EarGenie®, an innovative fNIRS device to measure infants brain response to sound.

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Introduction

EarGenie is an innovative hearing test utilizing fNIRS (functional near-infrared light) technology to measure the brain's response to sound.
By detecting variations in the brain's haemodynamic response to auditory stimuli, EarGenie can effectively assess a baby's hearing capabilities.

Auditory-evoked fNIRS responses

- Studies have shown speech stimuli can evoke an fNIRS response in infants.
- The responses were found to vary in morphology depending on the experimental design and stimulus properties.

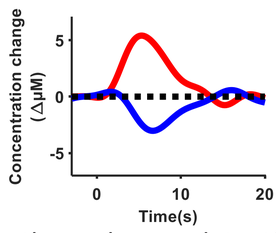


Figure 1: Example of the canonical haemodynamic response in infant fNIRS studies.

- Currently, we have a detection test: fNIRS response to a speech stimulus at differing sound levels.
- And a speech discrimination test: which demonstrates if a baby can hear the difference between contrasting speech sounds.

How can EarGenie help?

EarGenie provides the evidence

- The ***Speech Module*** measures detection and discrimination of speech at different levels
- The ***Hearing Module (in development)*** will provide a frequency specific measure of hearing acuity.

Babies with auditory neuropathy

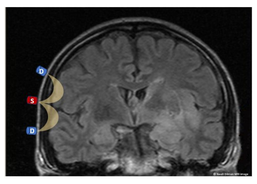
- How much can they hear?
- What is their speech discrimination like?

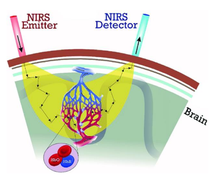
Babies with hearing loss

- Is a hearing aid fitting beneficial?
- Would a cochlear implant be better?
- Are their hearing aids or cochlear implant providing sufficient audibility?

fNIRS – the EarGenie technology

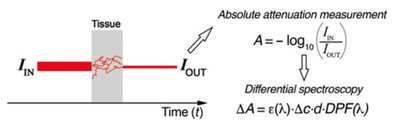
A





Neuronal activation

B



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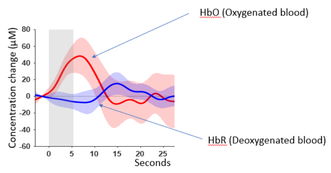
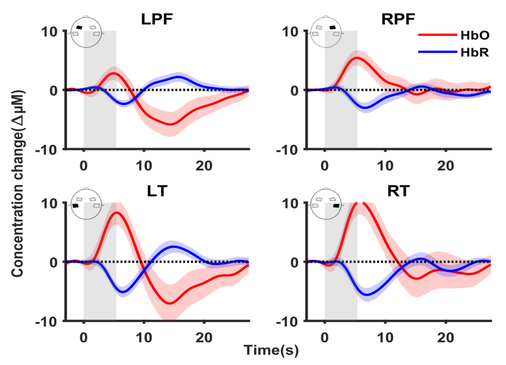


D

Panel A: S = Source (optode emitting light) D = Detector (optode detecting refracted light). Neurovascular coupling drives an increase in cerebral blood flow, an increase in oxygenated blood and a decrease in de-oxygenated blood to that region.
Optodes cover the auditory cortex and pre-frontal regions.
Panel B: Data is converted to the haemodynamic concentration change, oxyhaemoglobin (HbO) and de-oxyhaemoglobin (HbR), using the modified Beer-Lambert Law, and bandpass filtered between 0.01 and 0.25 Hz.
TDDR is used to correct motion artefacts. Channels with SCI <0.8 are discarded.
Data epoched from -3 to 27s of stimulus onset.
Baseline corrected to the average of –3 to 0 s.
Epochs averaged across channels in each region of interest.
Panel C: Haemodynamic Response is represented in a graphical output.
Panel D: The EarGenie Minimum Viable Product.

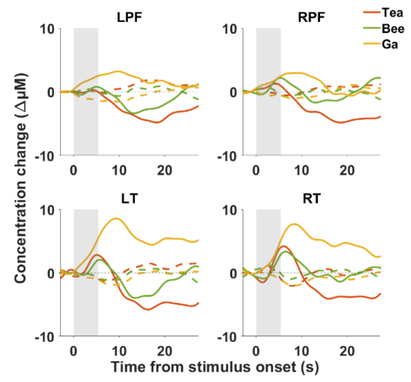
Results in normal hearing infants

Group Average Detection n=16



Regions of interest: L/RPF = left/right pre-frontal. L/RT=left/right temporal
All infants had detection responses present.

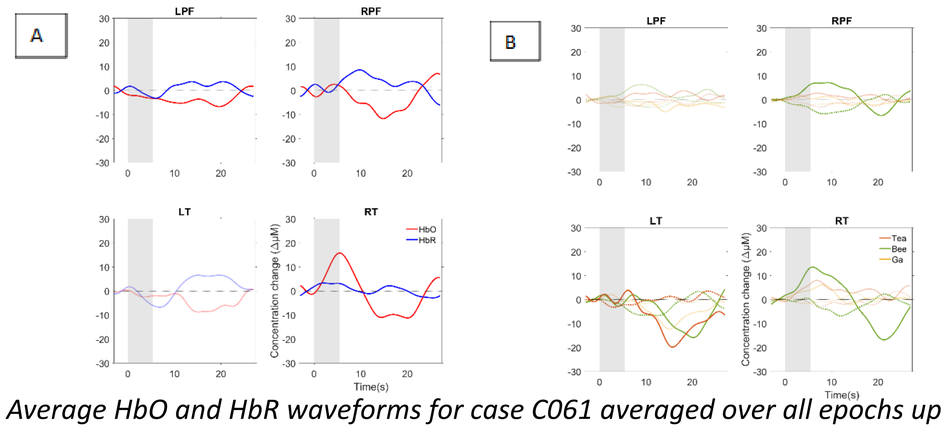
Group Average Discrimination



Average waveforms of responses (changes in HbO (solid) and HbR (dotted) to discrimination of "Ba" from "Tea", "Bee", and "Ga". Grey shaded region is the duration of the novel stimulus in the non-silence baseline.

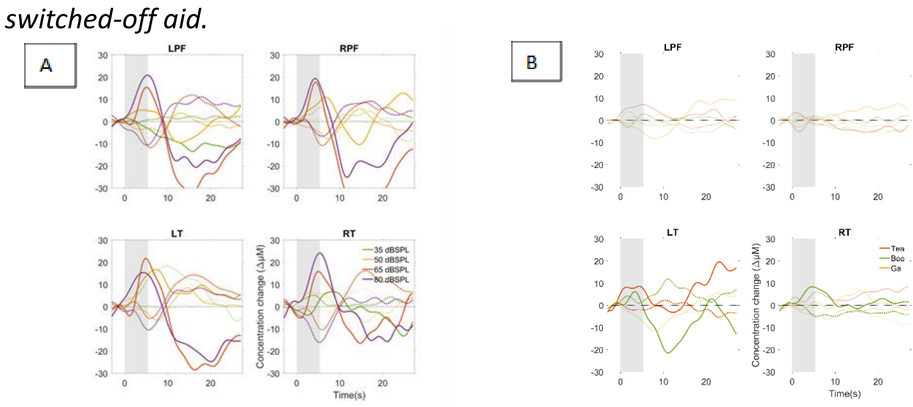
Results

Infant with a moderate sensorineural hearing loss on the right and a high frequency loss on the left. *Infant C061 right ear was tested while wearing her hearing aid. The speech sounds were presented via a loudspeaker at 65 dB SPL while her left ear was plugged with a sound attenuating plug.*



Average HbO and HbR waveforms for case C061 averaged over all epochs up to where the algorithm detected a response, or 12 epochs (faint lines) in instances where the analysis did not reach statistical significance.
***A:** the detection of "Ba" **B:** Discrimination of "Ba" from "Tea", Bee", and "Ga" (HbR denoted with dashed lines).*

Infant with a severe to profound sensorineural hearing loss in both ears. *Infant C078 right ear was tested in the aided condition, with the left ear blocked by his switched-off aid.*



*Average HbO and HbR waveforms for case C078 averaged over all 20 test epochs. **A:** the detection of "Ba" **B:** Discrimination of "Ba" from "Tea", Bee", and "Ga" (HbR dashed lines). This shows that C078 can detect conversational level speech, including quiet speech, and additionally showed that he can discriminate between the speech sounds "Ba" and "Bee" and "Ba" and "Tea". No significant response for "Ba" vs "Ga" was found in any ROI.*

Conclusion

- Our data suggests two separate response mechanisms simultaneously evoked by an auditory stimulus. An early positive peak in HbO followed by a long-duration negative dip.
- Application of EarGenie fNIRS tests shows a promising addition to Audiology assessment in the infant population.
- Our aim is to improve early intervention to facilitate improved language outcomes for children with hearing loss.
- We are currently running two clinical trials. The first is to ascertain the usefulness of fNIRS in clinical decision making, and the second trial is to test our first prototype with normal hearing subjects.

Acknowledgements

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