An Auditory Cognitive Perspective on Speech-in-Noise Understanding in Cochlear Implant Patients

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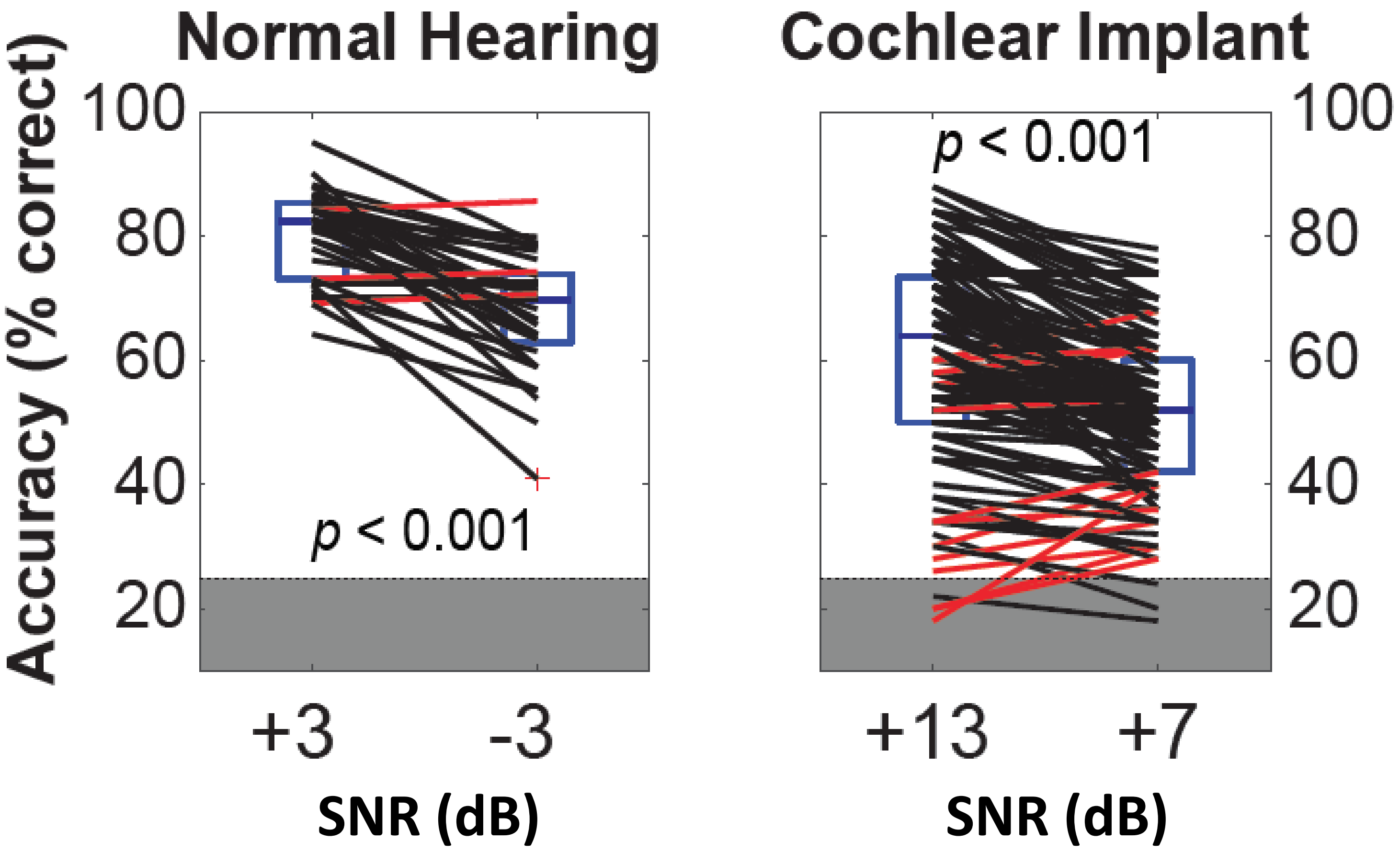
AAA 2023 + HearTECH EXPO
CELEBRATING THE AMERICAN ACADEMY OF AUDIOLOGY'S 35TH ANNIVERSARY!

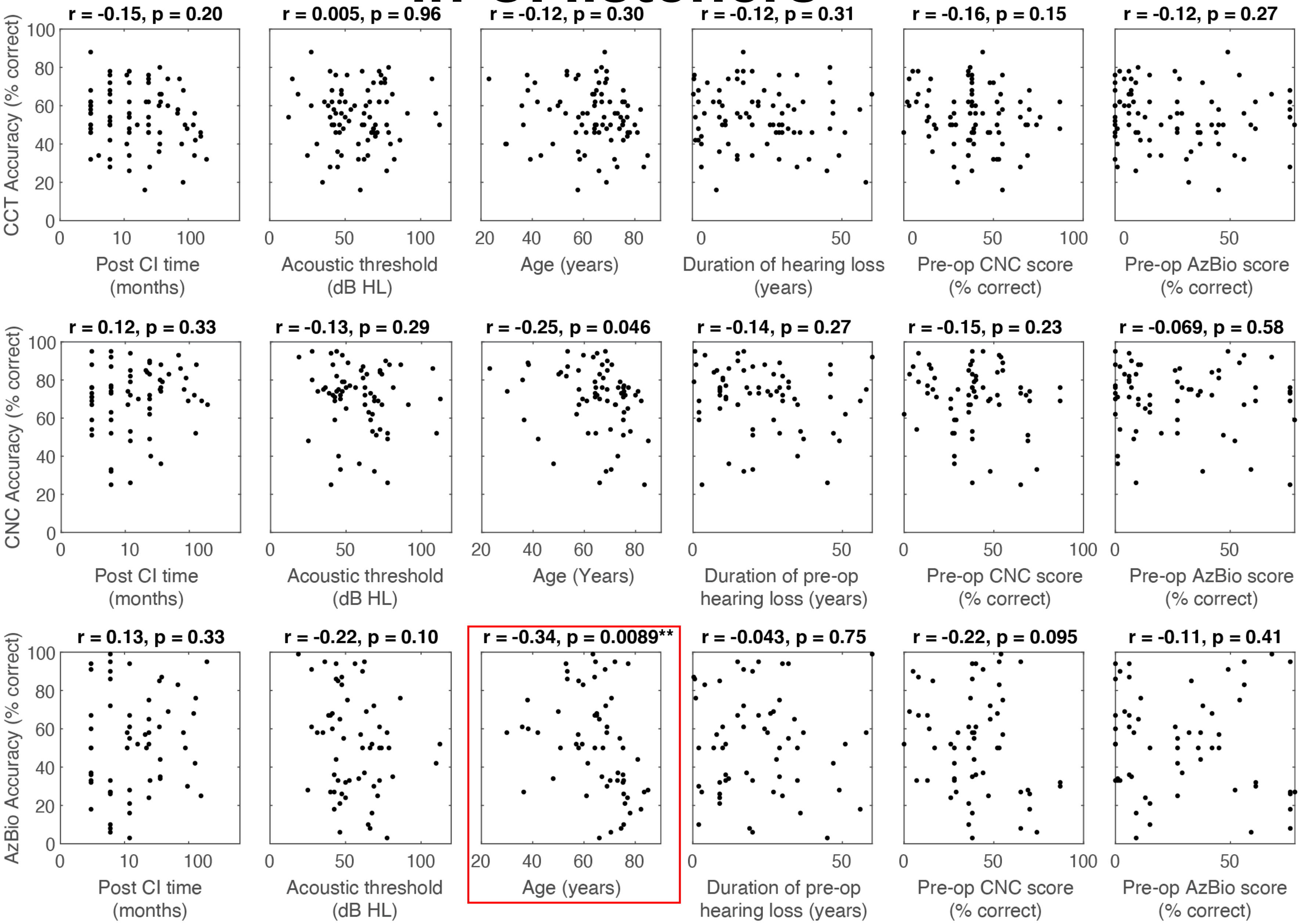
I have NO financial disclosures or conflicts of interest with the material in this presentation.

Large variability exists in speech-in-noise (SIN) performance



NIDCD priority:
"***identify sources of*** variance contributing to large ***individual differences*** in response to similar intervention strategies among people with hearing loss."

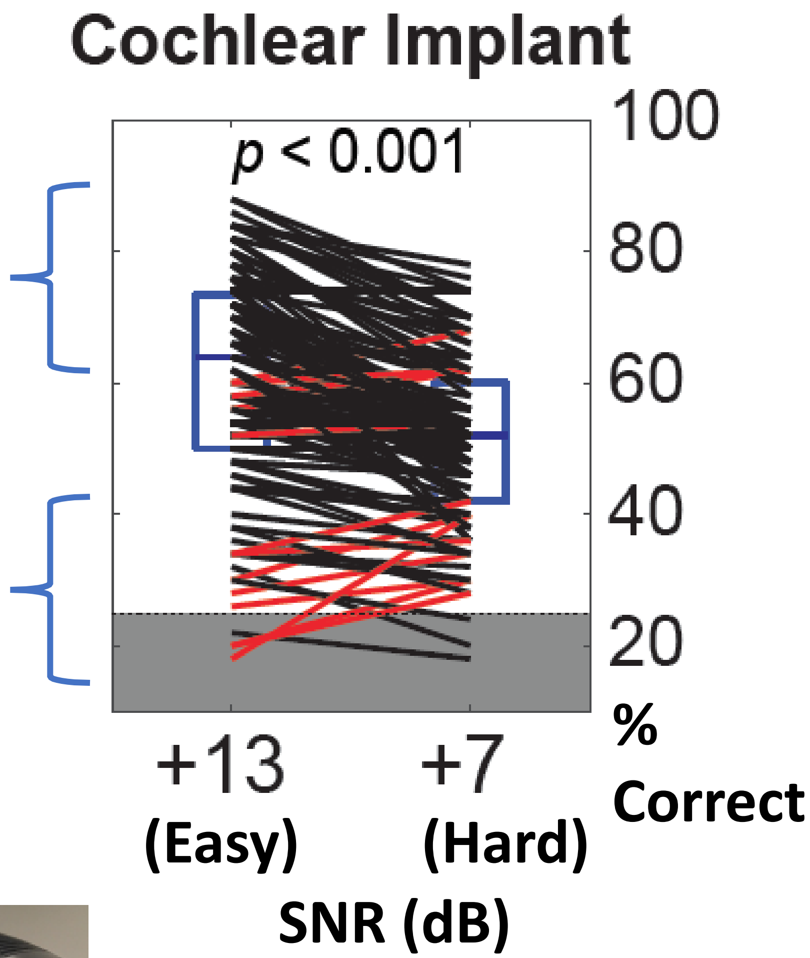
Most demographic factors fail predicting SIN variance in CI listeners



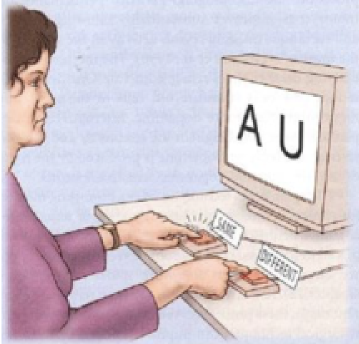
We try to understand…

Why these listeners do so *WELL*

Why these listeners do so *POOR*



using



Psychophysics

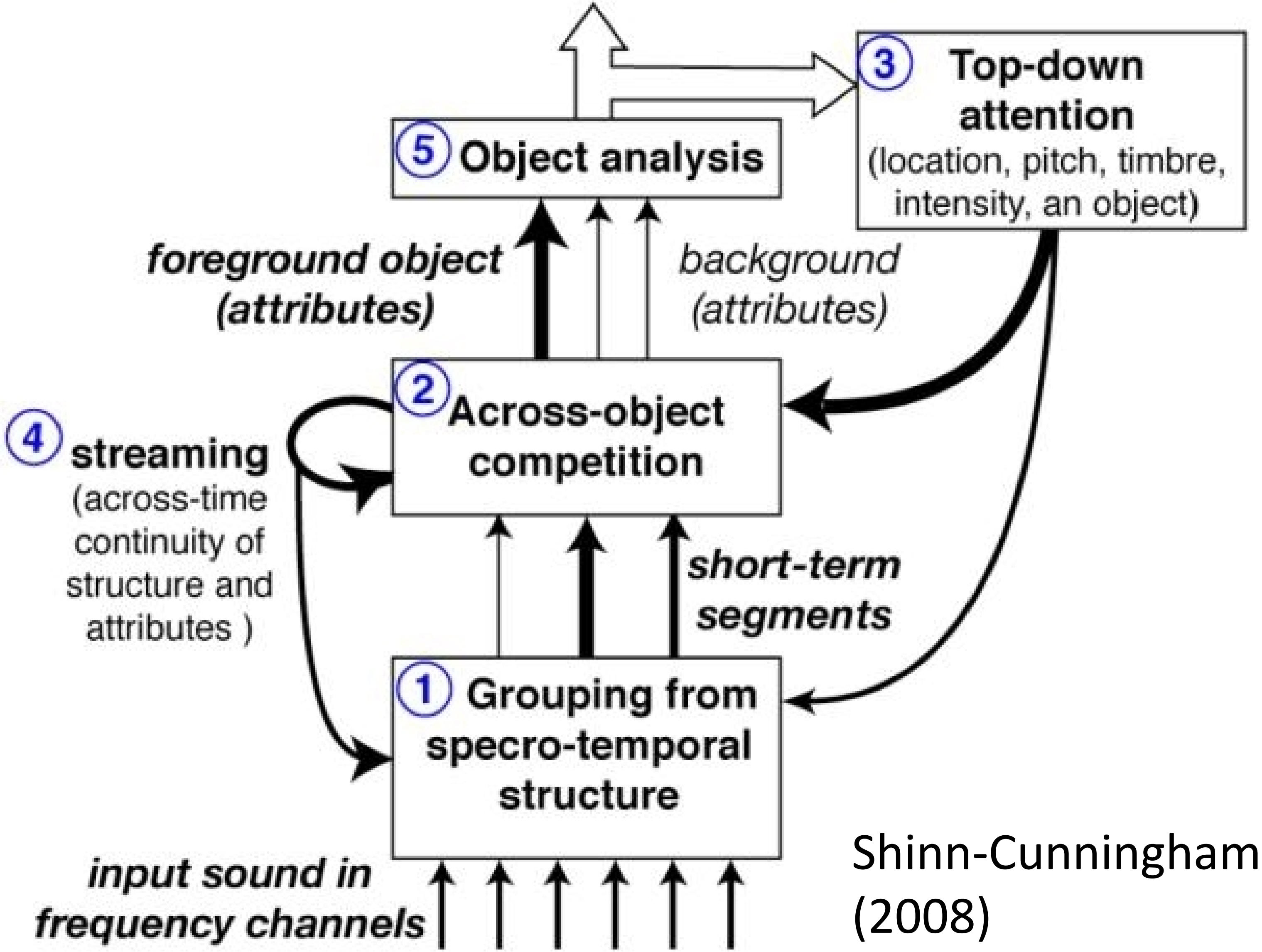
EEG

PET

Auditory cognition

‘The group of processes by which the brain makes sense of sound’

Object-based auditory attention



Shinn-Cunningham (2008)

Attention and Effort

DANIEL KAHNEMAN
The Hebrew University of Jerusalem

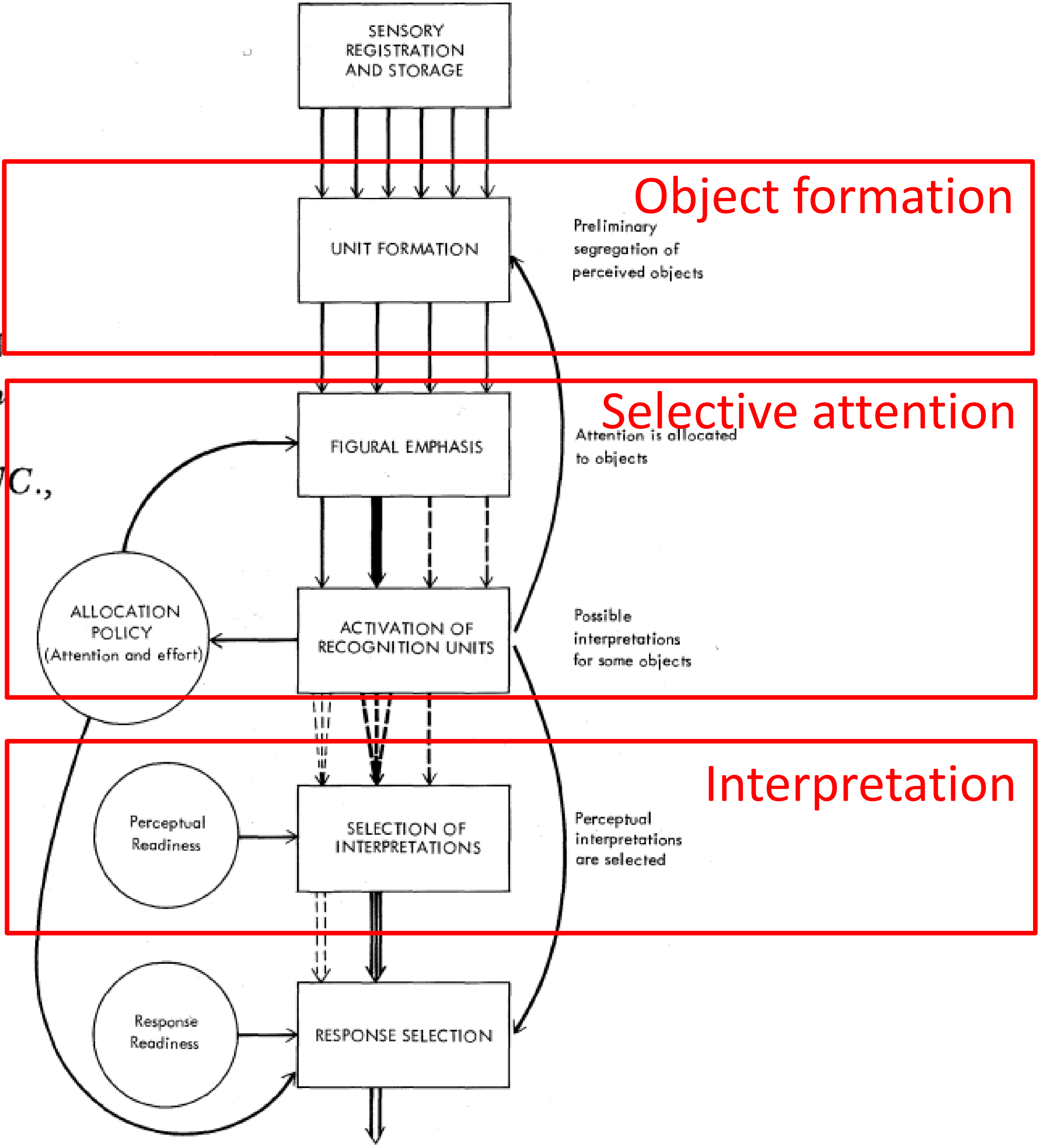
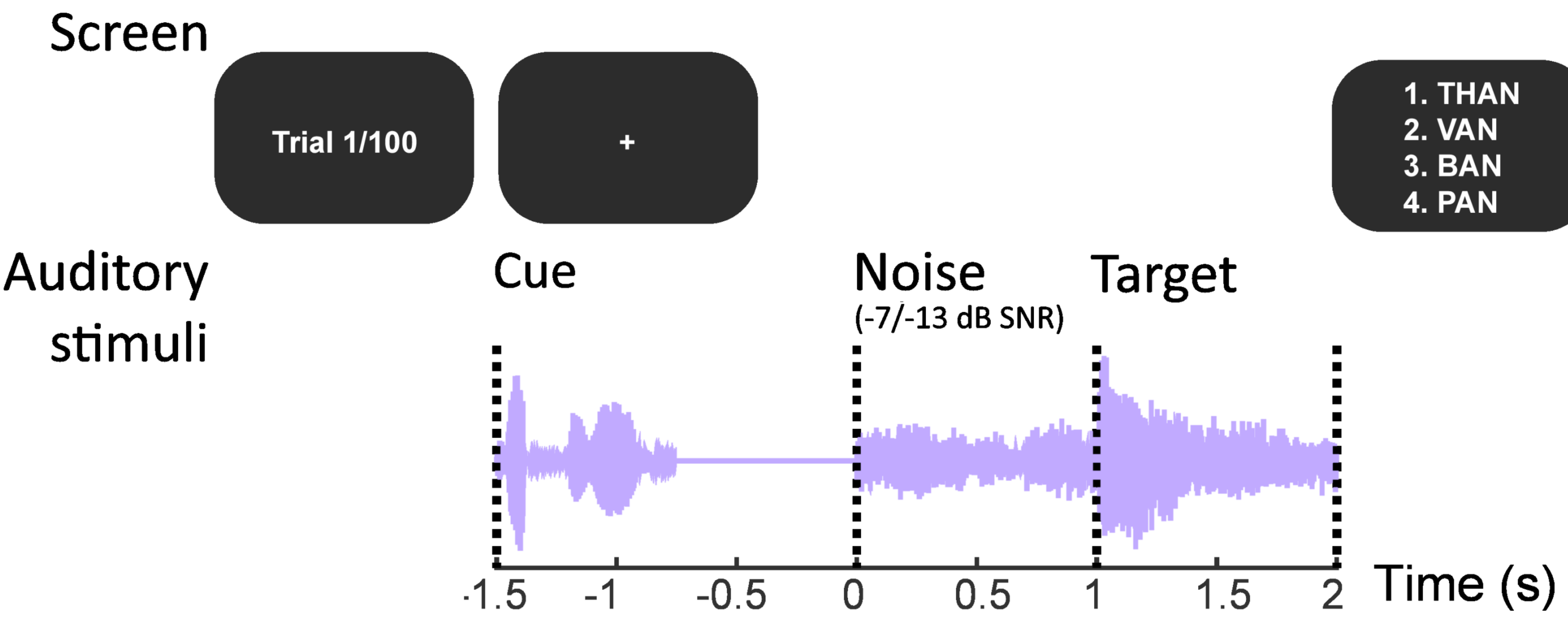


FIGURE 5-1
Schematic model for perception and attention.

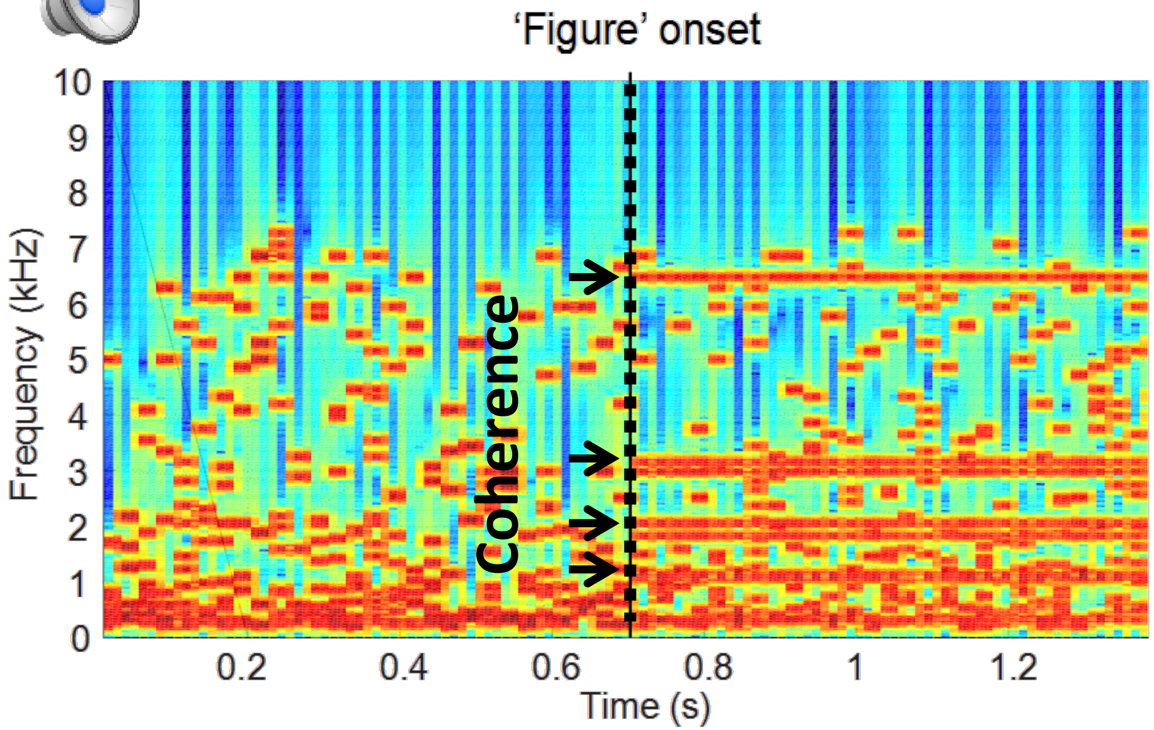
Auditory objects
… by way of visual objects

Auditory objects
… in the lab

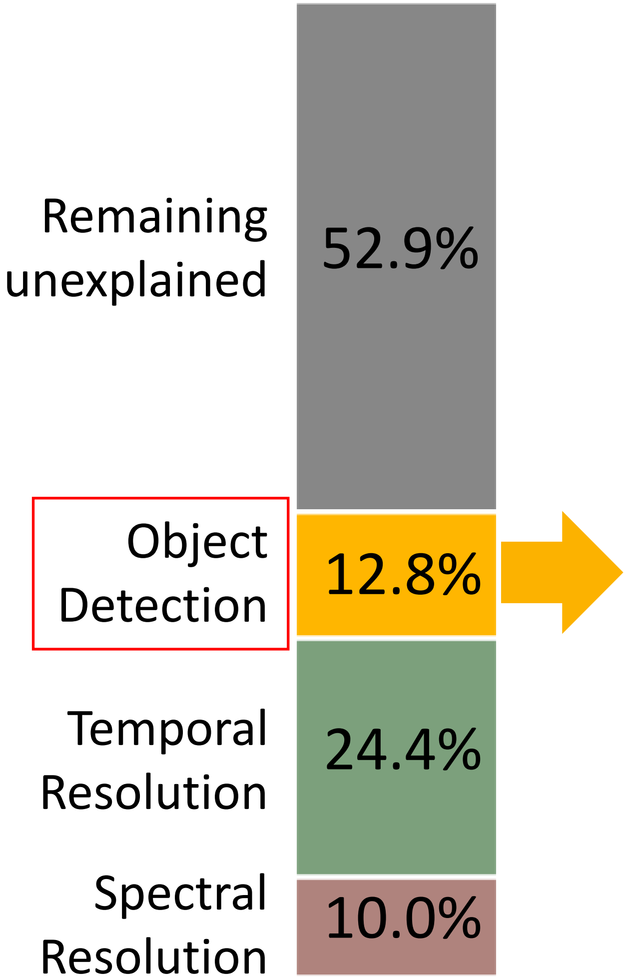


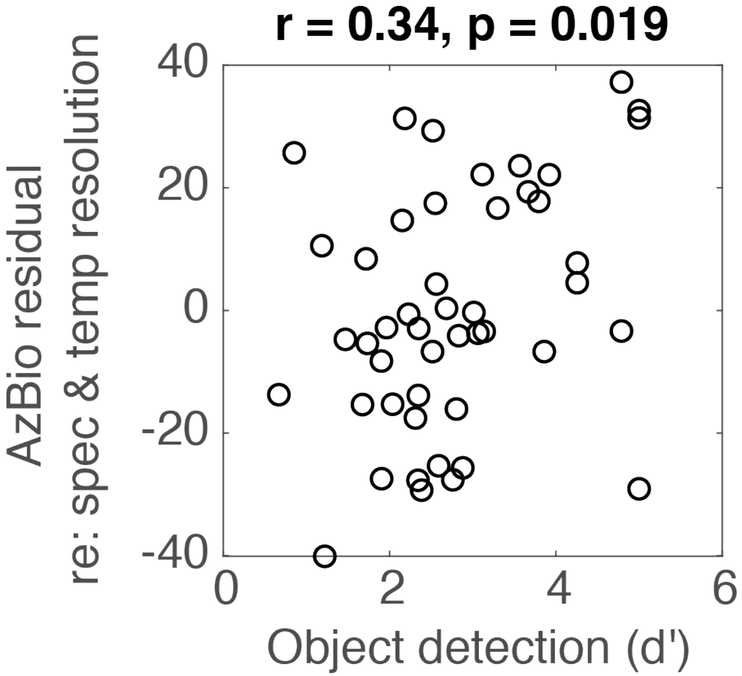
Auditory object detection predicts SIN performance
(47 cochlear implant users)

Auditory Figure Ground task



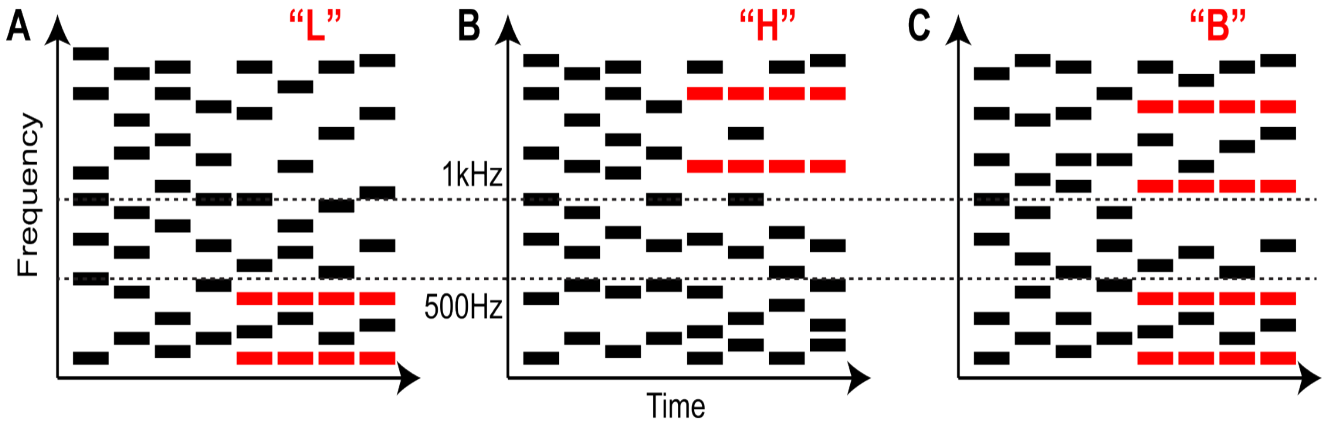
Speech-in-noise variance explained



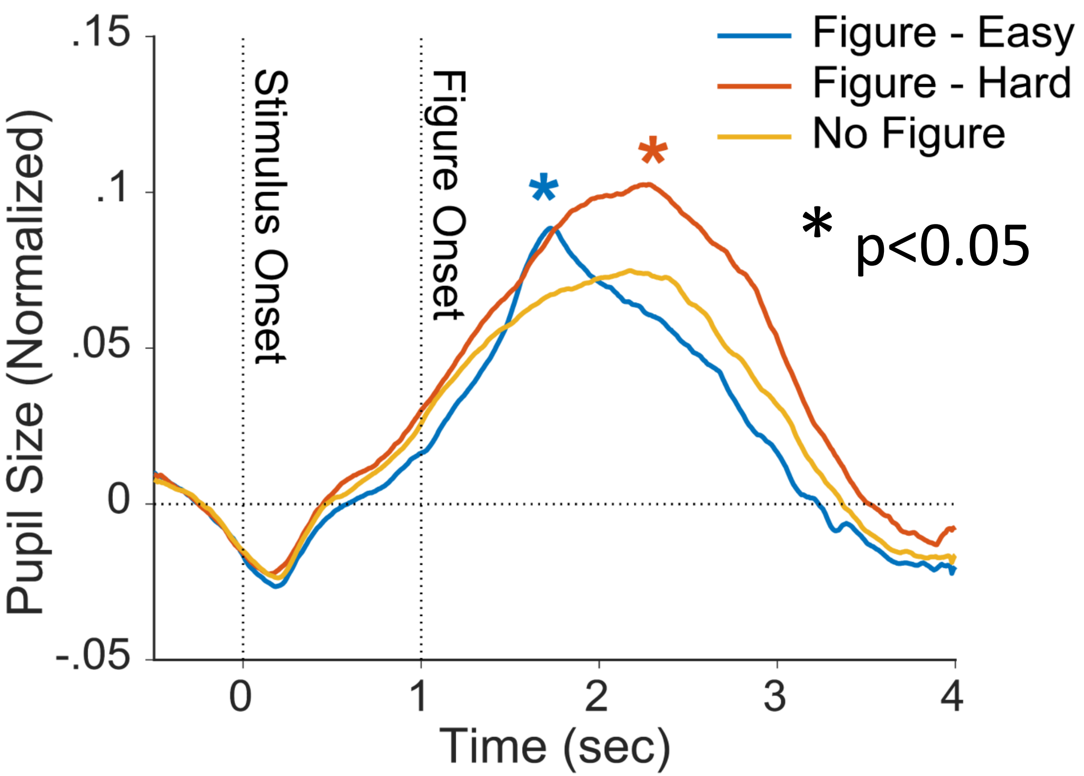


Choi et al, in revision

Complex auditory objects require greater ‘effort’ (pupil dilation) to detect

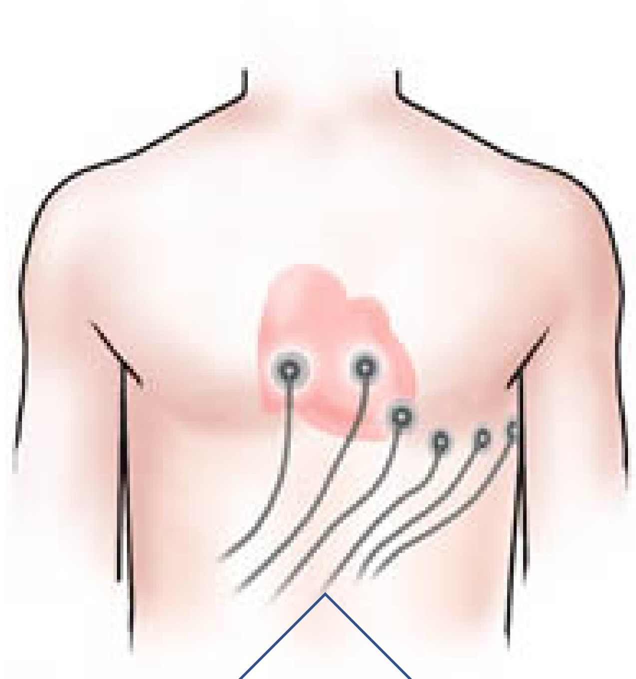


A. Low-frequency figure (“L”) tests acoustic hearing
B. High-frequency figure (“H”) tests electric hearing
C. Broadband figure (“B”) tests combined hearing

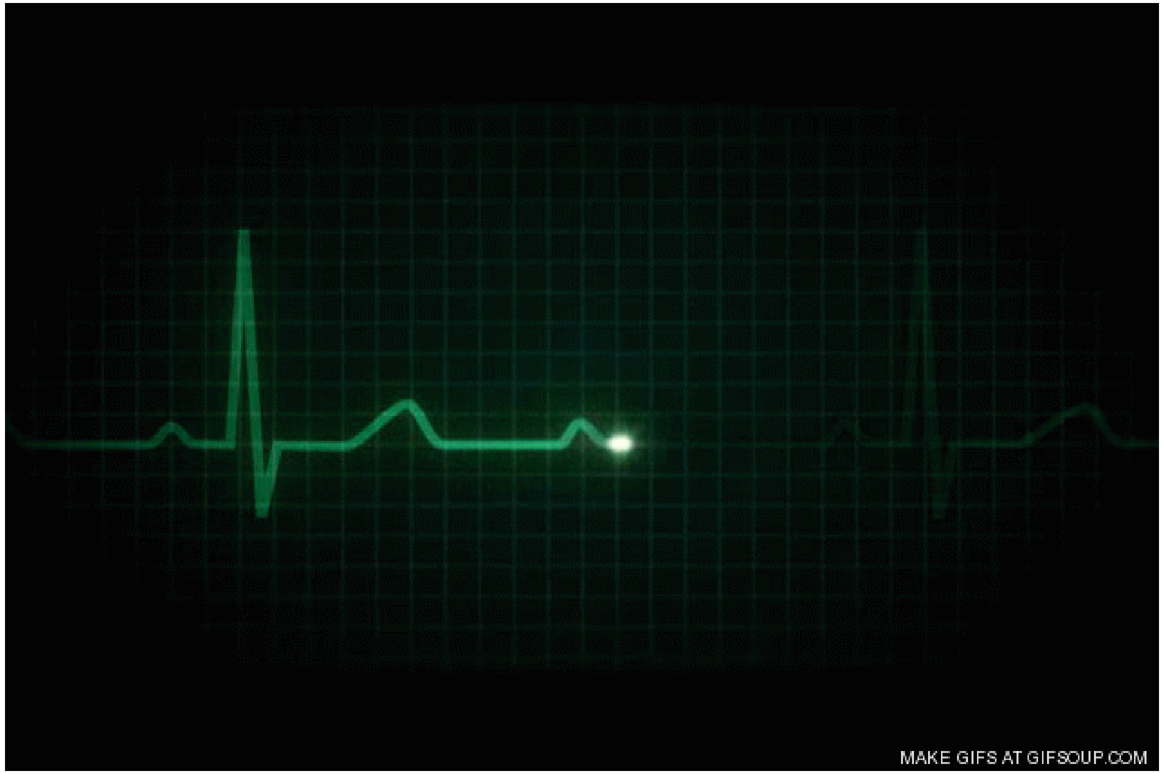


Distinct pupil responses to easy and hard FG detection (n=11).

EEG is like EKG

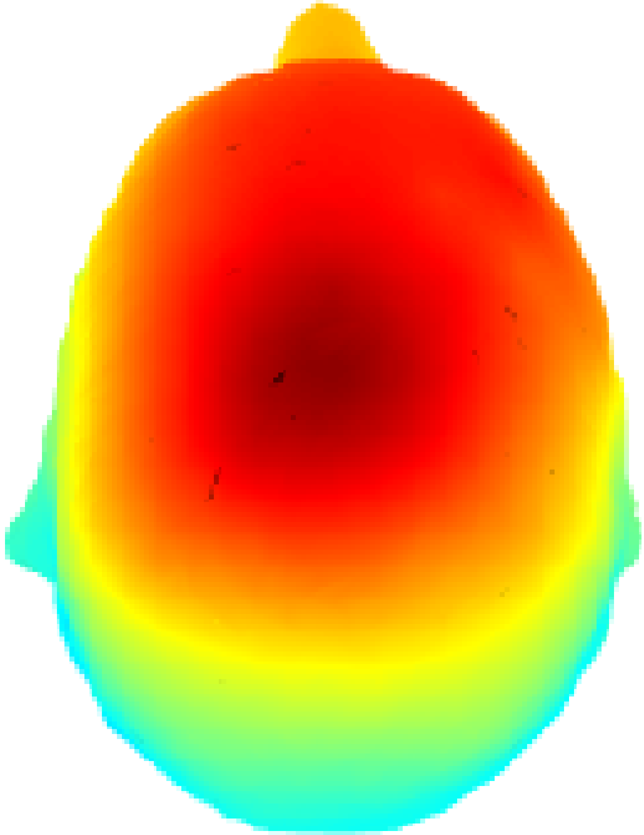


Electrodes attached on chest

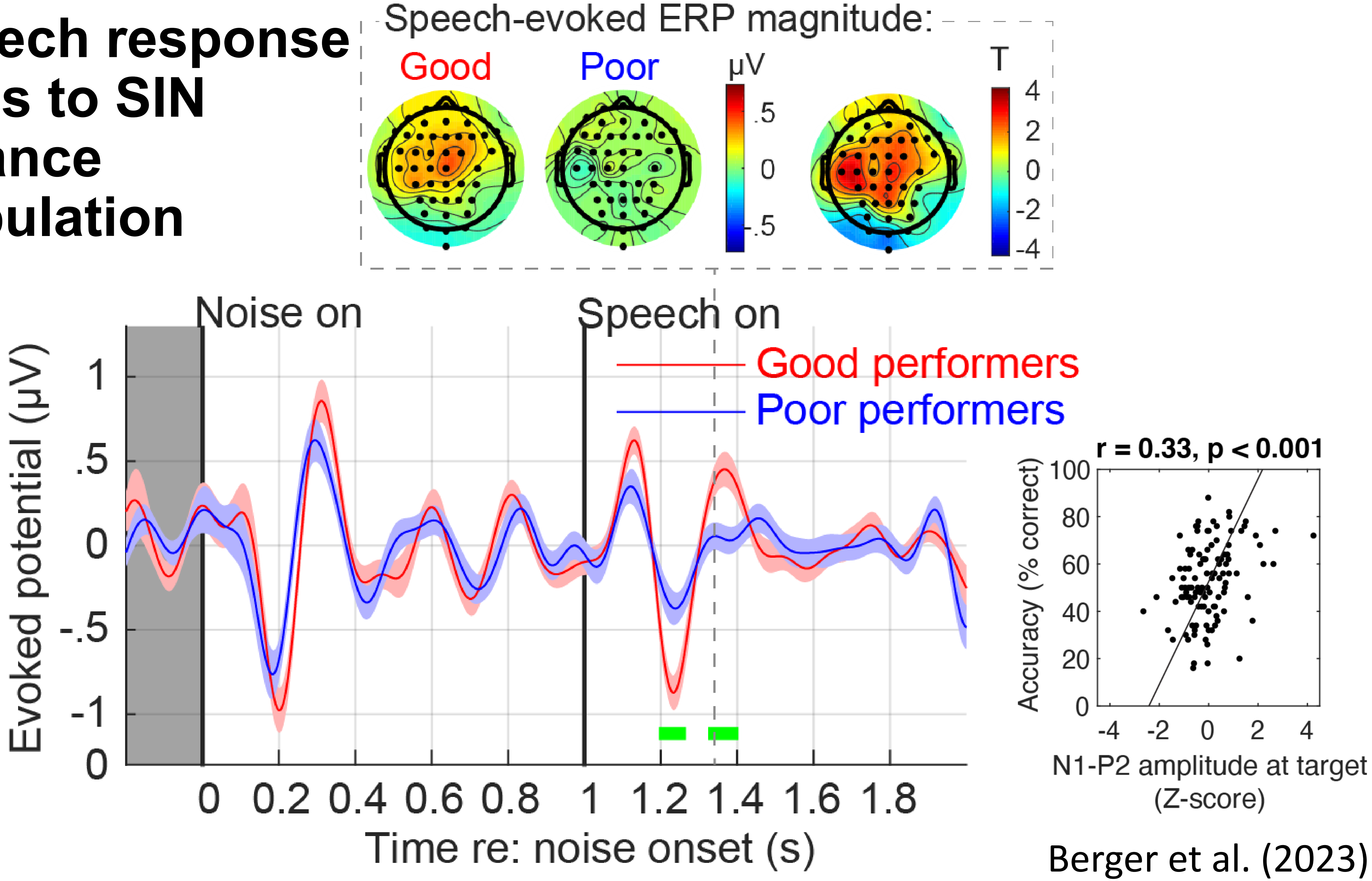


EEG can show how strongly brain responds to sounds

Electrodes attached on scalp

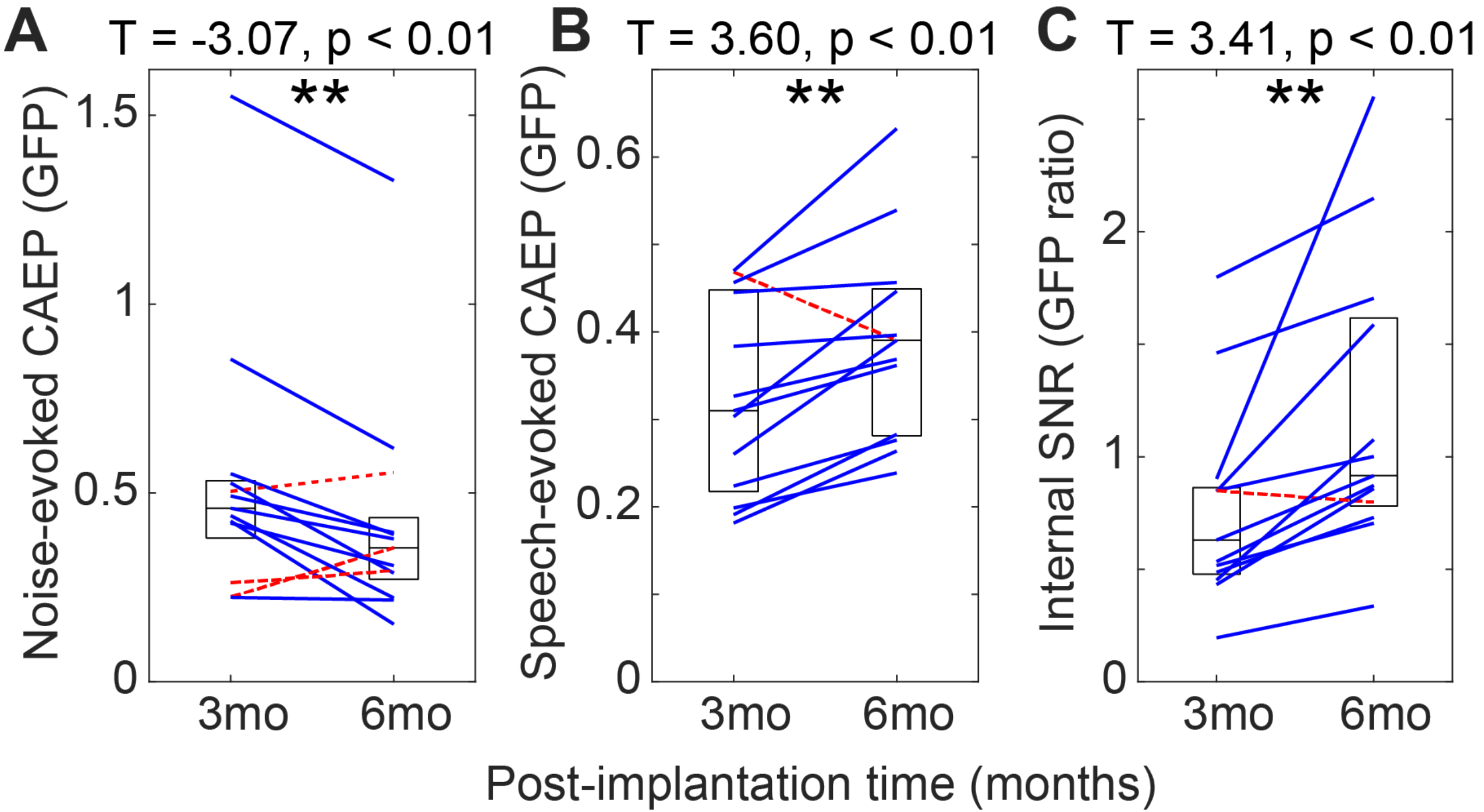


EEG speech response correlates to SIN performance in CI population



Berger et al. (2023)

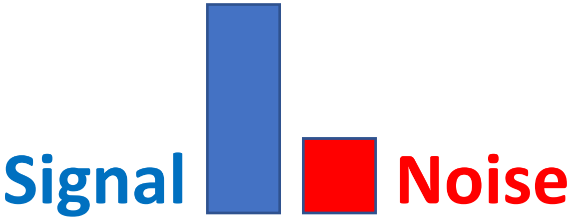
EEG response to SIN changes over time



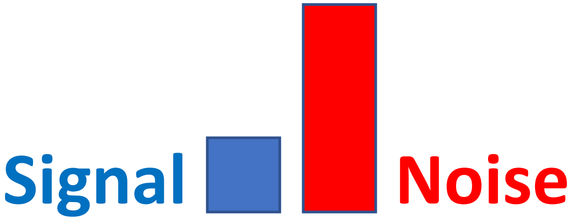
Smith et al. (in preparation)

Brain changes in SNR

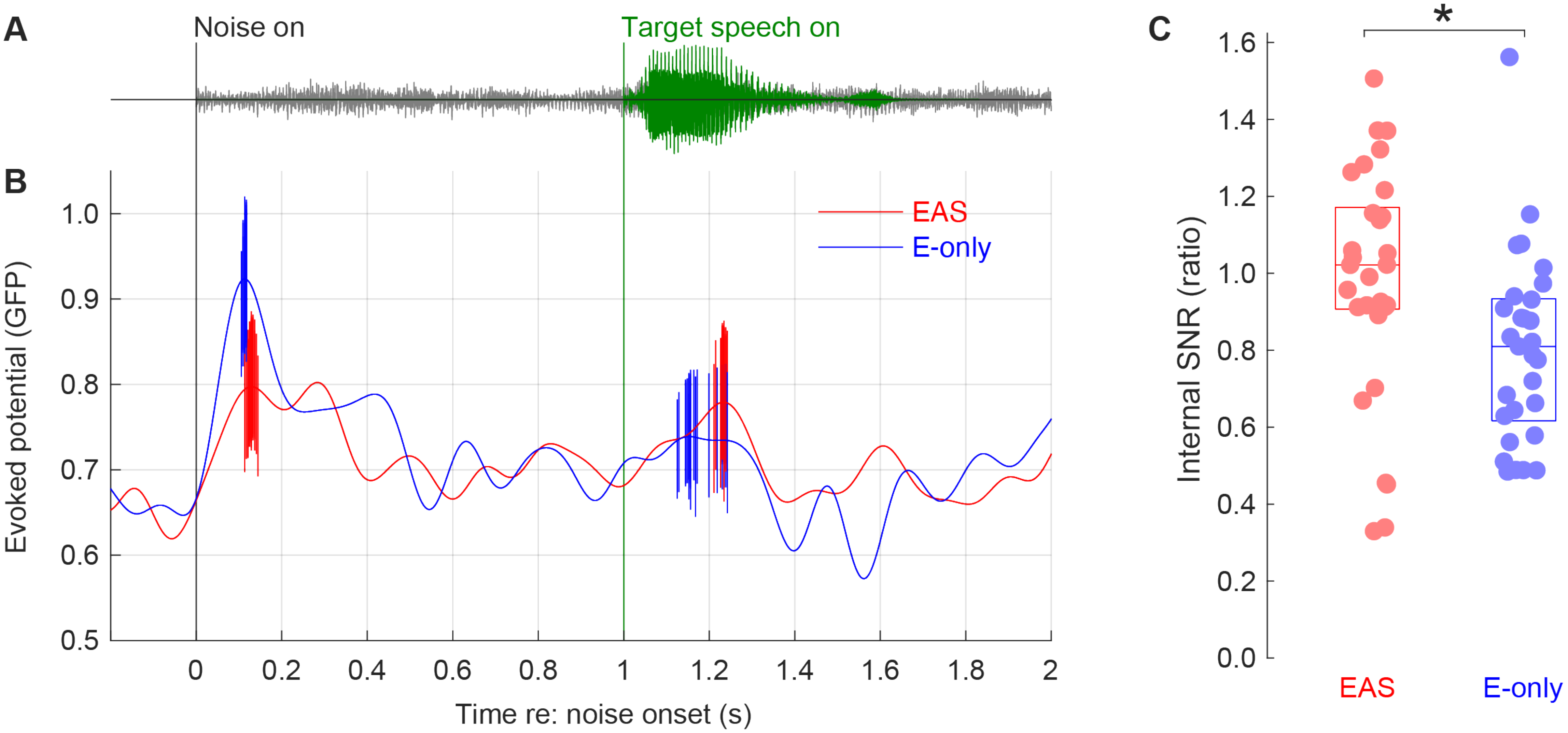
Good performers brain



Poor performers brain

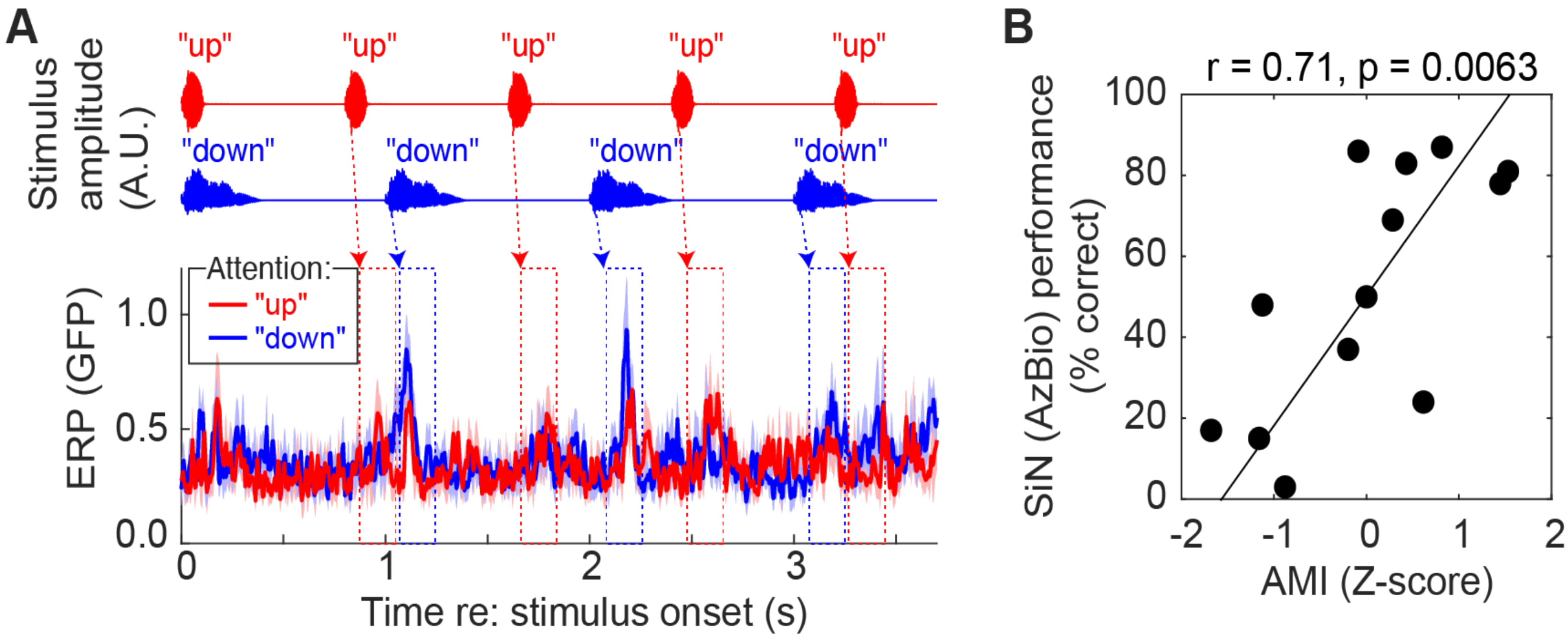


EAS yields higher EEG SNRs than electric-only



Shim et al. (2022)

Auditory attention performance correlates with SIN in CI users

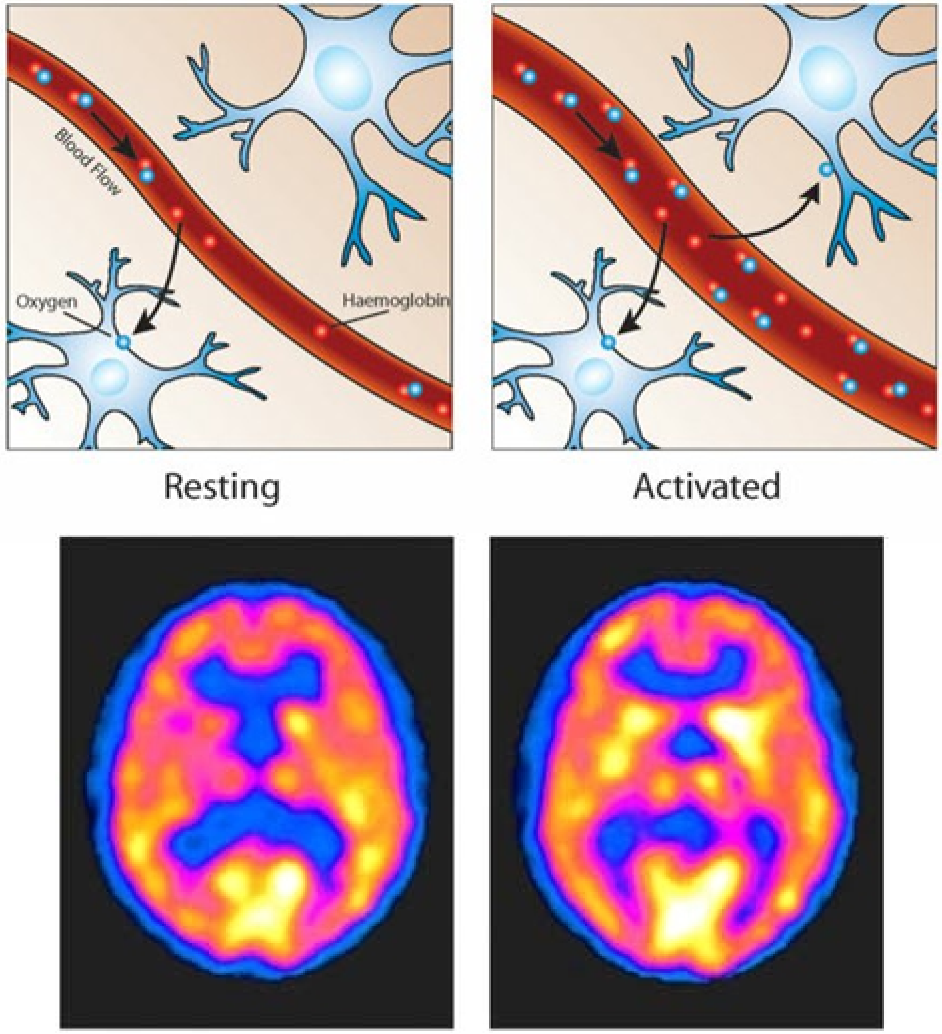


A. Endogenous attention paradigm, evoked potential (GFP) results from 13 CI users. **B.** Correlation between Attention Modulation Index and SIN.

PET neuroimaging of whole brain activity

PET/CT

Radio tracer [15O]Water
measures blood flow



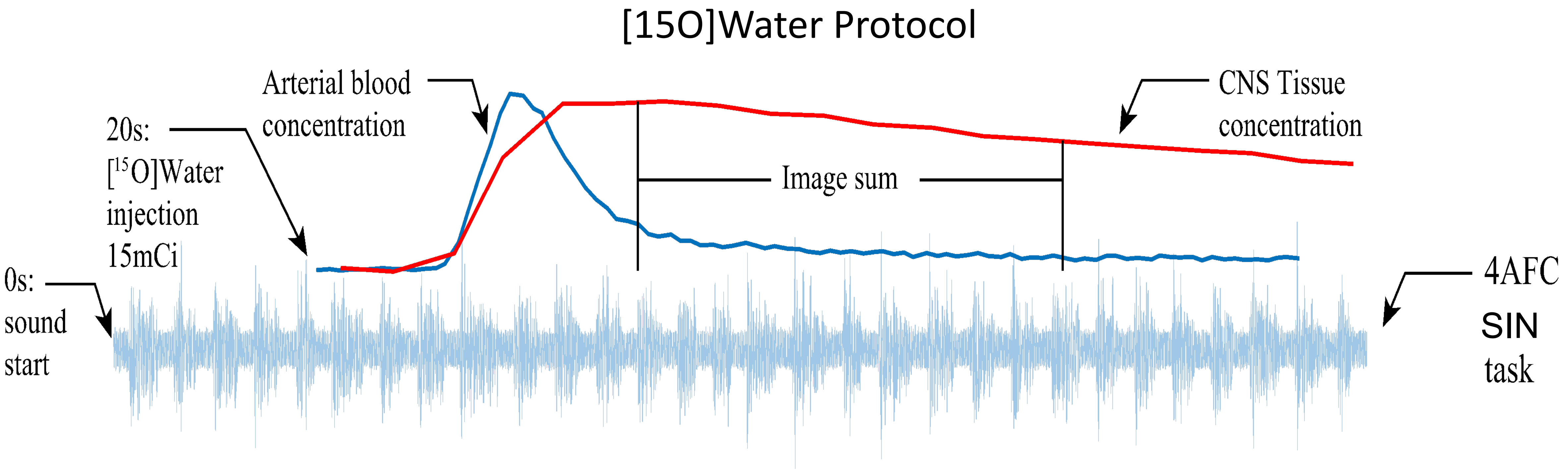
SIN [15O] Water PET study design

CI subject demographics

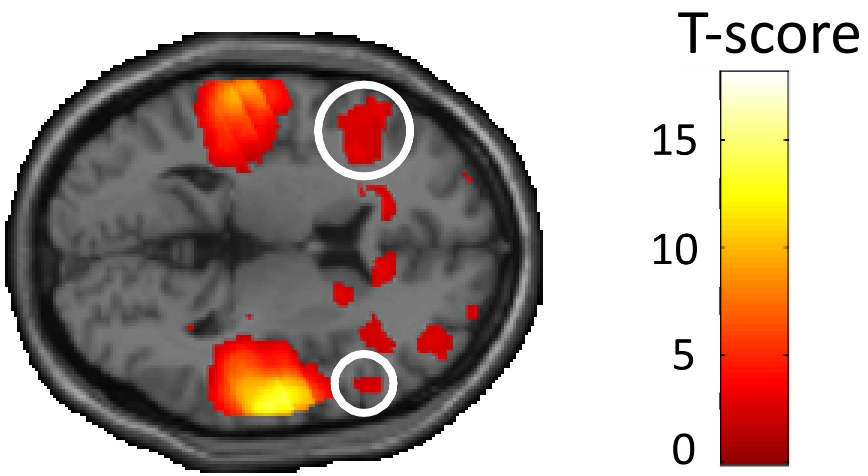
	Age	Sex	Left Ear	Right Ear
CI-01	61	M	HA	CI (N24/N6)
CI-02	64	F	CI (S12RW/N6)	HA
CI-03	53	F	CI (522/Kanso)	HA
CI-04	52	M	CI (L24/N6)	HA
CI-05	39	F	HA	CI (L24/N6)
CI-07	60	M	CI (L24/N6)	HA
CI-08	48	F	HA	CI (L24/N6)
CI-09	60	F	CI (S12/N6)	HA
CI-10	40	M	HA	CI (L24/N6)
Group	53	5 F	5 CI	4 CI

All subjects were EAS CI users with residual low frequency acoustic hearing bilaterally, and an implant on one side.

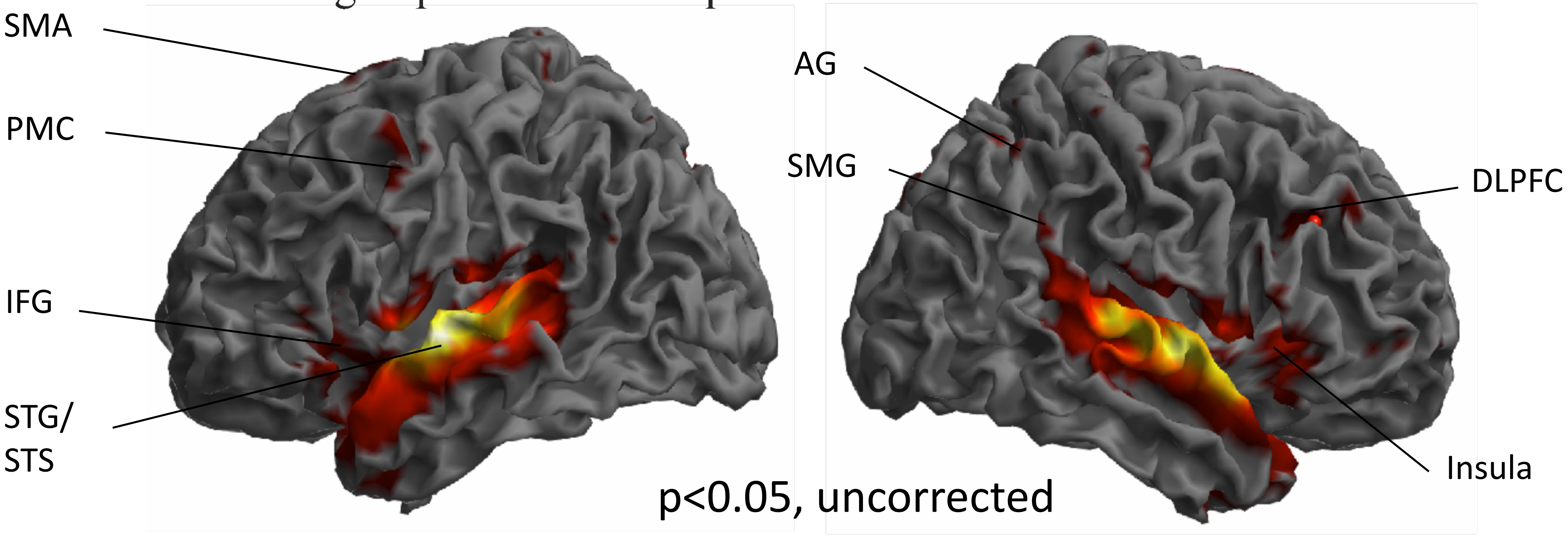
SIN [15O] Water PET study protocol



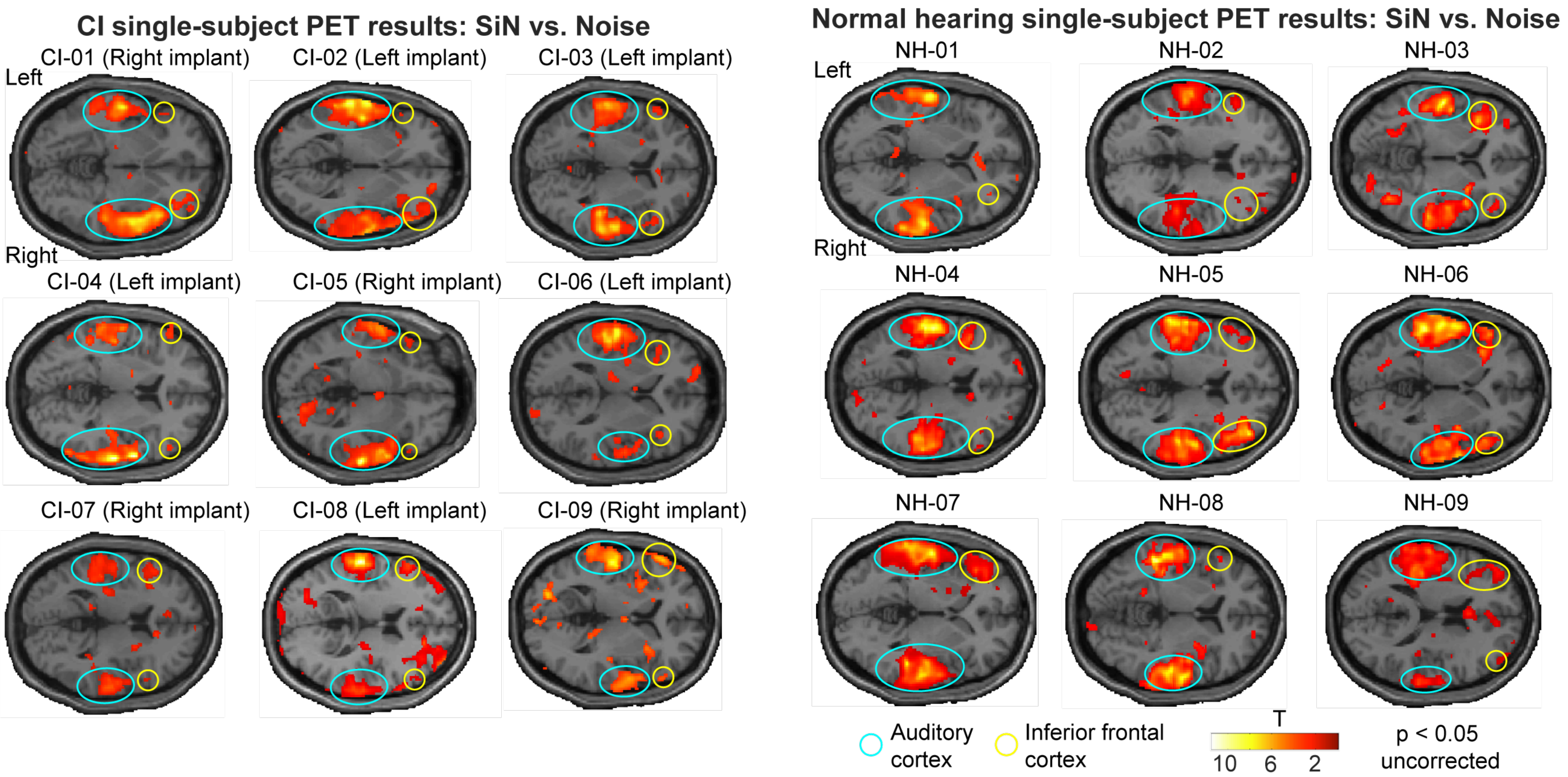
SIN [15O] Water PET study - CI group results



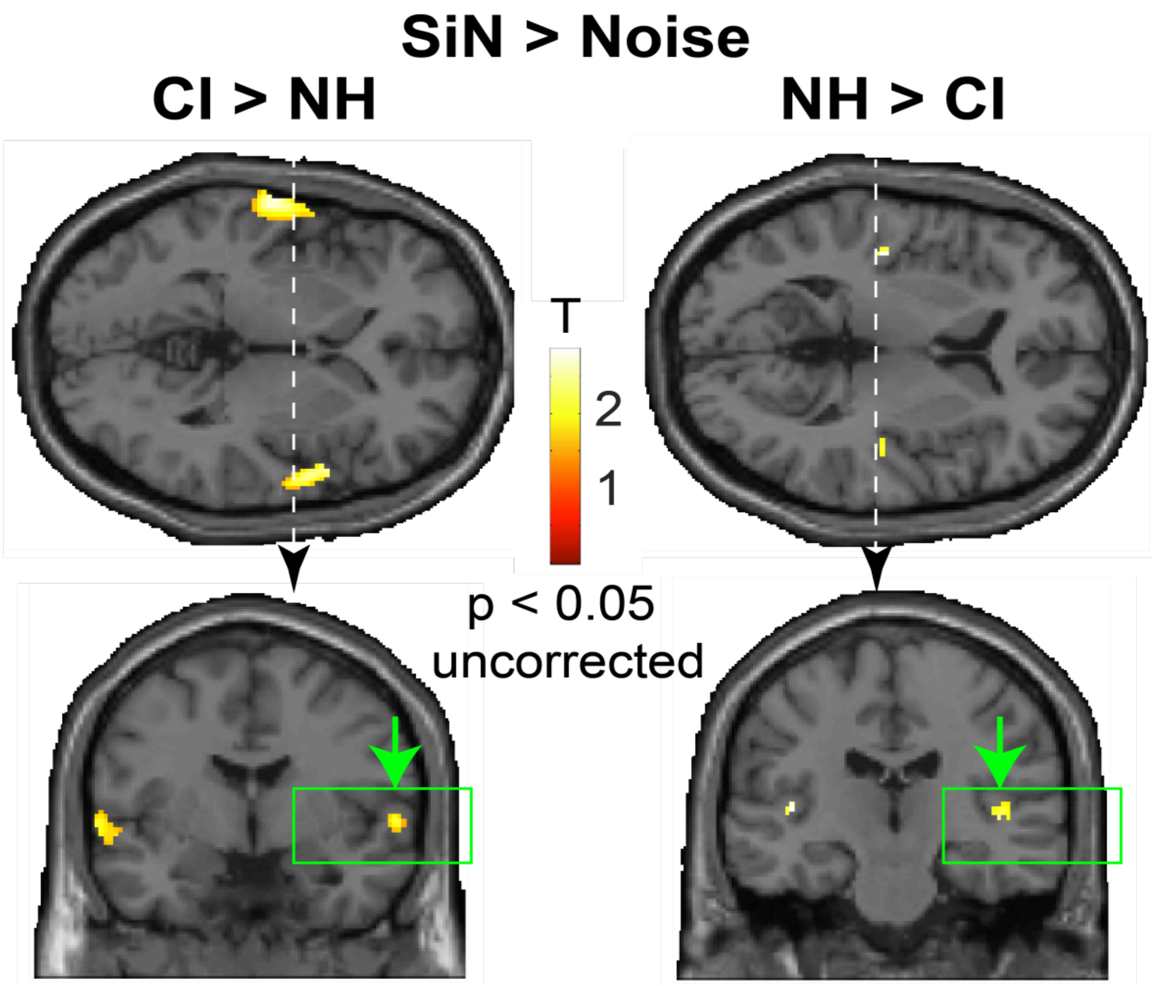
CI group PET results: Speech-in-noise vs. Noise



SIN PET single subject results show robust auditory and frontal activity

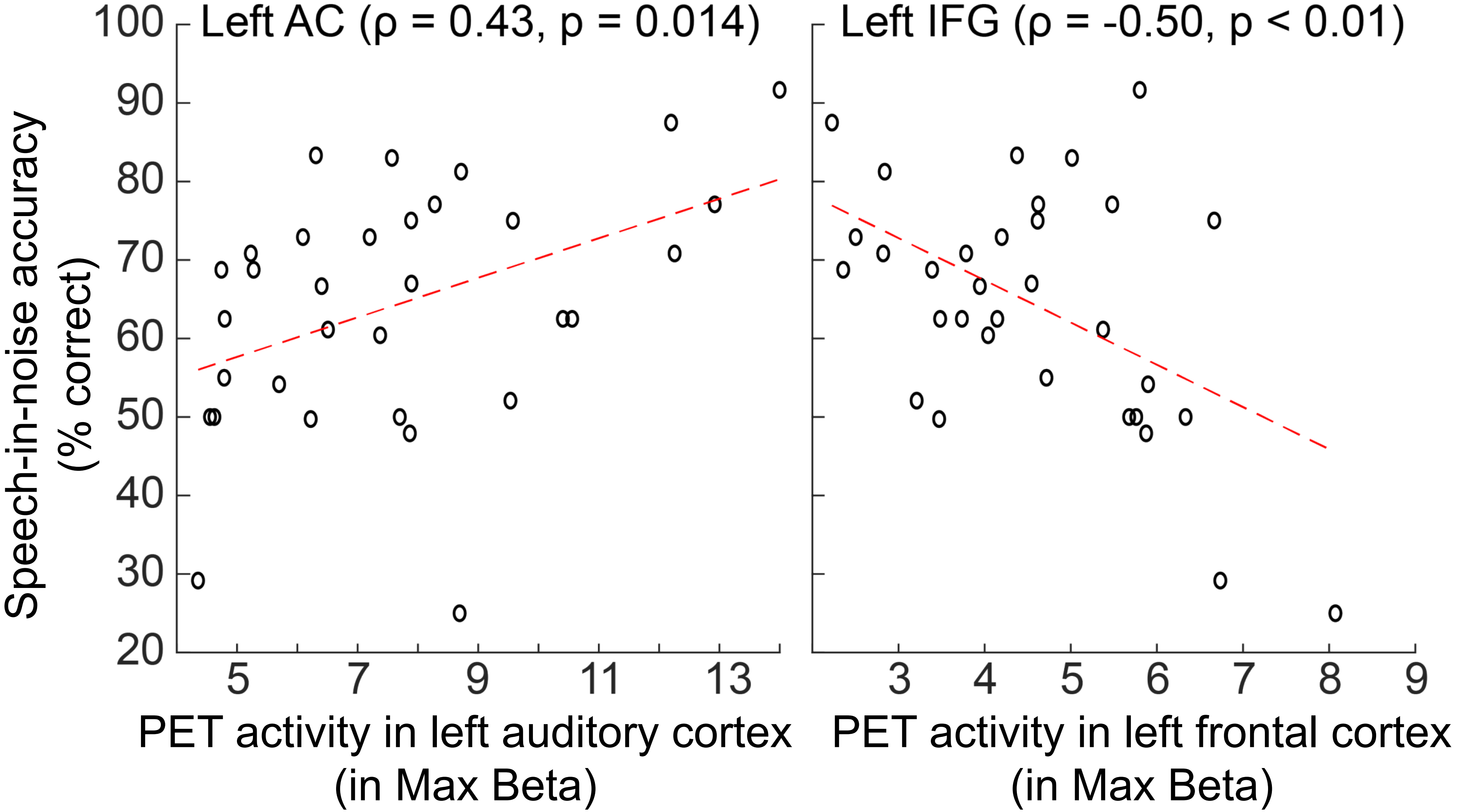


SIN PET group comparison results reveal auditory cortical differences



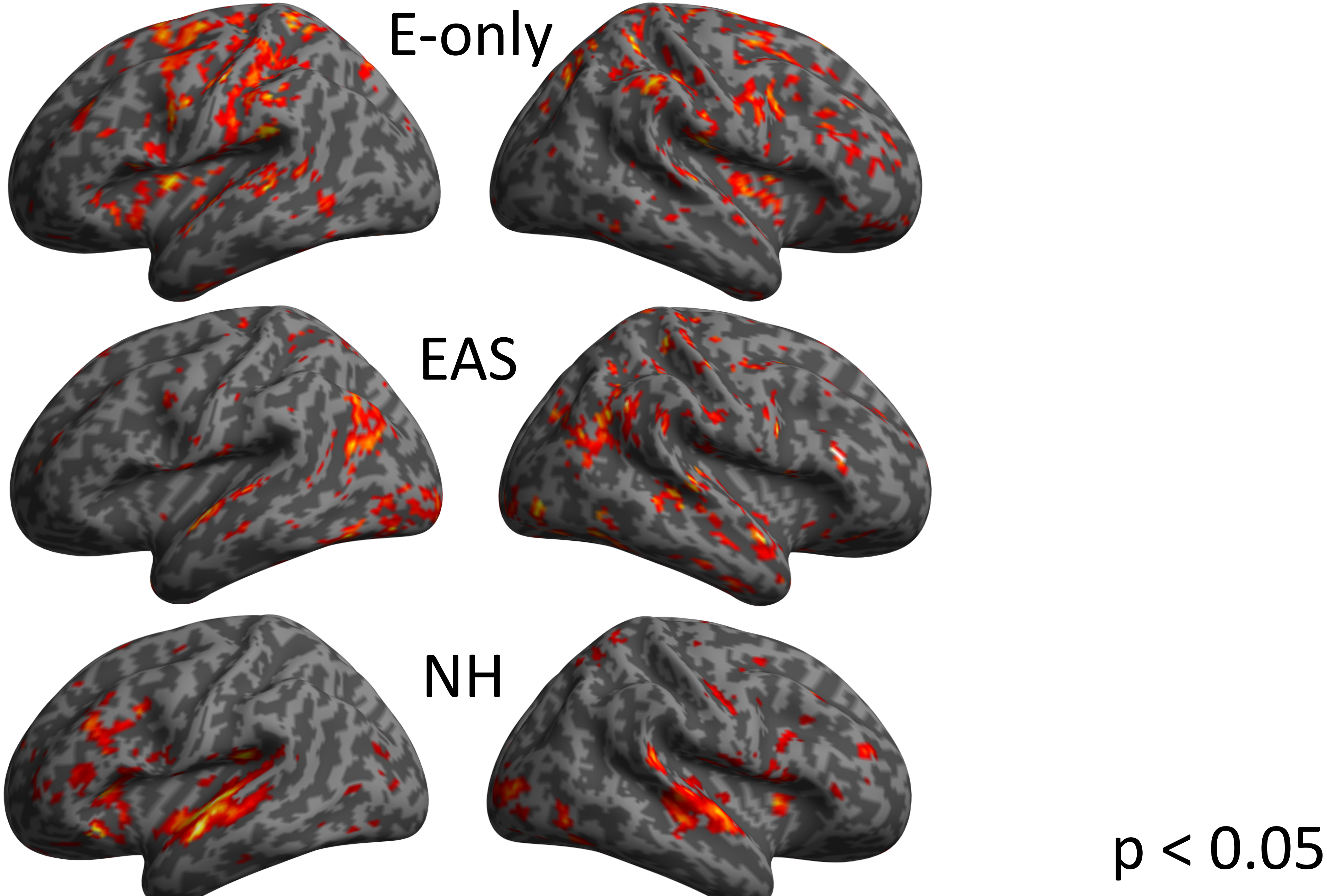
Differences in PET SIN activation between NH and CI groups. Activation is greater in primary auditory cortex in NH.

PET SIN study brain-behavior correlation



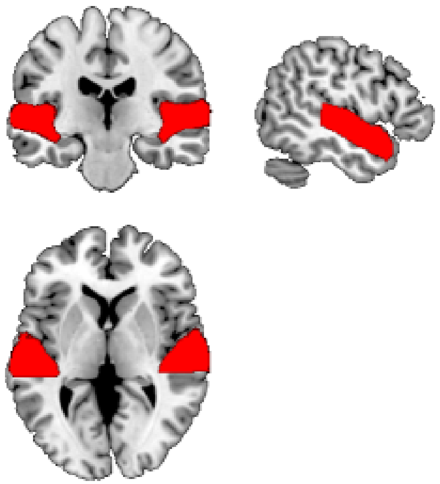
Correlation between PET response to SIN and SIN performance in 33 CI users.

PET: SIN vs. Control noise

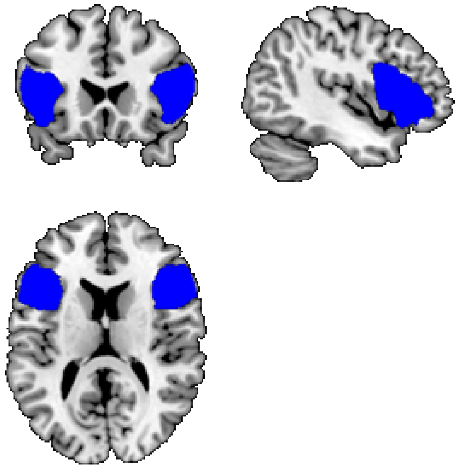


PET region of interest analysis: SIN vs. Control

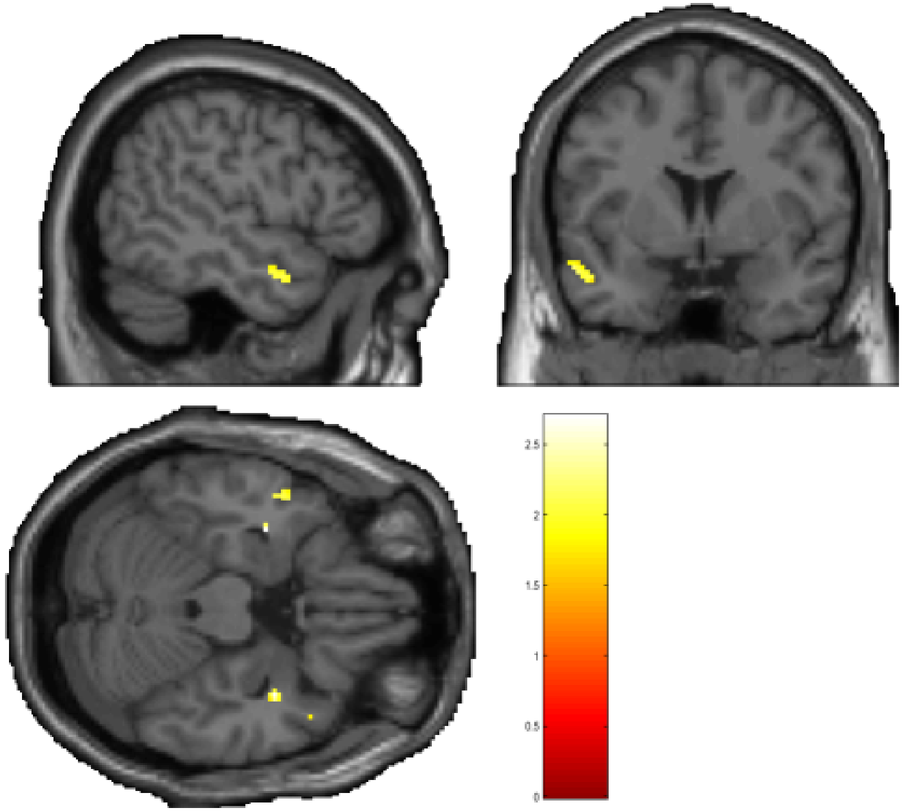
Auditory



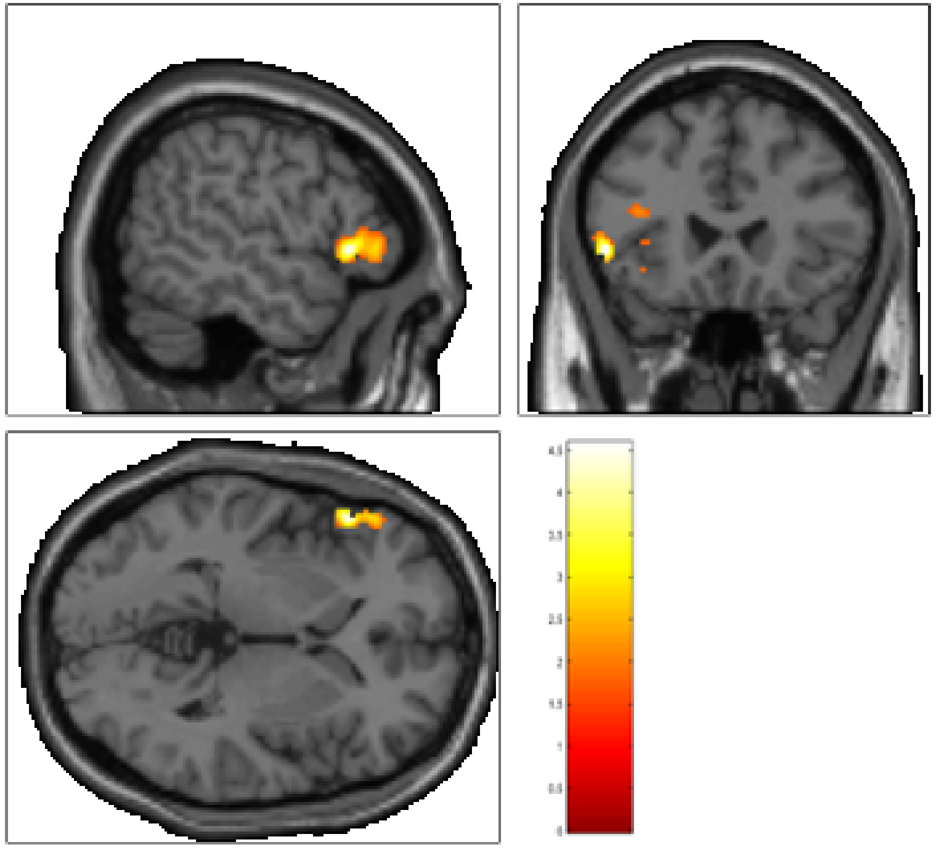
Frontal



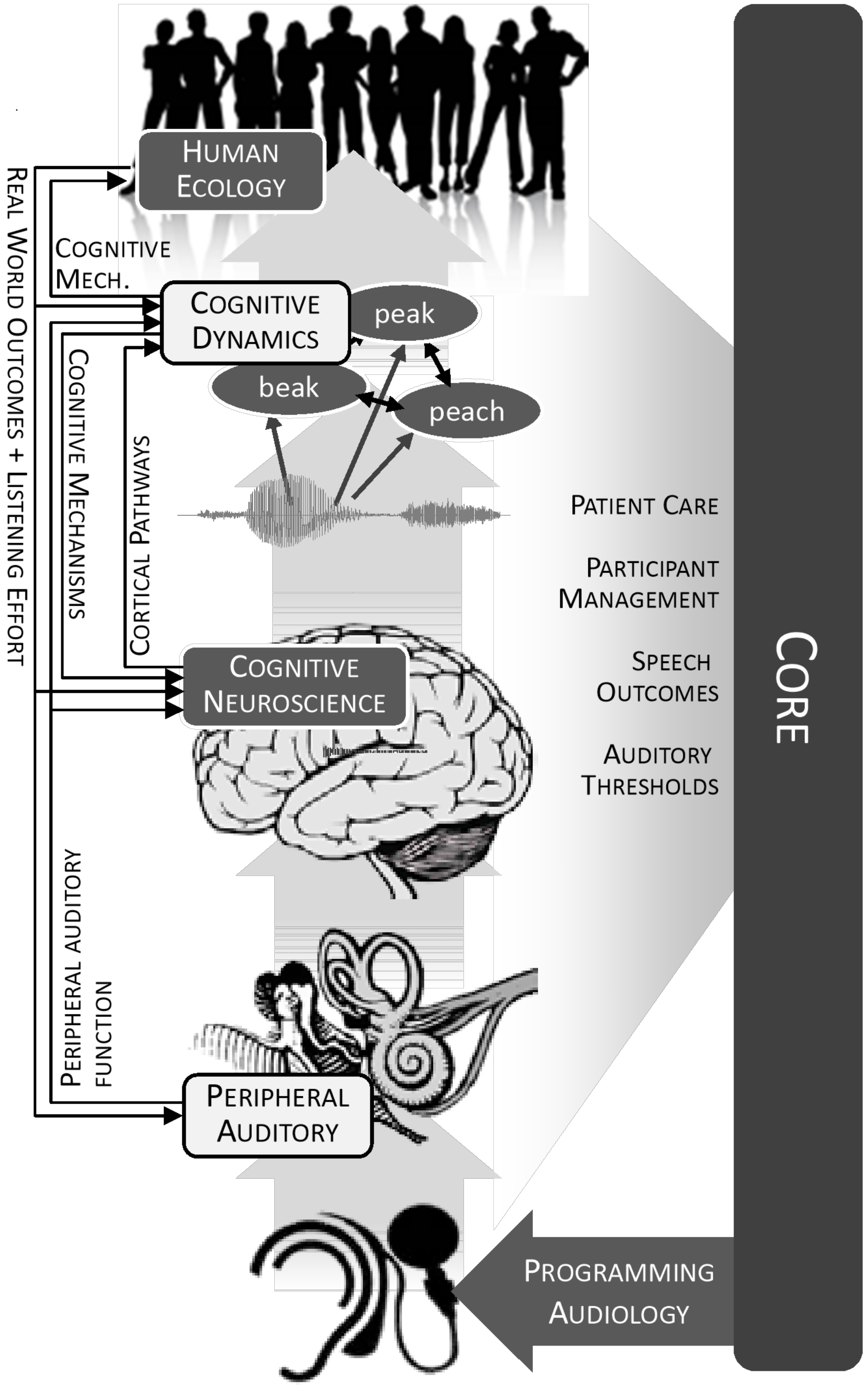
EAS (N=17) vs Non-EAS (N=22)
SIN > Control



p<0.05,
uncorrected



Auditory cognition lies between peripheral and linguistic processing



Many thanks to the patients

Iowa

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Francis Smith

Laura Kiskunas

Iowa Cochlear Implant Clinical Research Center

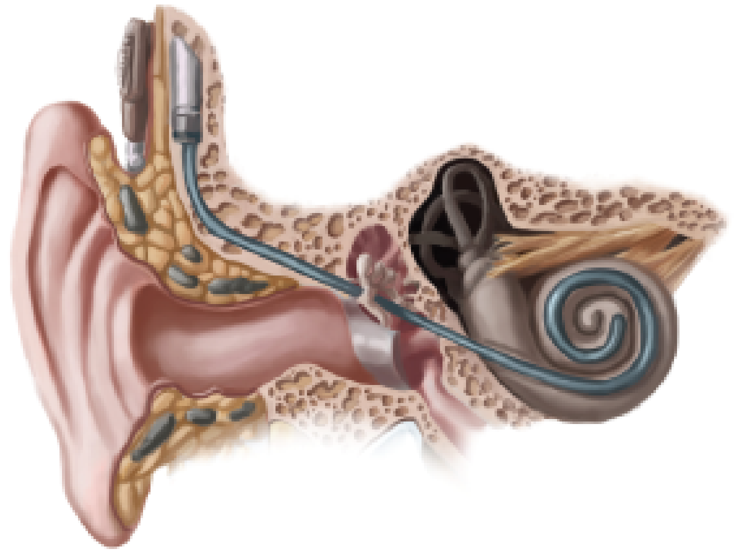
Newcastle

Tim Griffiths

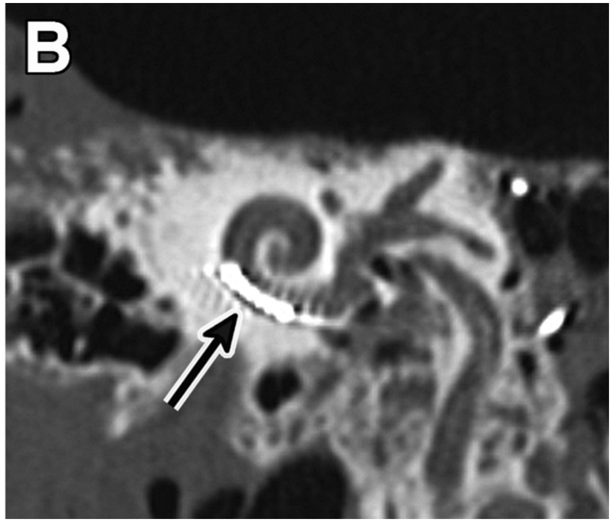
University College London

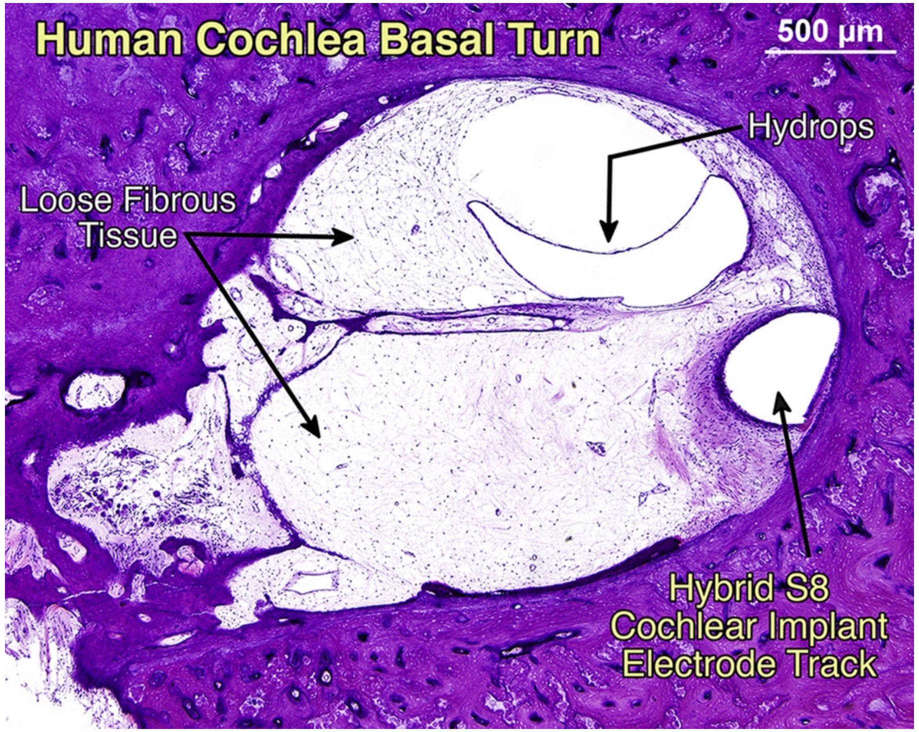
Cochlear implant trauma and fibrosis

- 17.6% trauma rate (Hoskison et al. 2017)



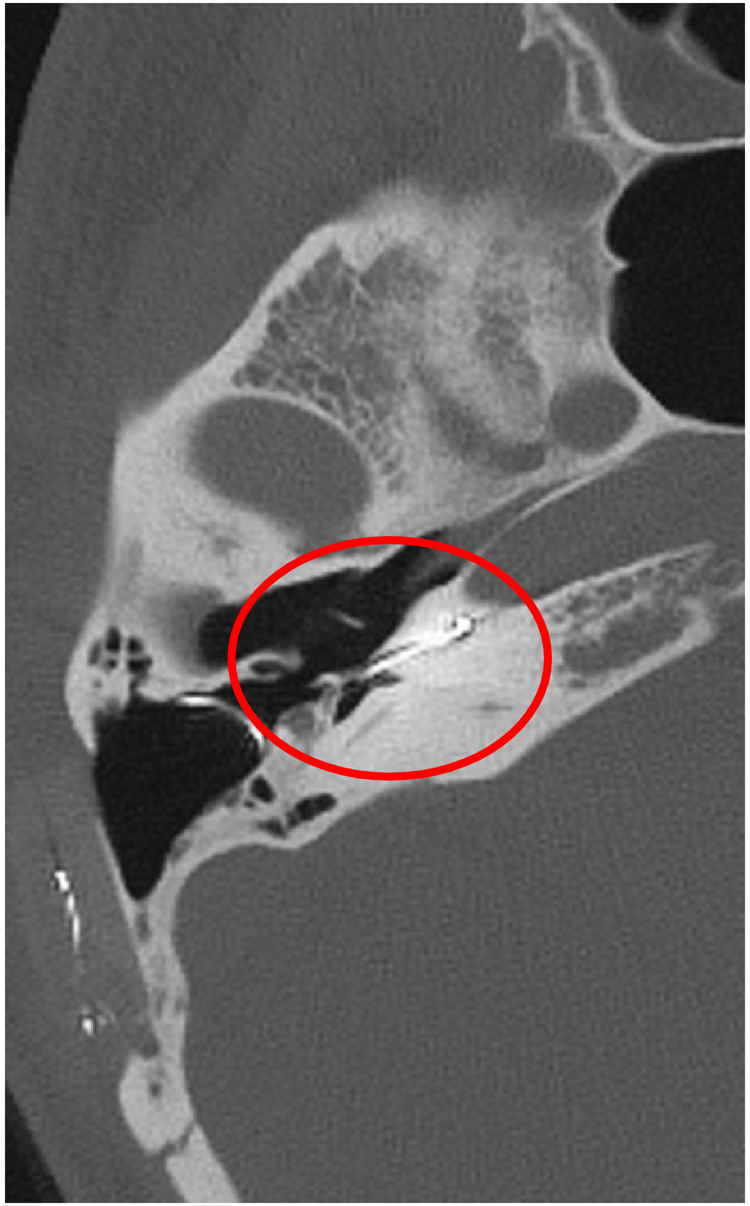
- Delayed hearing loss after implantation
  Quesnel et al. 2016





Standard CT imaging in vivo not sufficient to detect new tissue

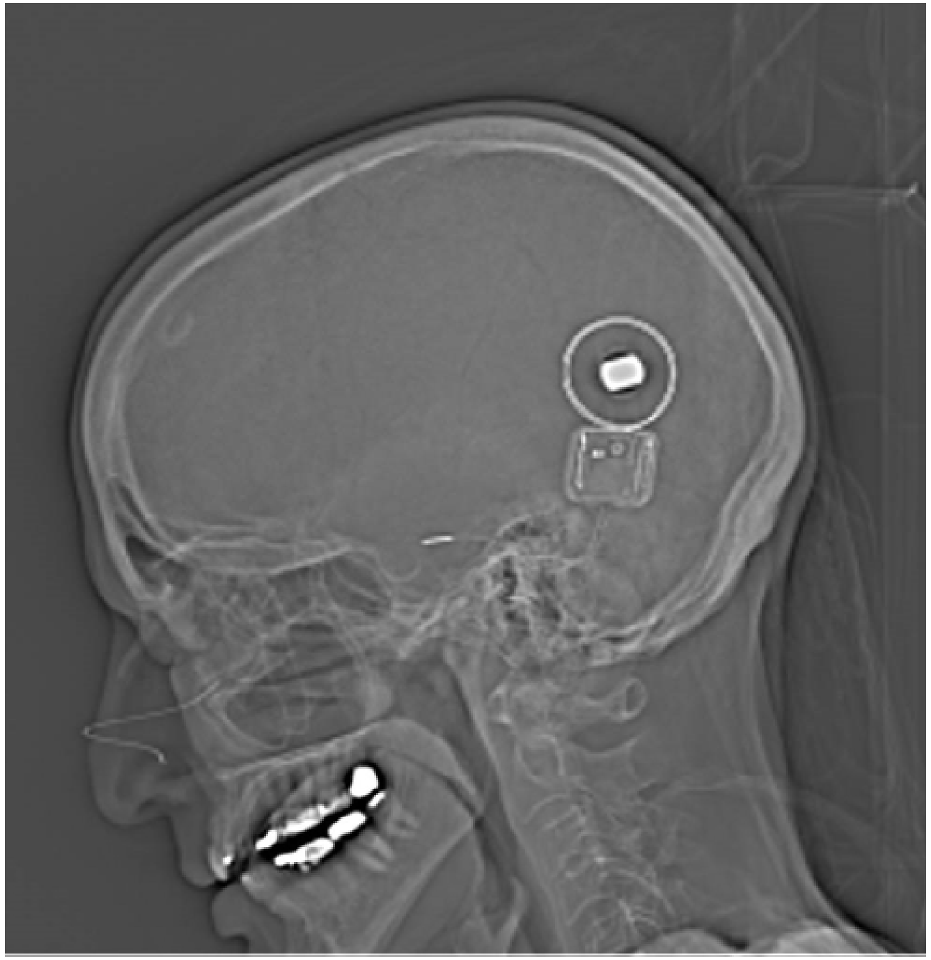
- Post-implant CT – Standard (1mm)



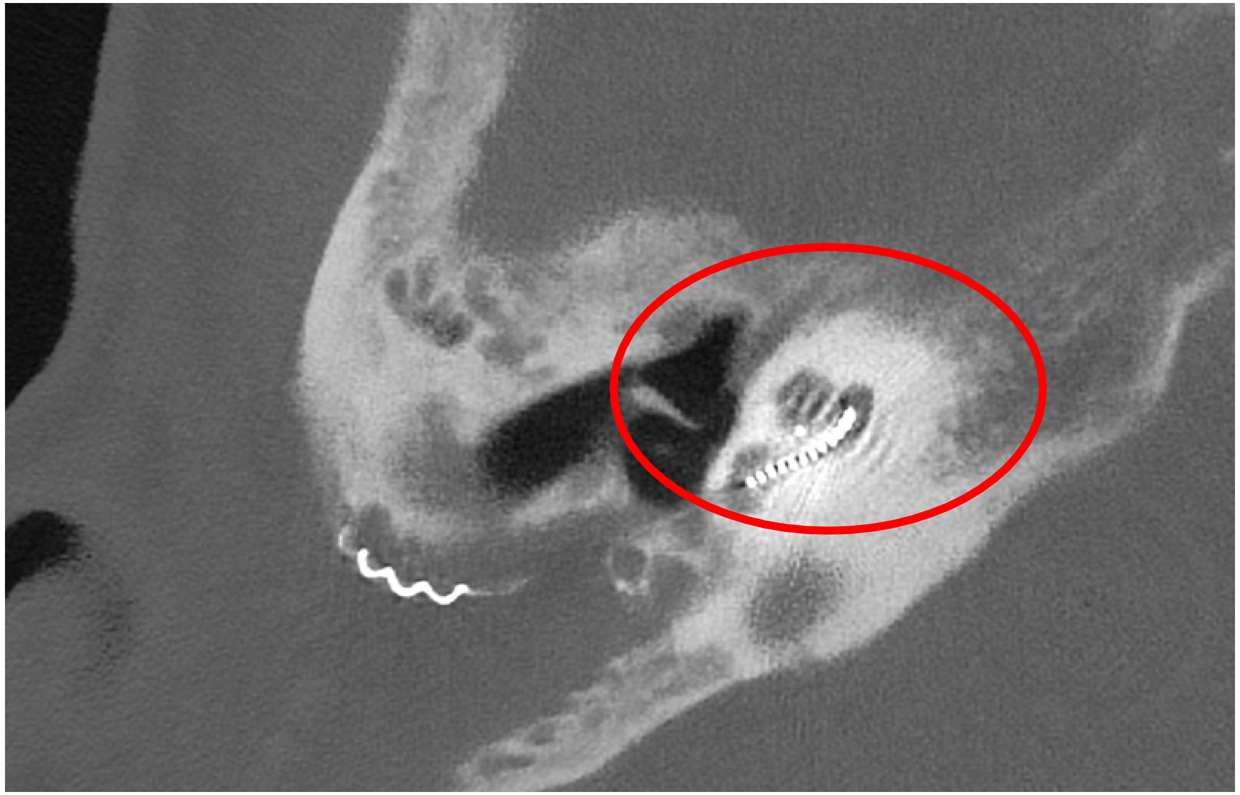
- Post-implant CT – Standard (0.4mm)

New high resolution photon counting CT imaging

- Post-implant CT – Photon-counting



- Contact 0.475x0.5mm; $0.15mm^2$



Potential to detect new bone formation