Functional connectivity between sensory and multimodal cortex in deaf and hearing adults revealed by time-lagged cross-correlation of the "fast" optical signal

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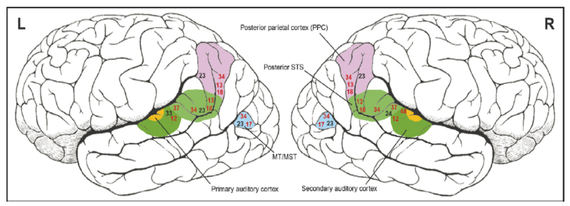
Abstract

- **Early deafness causes changes in peripheral visual attention**
  - **The useful field of view (UFOV) task** has shown that deaf subjects have lower presentation duration thresholds for determining the location of a peripheral target among distractors while performing a concurrent central discrimination task [1]
- **The current study:**
  - Seeks to determine which areas of the brain are related to this enhanced processing
  - Uses the **event-related optical signal (EROS)**, an imaging modality with similar spatial resolution to fMRI and a temporal resolution comparable to EEG
- **Spatial regions of interest include:**
  - V1/V2, lingual gyrus, primary auditory cortex
  - PPC, posterior STG/STS
- **Temporal regions of interest** - undefined
- Functional connectivity between ROIs determined using time-lagged forward cross-correlation of neural time series (seed = ROI peak, model = Granger causality)
- No deaf-hearing group differences at time points of peak activation (low power?)
- Deaf-hearing activation differences observed in posterior superior temporal regions – differing phase of activation between groups

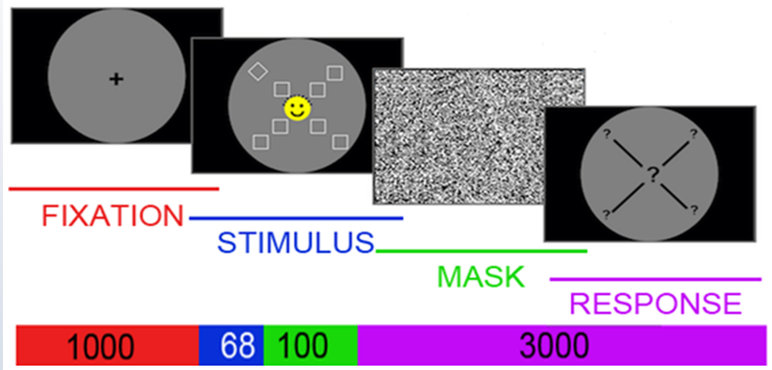
Introduction

- Many studies show enhancement of visual function in deaf individuals only for attentionally-demanding tasks in the periphery or in motion [2-3]
- In contrast, deaf individuals do not show basic sensory threshold differences from their hearing peers, when the location and timing of the stimulus is known [1, 2-4].
- This suggests that basic psychophysical differences cannot account for better performance in deaf individuals
- Brain imaging studies show that deaf individuals have different patterns of activation accompanying these changes in performance

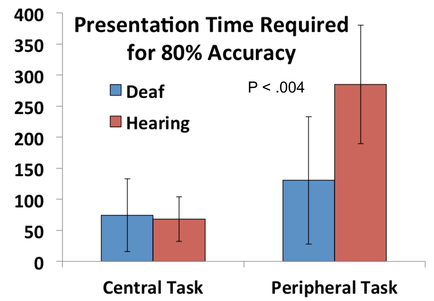


Hypotheses

- Deaf subjects will outperform their hearing peers on the peripheral task
- Deaf subjects will show greater activation of pST during the task – confined to right hemisphere [5-6]
- A functional network underlying task performance will involve visual **and** auditory sensory areas



Behavioral Results



Method

Useful Field Of View Task
- 2-AFC discrimination task at center
- Localization task at 20°

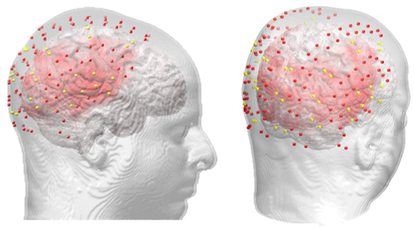
Participants

7 Deaf native signers 12 hearing non-signers

HL: M = 110 dB PTA

Diffusive Optical Imaging

ISS Imagent frequency domain oxymeter
- 64 IR sources (830 nm)
- 24 photon detectors
- DV = phase delay



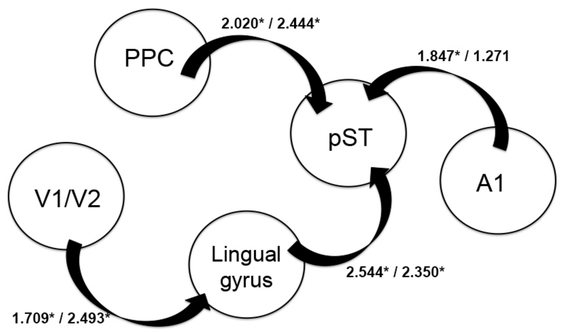
Spatial filter = 8 mm

Temporal filter = 1-6 Hz

Coverage area: occipital, temporal, parietal

Coverage depth: 2-3 cm

Functional Network

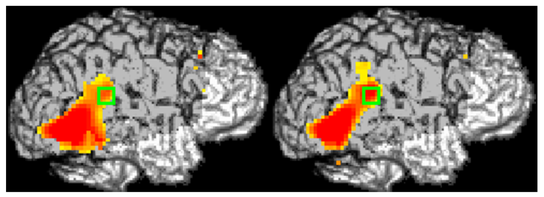


ROI Analysis: All Subjects

ROI	ROI Centroid x	y	z	Peak Time	Peak Location	Mean Delay Δ (picoseconds) Deaf	Hearing	p
V1-V2	-2	-86	2	153 ms[a]	cuneus	1.732	2.227	0.892
Left hemisphere								
lingual gyrus	-6	-58	3	844 ms[a]	lingual gyrus	2.019	2.437*	0.584
posterior parietal cortex	-36	-40	52	486 ms	IPL	1.292	1.953	0.480
posterior superior temporal cortex	-48	-36	8	870 ms[a]	MTG	2.019	2.466*	0.205
primary auditory	-55	-23	10	844 ms	STG	1.015	2.508	0.247
Right hemisphere								
lingual gyrus	23	-71	-2	51 ms[a]	lingual gyrus	1.074	1.810	0.900
posterior parietal cortex	32	-56	52	127 ms[a]	SPL	1.162	2.295*	0.886
posterior superior temporal cortex	56	-40	8	819 ms[a]	MTG	0.563	2.180*	0.352
primary auditory	55	-25	10	691 ms[a]	postcentral gyrus	1.789	1.852	0.476

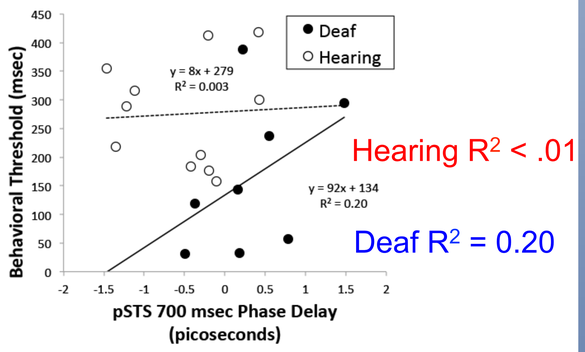
* Activity significantly greater than baseline ($p < .05$)

ROI Analysis: posterior ST area

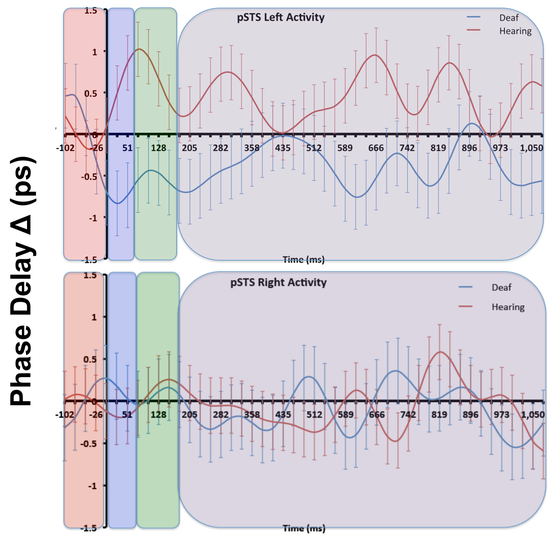


DEAF > HEARING contrast (RH) at 691 and 716 ms

Posterior ST . UFOV threshold



ROI Analysis: posterior ST area



Discussion

- Replication of Deaf advantage for localization of peripheral visual stimuli
- Useful Field of View task recruits visual, auditory and multisensory cortices
- Greater involvement of the right hemisphere compared to left hemisphere
- Replication of right-lateralized hyper-recruitment of posterior superior temporal areas in the Deaf
- RH posterior ST recruitment linked to behavior in Deaf but not in hearing
- Some evidence for stronger functional connectivity in right hemisphere in Deaf (V1/V2 – lingual gyrus – posterior ST), but more data needed

References

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