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Alternative Tinnitus Management Techniques Developed from Volitional Control Over the Activity of the Auditory Cortex

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Nelson, Jeremy T

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15. SUBJECT TERMS

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Alternative Tinnitus Management Techniques Developed from Volitional Control Over the Activity of the Auditory Cortex

Matthew S. Sherwood, PhD

Emily E. Diller, MS; Subhashini Ganapathy, PhD; Jeremy T. Nelson, PhD; Jason G. Parker, PhD

Tinnitus

- Lots of Debate
- Difficult to Study
  - Subjective
  - Highly Variable
- Various Models
  - Bottom-up Deafferentation
  - Top-Down Deficiencies

- Critical Gap in Treatment Technologies/Therapies

Our Therapeutic Idea

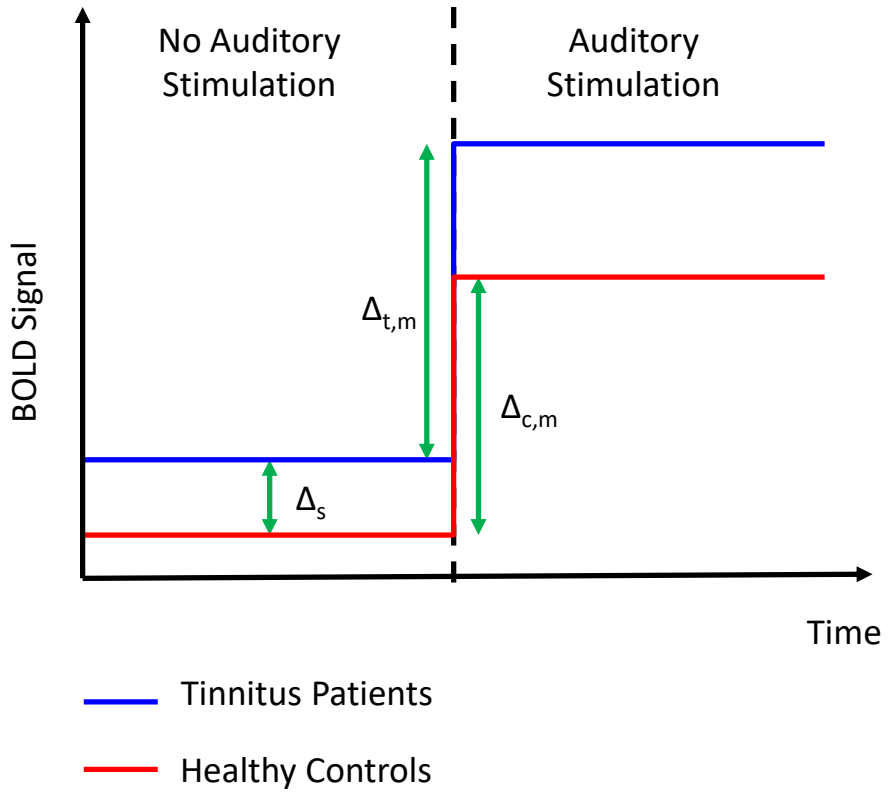
Phase 1

- Train control over the activity of the primary auditory cortex using functional MRI neurofeedback
- Assess changes in behavioral and neural measures
- Determine control methods resulting in greatest behavioral/neural effects

Phase 2

- Develop a simple application to train control methods in the absence of neurofeedback
- Determine changes in behavioral and neural measures
- Compare effects with functional MRI neurofeedback

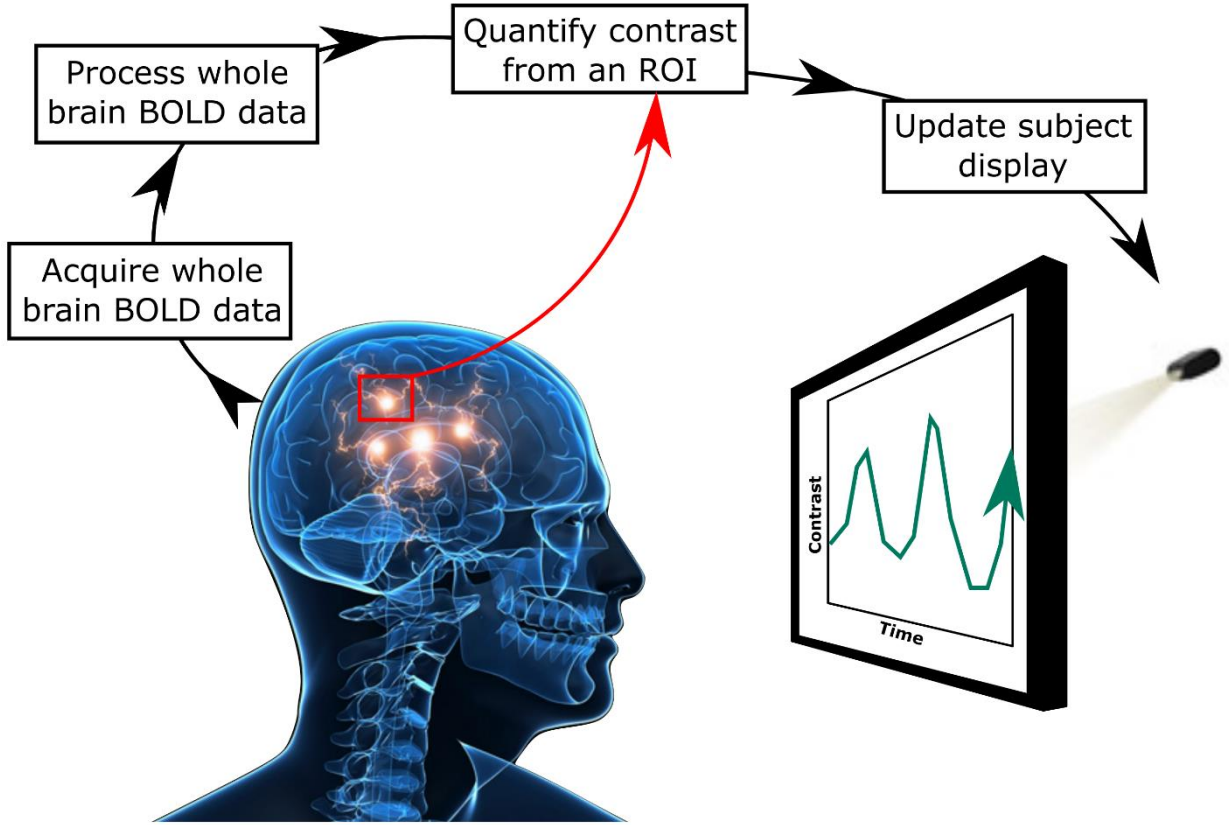
Findings from Functional Neuroimaging



- $\Delta_{t,m} - \Delta_{c,m} > 0$: Mean signal change between auditory stimulation and no stimulation is elevated in tinnitus patients[1,2]
- Δ_s: elevated steady-state metabolism[3,4]
  - Should result in increased BOLD signal and CBF
- Attentional, emotional and auditory network components are altered[5,6]

[1] Gu et al. (2010). Journal of Neurophysiology, 104(6), 3361-3370.
[2] Seydell-Greenwald et al. (2012). Brain Research, 1485, 22-39.
[3] Wang et al. (2001). Chinese Medical Journal, 114(8), 848-851.
[4] Schecklmann et al. (2013). Human Brain Mapping, 34(1), 233-240.
[5] Kim et al. (2012). International Journal of Audiology, 51(5), 413-417.
[6] Maudoux et al. (2012). PLoS ONE, 7(5), e36222.

Real-time fMRI Neurofeedback



Phase 1: Experimental Methods

27 Healthy Participants

- Written informed consent obtained prior to any experimental procedures

Grouping

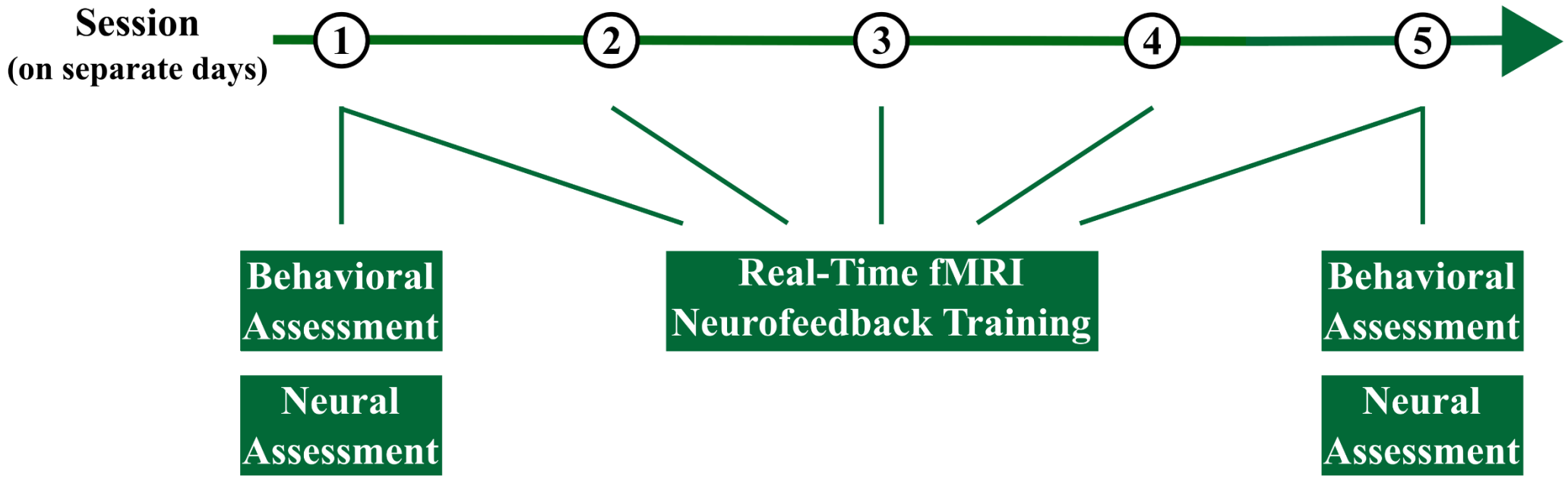
Experimental Group (EXP)

- *n* = 18 (mean age 23.2 ± 1.1 years, 11 males)
- Supplied real neurofeedback from Primary Auditory Cortex (A1)

Control Group (CON)

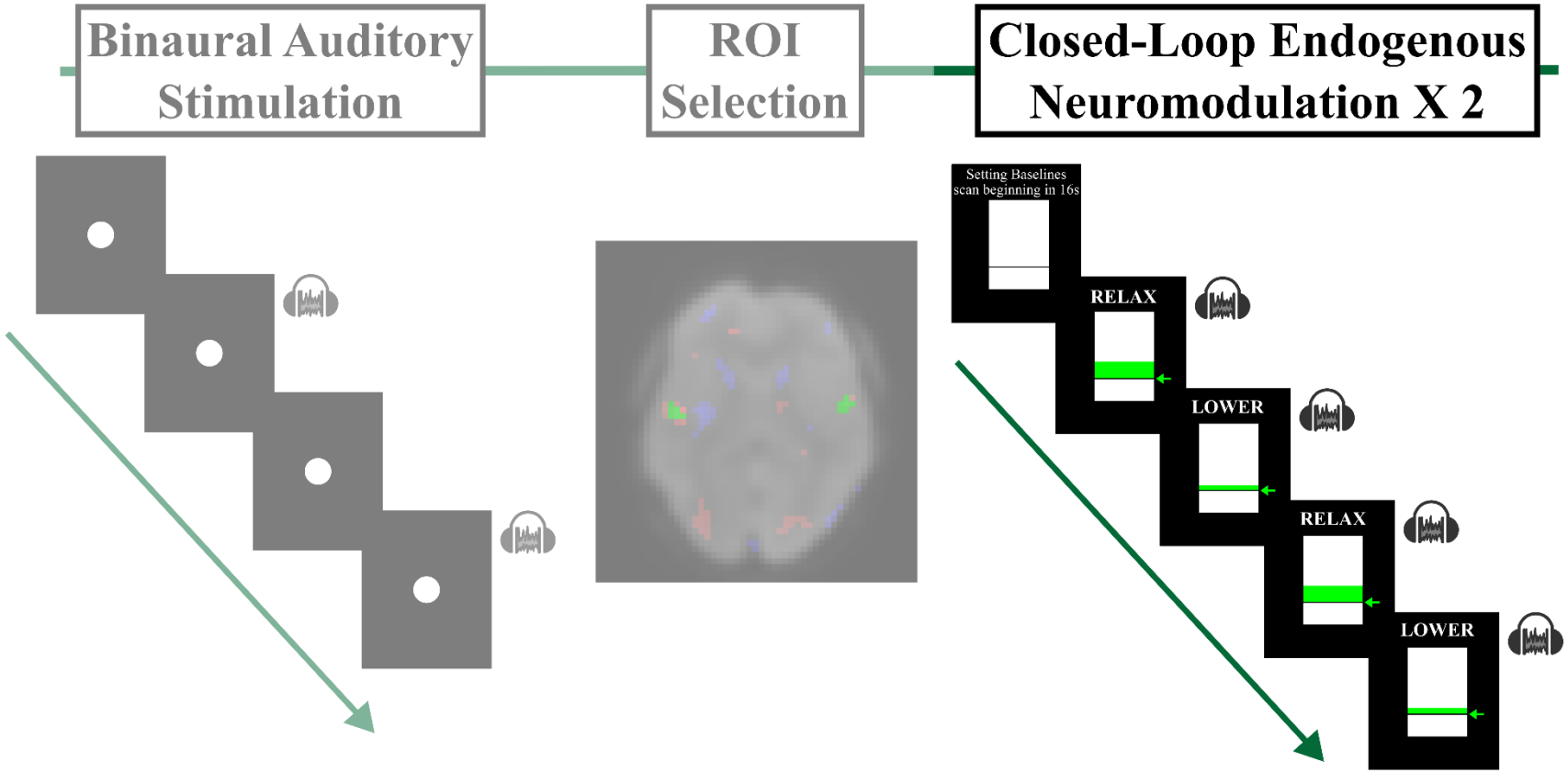
- *n* = 9 (mean age 24.4 ± 2.5 years, 4 males)
- Supplied sham neurofeedback

Phase 1: Experimental Methods (cont.)

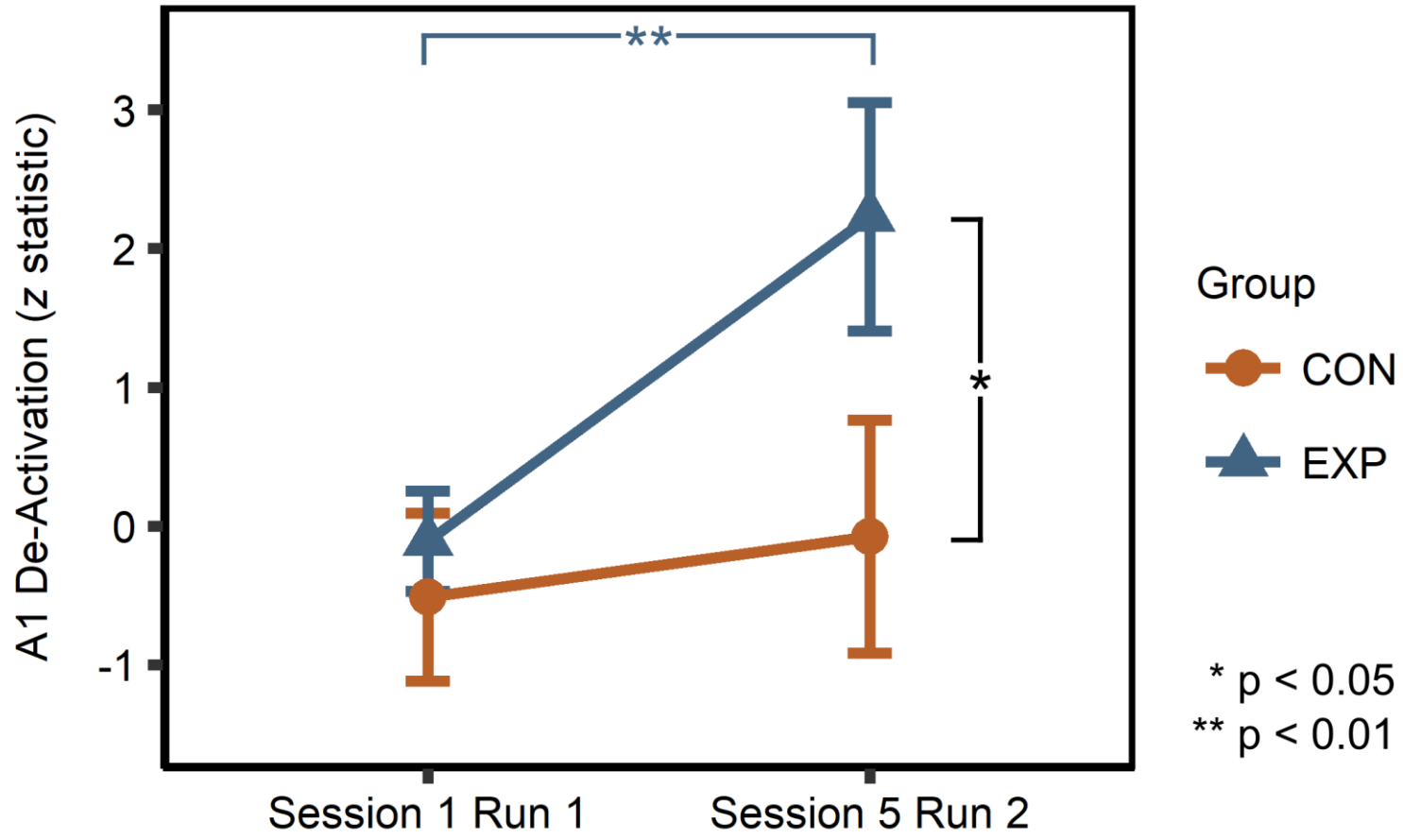


Experimental Methods (cont.)

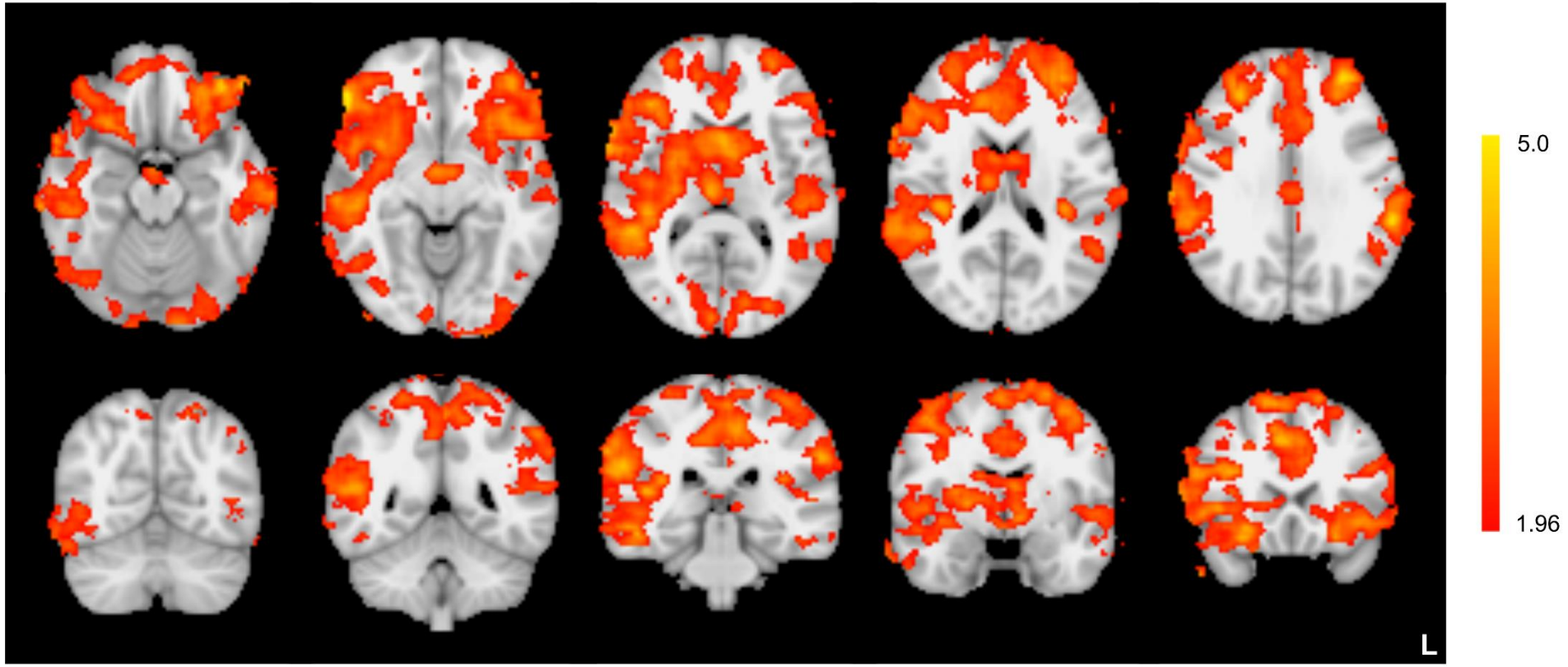
Neurofeedback Training



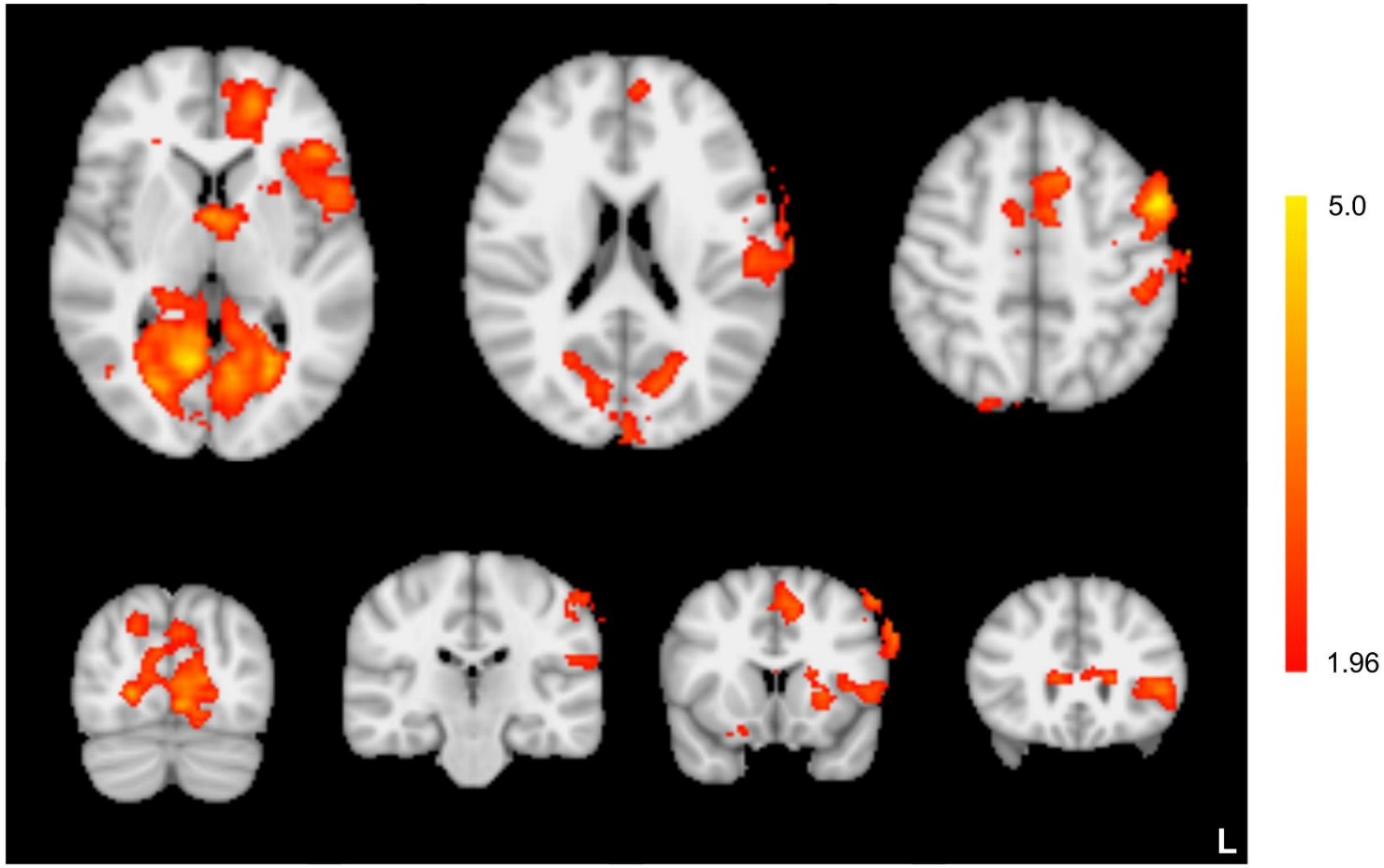
Phase 1: Results



Phase 1: Results (cont.)



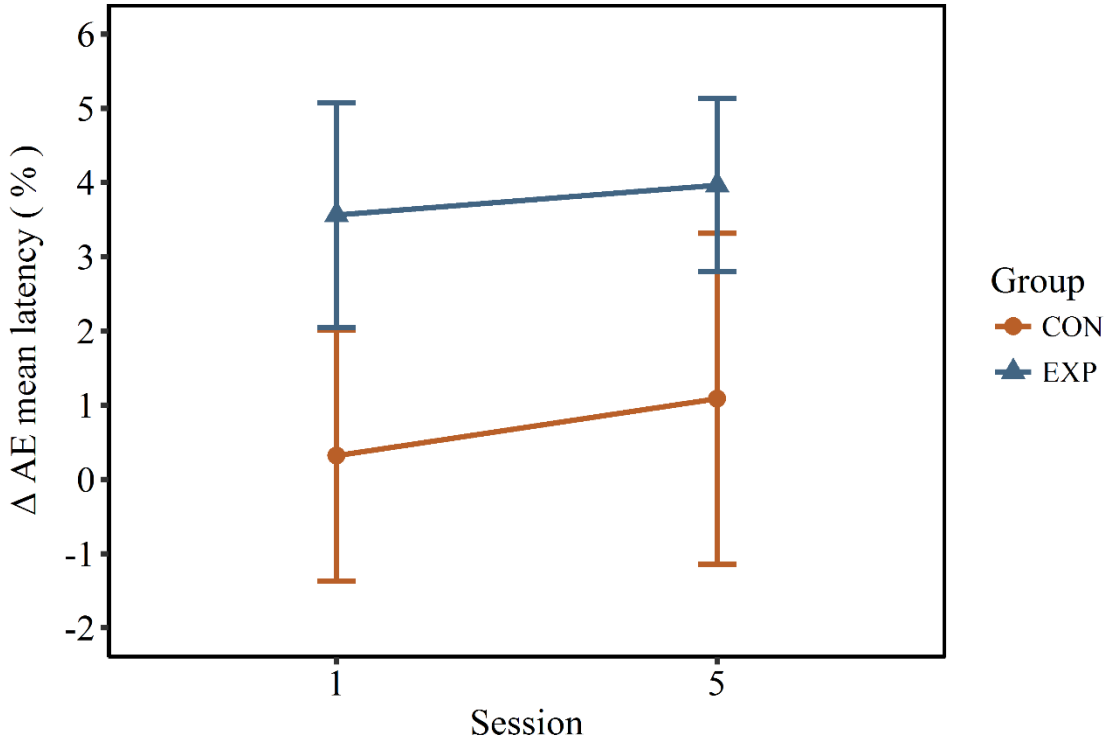
Phase 1: Results (cont.)

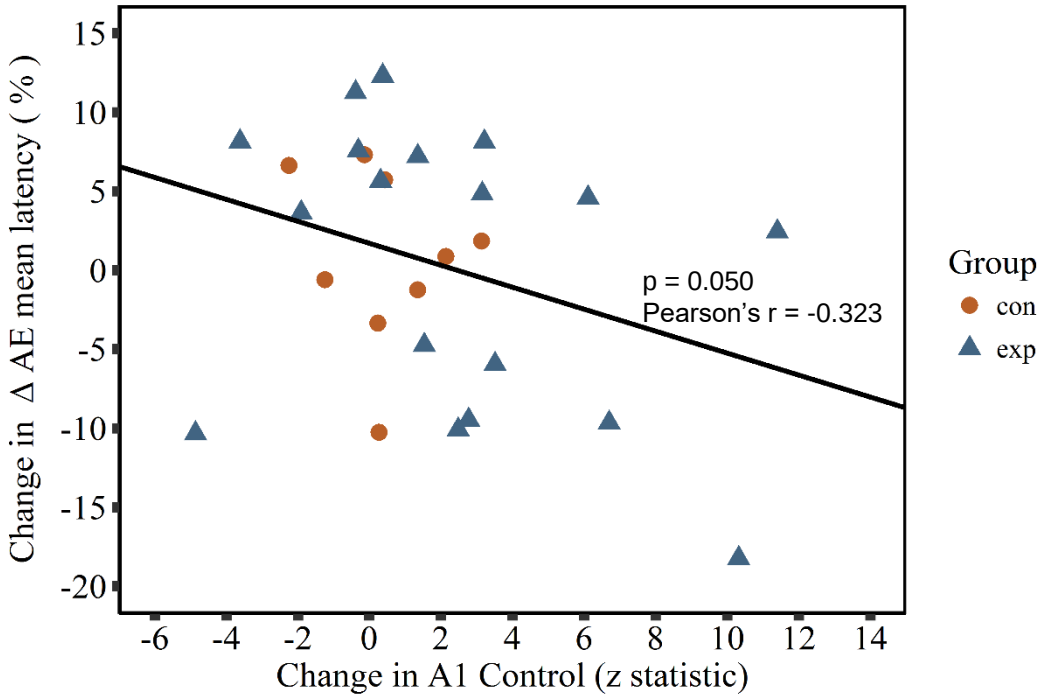


Phase 1: Results (cont.)

Attention to Emotion Task

- Assessed impact of emotion on attention
- Calculated the percent change in latency between emotional and neutral trials

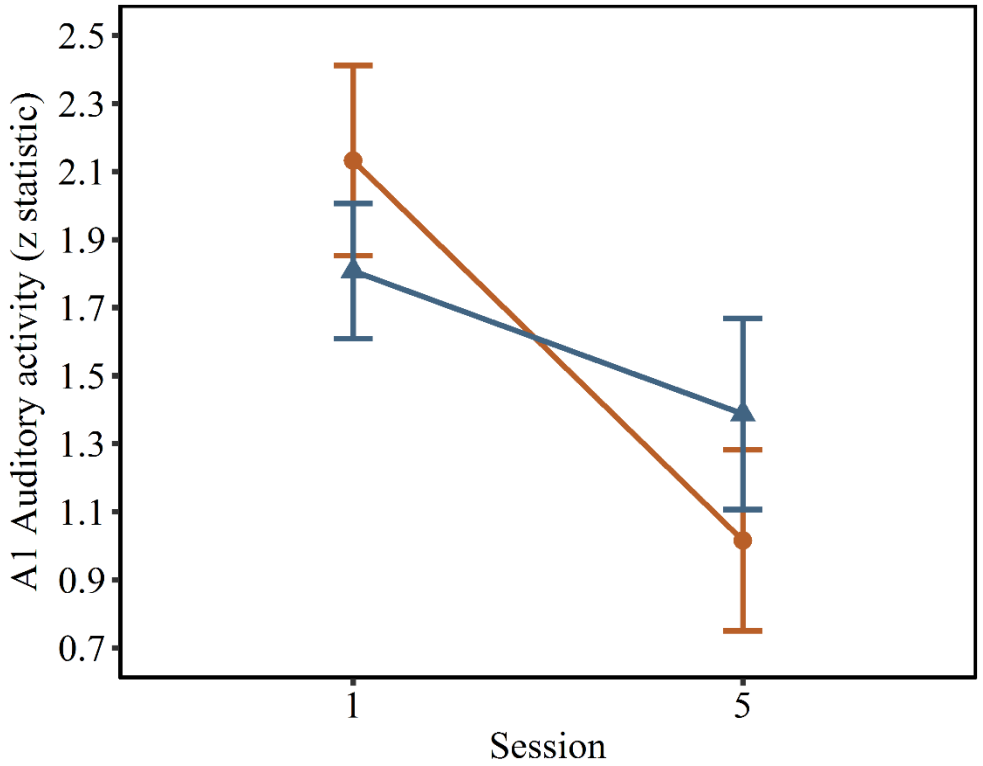




Phase 1: Results (cont.)

A1 Response to Auditory Stimulation

- Assessed A1 activation from binaural continuous noise
- Performed a 2x2x2 repeated measures ANOVA

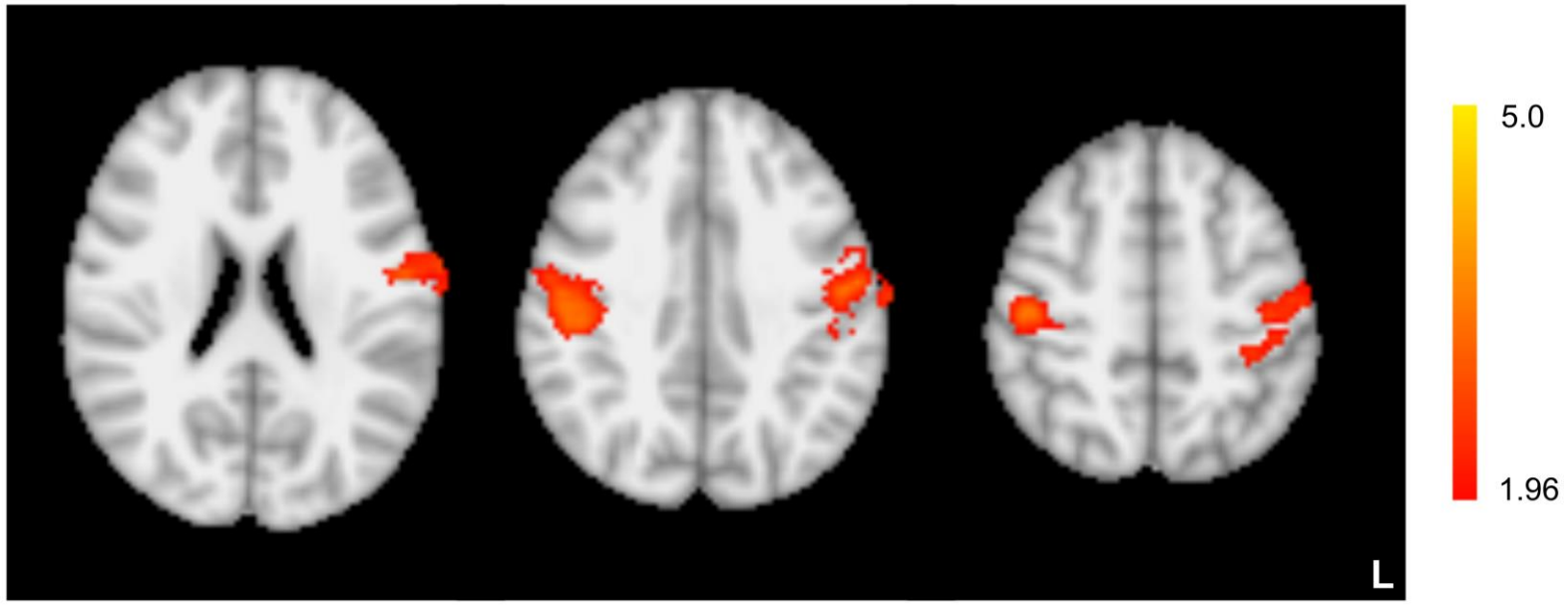


Source	Sig. (one-tailed)
Intercept	.000
Group	.478
Error	

Factor	Sig. (one-tailed)
Session	0.0115
Session * Group	0.142
Hemisphere	0.2205
Hemisphere * Group	0.1635
Session * Hemisphere	0.0975
Session * Hemisphere * Group	0.217

Phase 1: Results (cont.)

Response to Auditory Stimulation



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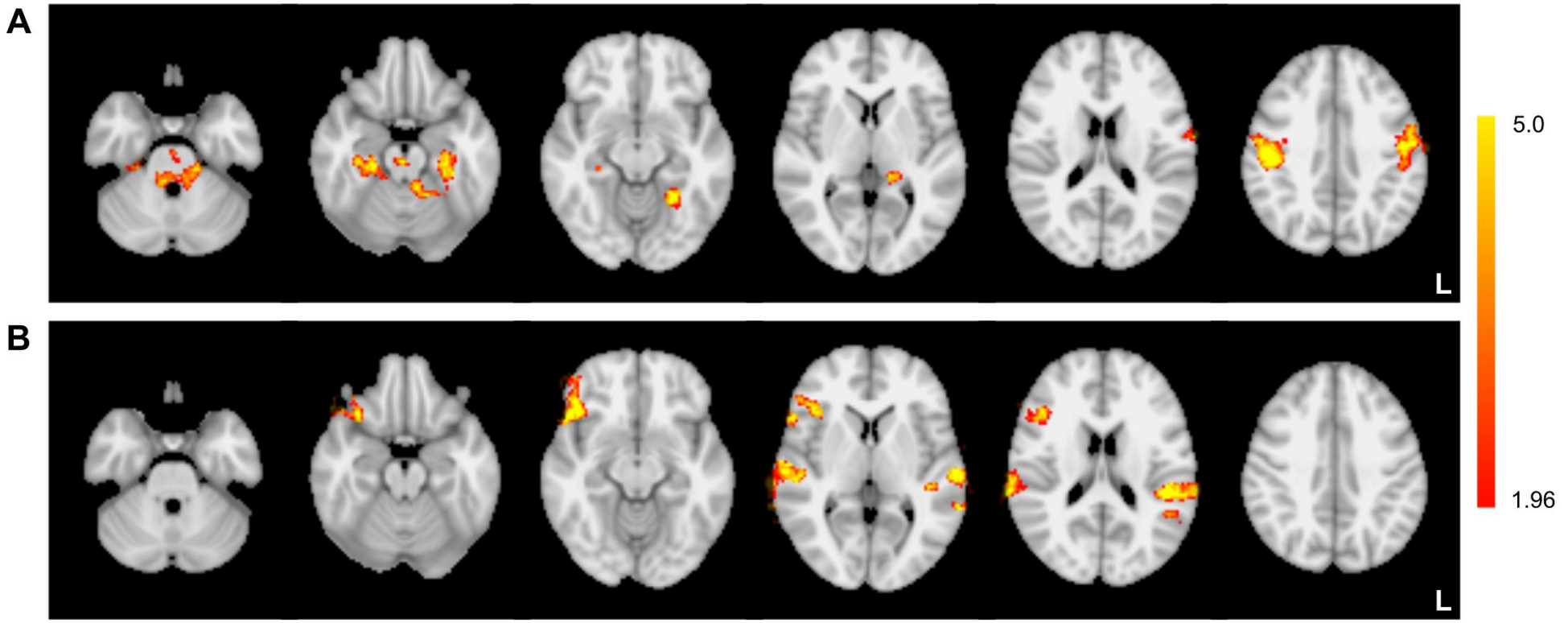
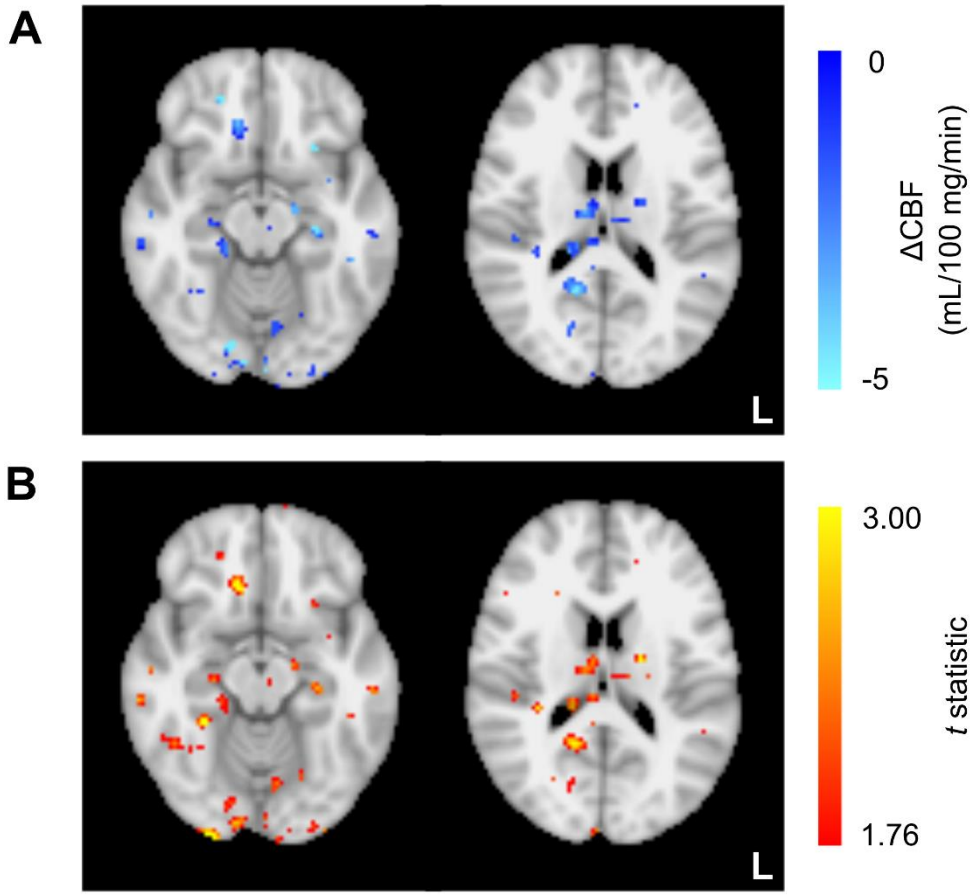
Response to Auditory Stimulation



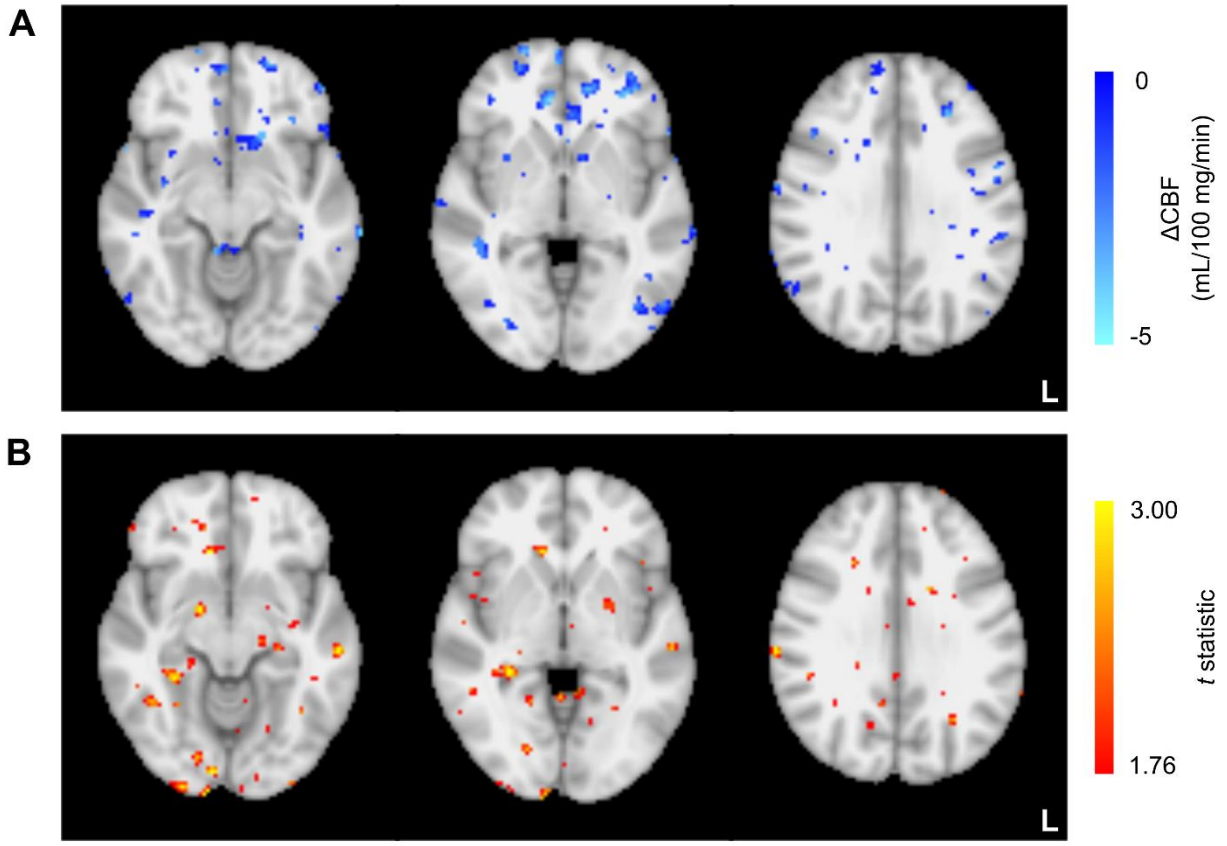
Phase 1: Results (cont.)

Steady-State Perfusion



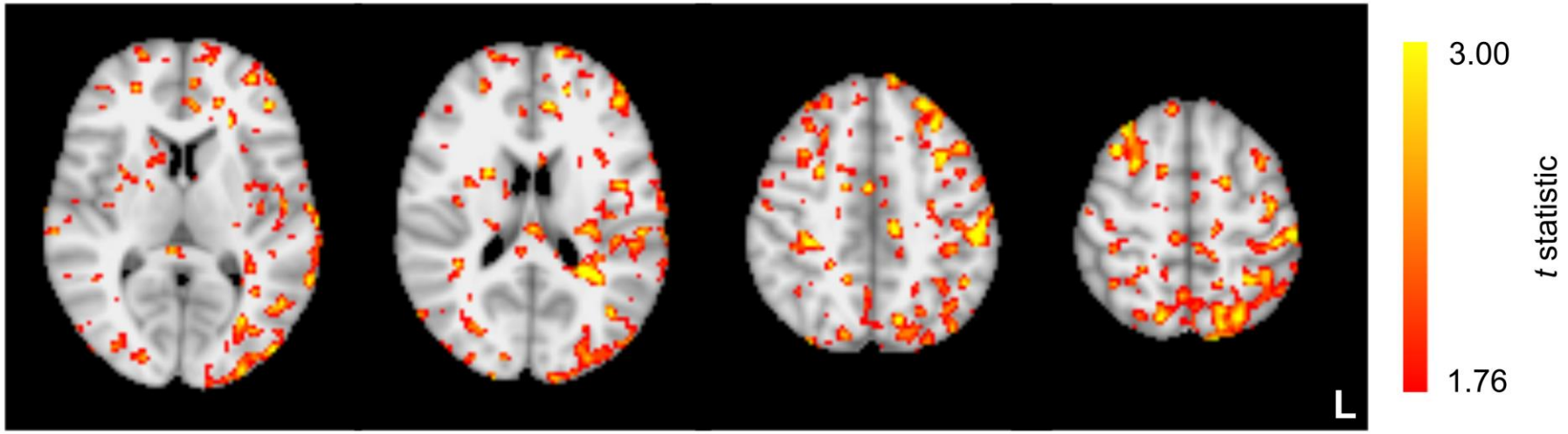
Phase 1: Results (cont.)

Steady-State Perfusion



Phase 1: Results (cont.)

Steady-State Perfusion



Phase 1: Discussion

- Previously, self-regulation via fMRI-NFT of the following have been implicated:
  - Activated cortical volume in A1 and the secondary auditory cortex[1]
  - A1 activation magnitude[2]

- This work indicates self-regulation over A1 deactivation magnitude is achievable using fMRI-NFT in the presence of auditory stimulation

[1] Yoo et al. (2006). NeuroReport, 17(12), 1273-1278.
[2] Haller et al. (2010). European Radiology, 20(3), 696-703.

Phase 1: Discussion (cont.)

- Enhanced emotional response to auditory stimulation has been reported in tinnitus patients[1,2]
  - Improved control over A1 led to a decreased effect of emotionally-charged stimuli on attention
- Tinnitus patients exhibit an elevated response in A1 activation to auditory stimuli[3,4]
  - Attempting volitional control over A1 was found to decrease the A1 activation arising from auditory stimuli
- Tinnitus patients exhibit elevated steady-state metabolism in A1
  - Observed increased perfusion in middle temporal gyrus and superior temporal gyrus

[1] Wunderlich et al. (2010). Audiology and Neurotology, 15(3), 137-148.
[2] Golm et al. (2013). Hearing Research, 295, 87-99.
[3] Gu et al. (2010). Journal of Neurophysiology, 104(6), 3361-3370.
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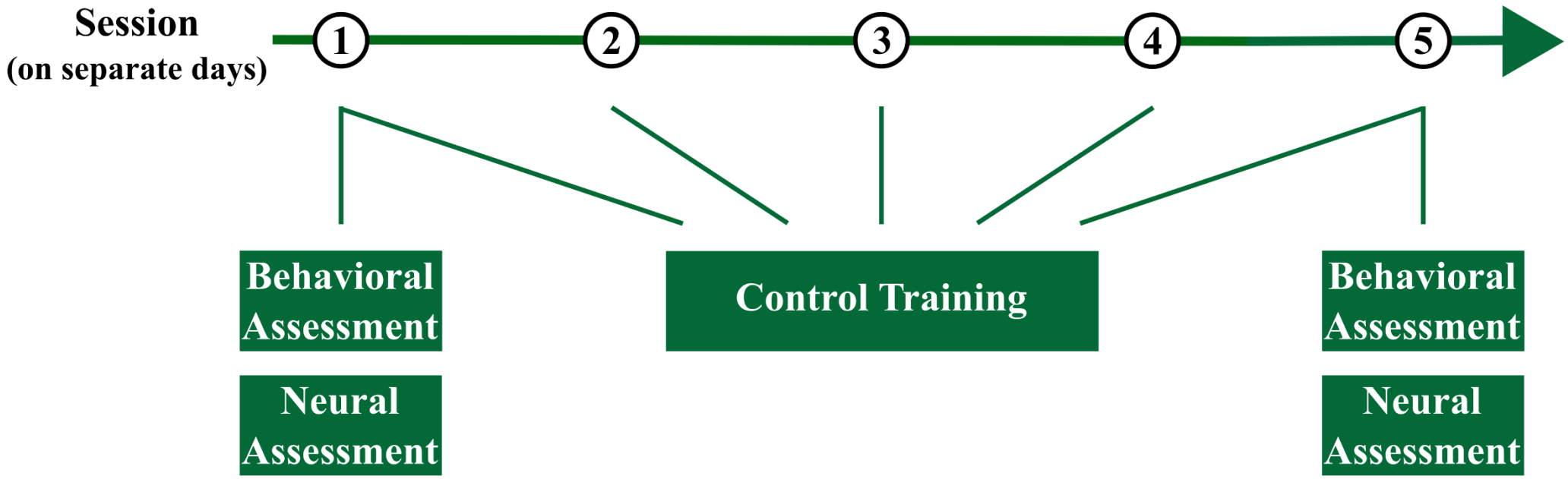
Phase 2: Experimental Methods



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