REPORT DOCUMENTATION PAGE

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1. REPORT DATE *(DD-MM-YYYY)*	2. REPORT TYPE	3. DATES COVERED *(From - To)*
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5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

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14. ABSTRACT

15. SUBJECT TERMS

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Cerebral Perfusion is Altered by Real-Time fMRI Neurofeedback-Directed Self-Regulation of the Primary Auditory Cortex

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DHA Defense Health Agency

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Disclosure Statement

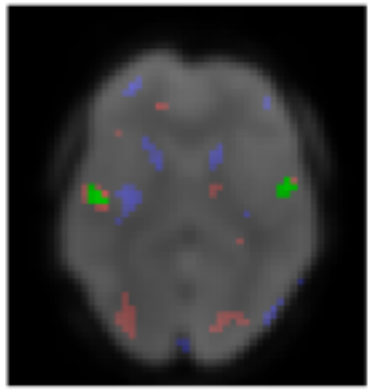
- Matthew Sherwood conducted the work presented as in his regular duties as an employee of Wright State University and is also a paid consultant for Infoscitex (A DCS Company)
- This research was sponsored by the U.S. Air Force (contract FA8650-16-2-6702).
- The views expressed are those of the authors and do not reflect the official views or policy of the Department of Defense and its Components. The U.S. Government is authorized to reproduce and distribute reprints for Governmental purposes notwithstanding any copyright notation thereon.
- The voluntary, fully informed consent of the subjects used in this research was obtained as required by 32 CFR 219 and DODI 3216.02_AFI 40-402.

Real-time fMRI Neurofeedback

Performed While Concurrently Acquiring Next EPI Volume

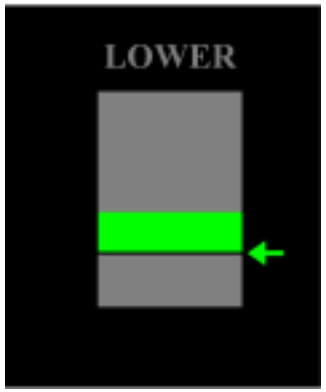
Collect a Single
2D EPI Volume

Pre-Process Single Volume
&
Extract Mean Signal from VOI



Calculate Percent Signal
Change from Baseline

Update Height of
Feedback Bar on Display



Why Resting Cerebral Perfusion

Resting perfusion represents the required glucose consumption to sustain constant brain processes

- Agreement between 3D pcASL and ^{15}O-water PET in older individuals[1]
- High reliability in 3D pcASL measurements in young and older individuals[1]

Resting glucose consumption can inform us of changes induced from closed-loop endogenous neuromodulation

[1]Xu et al. (2010). *NMR Biomed*. 23, 286-293. doi: 10.1002/nbm.1462

Experimental Methods

27 Healthy Participants

- Written informed consent obtained prior to any experimental procedures

Grouping

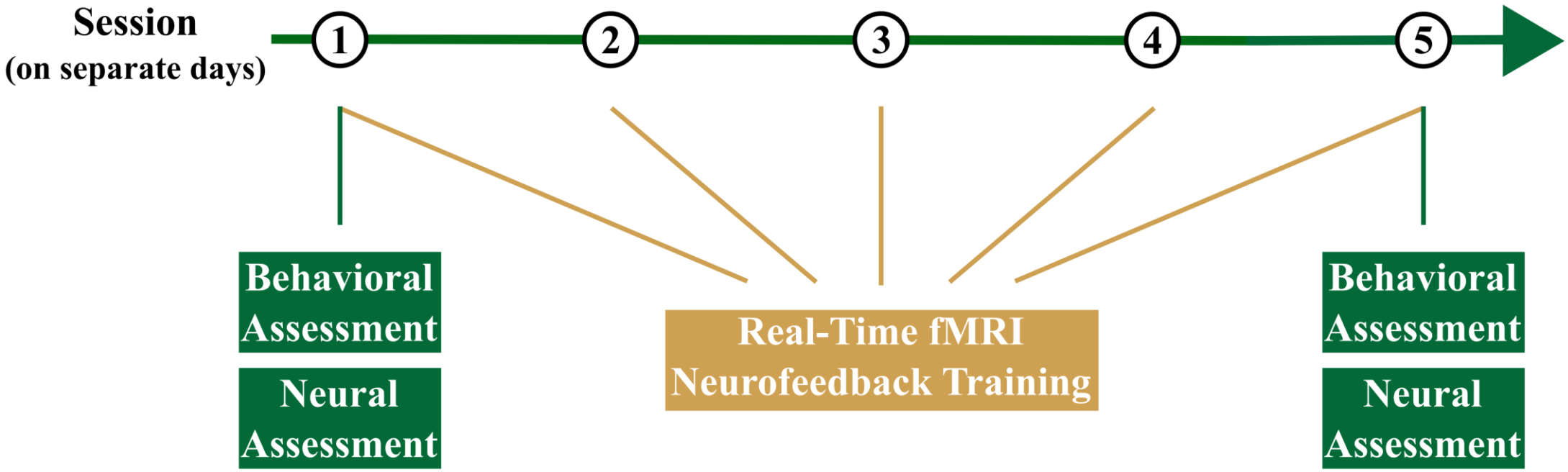
Experimental Group (EXP)

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

Control Group (CON)

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

Experimental Methods (cont.)



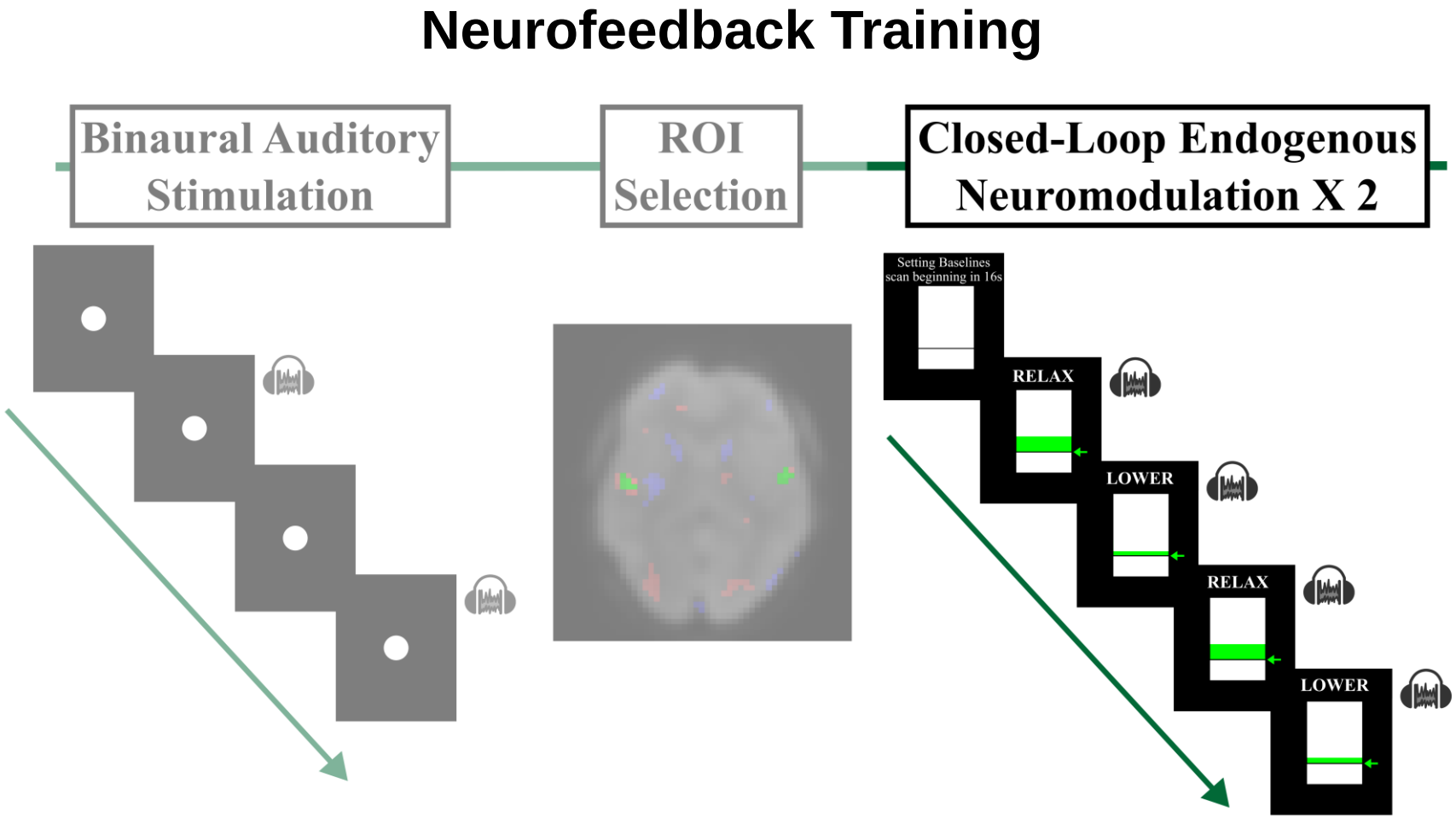
Experimental Methods (cont.)

Neural Assessment consisted of:

- Resting-state fMRI (5-mins)
- Sternberg fMRI (6-mins)
- Auditory fMRI (5-mins)
- Resting Arterial Spin Labeling (5-mins)
  - Default psuedo-continuous labeling and a 3D spiral readout with 8 arms[1]
  - 3 tag/control pairs

[1]Alsop et al. (2015). Magn. Reson. Med. 73(1), 102-16. doi: 10.1002/mrm.25197

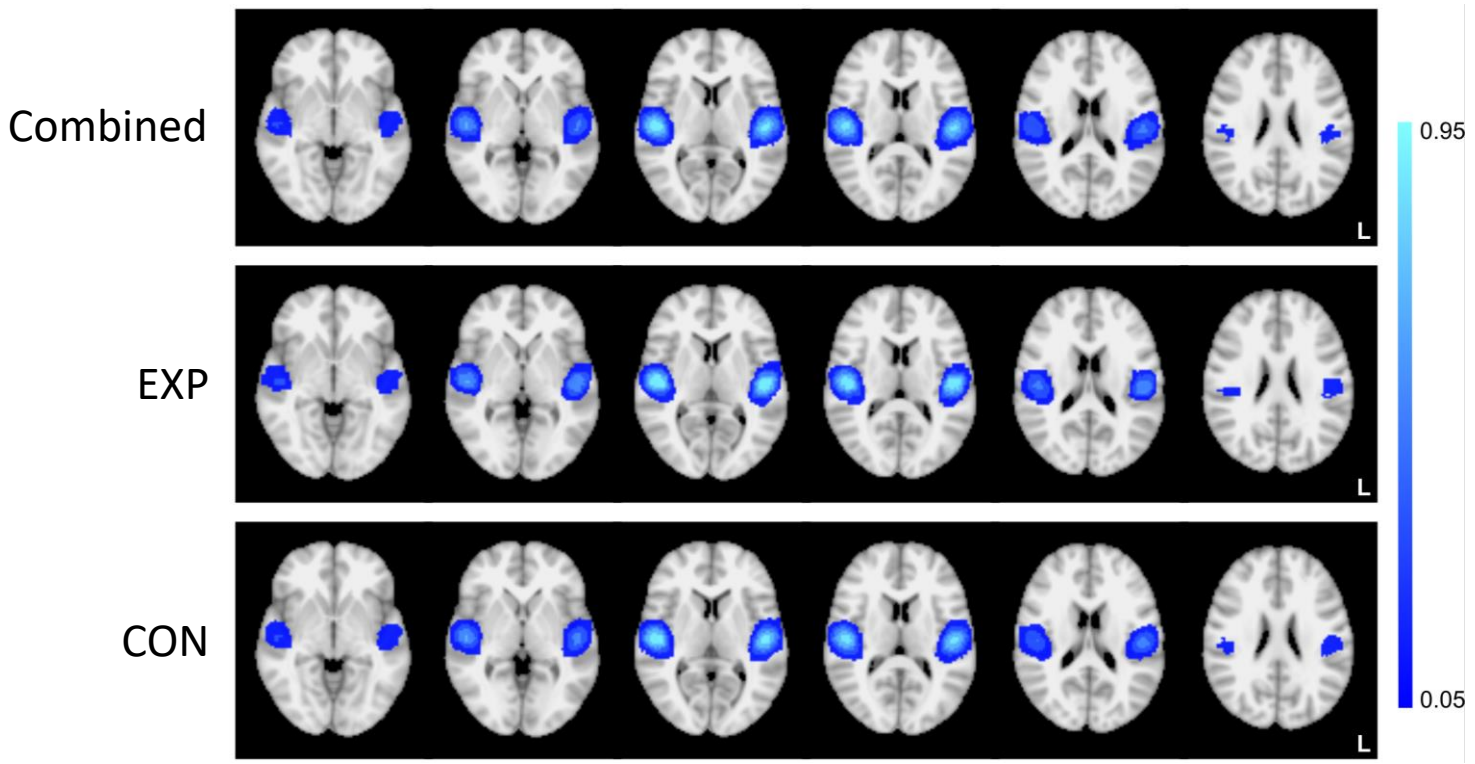
Experimental Methods (cont.)



Results

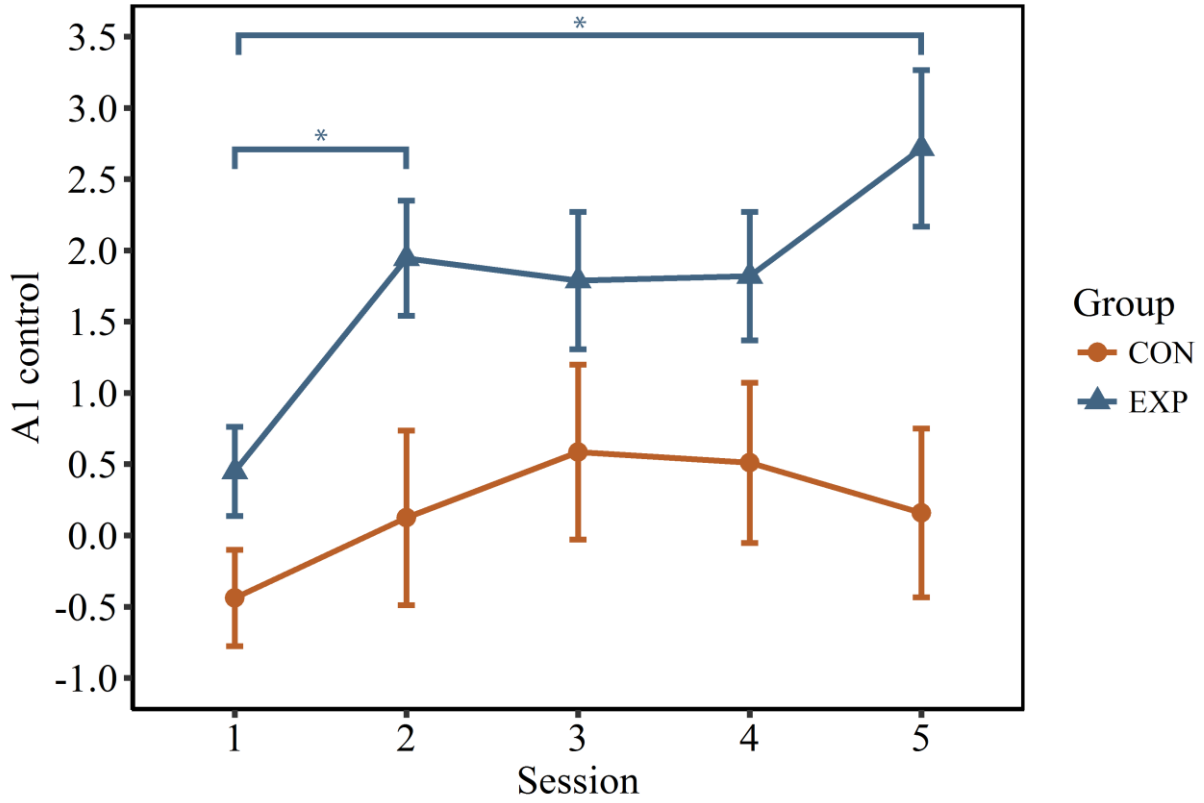
2x5 repeated measures ANOVA evaluated VOI size across sessions and groups

- No significant effects were observed
- Cumulative average VOI size was 1490mm^3 ± 283.15mm^3



Results (cont.)

- Computed average ROI deactivation during neurofeedback for each session and run
- Performed a 2x5x2 repeated measures ANOVA



Source	Sig. (one-tailed)
Intercept	.011
Group	.029
Error	

Factor	Sig. (one-tailed)
Session	.0175
Session * Group	.225
Run	.283
Run * Group	.175
Session * Run	.070
Session * Run * Group	.218

Results (cont.)

Computed the change in CBF from Session 1 pre-NFT to Session 5 post-NFT

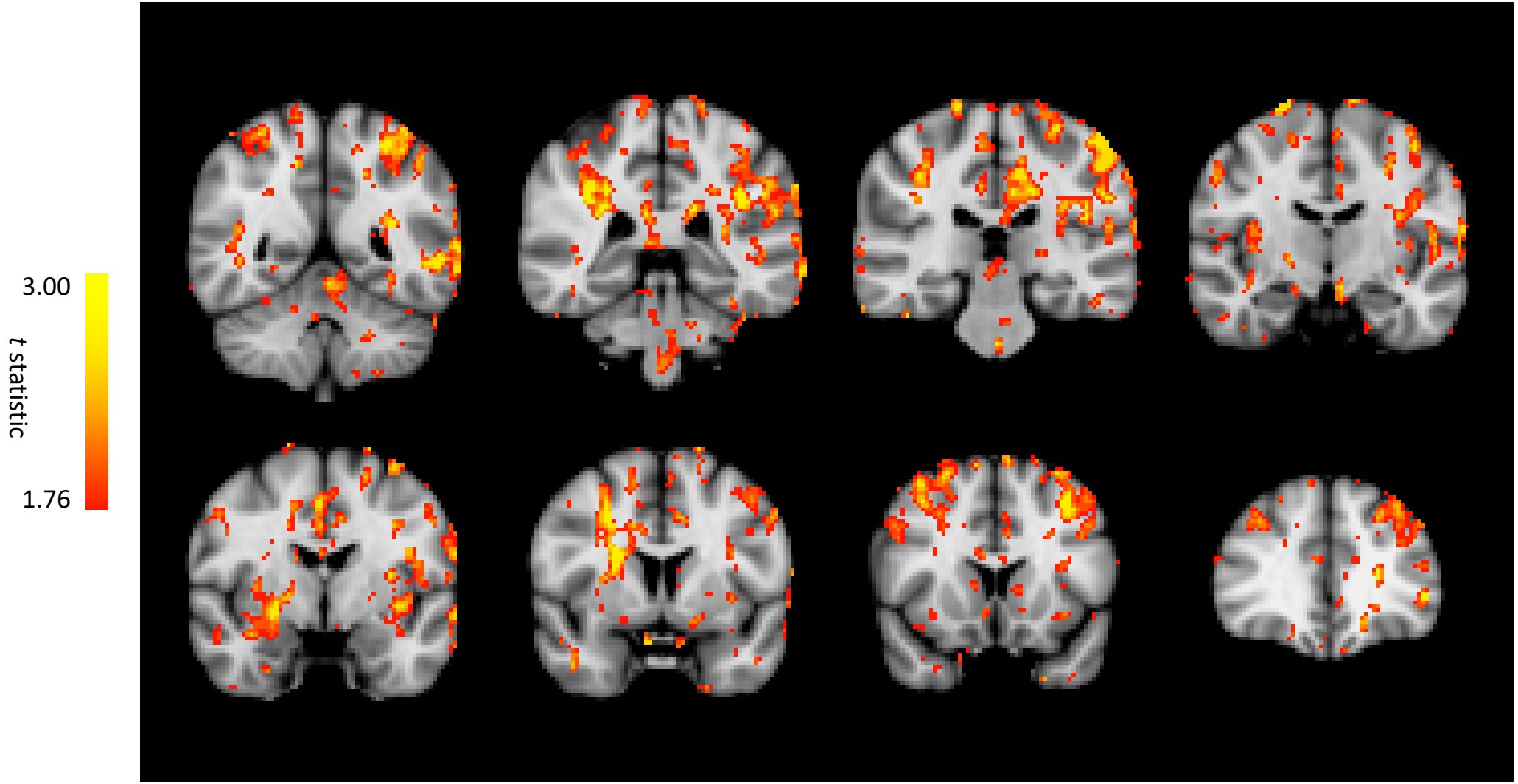
Used a permutation approach to conduct voxel-wise unpaired *t* tests to investigate the GROUP by SESSION effect on steady-state cerebral perfusion

- 1,000,000 permutations

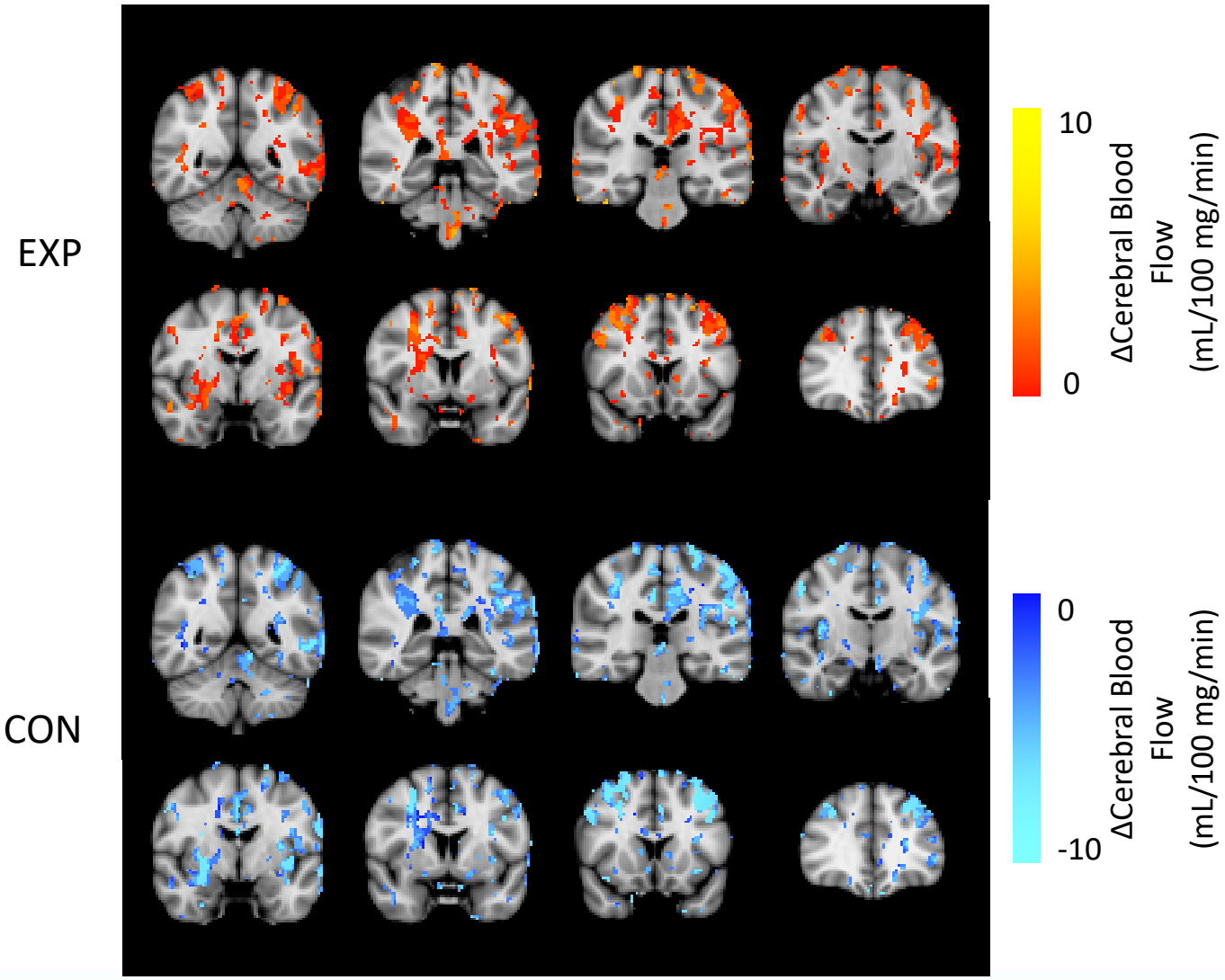
Cluster-corrected for family-wise error using a threshold of $Z > 1.76$ and $p < 0.05$[1]

[1]Worsley (2001). *Functional MRI: An Introduction to Methods,* 251-270

Results (cont.)



Results (cont.)



Conclusion

Utilized real-time fMRI neurofeedback to train control over the primary auditory cortex

Assessed resting cerebral perfusion prior to and following neurofeedback training

Determined significant differential changes in resting perfusion occur between real and sham neurofeedback

- Perfusion increased with real neurofeedback
- Perfusion decreased with sham neurofeedback

These results suggest real-time fMRI neurofeedback may augment resting glucose metabolism