
- NCC: localized “flicker”
- attention & awareness fully dissociable

**0**

**Cognitive Theories**

e.g. global neuronal workspace theory

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# The 3 NCC problem

When contrasting “aware” vs. “unaware” conditions, it’s difficult to distinguish…

- Preconscious processing (necessary but not sufficient)

  &

- Postperceptual processing (sufficient but not necessary)

  from…

- NCC-proper (necessary *and* sufficient)

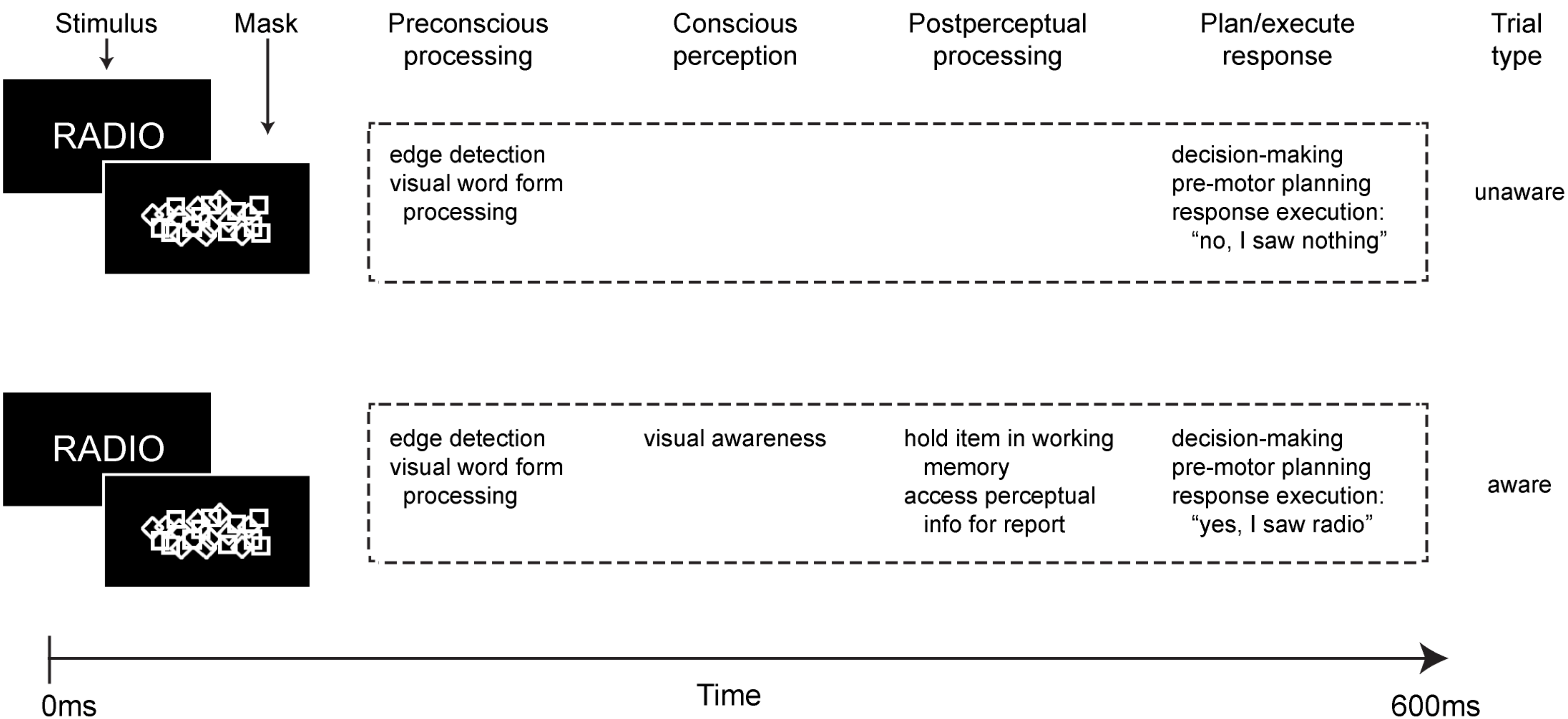
Aru, Bachmann, Singer, & Melloni (2012) *NeuroBioRev*

de Graaf et al. (2012) *NeuroBioRev*

# Paradigm comparison

Backward masking paradigm (at threshold)

Task = after each trial report percept, e.g. did you see a word (Y/N)? can you identify the word?



# Inattentional Blindness (IB) paradigm

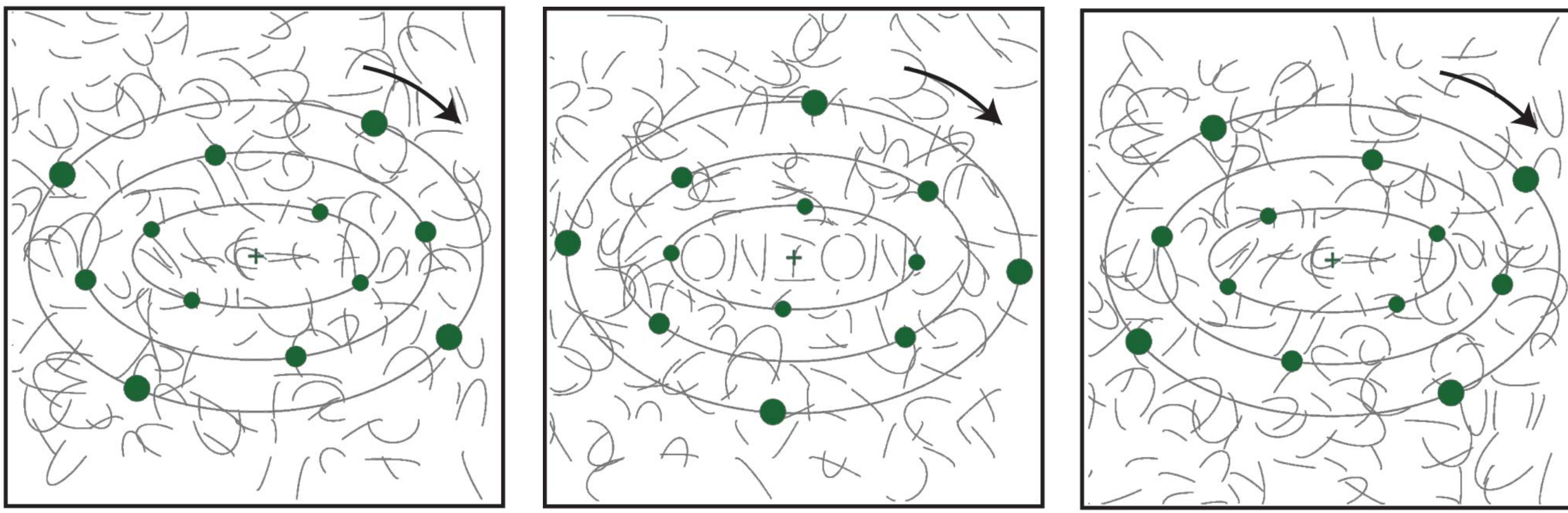
Video example of stimuli:

https://youtu.be/FONIOaZXzEg

# Inattentional Blindness (IB) paradigm

Words (22.5%)
Consonants (22.5%)
Scrambled (45%)

Scrambled | Animal Words (10%) | Scrambled



600-800ms | 300ms | 600-800ms

Time-lock ERPs

# Procedure

Phase 1:

Distracter Task

(unaware)

→ Awareness Assessment →

Phase 2:

Distracter Task

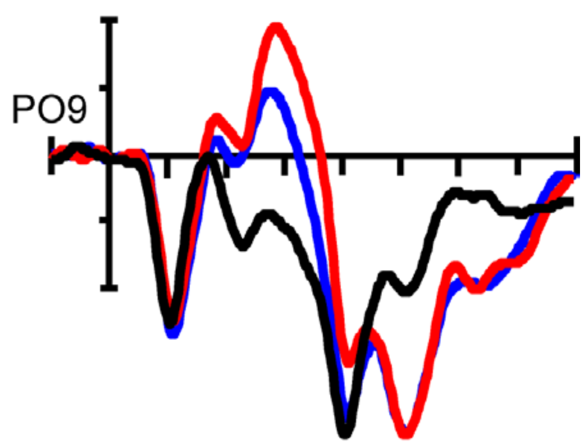
(aware)

→ Awareness Assessment →

Phase 3:

Word Recognition Task

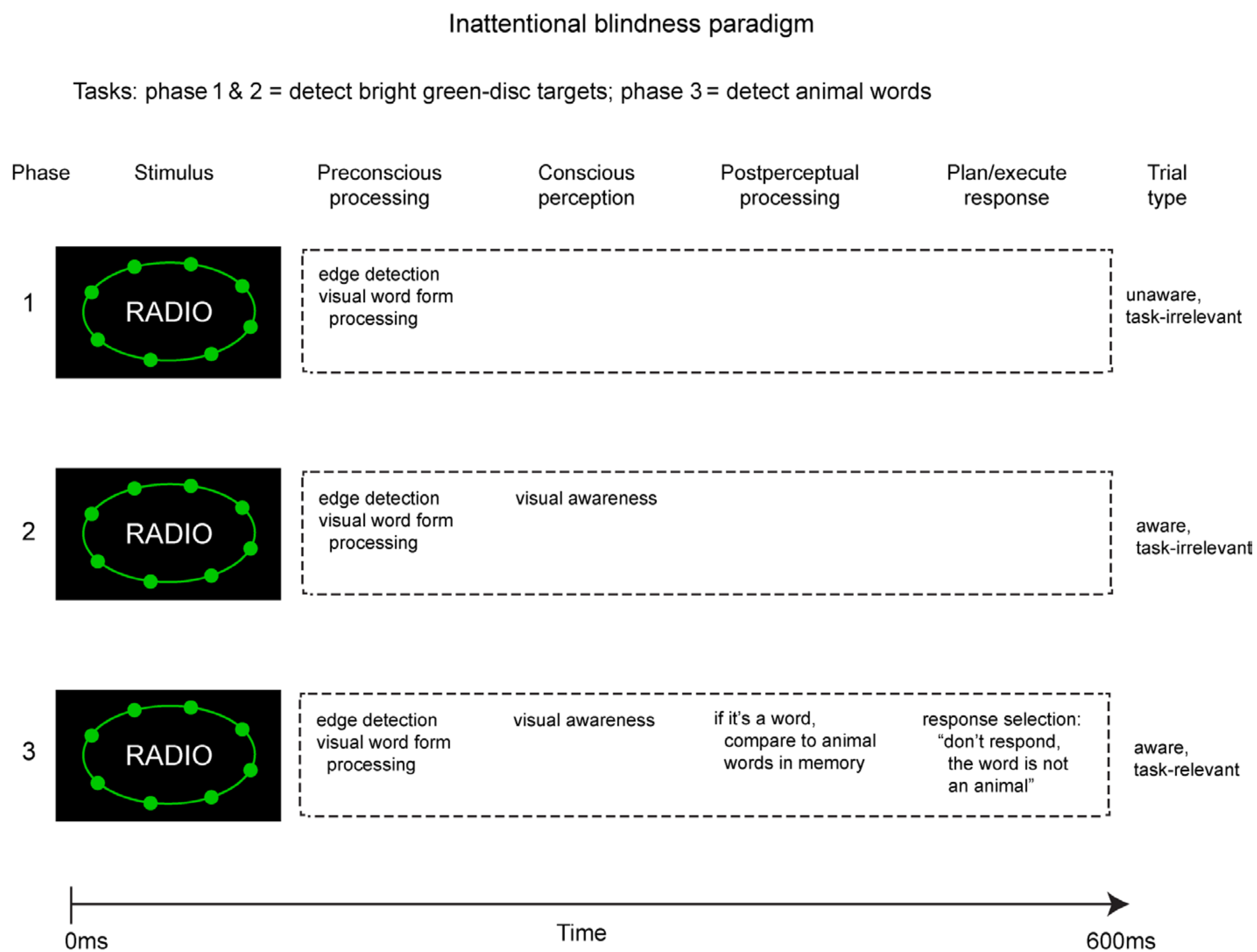
(aware + relevant)




<u># of stimuli per phase</u>:

- Words: 180
- Consonants: 180
- Scrambled: 360
- Animal Words: 80

- IB to shapes: Pitts, Martinez, & Hillyard (2012) *JoCN*
- IB to faces: Shafto & Pitts (in press) *JNeurosci*


Inattentional blindness paradigm
Tasks: phase 1 & 2 = detect bright green-disc targets; phase 3 = detect animal words
Phase
Stimulus
Preconscious processing
Conscious perception
Postperceptual processing
Plan/execute response
Trial type
1
RADIO
edge detection
visual word form processing
unaware, task-irrelevant
2
RADIO
edge detection
visual word form processing
visual awareness
aware, task-irrelevant
3
RADIO
edge detection
visual word form processing
visual awareness
if it's a word, compare to animal words in memory
response selection: "don't respond, the word is not an animal"
aware, task-relevant
0ms
Time
600ms

Phase 1:
Distracter Task
(unaware)

→

Phase 2:
Distracter Task
(aware)

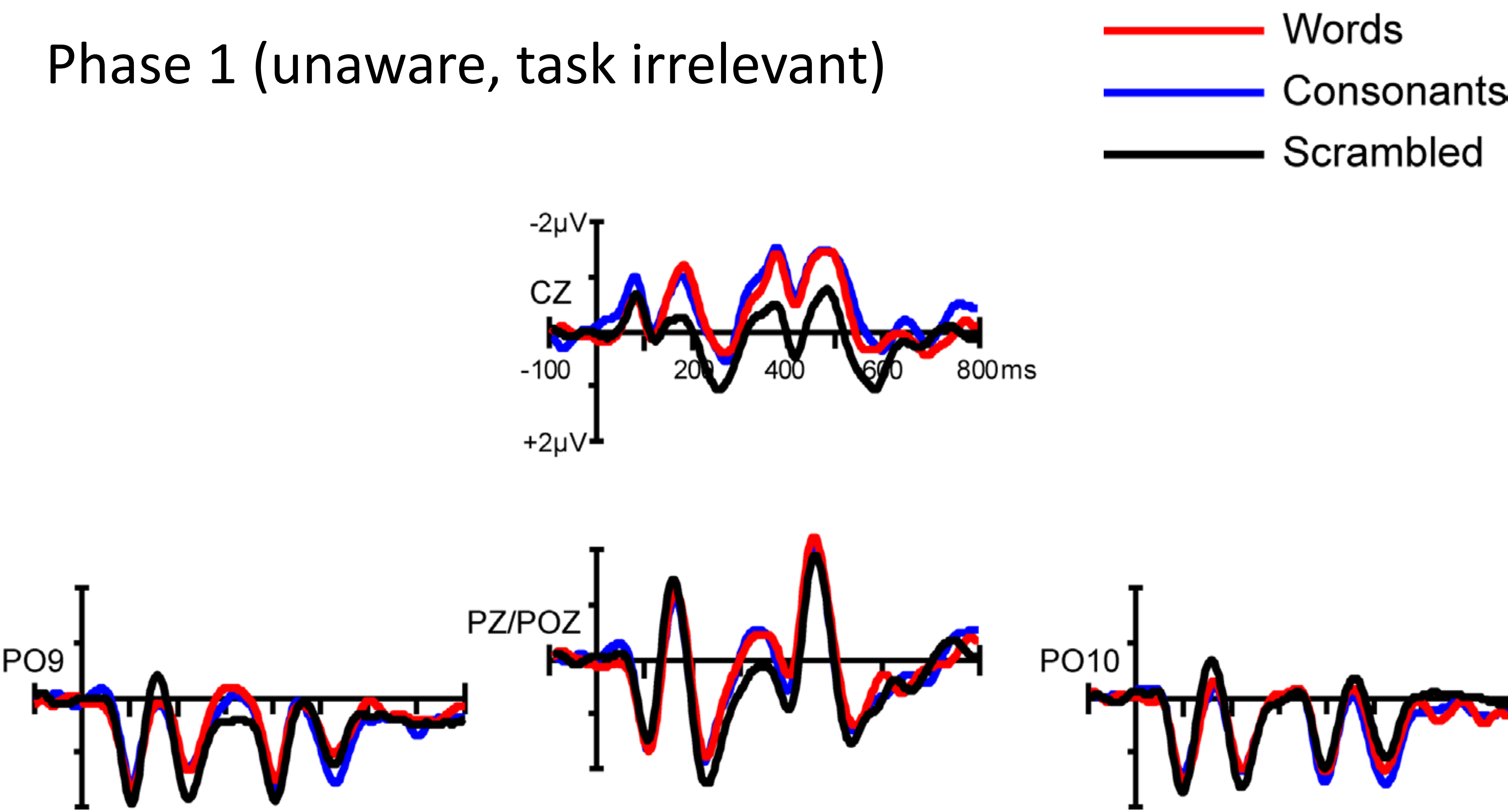
→

Phase 3:
Word Recognition Task
(aware + relevant)

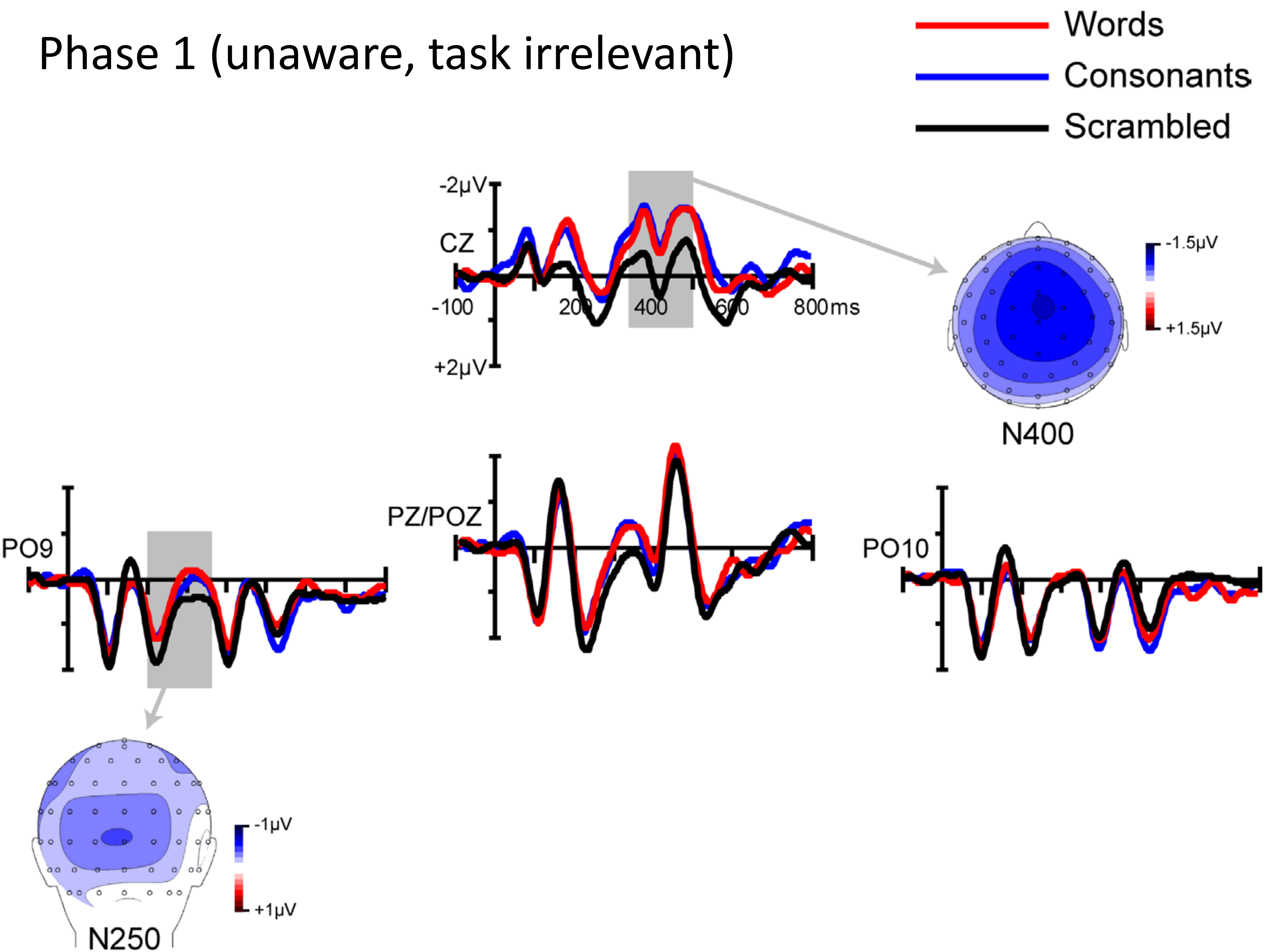
**Main Questions**:

- N250 and N400 during inattentional blindness (Phase 1)?
  (Appelbaum et al., 2009; Luck, Vogel, & Shapiro, 1996)
- P3b when subjects are aware of words (Phase 2) or only when words must be reported (Phase 3)?
  (Dehaene & Changeux, 2011)
- ERPs uniquely associated with awareness (Phase 2 vs. Phase 1), e.g. visual awareness negativity (VAN)?
  (Railo, Koivisto, & Revonsuo, 2011)

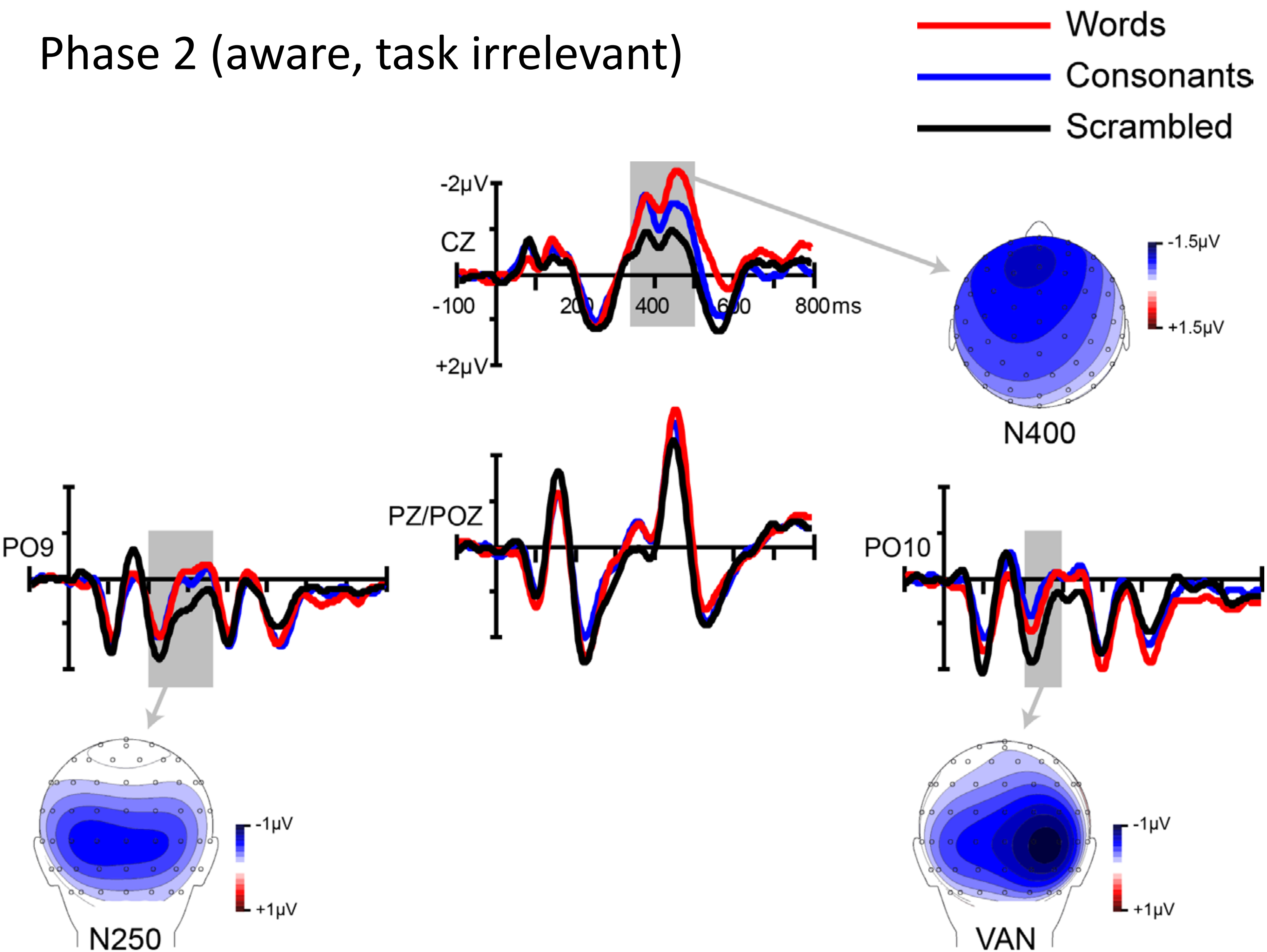
# Phase 1 (unaware, task irrelevant)



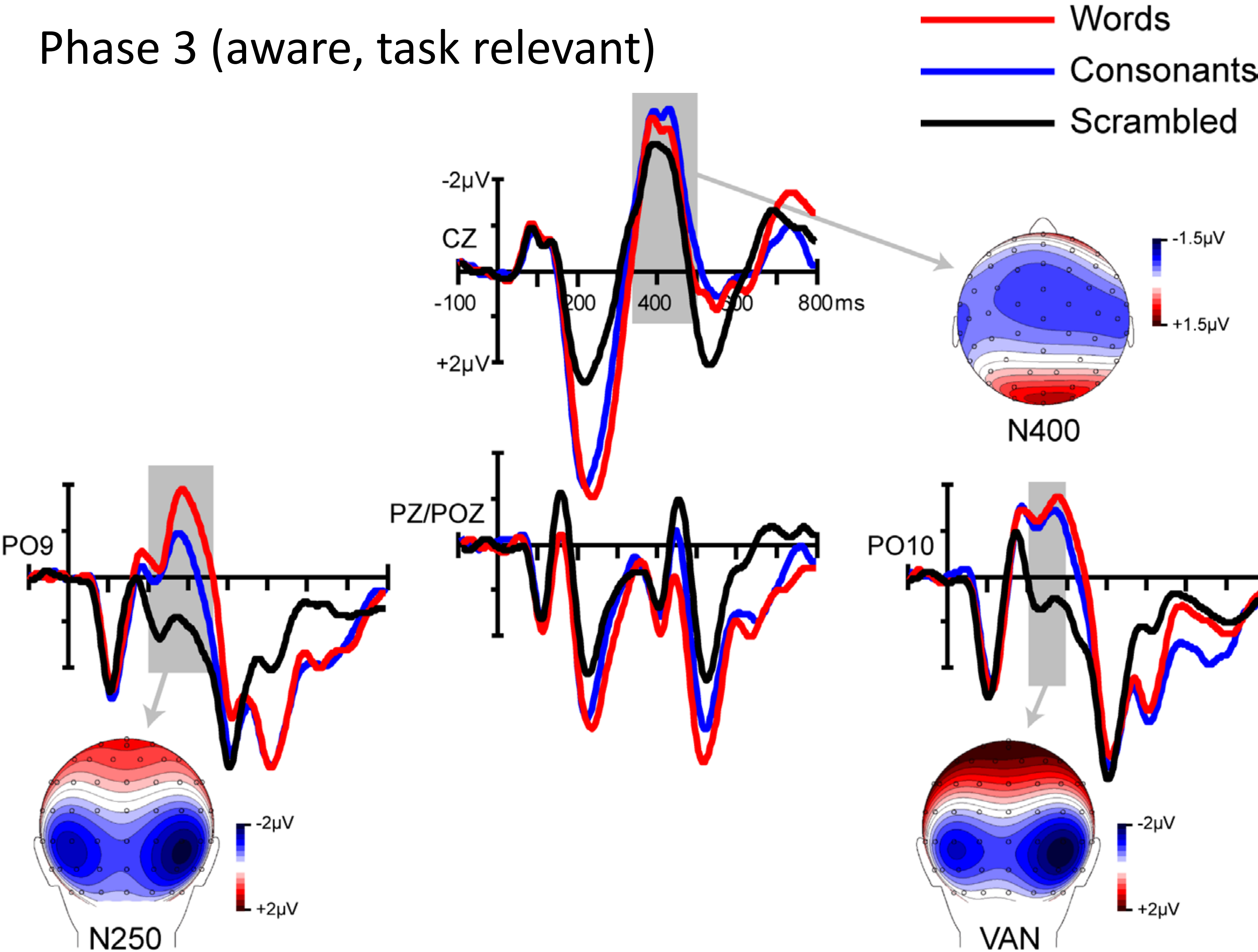
# Phase 1 (unaware, task irrelevant)



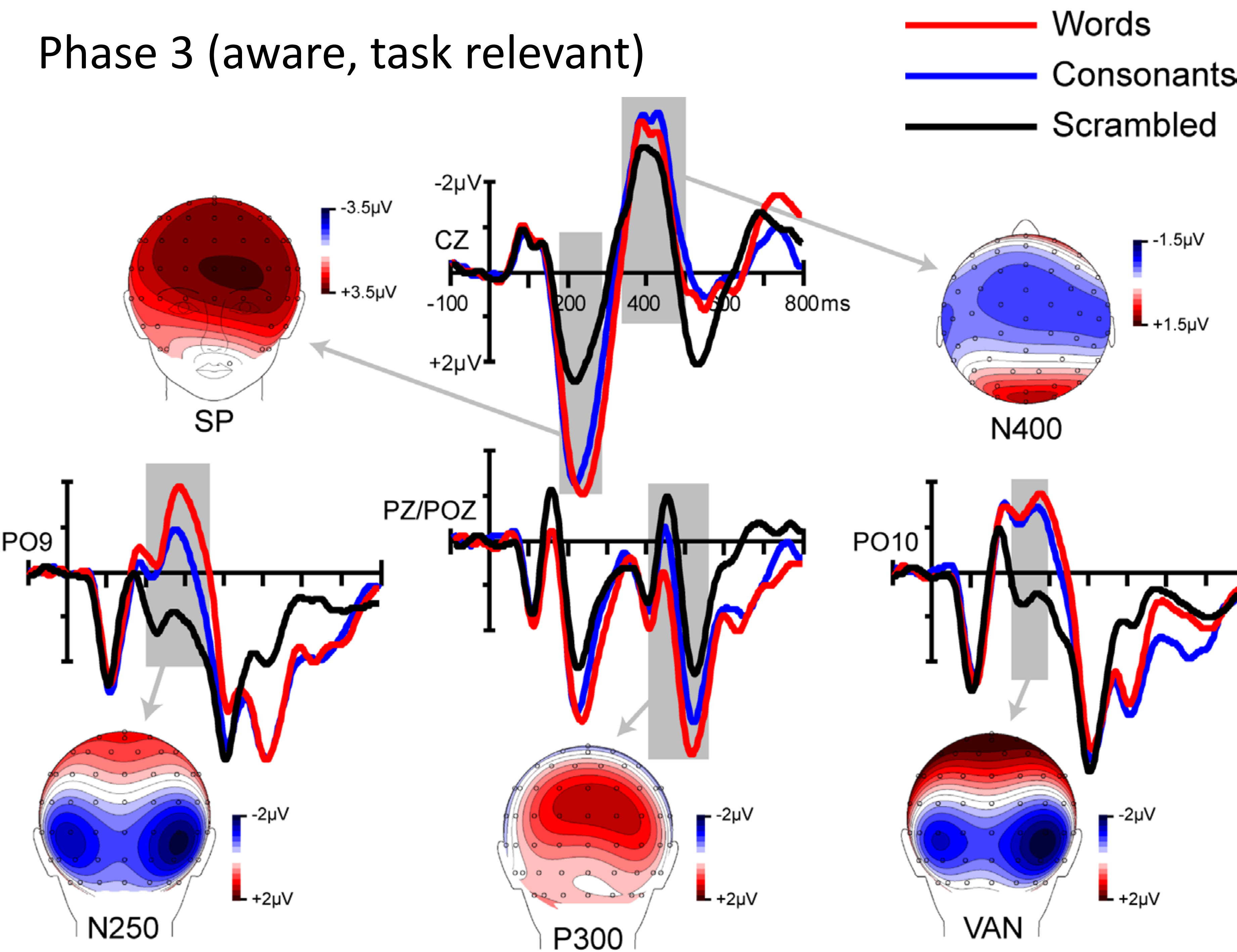
# Phase 2 (aware, task irrelevant)



# Phase 3 (aware, task relevant)

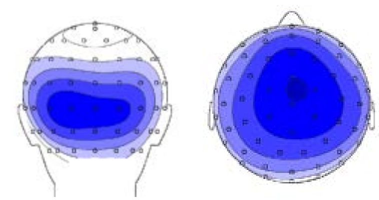


# Phase 3 (aware, task relevant)



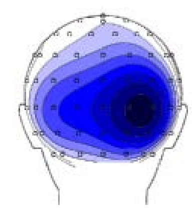
# Summary

- N250 and N400 *regardless* of whether subjects are aware of the word forms.
  - All phases (incl. unaware, task-irrelevant)



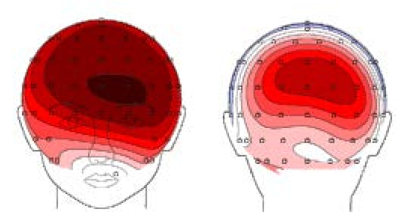
preconscious processing

- VAN (and word vs. consonant ERP difference) *only when* subjects are aware of the word forms.
  - Phase 2 (aware, task-irrelevant)
  - Phase 3 (aware, task-relevant)



NCC proper ?

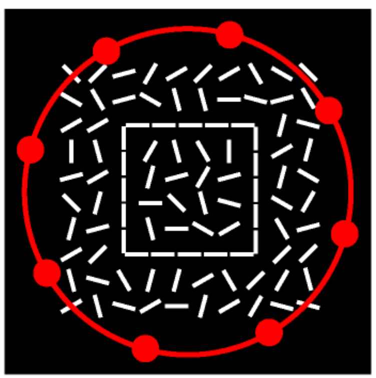
- SP, SN, and P3b *only when* words must be reported.
  - Phase 3 (aware, task-relevant)

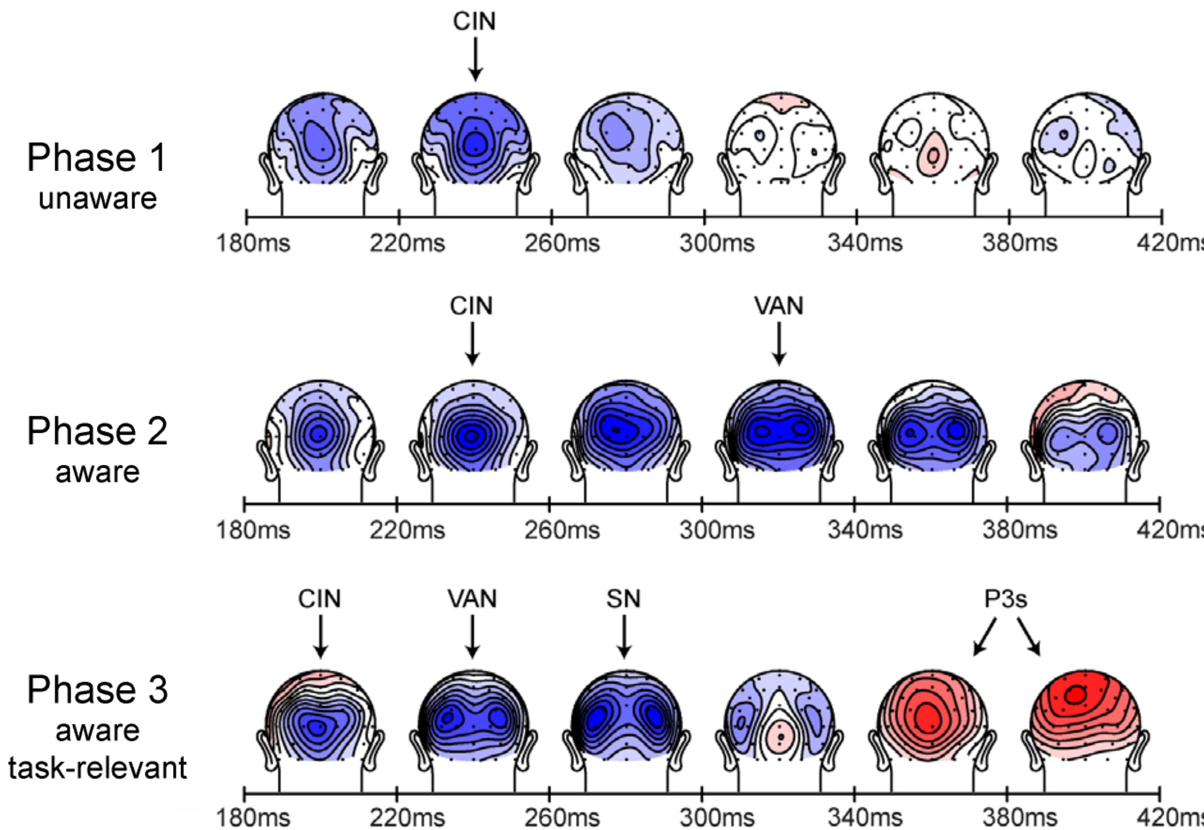


postperceptual processing

# Summary

Results consistent with our previous IB experiments: shapes

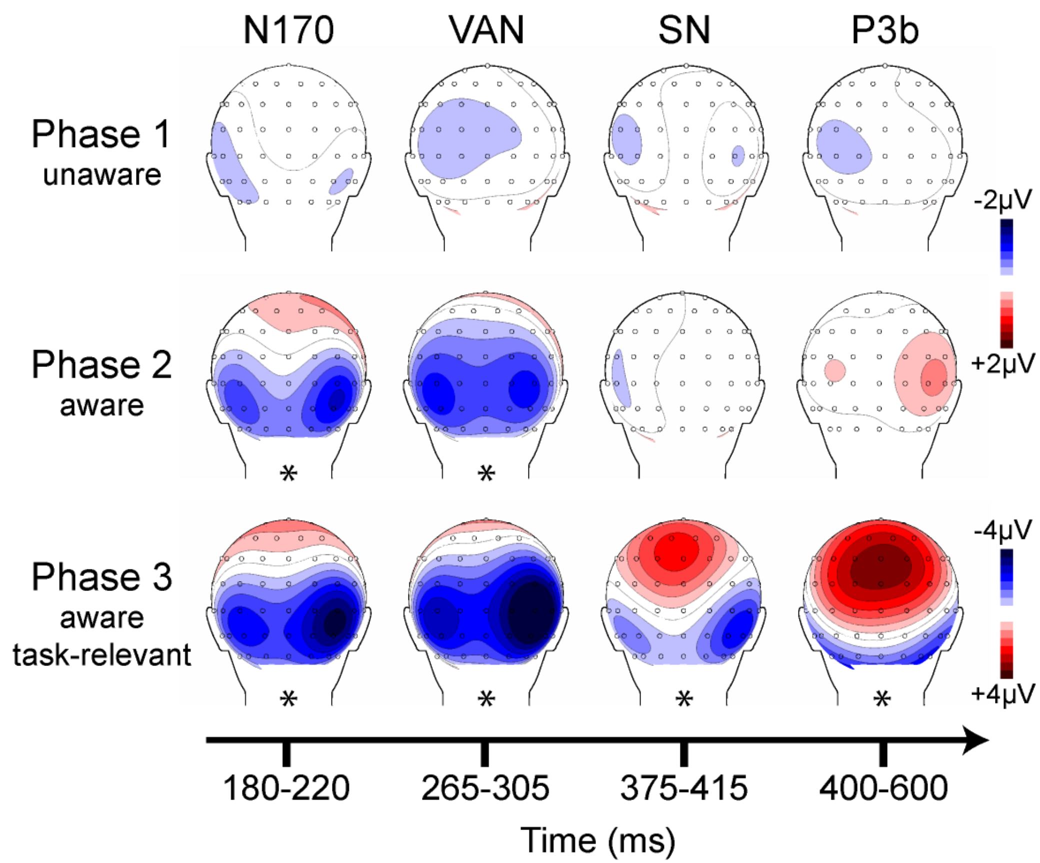





Pitts, Martinez, & Hillyard (2012) *JoCN*

# Summary

Results consistent with our previous IB experiments: faces

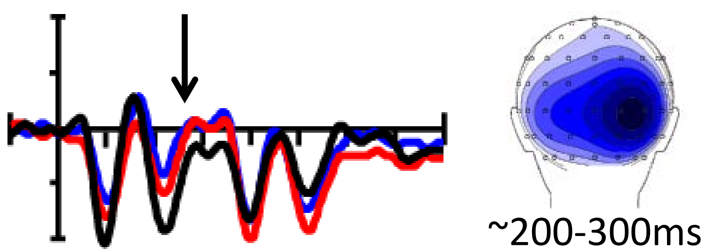



Shafto & Pitts (in press) *JNeurosci*

# Summary

Overall pattern of results (shapes, faces, words)

- extensive preconscious processing during IB
- late, wide-spread “ignition” related to reporting one’s awareness
- early, more localized “flicker” related to awareness *per se*




VAN

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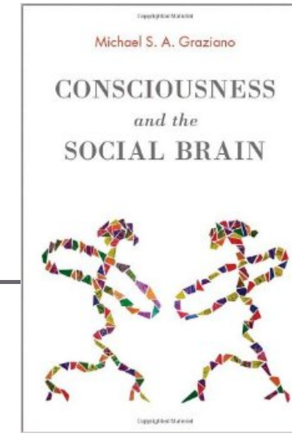
# Alternative theories?




**Attention Schema Theory**

- *perceptual* theory of awareness (vs. sensory or cognitive)
- awareness is a perceptual model of attention
- specific computation = "person X is attending to Y"
  - X can be oneself or someone else (hence the "social" part)
  - Y can be a sensory stimulus or a thought, emotion, memory, etc.
- predicts: single dissociation btw attention & awareness √
- predicts: mid-latency, non-global NCC √

**Is VAN a signature of this awareness computation?**

Graziano & Kastner (2011) *CogNeurosci*

Graziano (2013) *Consciousness and the Social Brain*

# Thank you for your attention and awareness!

Collaborators:

- Steve Hillyard
- Antígona Martínez
- Enriqueta Canseco-Gonzalez
- Kathryn Schelonka
- Chris Graulty
- Juliet Shafto
- Jennifer Padwal
- Daniel Fennelly
- Stephen Metzler

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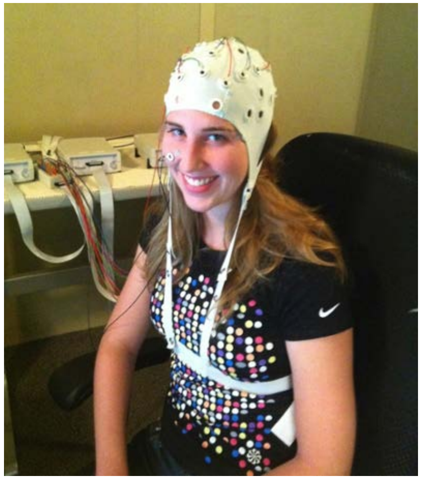
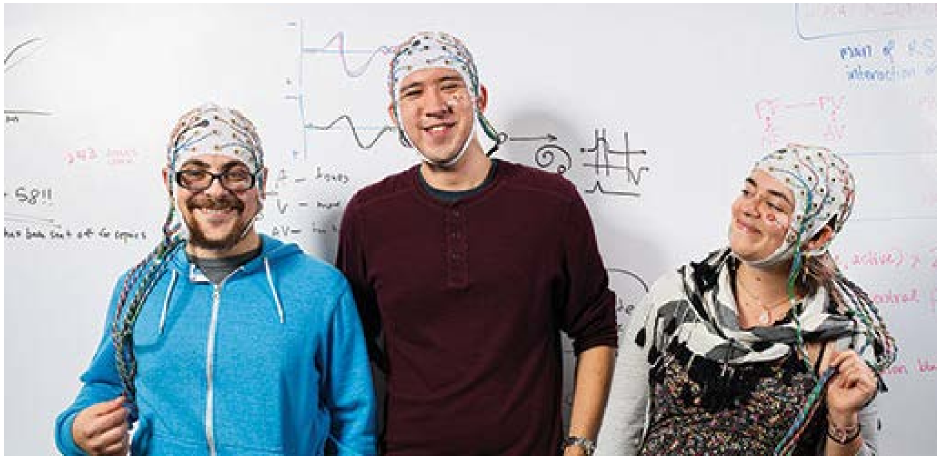
- NIMH
- NSF
- Reed College

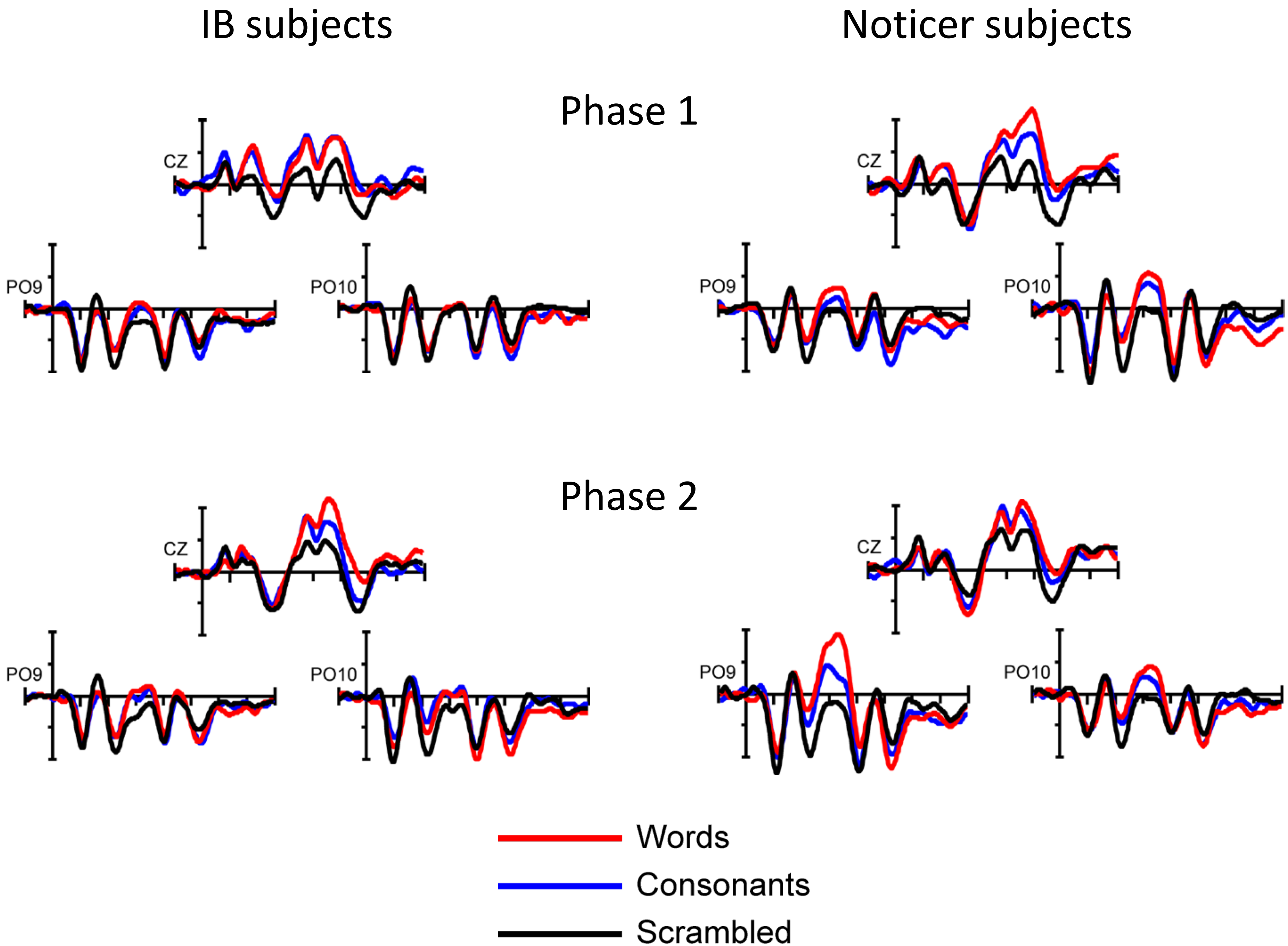




SCALPLAB

Sensation Cognition Attention Language Perception

www.reed.edu/psychology/scalp


IB subjects
Noticer subjects
Phase 1
CZ
PO9
PO10
CZ
PO9
PO10
Phase 2
CZ
PO9
PO10
CZ
PO9
PO10
Words
Consonants
Scrambled