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Neurophysiological Changes Underlying Inhibitory Control in Mild Age-Related Hearing Loss

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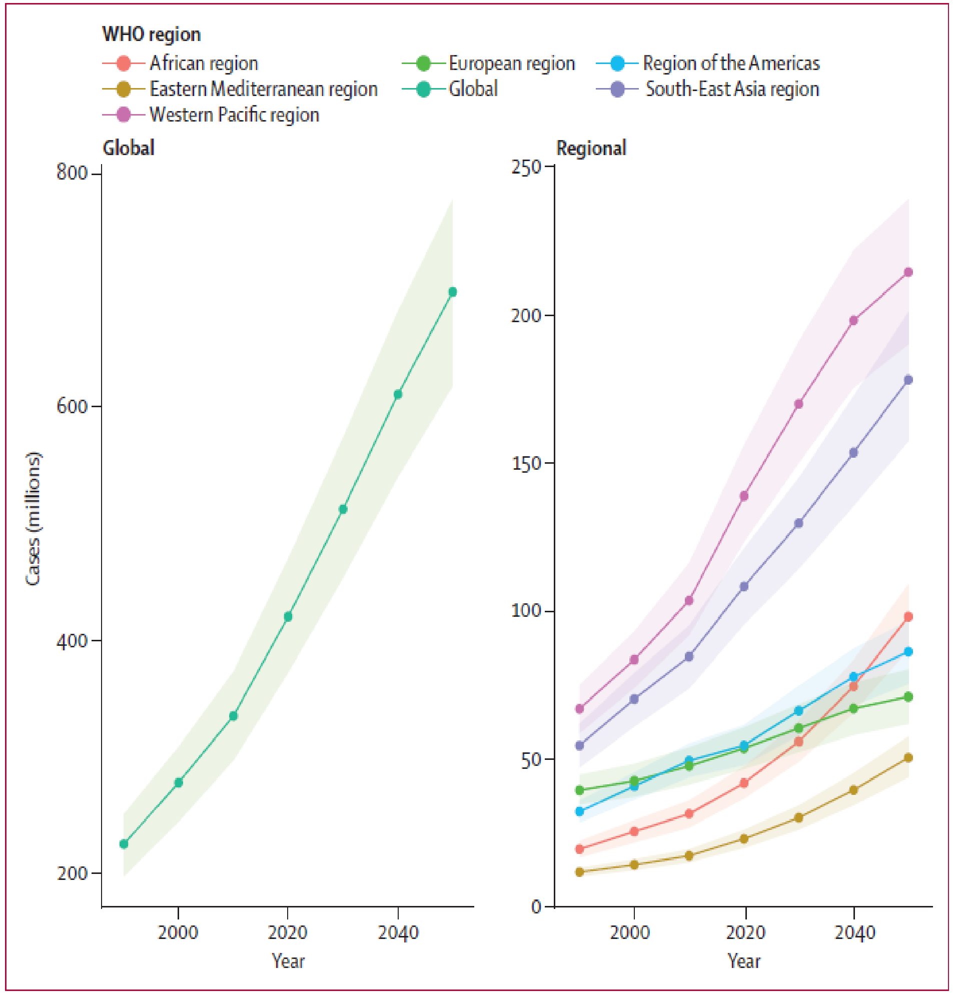
- Areas of expertise/interest
  - Aging
  - Hearing loss
  - Cognition
  - Audiology
  - Auditory cognitive neuroscience

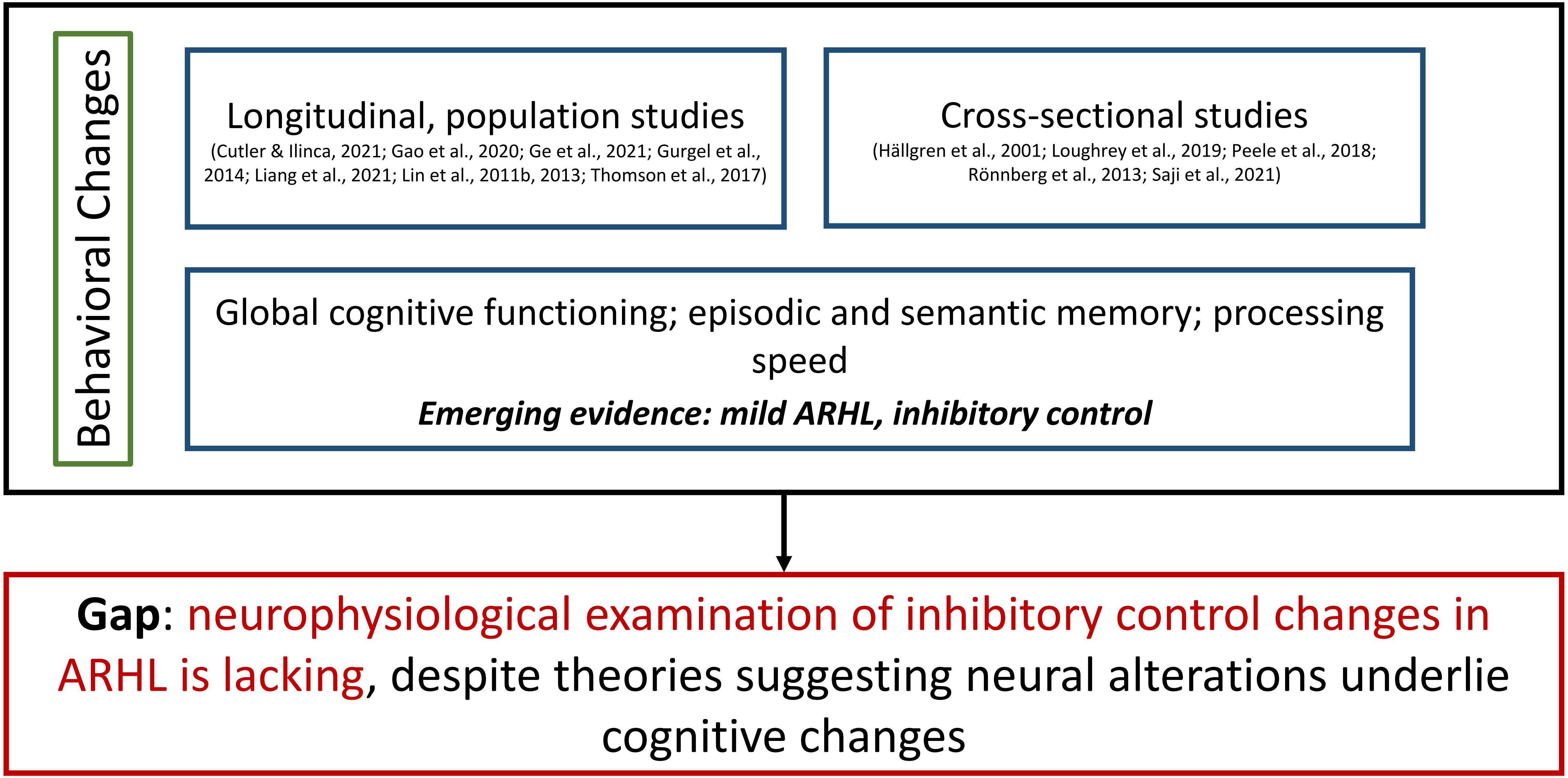
Age-Related Hearing Loss (ARHL)

- ~400 million live with hearing loss
  - Age-Related Hearing Loss (ARHL): Gradual loss of hearing with age (Cruickshanks et al., 2003; NIDCD, 2018)
    - *Most prevalent* (Haile et al., 2021)
    - Leading cause of Global Years Lived with Disability (GLDs)
- By 2050: ~700 million
  - ARHL leading cause



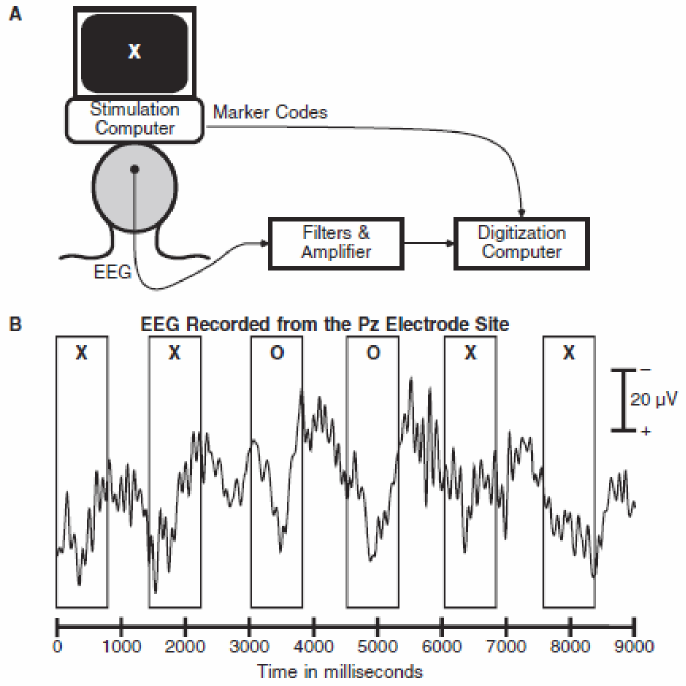
Prevalence of hearing loss 35 dB or greater, 1990-2019,with forecasts to 2050, by WHO region. Retrieved from Haile et al. (2021)

Cognitive Alterations in ARHL



Event-Related Encephalography (EEG)

- Captures neural activity time-locked to specific events (e.g., stimuli of inhibitory control paradigm)
- Real-time changes in neurophysiological mechanisms underlying cognitive processes
- **Current Study**:
    - Primary Aim: Used EEG to examine neurophysiological changes corresponding to inhibitory control tasks in those with unaided mild ARHL relative to normal hearing controls with comparable age- and education.
    - Secondary Aim: Association between speech-in-noise recognition, a common problem reported by those with ARHL, and EEG correlates of inhibitory control

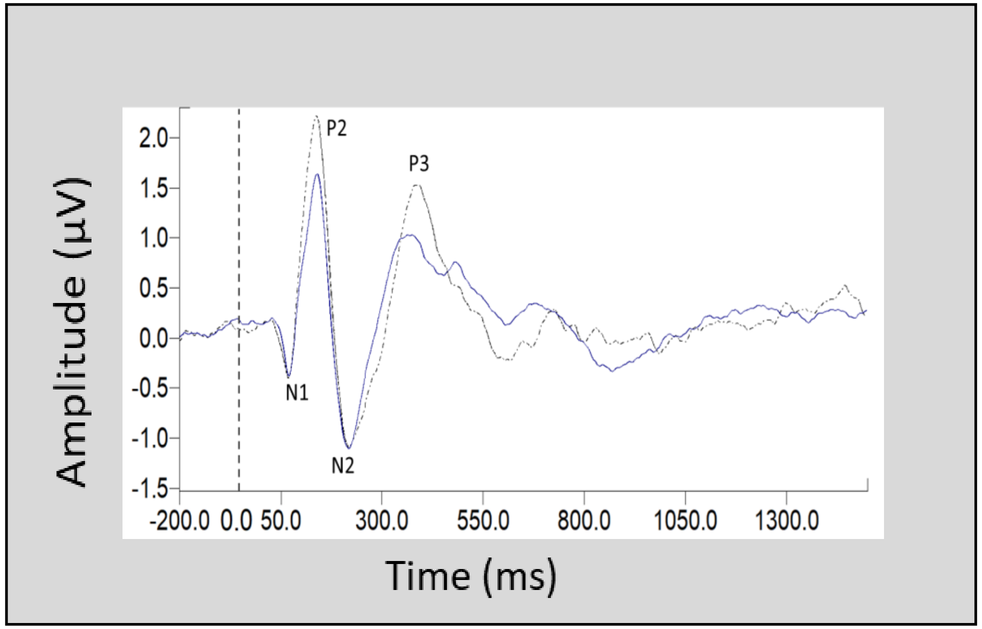


Source: Luck, S. J. (2005). An introduction to event-related potential technique

EEG Analyses

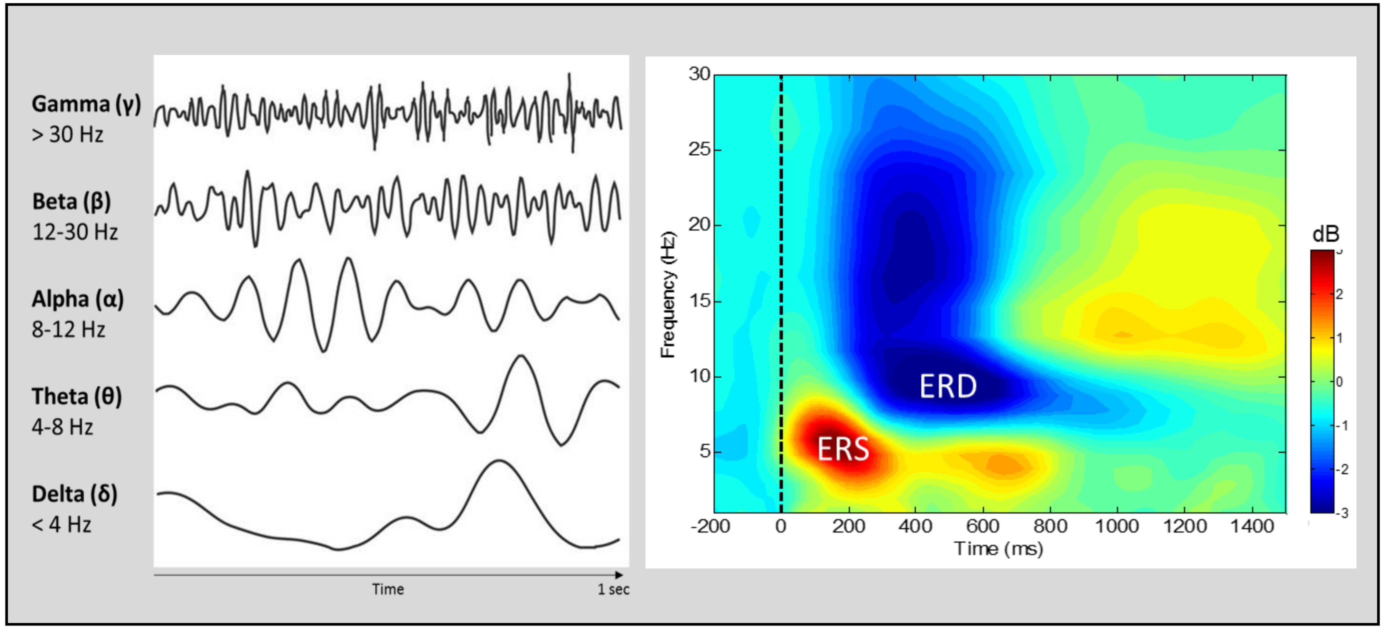
Event-Related Potentials (ERPs) *Time* (Hillyard & Allo-Vento; Luck, 2005; Woodman, 2010)	Event-Related Spectral Perturbation (ERSPs) *Frequency and Time* (Klimesch et al., 1997; Makeig, 1993; Pfurtscheller & Klimesch, 1992)

Latency and amplitude



Mean power

- Event-related synchronization (ERS)
- Event-related desynchronization (ERD)



Methods

Participant Demographics

	ARHL	NH	*p*
Total N	17	25	--
Age (years)	67.18 (7.26)	66.04 (7.05)	.615
Education (years)	17.82 (3.48)	17.20 (2.30)	.489
Sex	13F/4M	17F/8M	.406

Quick Speech-in-Noise Test

(QuickSIN, Killion et al., 2004)

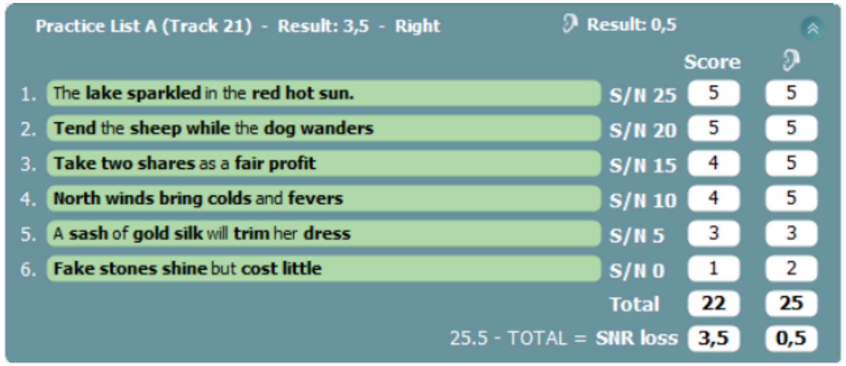
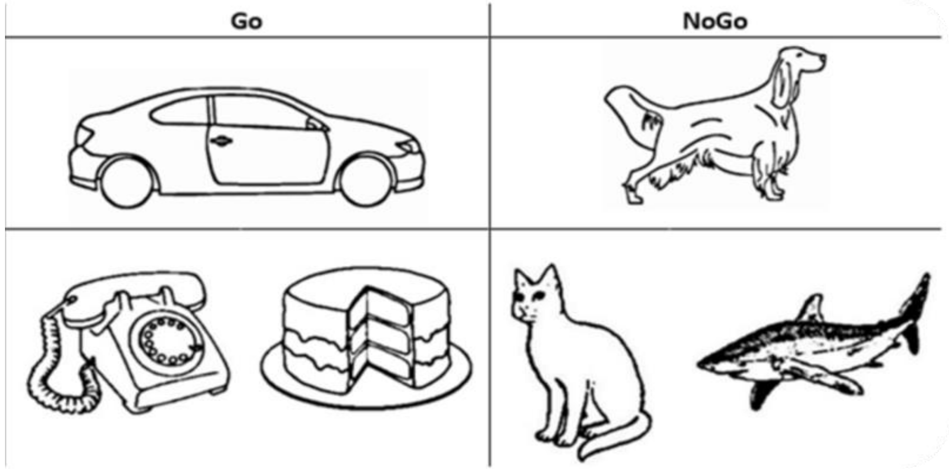


Image: Interacosutics.com

Go/NoGo Tasks (Maguire et al., 2009, 2011; Mudar et al., 2015)

Single-Car Task

Object-Animal Task



Instruction: "You are going to see some dogs/animals and cars/objects. When you see a dog/animal, do not push the button. Press the button for anything that is not a/an dog/animal. Be as quick and as accurate as possible".

Car/Objects (Go Item): 160 Trials (80%)
Dog/Animals (NoGo Item): 40 Trials (20%)

Stimulus Presentation
Duration: 300 ms
Fixation ("+"): 1,700 ms

EEG Acquisition

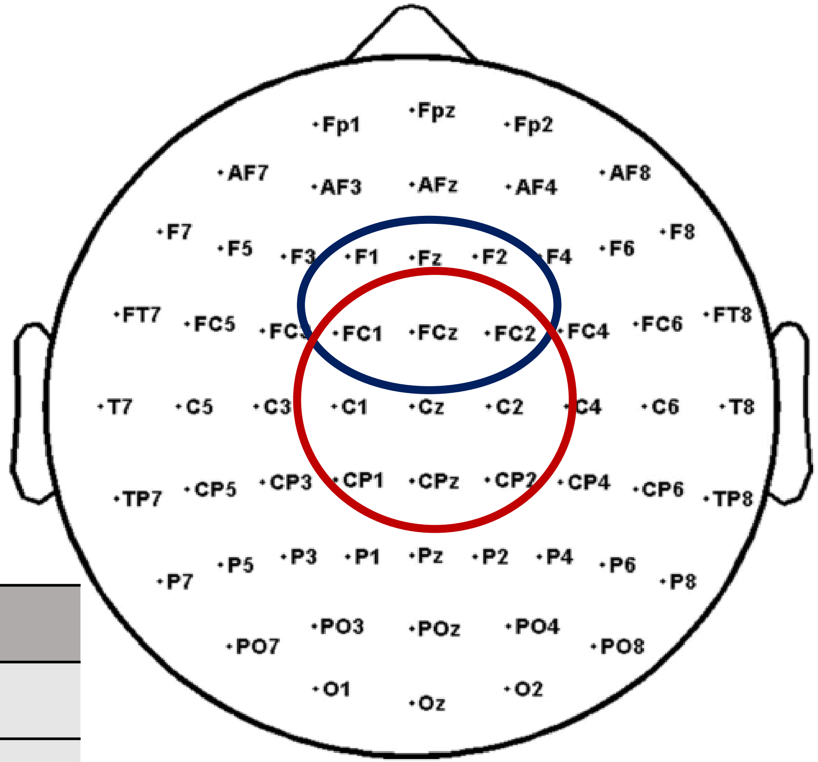
- Continuous EEG is recorded during Go/NoGo task using 64-electrode Neuroscan Quik-cap
- Neuroscan EEG system
  - Neuroscan SynAmpsRT amplifier (sample rate: 1000 Hz, bandpass filter: DC-200 Hz)
  - Scan v4.5 software
- Reference electrode between Cz and CPz; electrode impedances < 10 kΩ
- Vertical electrooculogram: above and below left eye

EEG Pre-Processing

- Neuroscan edit will be used to process raw EEG offline
- Identification of poorly functioning electrodes; removed from analyses
- Eye blinks correction
- Data epoching: -500 to 1500 ms
- Epochs with amplitudes > 75 µV: rejected
- Epochs will then be re-referenced to average potential of whole scalp

ERP Analyses

- Neuroscan Edit
- Baseline correction: -500 to 0
- Interpolation of data to sites of bad electrodes
- ERP averages created separately for trials (Go/NoGo); task (Single-Car/Object-Animal)



	N2*	P3*
Time-window	150 to 300 ms	250 to 600 ms
Electrode sites	• Average of six • Frontal (F1, Fz, F2) • Frontocentral (FC1, FCz, FC2)	• Average of nine • Frontocentral (FC1, FCz, FC2) • Central (C1, Cz, C2) • Centroparietal (CP1, CPz, CP2)

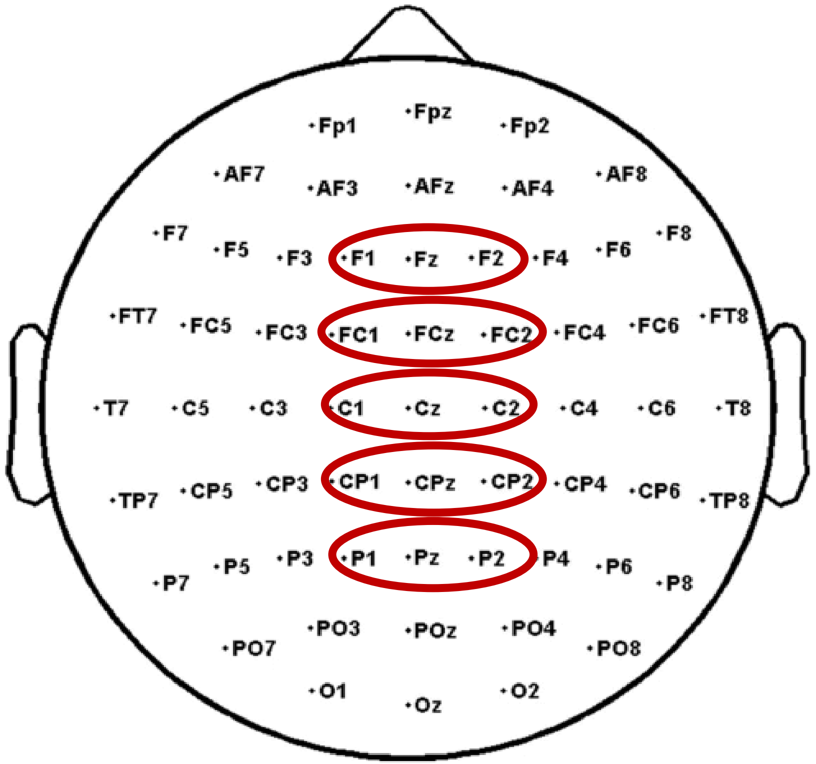
***ERP Measures**: Latency and Amplitude*

*Maguire et al. (2009, 2011); Mudar et al. (2015)

ERSP Analyses

- EEGLAB toolbox with *newtimef.m* function (Delorme & Makeig, 2004)
- Short-time Fourier transform, Hanning window tapering
- 512 ms sliding window, 10 ms step size, pad ratio of 2 ≈ 1 Hz frequency resolution
- Baseline correction using gain model (Grandchamp & Delorme, 2011)

Time-windows (ms)	• 150-300 ms • 300-650 ms
Electrode clusters*	• Frontal (F1, Fz, F2) • Frontocentral (FC1, FCz, FC2) • Central (C1, Cz, C2) • Centroparietal (CP1, CPz, CP2) • Parietal (P1, Pz, P2)
Measures*	• Event-related synchronization: theta band (4-7 Hz) • Event-related desynchronization: low (8-10 Hz) and high-frequency (11-13 Hz) alpha band



*Lydon et al. (2022); Mudar et al. (2019); Nguyen et al. (2017)

Statistical Analyses

- General Linear Models (GLMs)
  - Separate for Single-Car and Object-Animal task

- Behavioral Data (accuracy)
  - Between-subject: group (ARHL/NH)
  - Within-subject: trial type (Go/NoGo)

- ERP Data (N2, P3 latency and amplitude)
  - Between-subject: group (ARHL/NH)
  - Within-subject: trial type (Go/NoGo)

- ERSP Data (Theta synchronization; low- and high-alpha desynchronization)
  - Between-subject: group (ARHL/NH)
  - Within-subject: trial type (Go/NoGo)

- Alpha at .05
- Bonferroni corrections for multiple comparisons

Statistical Analyses

Associations

- Partial Pearson's correlations
  - Binaural QuickSIN score - ERP/ERSP measures
  - Control variable: Better-ear PTA (measure of peripheral hearing)
- *<u>Guided by findings of group differences</u>*
  - Correlations with ERP/ERSP measures where significant effects of group and/or interactions between group and trial observed

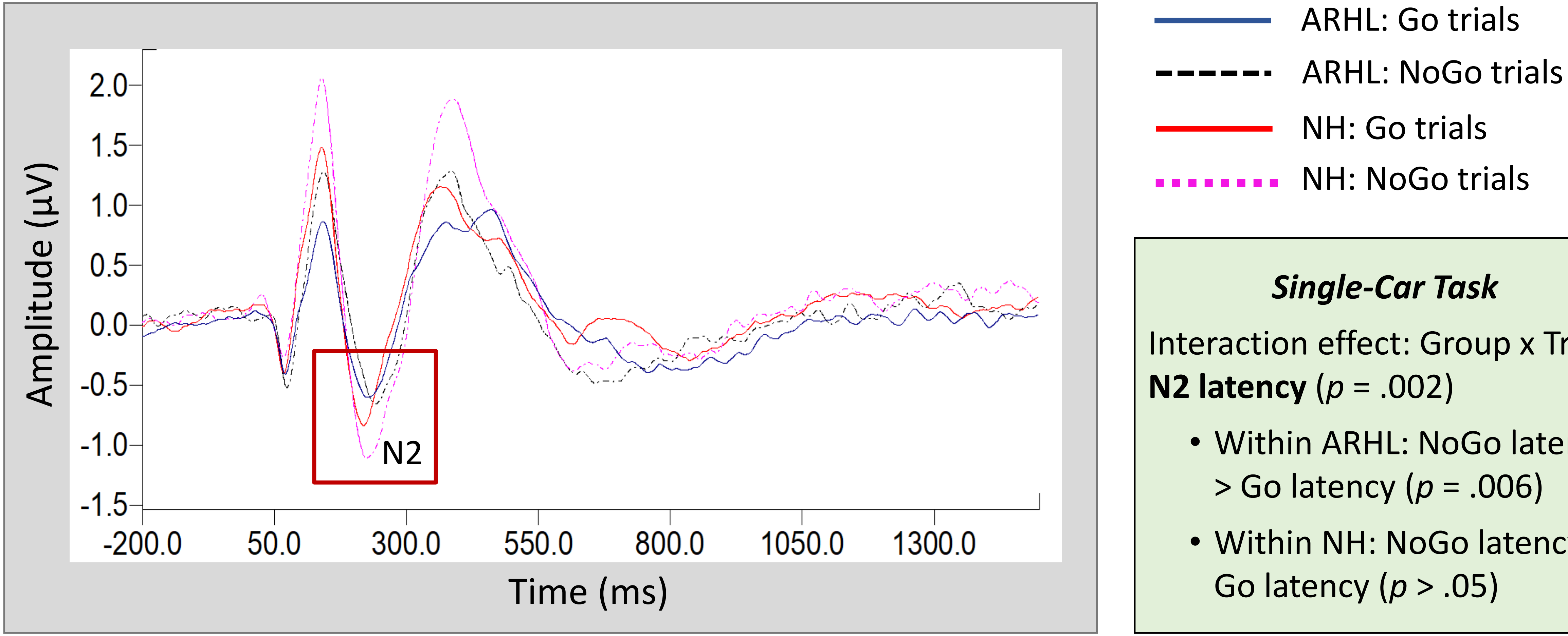
Behavioral Data: Accuracy

- Interaction effect: Group x Trial in Single-Car Task ($p = .019$)
  - Within ARHL: NoGo < Go ($p < .001$)
  - Within NH: NoGo ≅ Go ($p > .05$)

ARHL Group: Alterations in inhibiting responses to NoGo trials relative to Go trials

Impaired inhibitory control tied to perceptual processing in unaided mild ARHL

N2 ERP Latency, 150-300 ms

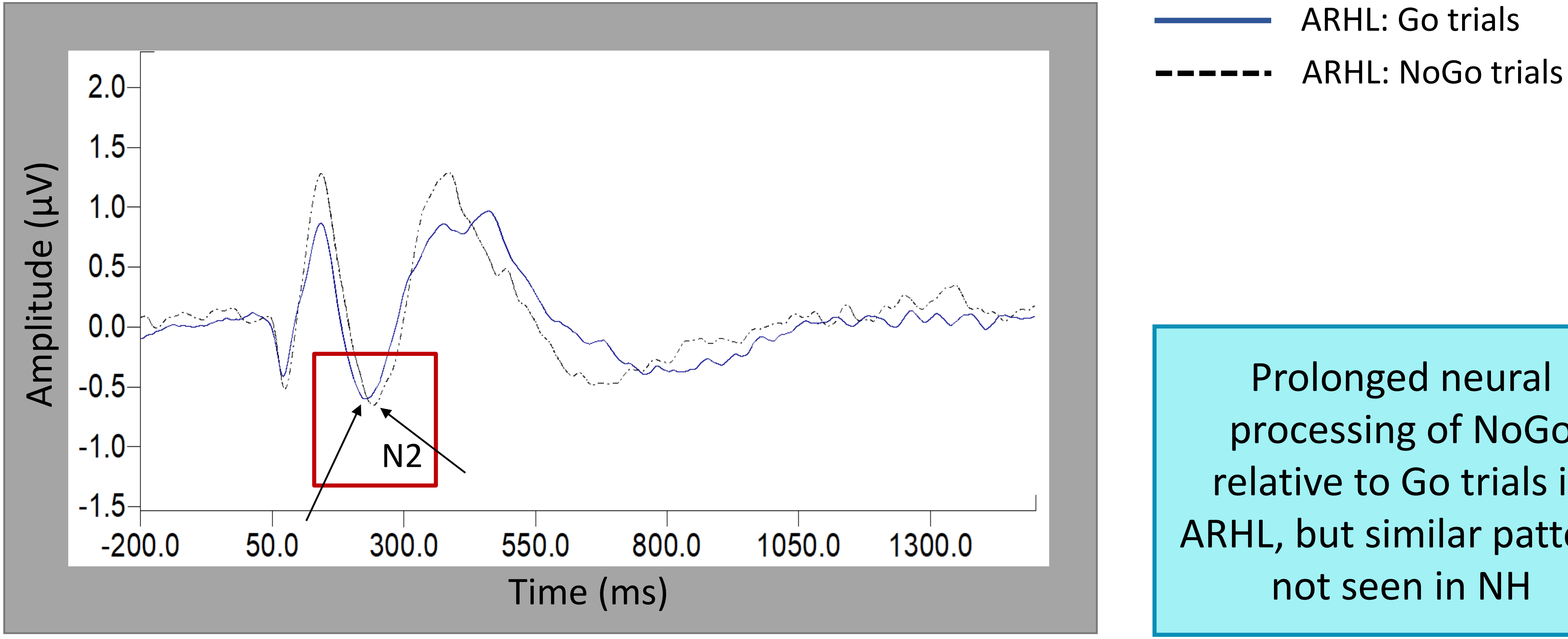


Single-Car Task

Interaction effect: Group x Trial, **N2 latency** (*p* = .002)

- Within ARHL: NoGo latency > Go latency (*p* = .006)
- Within NH: NoGo latency ≅ Go latency (*p* > .05)

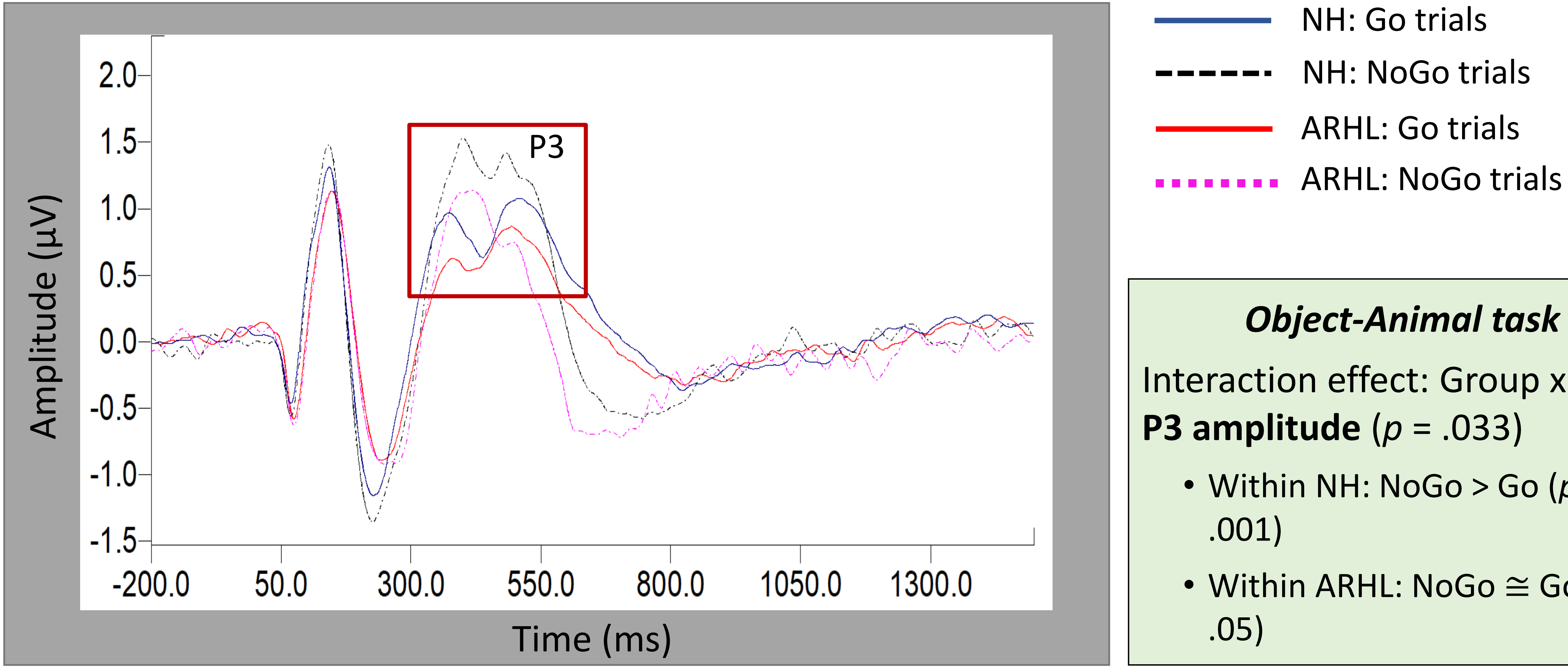
N2 ERP Latency, 150-300 ms



Single-Car Task

Prolonged neural processing of NoGo relative to Go trials in ARHL, but similar pattern not seen in NH

P3 ERP Mean Amplitude, 250-600 ms

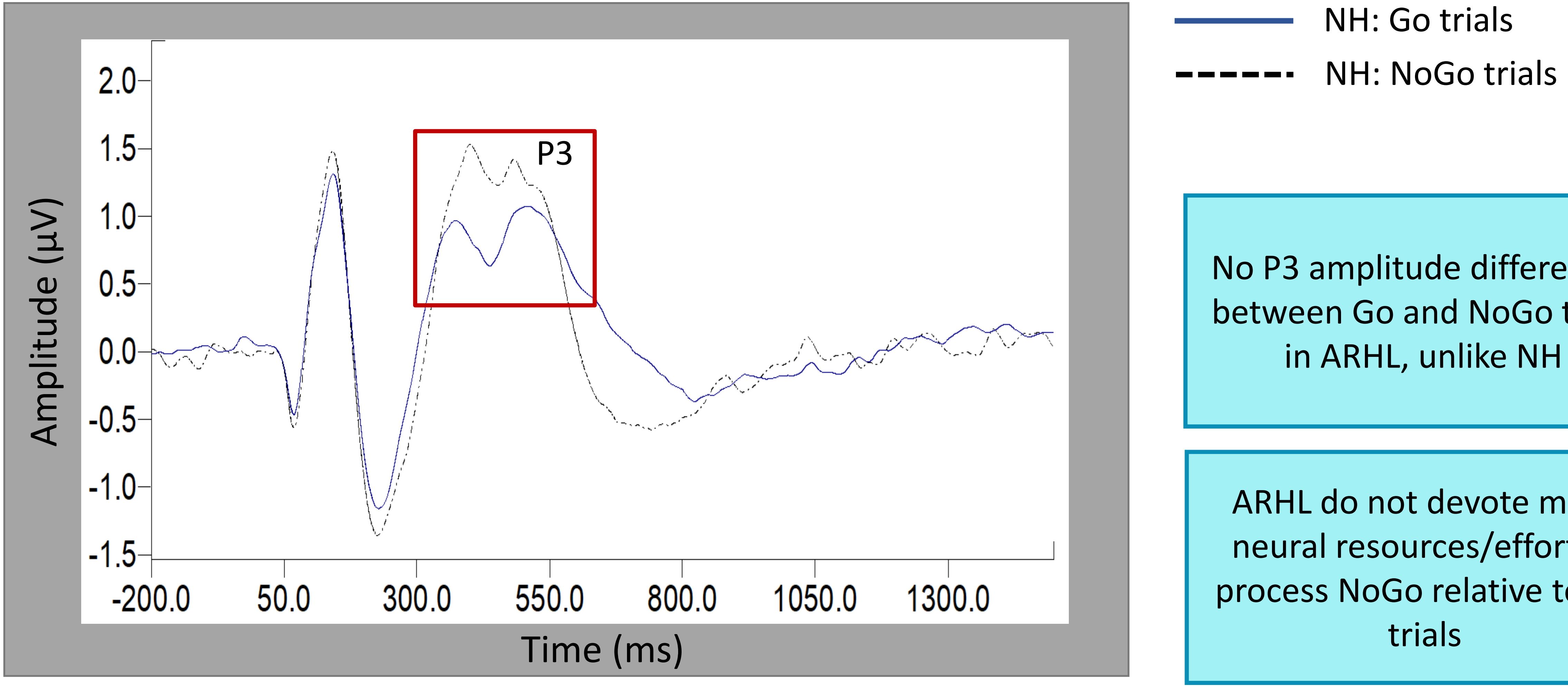


Object-Animal task

Interaction effect: Group x Trial, **P3 amplitude** (p = .033)

- Within NH: NoGo > Go ($p < .001$)
- Within ARHL: NoGo ≅ Go ($p > .05$)

P3 ERP Mean Amplitude, 250-600 ms



No P3 amplitude differences between Go and NoGo trials in ARHL, unlike NH

ARHL do not devote more neural resources/effort to process NoGo relative to Go trials

High-Frequency Alpha Desynchronization, 300-650 ms

Single-Car Task

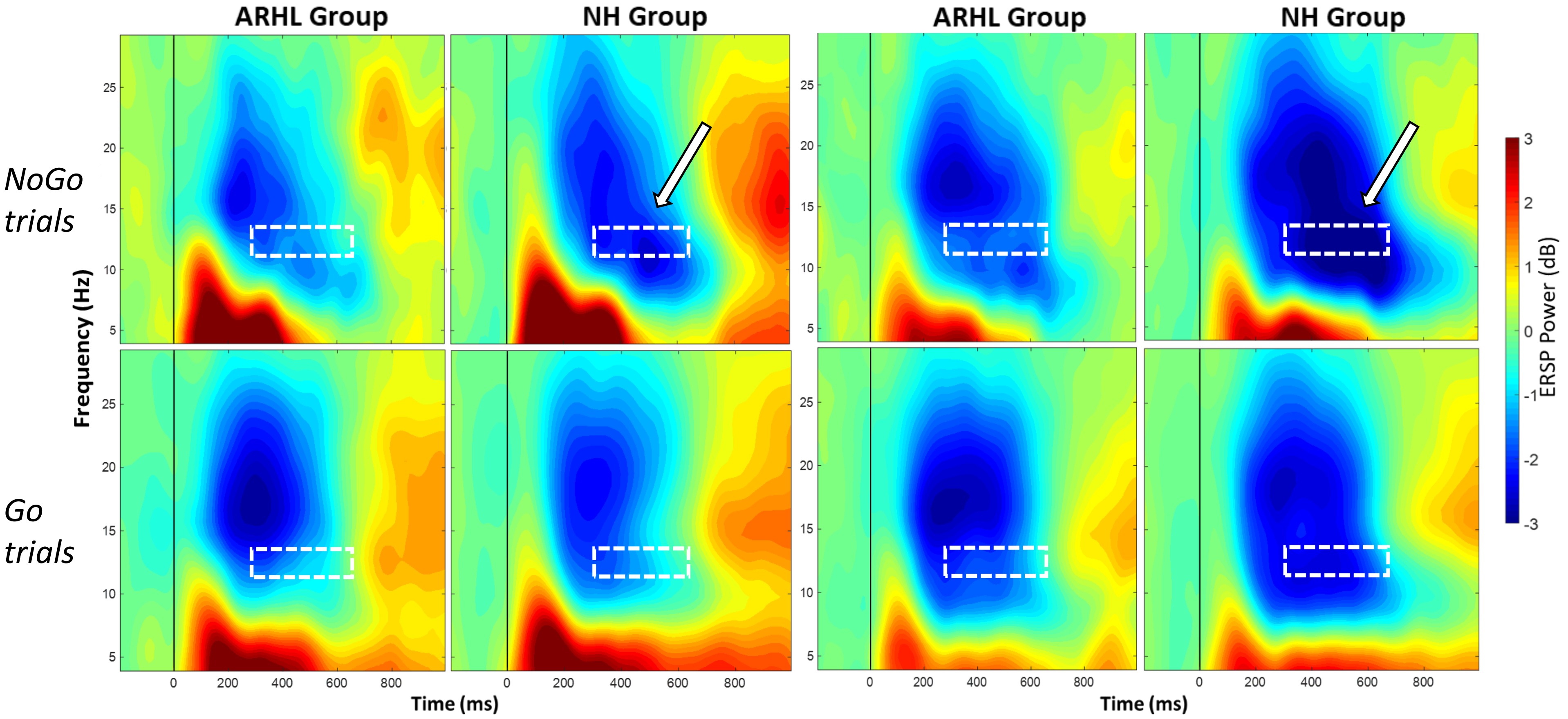
- Interaction effect: Group x Trial (300-650 ms; $p = .019$)
  - Within NH: NoGo > Go ($p < .001$)
  - Within ARHL: NoGo ≅ Go ($p > .05$)

Object-Animal Task

- Interaction effect: Group x Trial (300-650 ms; $p = .002$)
  - Within NH: NoGo > Go ($p < .001$)
  - Within ARHL: NoGo ≅ Go ($p > .05$)

No high-frequency alpha desynchronization differences between Go and NoGo trials in ARHL, unlike NH

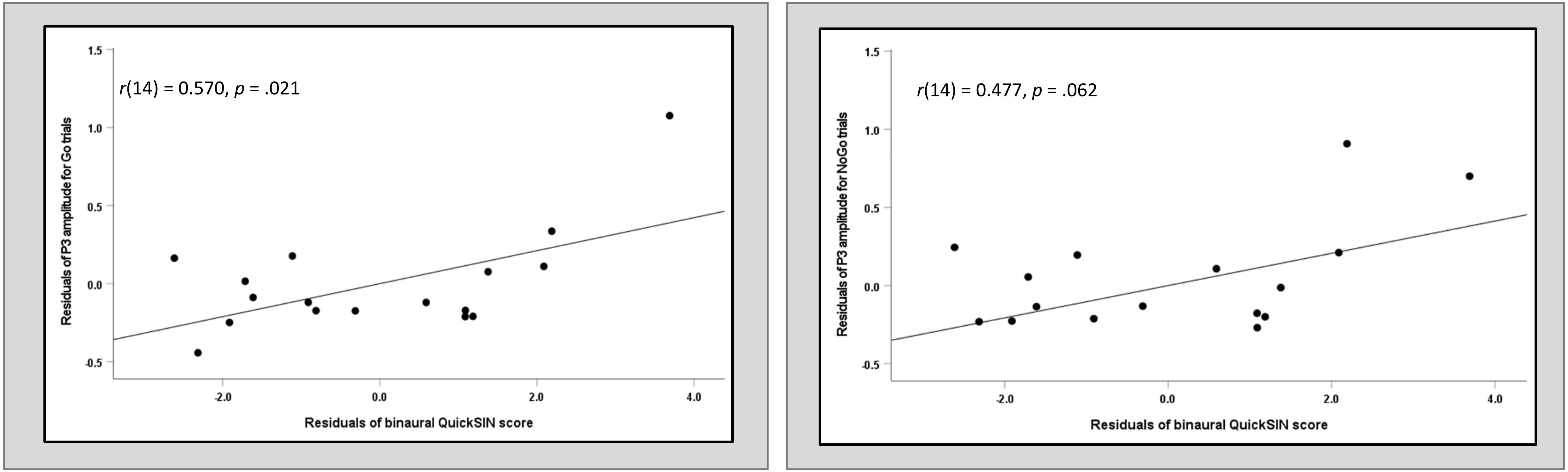
ARHL do not devote more neural resources/effort to process NoGo relative to Go trials



Single-Car Task; Frontocentral Electrodes

Object-Animal Task; Central Electrodes

QuickSIN and P3 ERP in ARHL



Within ARHL group, worse central hearing related to increased neural effort/resources for performing inhibitory control task

Conclusion

- Different neural processing patterns across Go and NoGo trials in mild ARHL and NH groups
  - Neural differentiation for trial type seen early on in ARHL, although this differentiation not maintained in later time periods of processing
- Even mild ARHL affects neurophysiological mechanisms underlying inhibitory control
- Neurophysiological alterations observed even on visual tasks → modality-independent changes in inhibitory control in mild ARHL
- In ARHL, those with worse SiN recognition tend to exhibit greater neural effort/resources to perform inhibitory control task

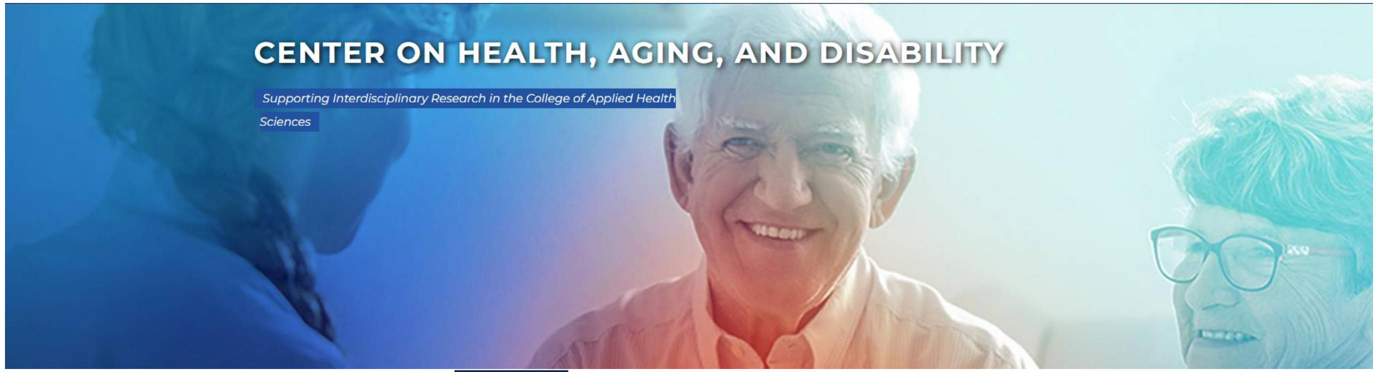
Limitations

- Small sample size
- Unequal groups
  - No 1:1 age- and education-matching of groups
- Future work examining visual inhibitory control is needed to examine the replicability of current findings

THANK YOU!

OUR PARTICIPANTS

American Speech-Language-Hearing
FOUNDATION



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