Isolating NCCs that are necessary and sufficient for visual awareness

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Necessity & Sufficiency

Goal: distinguish neural correlates of...

1) Preconscious processing (necessary but not sufficient)

2) Conscious perception (necessary \textit{and} sufficient)

3) Postperceptual processing (sufficient but not necessary)

Previous Paradigms & Findings

- Masking, Attentional Blink: aware vs. unaware contrasts
- Awareness = widespread “ignition” of cortical activity

- EEG signatures of awareness = P3 & Gamma Oscillations

Dehaene & Changeux (2011) *Neuron*
Problem with Previous Paradigms?

Masking, Attentional Blink:
- Unaware = no PPP; Aware = PPP

Different paradigms needed to address this problem...
The Inattention Paradigm

- Inattentional Blindness (IB)
  - “Failure to perceive unexpected objects or events because attention is focused on another task”
  - Simons & Chabris (1999); Mack & Rock (1998)
Inattention Paradigm adapted for EEG/ERP

- Video Example of Stimuli:
  http://www.youtube.com/watch?v=8-9NAFUn_CI
Stimuli

Square or Random

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

-2μV  |  +2μV  |  400ms

Square Pattern  |  Random Array
Procedure

Phase 1:
Distracter Task
( unaware)

Phase 2:
Distracter Task
( aware)

Phase 3:
Pattern Recognition
Task
( aware + relevant)

Awareness Assessment

Awareness Assessment

# of Stimuli:
Random: 300
Square: 240
Diamond: 60

-100
-2µV
+2µV
400ms

Square Pattern
Random Array
Awareness assessment

1) During the experiment, did you notice any patterns within the little white lines?

☐ Yes  ☐ No

2) If you did see any patterns, please describe (or draw) what you saw in as much detail as possible:
3) Rate how confident you are that you saw each pattern during the experiment.

Please use the following scale:

1 = very confident I did not see it
2 = confident I did not see it
3 = uncertain
4 = confident I saw it
5 = very confident I saw it

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Behavioral results (awareness assessments)

Phase 1: Confidence Ratings

Number of Subjects

Confidence in seeing square
(1=least : 5=most)

Phase 2: Confidence Ratings

Number of Subjects

Confidence in seeing square
(1=least : 5=most)

Did not report square

Reported seeing square
Paradigm comparison

Masking, Attentional Blink:
- Unaware = no PPP; Aware = PPP
Paradigm comparison

Inattentional Blindness:

- Unaware = no PPP; **Aware = no PPP;** **Aware⁺ = PPP**

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<td>compare current perceptual info to target held in WM...</td>
<td>decision-making: “don’t respond, it’s a square”</td>
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Phase 1 (unaware, task irrelevant)
Phase 2 (aware, task irrelevant)
Phase 3 (aware, task relevant)

- 180ms
- 220ms
- 260ms
- 300ms
- 340ms
- 380ms
- 420ms

-1.25μV to +1.25μV

-4μV to +4μV

PO7

PO8

OZ

Square Pattern

Random Array
Between Subjects

IB subjects

Noticer subjects

Phase 1

Phase 2

OZ

PO8

Red: Square Pattern

Blue: Random Array
Between Subjects

IB subjects  Noticer subjects

Phase 1

-1.25μV  +1.25μV

Phase 2

Pitts, Martinez, & Hillyard (2012) *JCogNeuro*
Time-Frequency Results (IB subjects)

Phase 1
(unaware, task irrelevant)

Phase 2
(aware, task irrelevant)

Phase 3
(aware, task relevant)

Pitts et al. (in prep)
Time-Frequency Results (noticer subjects)

Phase 1
(aware, task irrelevant)

Phase 2
(aware, task irrelevant)

Phase 3
(aware, task relevant)

Pitts et al. (in prep)
Interim Summary

- Early (~180ms) ERP negativity *regardless* of whether subjects are aware of the shapes.
  - Phase 1 (unaware, task irrelevant)

- Subsequent (~260ms) ERP negativity *only when* subjects are aware of the shapes.
  - Phase 2 (aware, task irrelevant)

- Widespread activity and gamma (>300ms) *only when* shapes are task relevant.
  - Phase 3 (aware, task relevant)

preconsciou processing

NCC ?

postperceptual processing
Follow-up Experiments

- Early (~180ms) ERP negativity *regardless* of whether subjects are aware of the shapes.
Preconscious Processing

Contours task irrelevant:

Contours task relevant:

Pitts & Martinez (in press) *Cognitive Electrophysiology of Attention*
Follow-up Experiments

- Widespread activity and gamma (>300ms) *only when* shapes are task relevant.
Postperceptual Processing

- Attend shape or color (counterbalanced blocks)
- P3 & Gamma for clearly perceived, but irrelevant shapes?

Pitts et al. (in prep)
Postperceptual Processing

Shapes task irrelevant:

Shapes task relevant:

Pitts et al. (in prep)
Follow-up Experiments

- Subsequent (~260ms) ERP negativity *only when* subjects are aware of the shapes.

NCC ?
NCC for faces

Face Pattern  Random Array  Distracter Task

Shafto & Pitts (in prep)
Time-Frequency Results

Phase 1
(unaware, task irrelevant)

Phase 2
(aware, task irrelevant)

Phase 3
(aware, task relevant)

Shafto & Pitts (in prep)
Conclusions

- P3 & Gamma reflect “ignition” of postperceptual processes
- NCC: local “flicker” instead of widespread “ignition”?  
- Important to isolate NCC from pre & postperceptual processes

![Graph showing P3 and Gamma waves with Nd2/VAN label and time range 200-300ms]
Thank you for your attention and awareness!

Collaborators:
- Steve Hillyard
- Antígona Martínez
- Juliet Shafto
- Jennifer Padwal
- Daniel Fennelly

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- KIBM
- NIMH
- NSF
- Reed College

www.reed.edu/psychology/scalp
ERP correlations with awareness reports

Nd1 220-260ms  
Confidence Ratings  
Nd2 300-340ms  

Nd1 220-260ms  
Frequency Ratings  
Nd2 300-340ms  

very confident 
did not see square  
unsure  
very confident 
saw square  

very confident 
did not see square  
unsure  
very confident 
saw square  

very confident 
did not see square  
unsure  
very confident 
saw square  

very confident 
did not see square  
unsure  
very confident 
saw square  

very confident 
did not see square  
unsure  
very confident 
saw square  

very confident 
did not see square  
unsure  
very confident 
saw square  

r = -.14  
p = .453  

r = -.49  
p = .005*  

r = -.21  
p = .251  

r = -.59  
p = .001*
4) Estimate how often you saw each pattern.

Please use the following scale:

1 = never
2 = rarely / less than 10 times
3 = infrequently / 10-50 times
4 = frequently / 50-100 times
5 = very frequently / more than 100 times

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Phase 1: Frequency Ratings

Phase 2: Frequency Ratings

- Red: Subjects unaware of patterns in phase 1
- Black: Subjects aware of patterns in phase 1
Behavioral results (distracter task)

No performance difference for aware vs. unaware (within or between subjects)
Phase 1: unaware

220ms

Phase 2: aware

220ms
300ms

Phase 3: aware + task relevant

180ms
220ms
260ms
380ms
420ms

Source Estimates (LORETA)