[15O]Water PET study of speech in noise processing in cochlear implant patients

P.E. Gander[1], L.L. Ponto[2], I. Choi[3], B. McMurray[4], T.D. Griffiths[5,6]

[1]Department of Neurosurgery, [2]Department of Radiology, [3]Department of Communication Sciences and Disorders, [3]Department of Psychological and Brain Sciences, The University of Iowa, Iowa City, IA, USA,
[4]Institute of Neuroscience, Newcastle University, Newcastle-Upon-Tyne, UK, [5]Wellcome Trust Centre for Neuroimaging, University College London, London, UK

1 Introduction

- Functional imaging of subjects with cochlear implants (CI) is difficult: MRI impossible with most current devices
- Here we show activation due to SIN can be achieved at a single-subject level

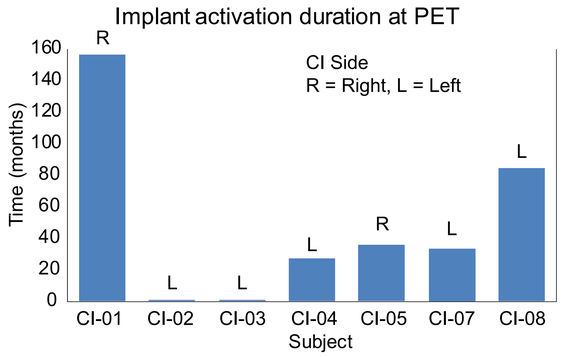
2 Methods

- We measured [15O]Water positron emission tomography (PET) blood flow in a group of seven CI patients and one normal hearing participant
- All CI subjects use a (hybrid) implant device which preserves low frequency acoustic hearing and involves insertion of a short electrode in the basal turn of the cohclea to provide electrical high frequency hearing
- Subjects listened to 2-min blocks of continuous sentences in noise [1] or noise alone (matched on RMS sound
- level); On a given run for speech in noise (+7 dB), 30 unique sentence tokens (~2.5 sec length) were presented (1.5 sec inter stimulus interval); We acquired 12 scans (6 each condition, random order) to allow for single subject inference; PET data were analyzed in SPM12 using a flexible factorial model

Subject demographics

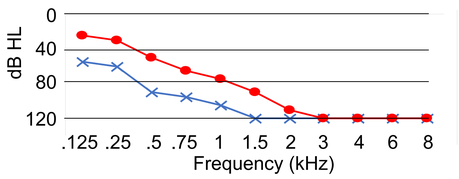
	Age	Sex	Left Ear	Right Ear
CI-01	61	M	HA	CI (N24/N6)
CI-02	64	F	CI (S12RW/N6)	HA
CI-03	53	F	CI (522/Kanso)	HA
CI-04	52	M	CI (L24/N6)	HA
CI-05	39	F	HA	CI (L24/N6)
CI-07	60	M	CI (L24/N6)	HA
CI-08	48	F	HA	CI (L24/N6)
Group	53.86	4 F	4 CI	3 CI

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



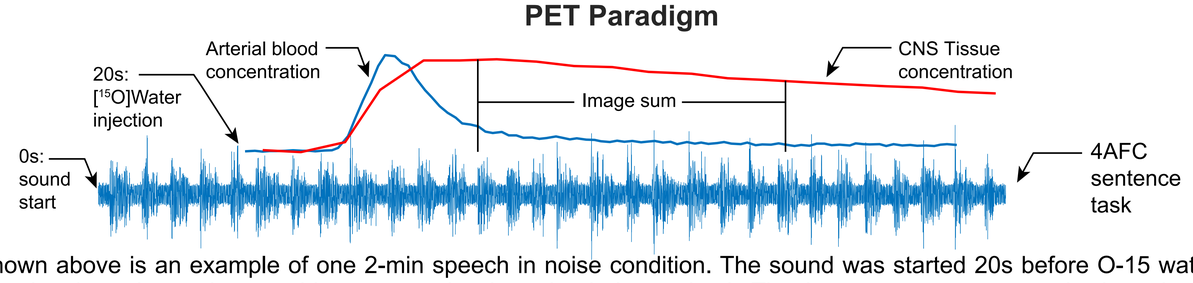
Two subjects (CI-02 and CI-03) were scanned one month before activation and within one month of activation, both were performing well. The reminaing five subjects were established, successful CI users.

Example hybrid CI subject audiogram



Residual acoustic hearing is typically within the mild to moderate hearing loss range up to 1kHz.

PET Paradigm



Shown above is an example of one 2-min speech in noise condition. The sound was started 20s before O-15 water injection in order to have subjects on task when the bolus arrived. The image sum was started when tissue concentration was stable and free of bolus artifact, and then summed over 40s. At the end of the speech in noise block subjects were given a 4AFC task to identify a sentence they heard in the previous 2min. Subjects were also instructed to listen to the sound during the noise conditions.

4 Conclusions

- Successful demonstration of network for SIN at single subject and group level
- The two subjects scanned immediately before and after implantation do not show striking changes in the fronto -temporal network, but we propose further experiments to look at this sequentially over a period of two years
- The further analyses will specifically test the hypothesis that auditory cortex activation changes over a period of months after implantation and that the inferior frontal activation reflects listening effort that will decrease during hearing rehabilitation

References

[1] Wild CJ, Yusuf A, Wilson DE, Peelle JE, Davis MH, Johsnrude IS (2012) J Neurosci, 32, 14010-14021.

Contact information

phillip-gander@uiowa.edu

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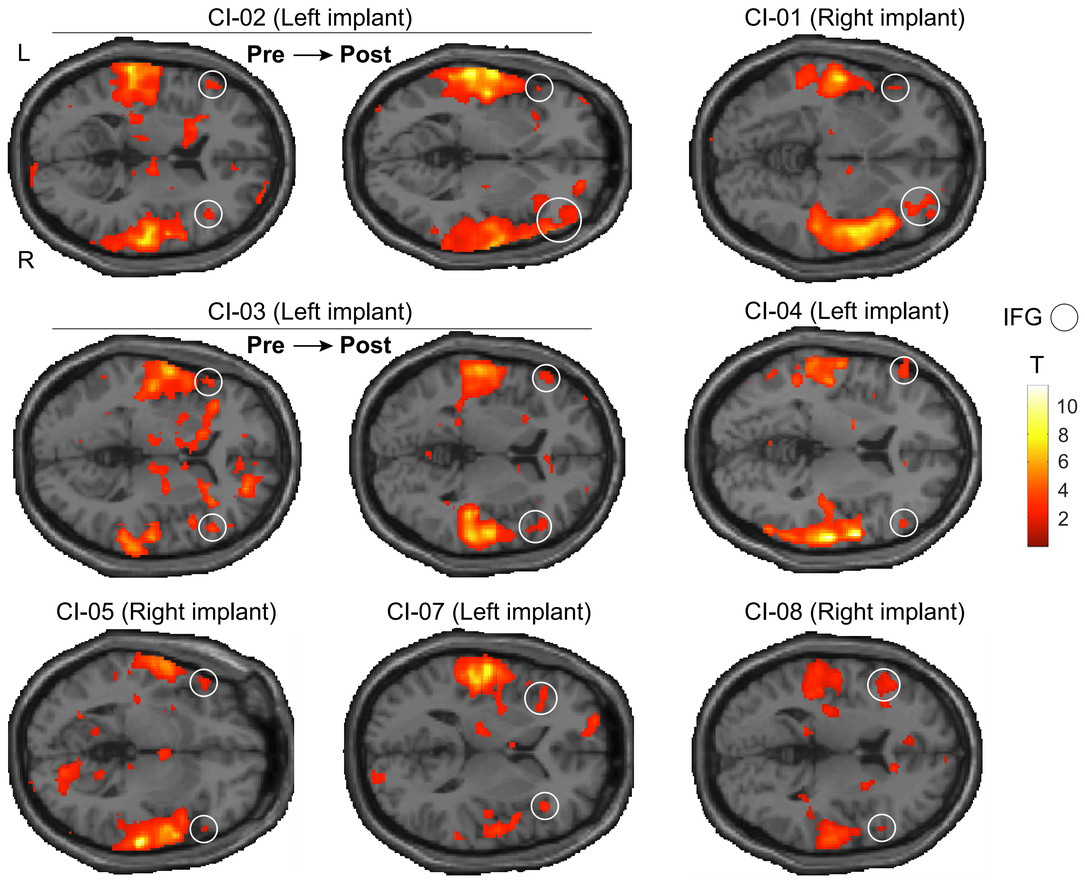
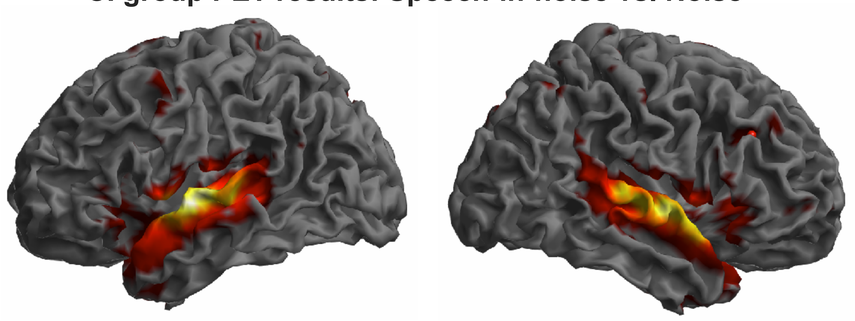
3 Results

CI single subject PET results: Speech-in-noise vs. Noise



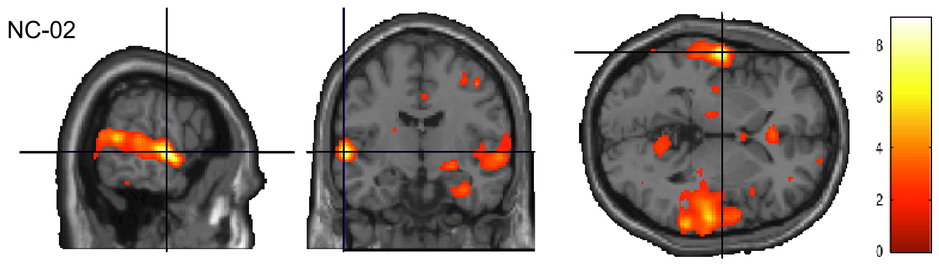
In every subject bilateral activity is seen in auditory and inferior frontal cortex. Images are oriented to show inferior frontal acitivty bilaterally, and are displayed at p<0.05 whole brain threshold. Peak activity in each subject was observed in planum temporale.

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



Activation was observed in the group results in additional areas to bilateral auditory and inferior frontal cortex, which included: supplementary motor cortex, premotor cortex, intraparietal sulcus, dorsolateral prefrontal cortex, hippocampus, insula, supramarginal gyrus, and angular gyrus. Images are displayed at p<0.05 whole brain threshold.

Normal hearing control subject PET results: Speech-in-noise vs. Noise



Single subject normal control with same stimulus. Hearing screen results were below 25dB HL at 0.5, 1, 2, and 4 kHz. No activation was observed in infreior frontal cortex at p<0.05, however at the more relaxed threshold of p<0.1 bilateral inferior frontal activity was observed. Lines denote orthogonal section locations.