Studying brain activity in children and adults who are deaf and using cochlear implants
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INTRODUCTION

- Deafness is a major communication and health problem that affects more than 10% of the population
- Profound deafness occurs in 4 to 11 per 10,000 children
- Cochlear implants have become available as a clinical treatment for providing auditory stimulation.
- Some patients perform extremely well, while others have poor outcomes.
- Neuro-imaging methods are needed to evaluate and predict poor vs. good outcomes.

CAUSES OF HEARING LOSS

Noise Exposure

Genetic, aging, unknown

Central "loss" of processing (e.g., hard to process speech)

Drug induced

COCHLEAR IMPLANTS

- Modern bionic ear – feat in biomedical engineering
- Introduce sound to the auditory nerve, through electrical stimulation
- Inventions in Australia internationally recognized
- Provided to infants, children and adults
- Does not restore hearing "perfectly" but transitions patients into the world of hearing

Brain areas mapped out:

- We compare brain activity in patients who have excellent, good, poor language outcomes.
- We look for brain areas that are "normal" vs. "under activated" vs. "over activated".
- We look for connectivity between the right and left.
- **Purpose:** Develop neural "markers" for predicting outcomes with cochlear implants for people who are deaf.

FUNCTIONAL NEURO-IMAGING

- fNIRS (functional near-infrared spectroscopy) has been validated compared with fMRI (functional magnetic resonance imaging) [Cui et al., 2011].
- Uses laser technology instead of magnetic, thus it is safe to use with cochlear implant patients who have metal in their head.
- Records changes in blood oxygen, like the fMRI.
- Records activity in the superficial brain layers.
- Used to assess functional connectivity between different brain areas.

VARIEBLE OUTCOMES IN LANGUAGE ACQUISITION IN CHILDREN WITH COCHLEAR IMPLANTS WHO HAVE HIGH IQ SCORES

- Children with cochlear implants show variability on standardized language measures.
- Dashed lines show normal-children-range (+/1 standard deviation).
- Panel A: Core language scores are distributed with more than 1 standard deviation around the mean. Numerous children fall below 1 SD.
- Panel B: IQ scores show that this group of children was at or above the +1.5 S.D. for the normal population.

ADDITIONAL FUTURE DIRECTIONS

Benefits of two ears (binaural hearing): How does the brain integrate input from the two ears?

- **Sound localization and Speech reception in background noise**
- From: Friederici and Gierhan (2013)

- The brain takes information from the right and left ears, and computes sound locations: BINAURAL HEARING (references by Litovsky and colleagues).
- **Bilateral cochlear implantation is growing rapidly, but many implants have poor localization and poor speech understanding in noise.**
- Questions:
  a) Is the cause central or peripheral?
  b) Can we measure neural changes with experience?
  c) Can we use fNIRS as a measure of brain integrity?

ACKNOWLEDGEMENT

- Work funded by the National Institutes of Health (NIH-NIDCD)
- Grant Numbers R01-DC003083; R01-DC008365.
- Australian-American Fulbright Commission.
- The Waisman Center and the University of Melbourne Medical Bionics Department.

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