Isolating neural signatures of conscious speech perception with a “no-report” sine-wave speech paradigm

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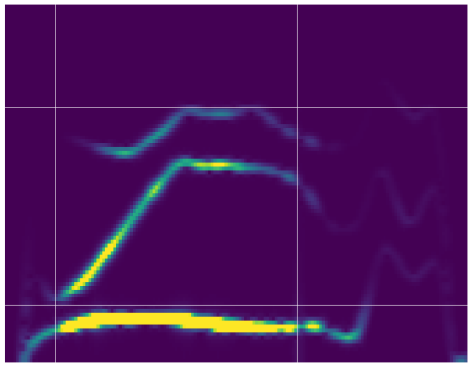

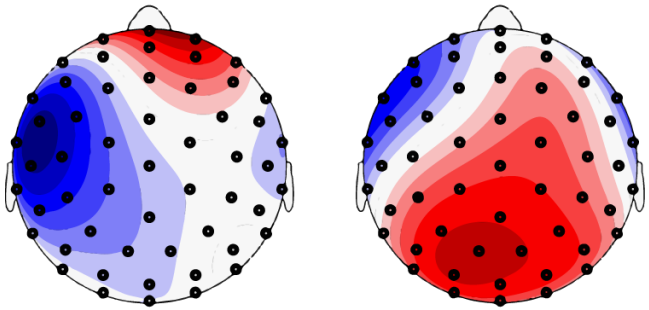

ASSC 2018

Isolating content-specific NCCs

Goals of research program

Develop paradigms to enable neural contrasts between:

- perceived vs. not-perceived
- task-relevant vs. task-irrelevant

Test theories that make conflicting predictions:

- local recurrency vs. global ignition
- first-order vs. higher-order

Address basic outstanding questions:

- where are NCCs roughly located (anterior vs. posterior)?
- when do NCCs roughly emerge (early vs. late)?

Forum

CellPress

Testing domain-general theories of perceptual awareness with auditory brain responses

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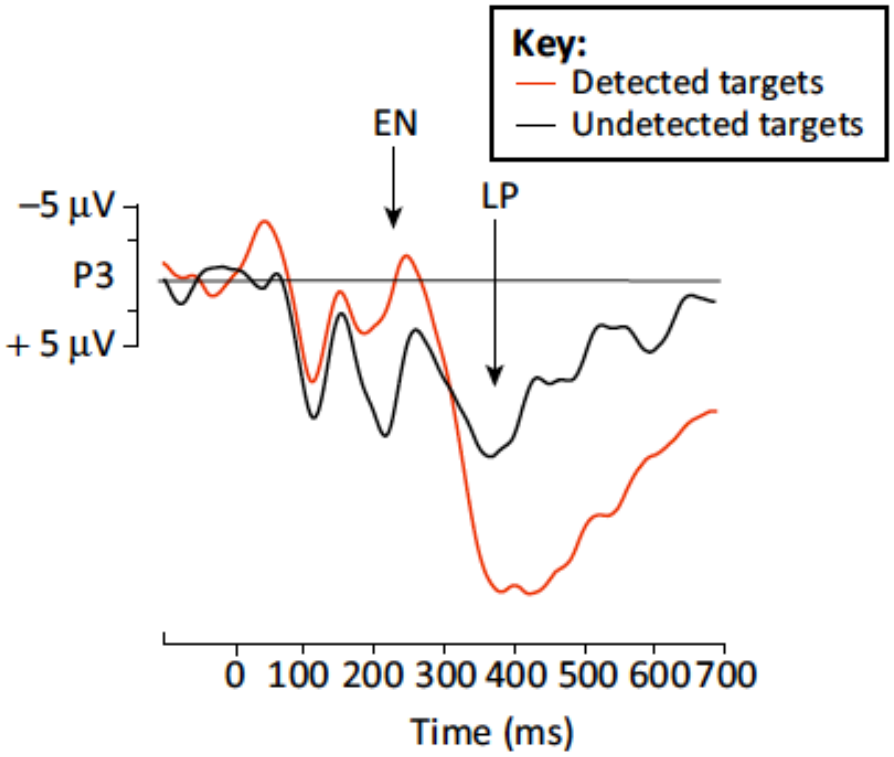
Awareness Manipulations

- masking
- threshold detection
- change blind/deafness
- inattentional blind/deafness
- attentional blink
- bistable perception



Sine-Wave Speech (SWS)

SWS:

original speech:

Previous SWS experiments (EEG, fMRI, ECoG)

- Liebenthal et al. (2001) *JASA*
- Liebenthal et al. (2005) *Cerebral Cortex*
- Dehaene-Lambertz et al. (2005) *NeuroImage*
- Möttönen et al. (2006) *NeuroImage*
- Khoshkhoo et al. (2018) *Brain and Language*

task-irrelevant → task-relevant

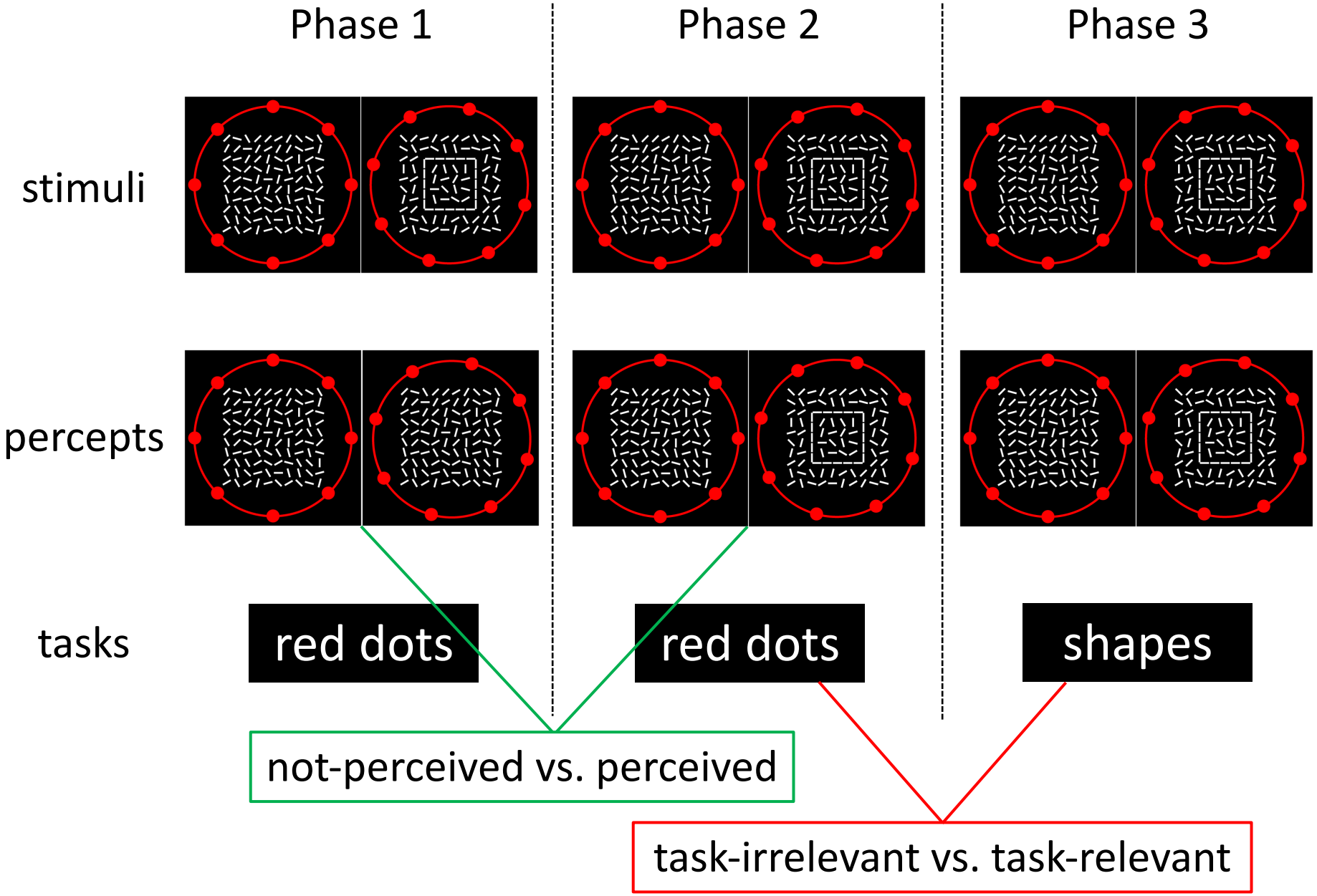
OR

task-relevant → task-relevant

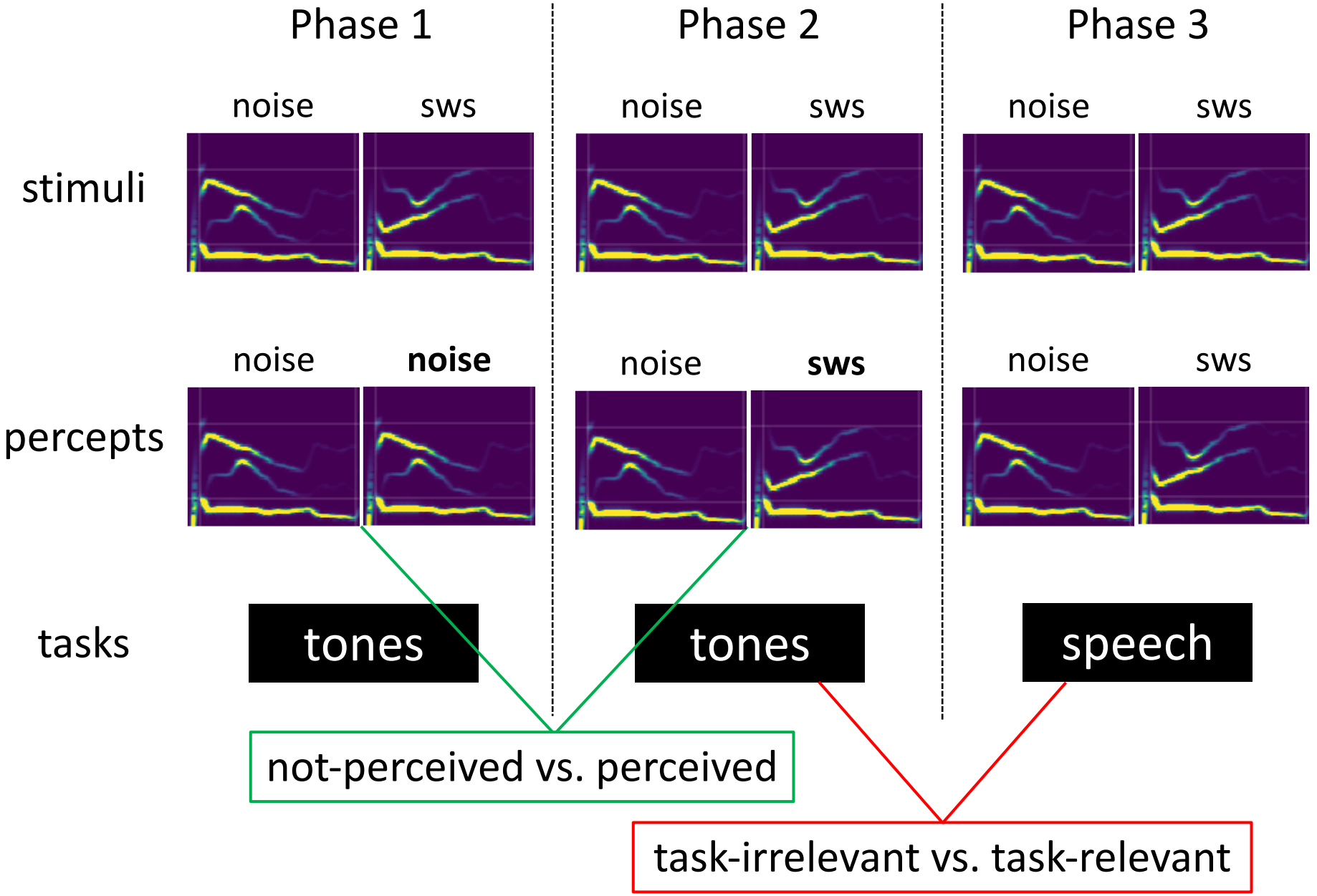
task-irrelevant → task-irrelevant

http://www.lifesci.sussex.ac.uk/home/Chris_Darwin/SWS/

“No report” inattentional blindness paradigm



“No report” sine-wave speech (SWS) paradigm



Stimuli

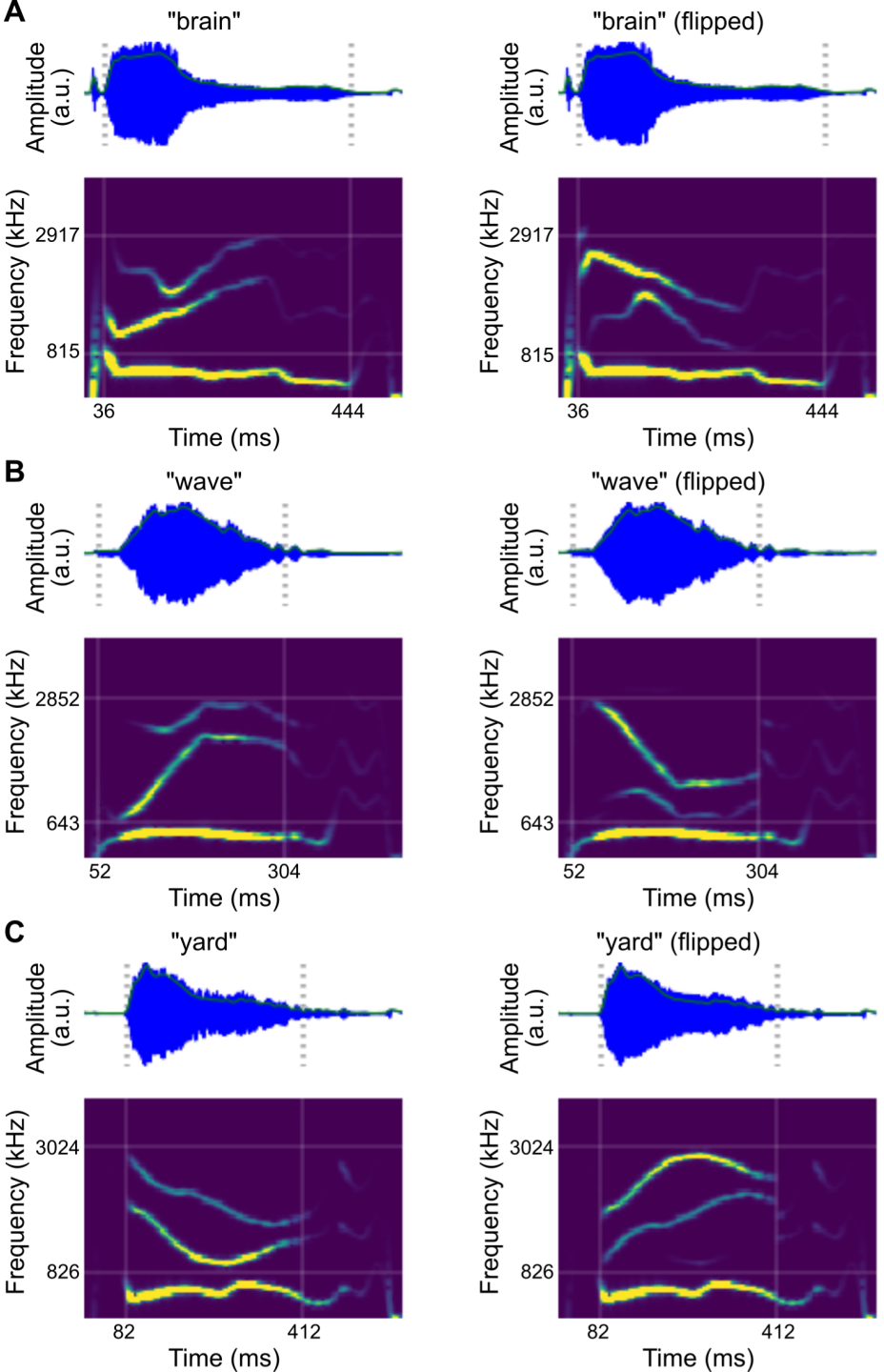
SWS:

brain wave yard

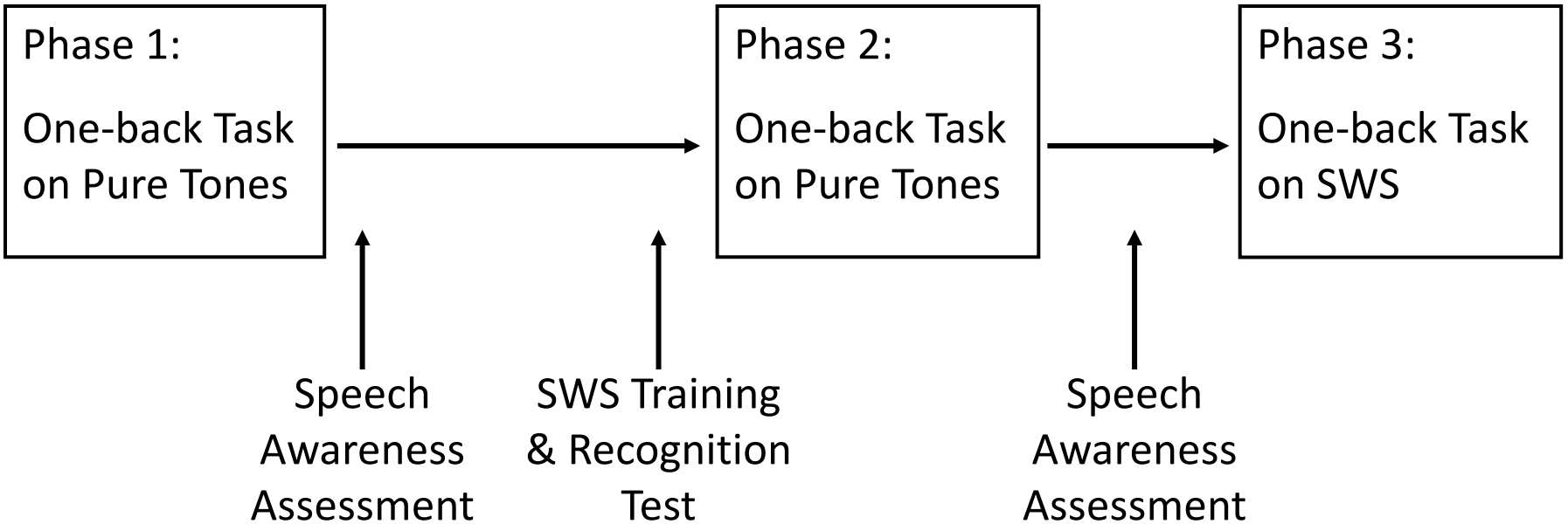
Noise (flipped SWS):

Pure Tones:

low med high



Procedure



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

SWS: 300 (100 per word)

noise: 300 (100 per noise)

tones: 300 (100 per tone)

example stim sequence

<u># of one-backs per phase</u>:

SWS: 30 (10 per word)

noise: 30 (10 per noise)

tones: 30 (10 per tone)

Speech awareness assessment (after phase 1 & 2)

1. In your own words, describe what the computer-generated noises sounded like.

2. Did you hear any of the following in the computer-generated sounds? For each of the categories in the table below, circle a number representing your experience.

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

Distorted music	1	2	3	4	5
Distorted words	1	2	3	4	5
Distorted environmental sounds	1	2	3	4	5
Distorted animal sounds	1	2	3	4	5

5. If you marked a “4” or “5” for hearing the computer-generated noises as “distorted words”, please write down the words you heard.

SWS training & recognition test (btw phase 1 & 2)

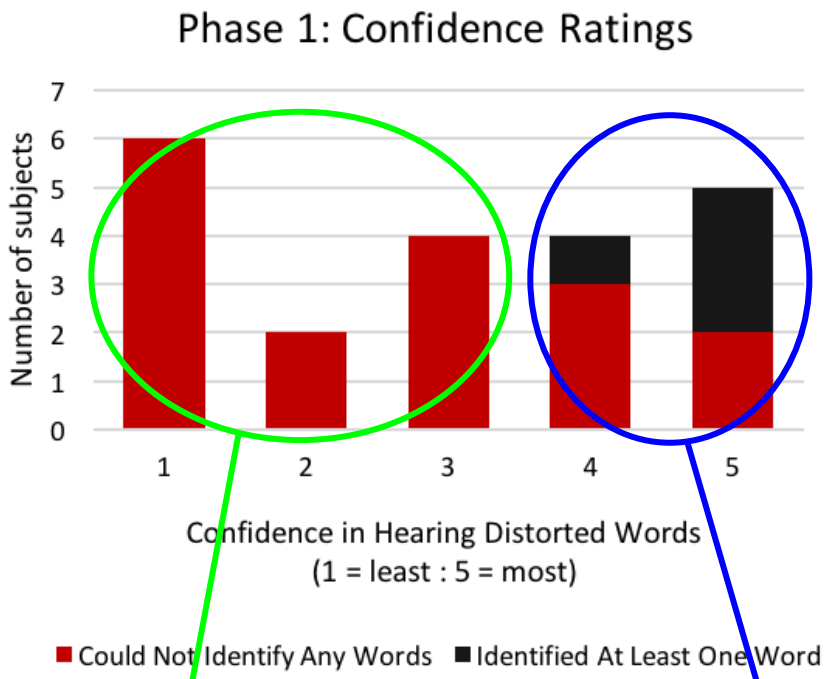
9 Stimuli:	**brain**	language	world
	chill	speech	**yard**
	church	**wave**	zombie

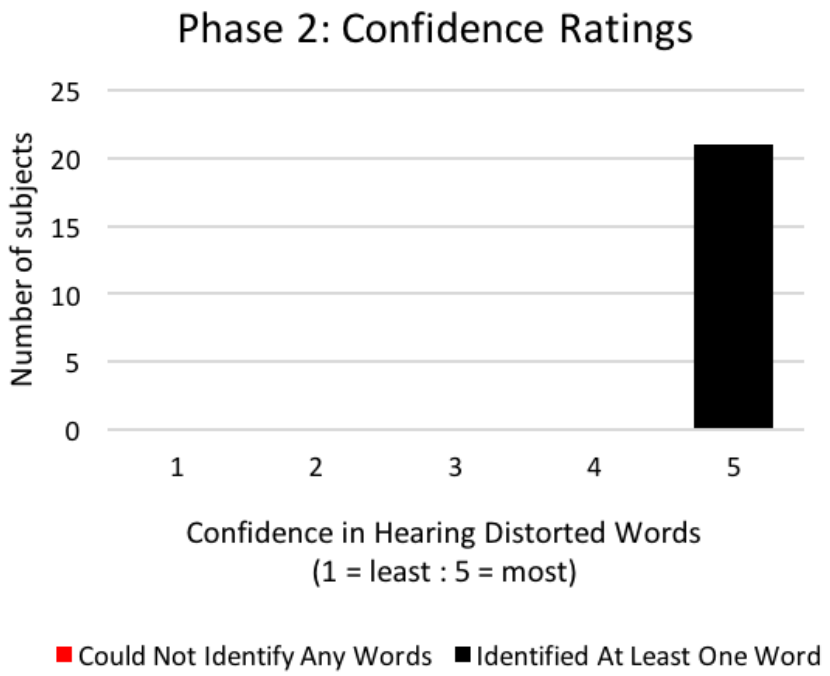
1) Self-paced training
   - SWS → Original Speech → SWS
   - repeat until clearly hear SWS as speech

2) Speech recognition test
   - 9 SWS + 3 noise (flipped) versions of “brain”, “wave”, “yard”
   - 10 AFC task (9 words + 1 “no word” option)

Accuracy = 94% total; **99%** for “brain”, “wave”, “yard”

Behavioral results: speech awareness

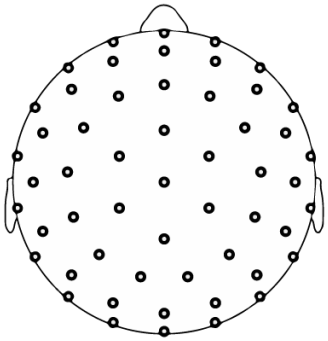




speech not-perceived (N=12)

speech perceived (N=9)

SWS stimuli, speech not-perceived in phase 1 (N=12)

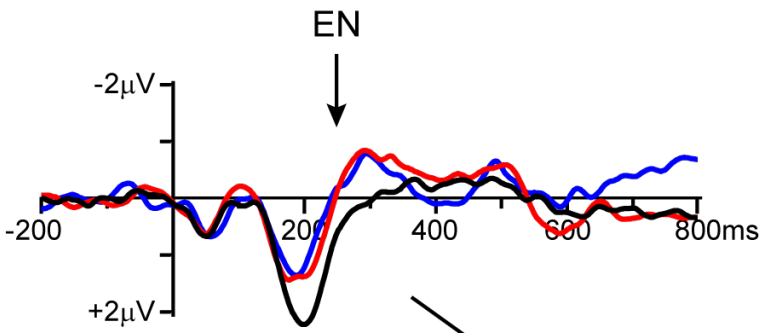


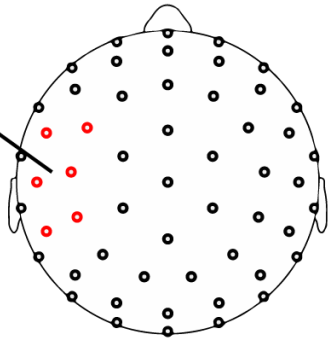
Ph1: heard noise, task-irrel

Ph2: heard speech, task-irrel

Ph3: heard speech, task-rel

SWS stimuli, speech not-perceived in phase 1 (N=12)





Ph1: heard noise, task-irrel

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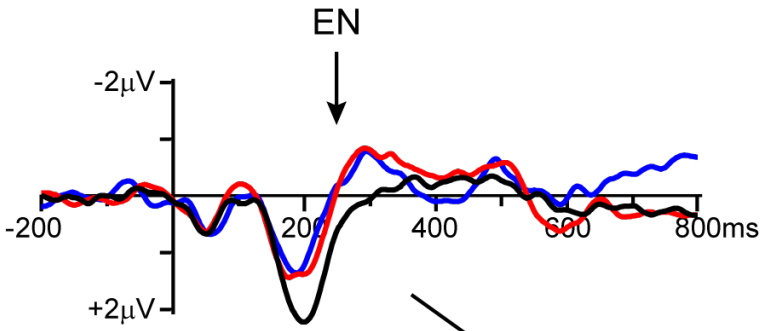
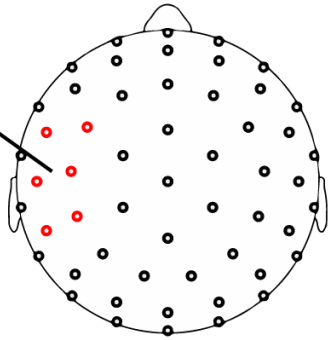
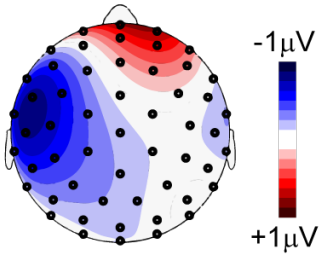
Ph3: heard speech, task-rel

SWS stimuli, speech not-perceived in phase 1 (N=12)





Difference
[Phase 2 - Phase 1]



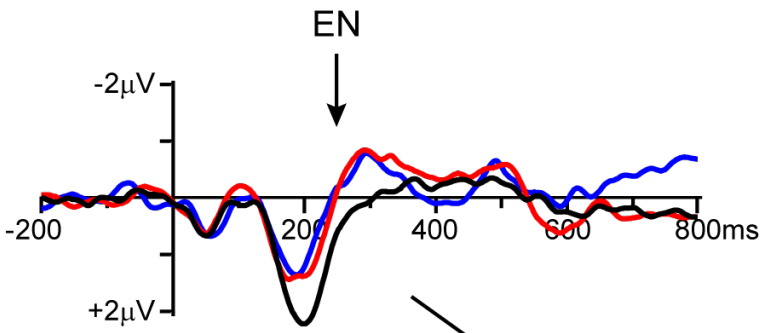
200-300ms

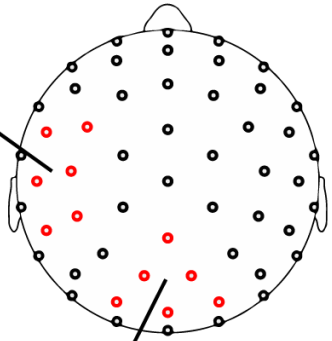
Ph1: heard noise, task-irrel

Ph2: heard speech, task-irrel

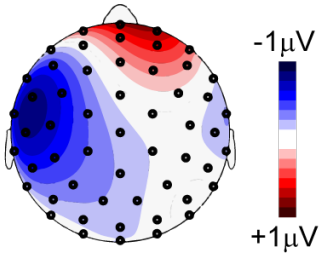
Ph3: heard speech, task-rel

SWS stimuli, speech not-perceived in phase 1 (N=12)

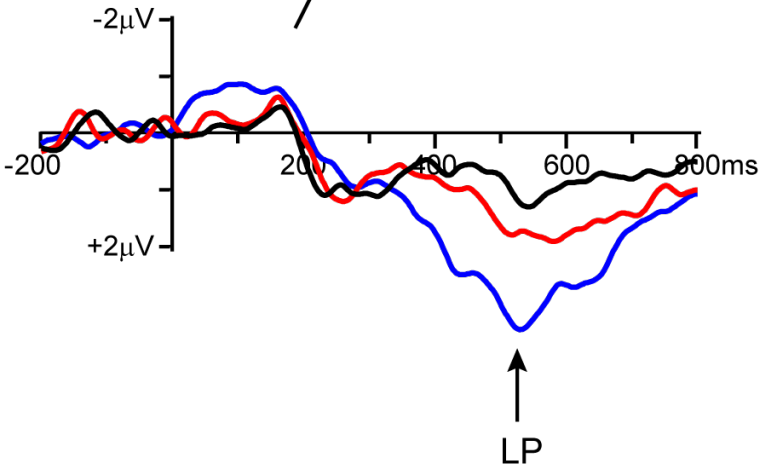




Difference
[Phase 2 - Phase 1]



200-300ms

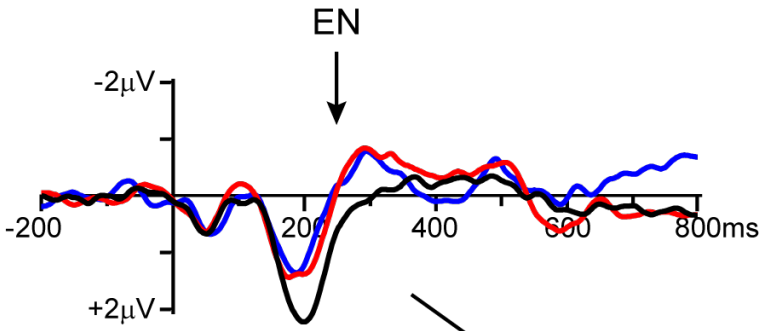


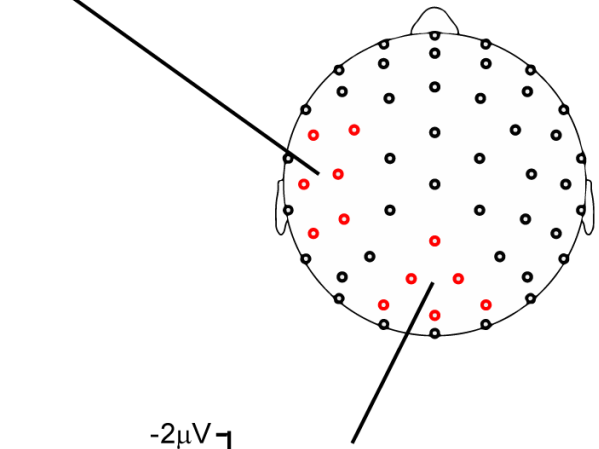
Ph1: heard noise, task-irrel

Ph2: heard speech, task-irrel

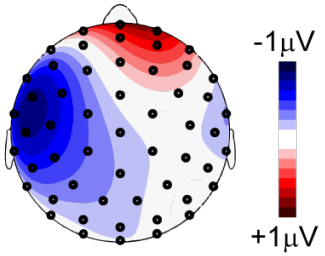
Ph3: heard speech, task-rel

SWS stimuli, speech not-perceived in phase 1 (N=12)

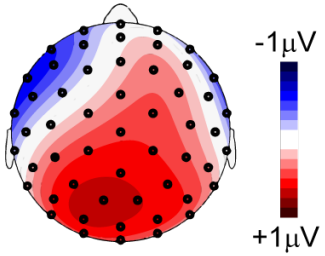




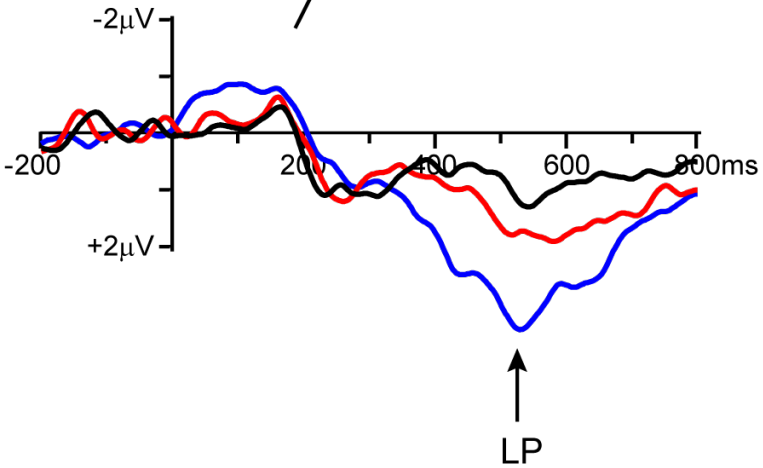
Difference
[Phase 2 - Phase 1]



200-300ms



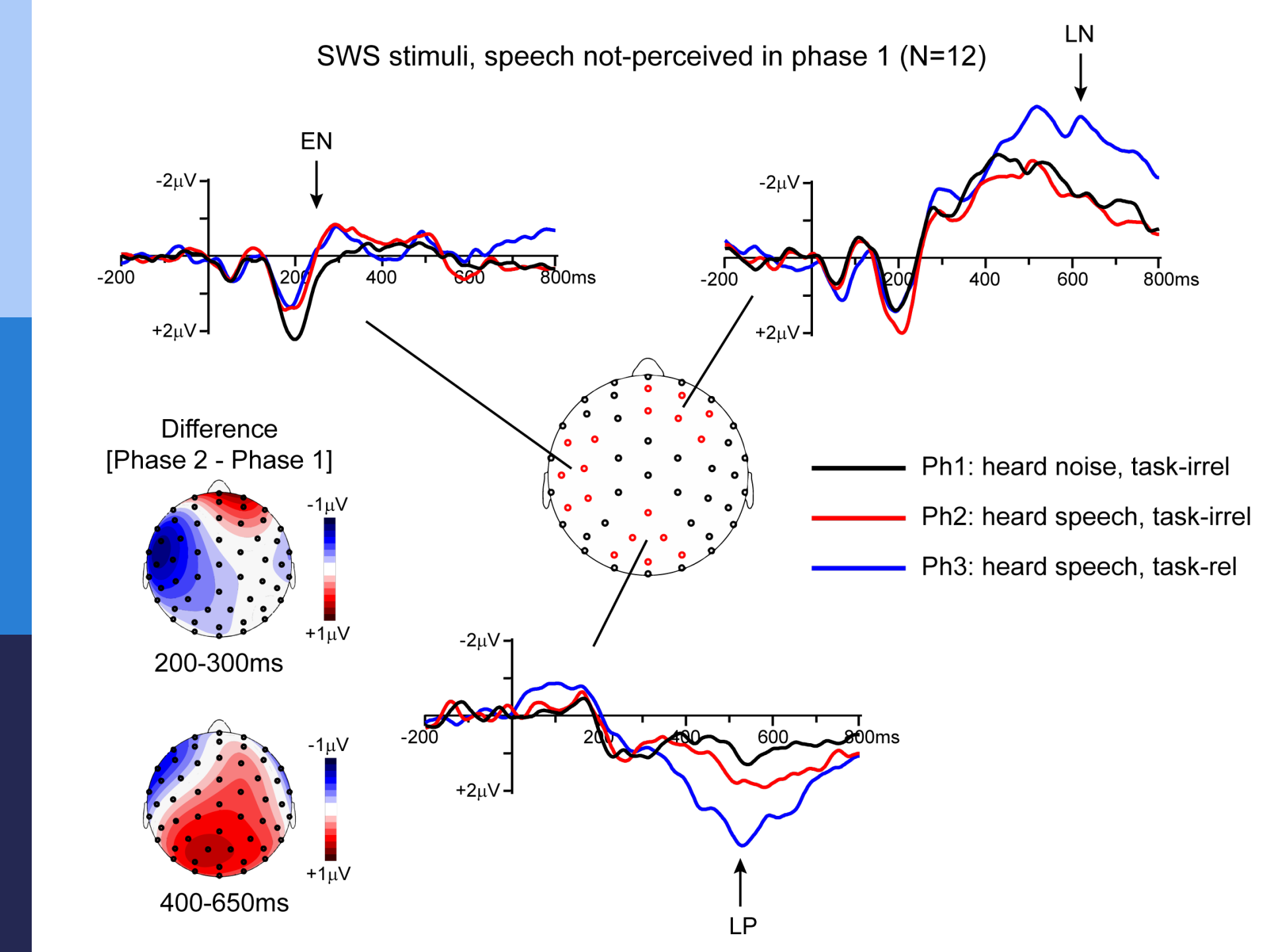
400-650ms

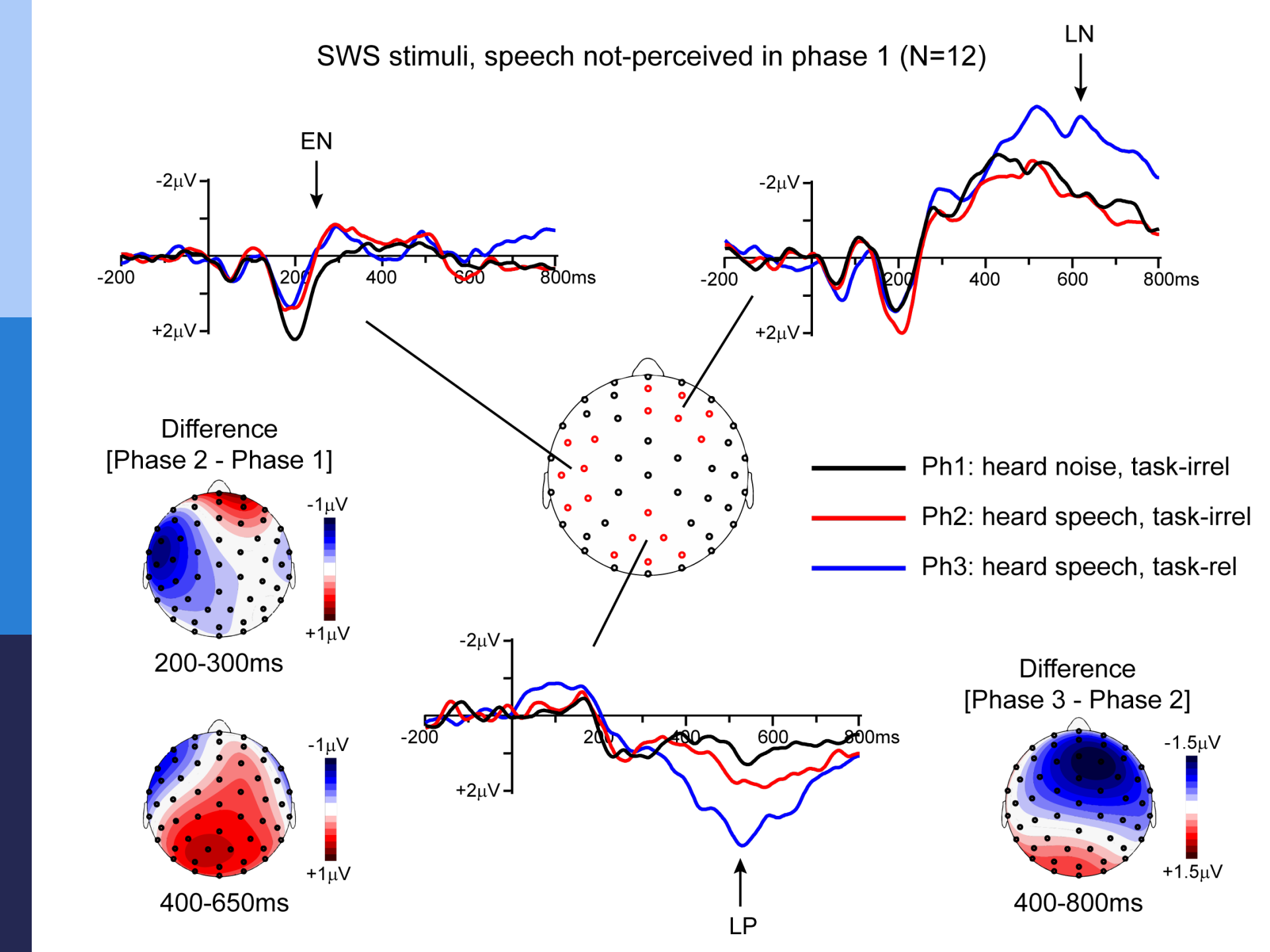


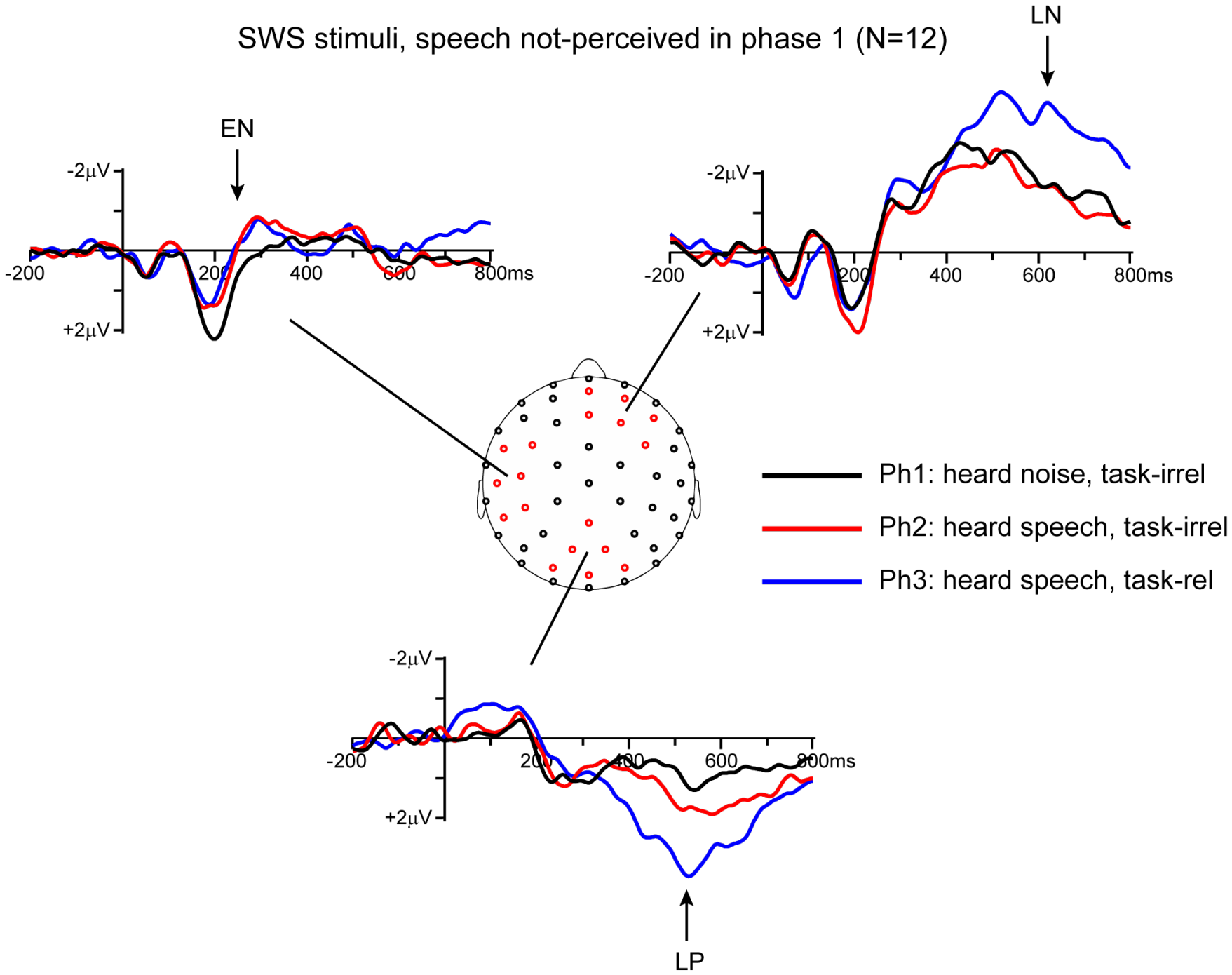
Ph1: heard noise, task-irrel

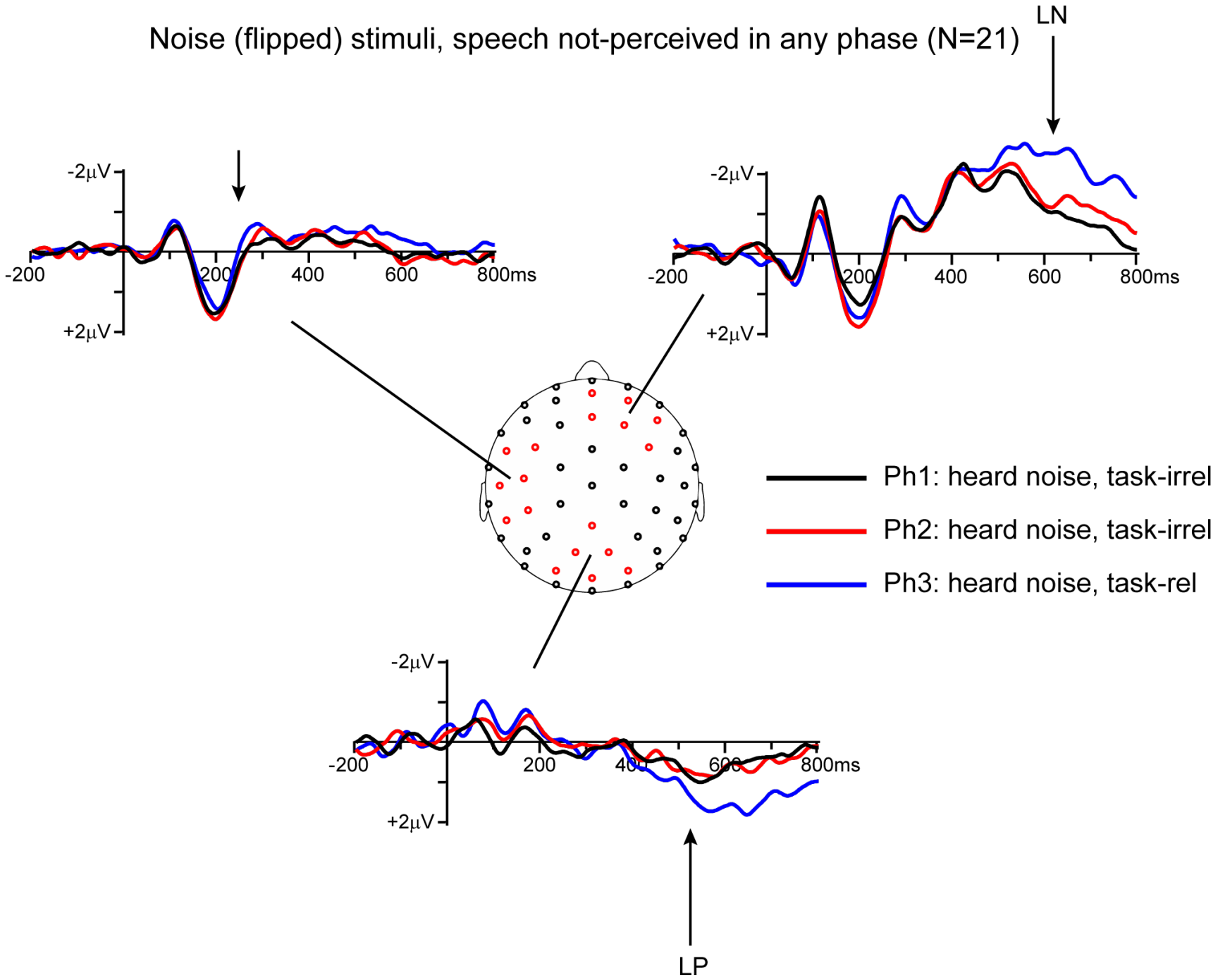
Ph2: heard speech, task-irrel

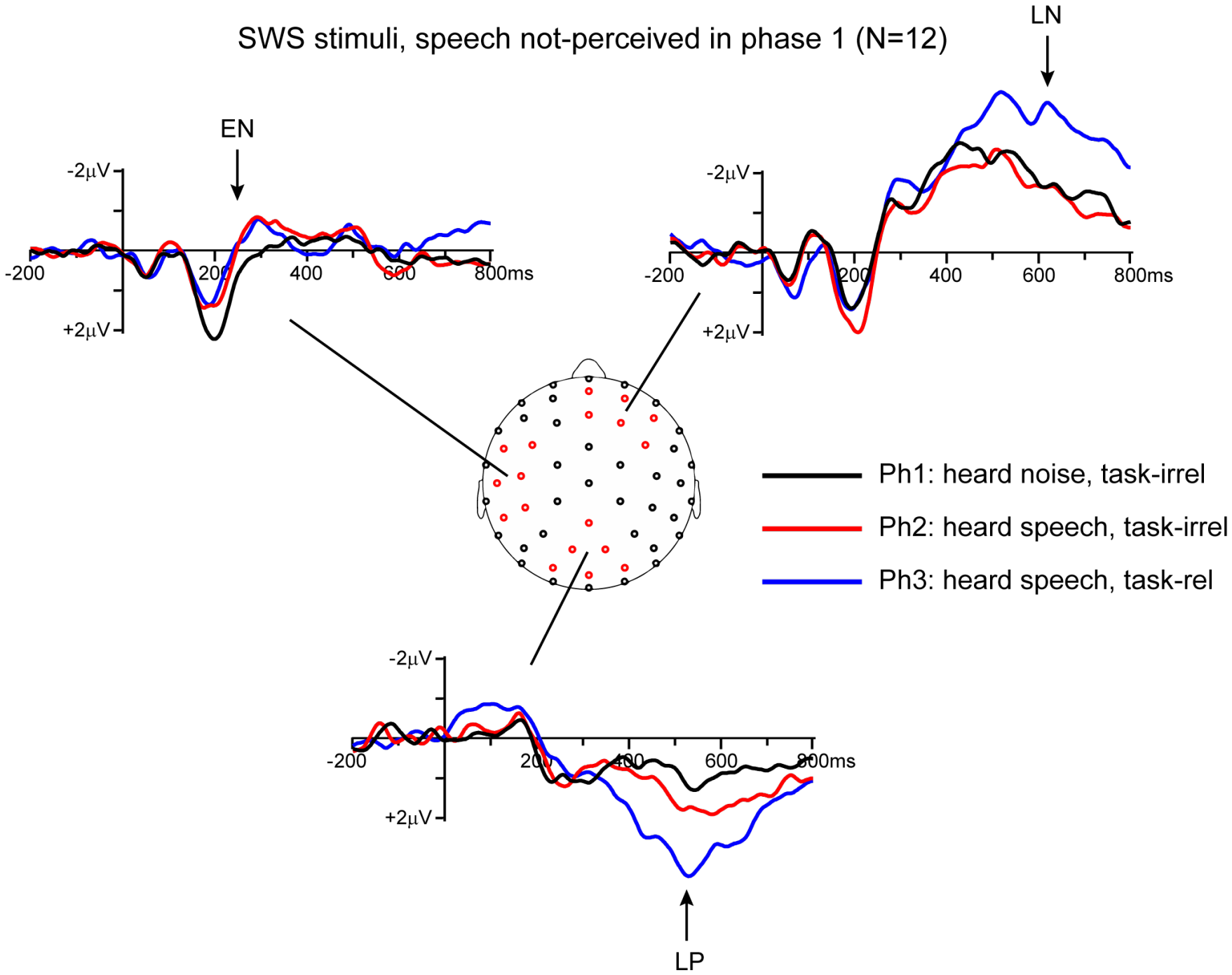
Ph3: heard speech, task-rel

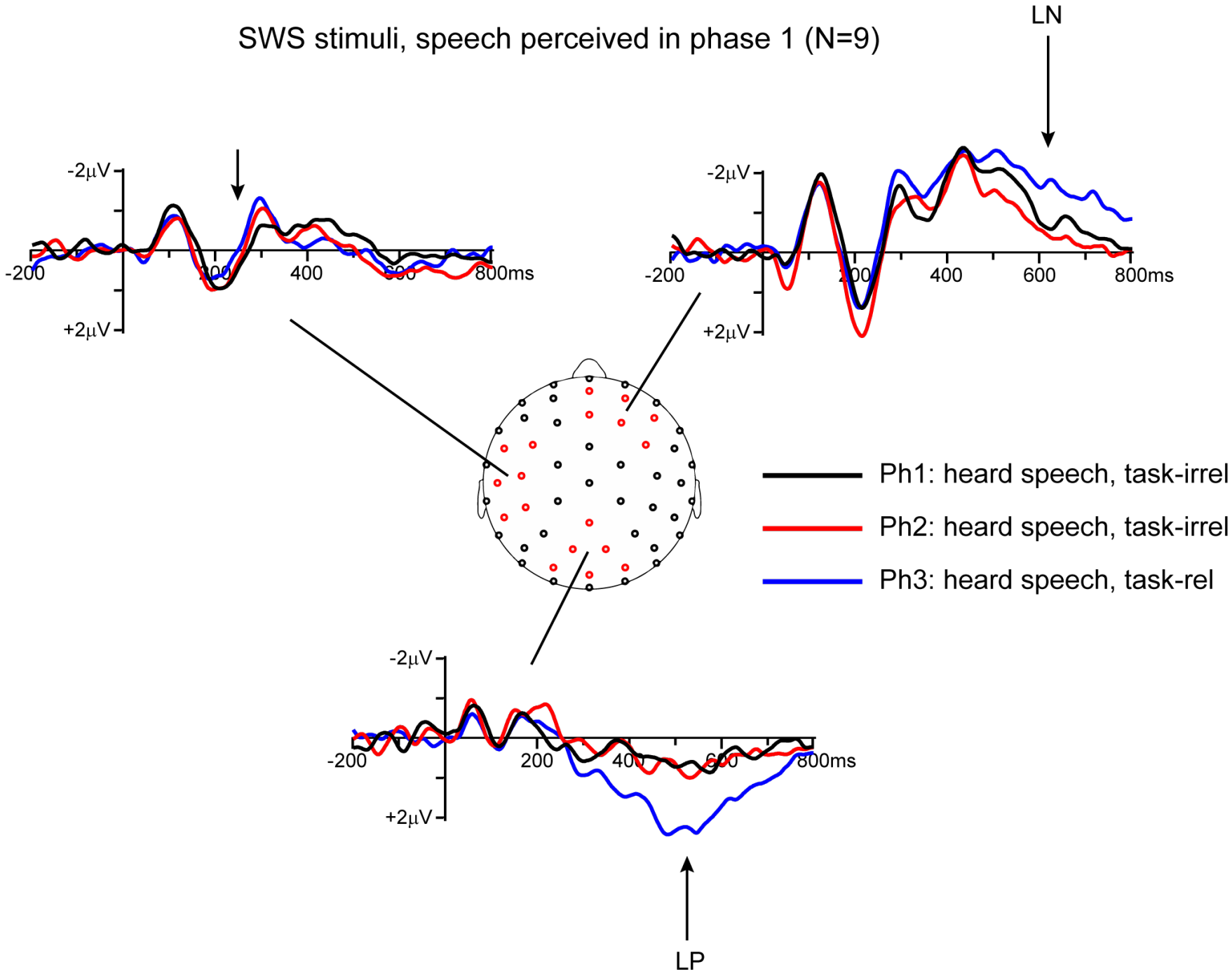

SWS stimuli, speech not-perceived in phase 1 (N=12)
EN
LN
-2μV
+2μV
-200
200
400
600
800ms
Difference
[Phase 2 - Phase 1]
-1μV
+1μV
200-300ms
400-650ms
LP
Ph1: heard noise, task-irrel
Ph2: heard speech, task-irrel
Ph3: heard speech, task-rel


SWS stimuli, speech not-perceived in phase 1 (N=12)
EN
LN
-2μV
+2μV
-200
200
400
600
800ms
Difference
[Phase 2 - Phase 1]
-1μV
+1μV
200-300ms
400-650ms
LP
Difference
[Phase 3 - Phase 2]
-1.5μV
+1.5μV
400-800ms
Ph1: heard noise, task-irrel
Ph2: heard speech, task-irrel
Ph3: heard speech, task-rel


SWS stimuli, speech not-perceived in phase 1 (N=12)
EN
LN
LP
-2μV
+2μV
-200
200
400
600
800ms
Ph1: heard noise, task-irrel
Ph2: heard speech, task-irrel
Ph3: heard speech, task-rel


Noise (flipped) stimuli, speech not-perceived in any phase (N=21)
LN
-2μV
+2μV
-200
200
400
600
800ms
Ph1: heard noise, task-irrel
Ph2: heard noise, task-irrel
Ph3: heard noise, task-rel
LP

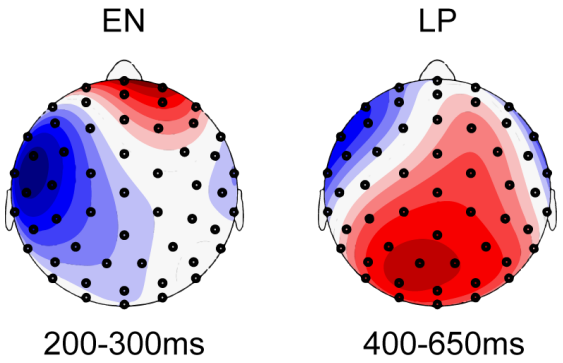

SWS stimuli, speech not-perceived in phase 1 (N=12)
EN
LN
LP
-2μV
+2μV
-200
200
400
600
800ms
Ph1: heard noise, task-irrel
Ph2: heard speech, task-irrel
Ph3: heard speech, task-rel


SWS stimuli, speech perceived in phase 1 (N=9)
LN
-2μV
+2μV
-200
200
400
600
800ms
Ph1: heard speech, task-irrel
Ph2: heard speech, task-irrel
Ph3: heard speech, task-rel
LP

Results summary

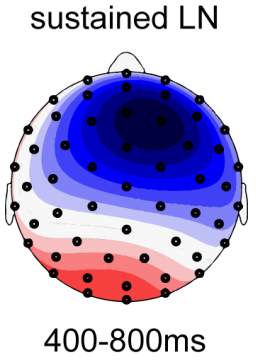
Perceiving vs. Not-perceiving speech [phase 2 vs. 1]:

- early negativity (EN: 200-300ms)
- late positivity (LP: 400-650ms)



Task-relevant vs. Task-irrelevant speech [phase 3 vs. 2]:

- differences early & late in time, including…
- larger late positivity (300-650ms)
- unique sustained late negativity (400-800+ms)



Conclusions & Open Questions

- Perceptual differences much smaller than task differences
- Important to develop paradigms to enable perceived vs. not-perceived contrasts for *task-irrelevant* stimuli
- Which stages of processing do the EN and LP index?

EN = NCC LP = post-perceptual	-OR-	EN = preconscious LP = NCC
EN = NCC LP = NCC	-OR-	EN = detection LP = identification

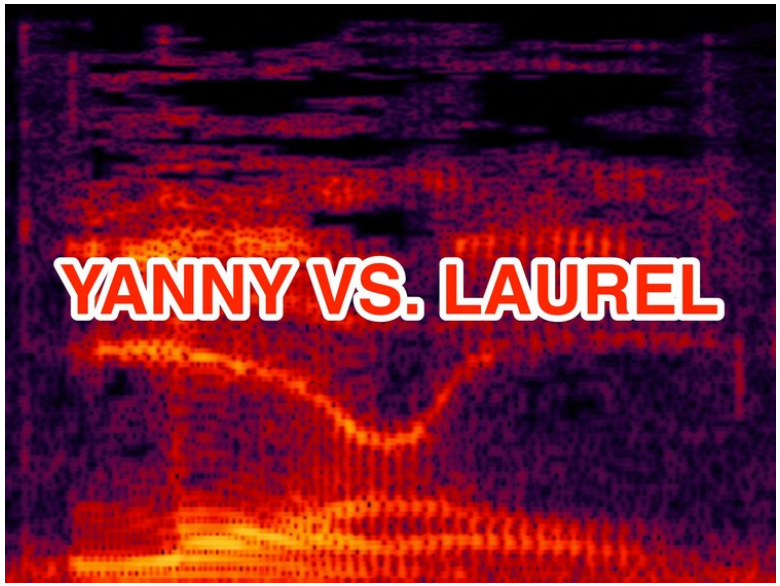
Thank you for your attention and awareness!

Collaborators:

- Andy Dykstra
- Enriqueta Canseco-Gonzalez
- James Glass
- Camille Hendry
- Steve Hillyard

Funding:

- Reed College
- Esther Hyatt Wender Fellowship



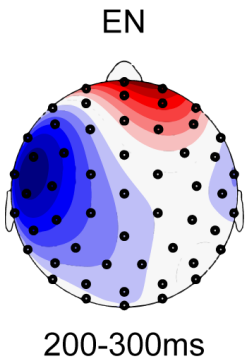
SCALPLAB

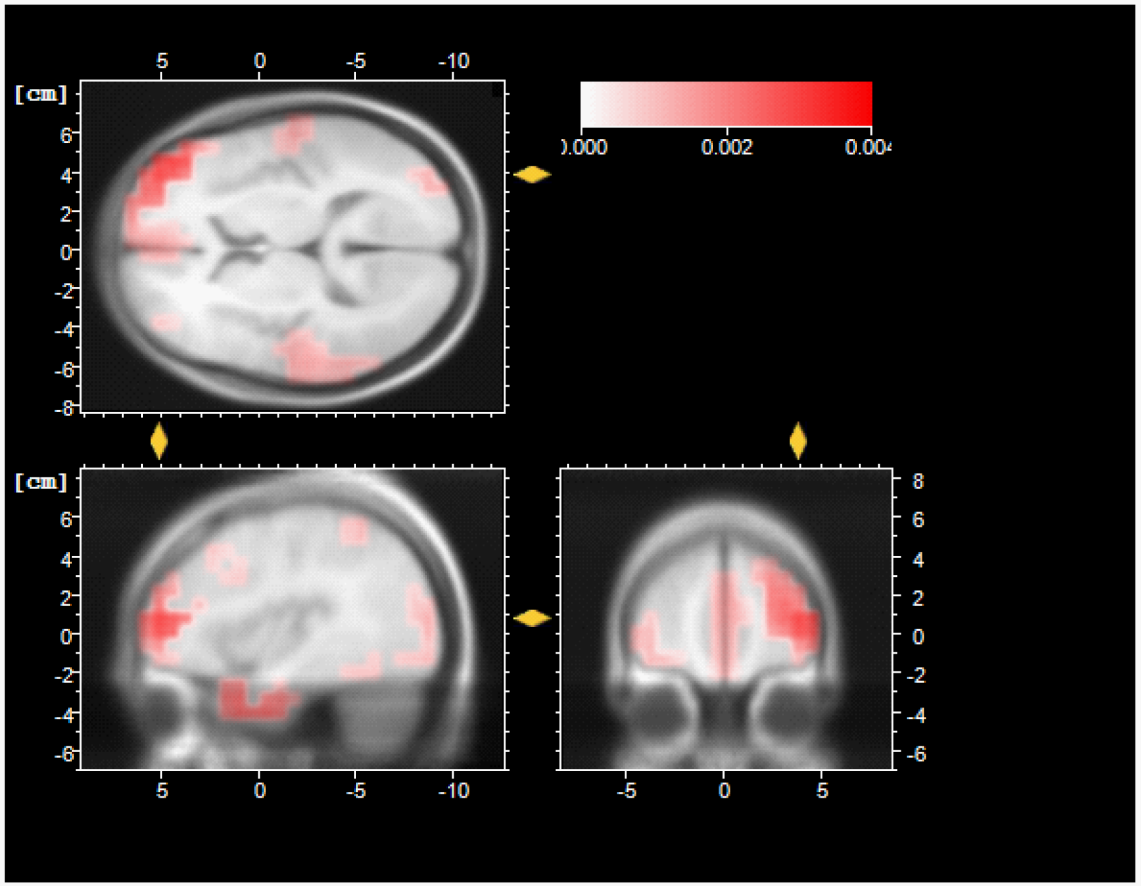
Sensation Cognition Attention Language Perception

www.reed.edu/psychology/scalp

Source estimate of EN (200-300ms): left PFC

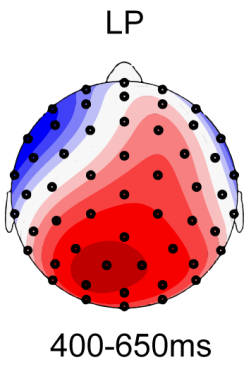
Inferior Frontal Gyrus - BA 10

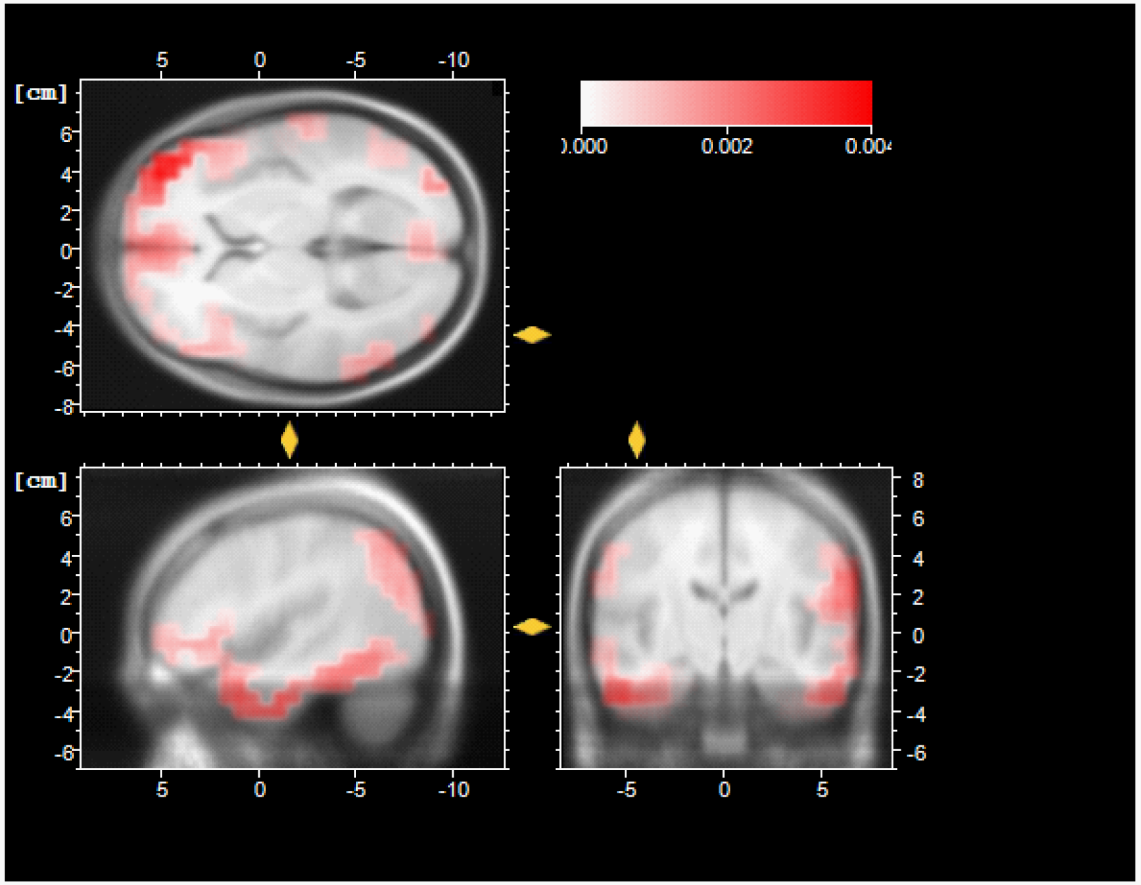




Source estimate of LP (400-650ms): global

[inferior frontal, superior temporal, inferior parietal, etc.]

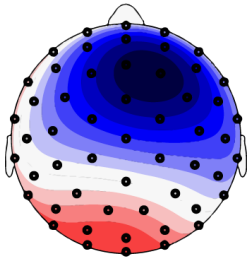




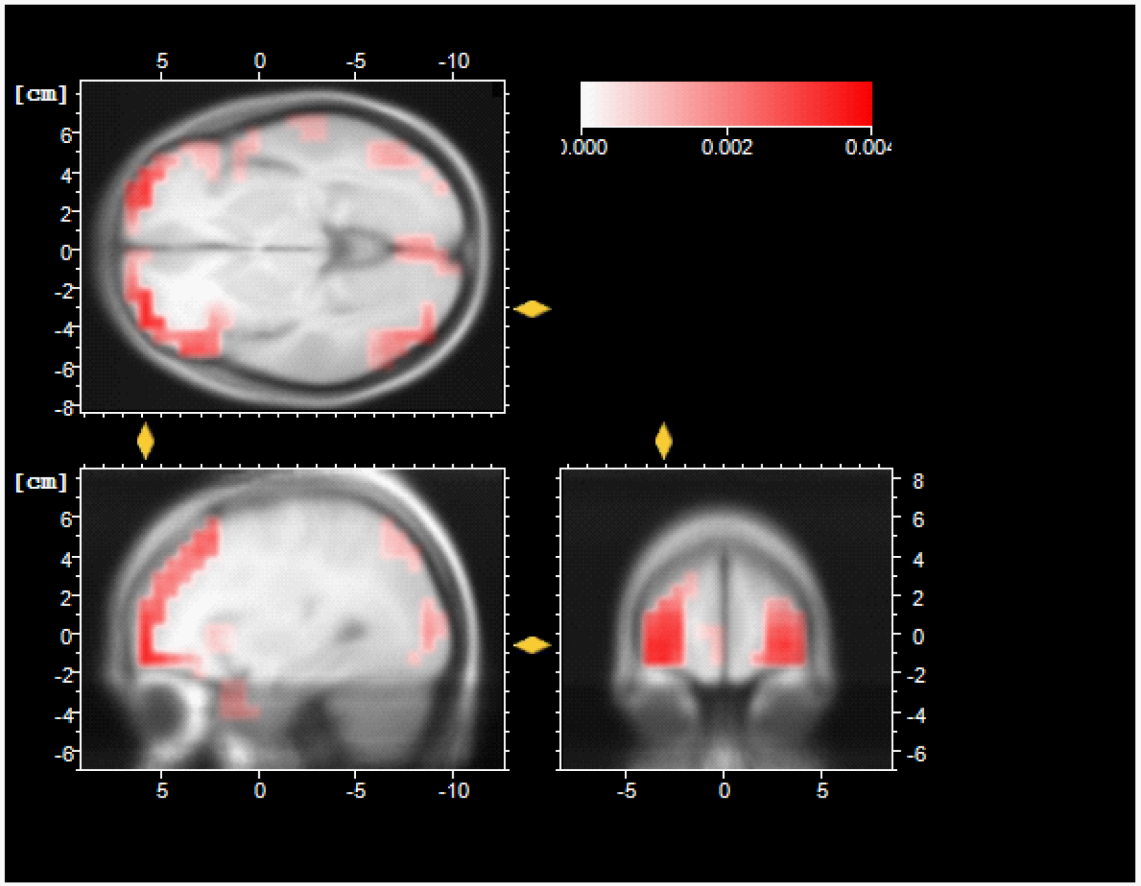
Source estimate of LN (400-800ms): bilateral PFC

Middle Frontal Gyrus - BA 10

sustained LN

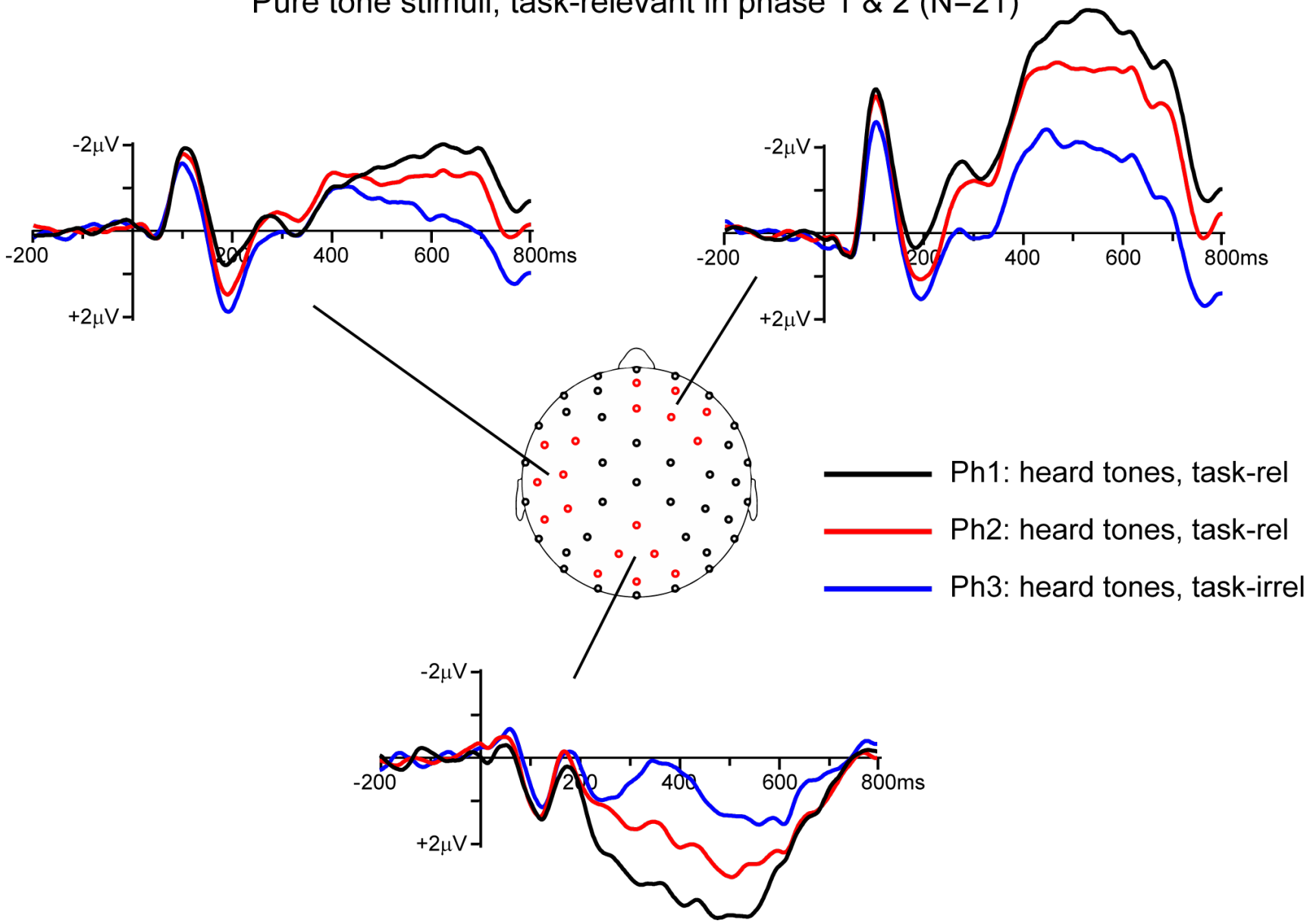


400-800ms



(X= -31, Y= 59, Z= -6)
Best Match at 1mm
Brodmann area 10
Frontal Lobe
Middle Frontal Gyrus

Pure tone stimuli, task-relevant in phase 1 & 2 (N=21)



Behavioral results