Neuroplasticity and Bilateral Cochlear Implantation

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Introduction

- evolution/plasticity
  - genetic
  - facultative

- feature extraction
  - binaurality

- assembly of the auditory environment
  - effort
Introduction

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Evolution/Plasticity

Starlings at Otmoor  http://www.youtube.com/watch?v=XH-groCeKbE (Dylan Winter)
Human = Communicators

- olfaction
- vision
- motor skill

- audition
- linguistic ability
- executive function
Feature Extraction

- pattern recognition
- learn rules
  - fidelity
  - experience
  - consistency
SickKids Bilateral Experience

Simultaneous implants
- n=198
- Age at implant = 3.0 ± 3.5 yrs

Sequential implants
- n=180
- Age at 1st implant = 3.4 ± 3.1 yrs
- Age at 2nd implant = 9.6 ± 4.7 yrs
- Inter-implant delay = 6.1 ± 3.9 yrs
Brainstem Asymmetry

Gordon, et al., 2010
Studying Binaural Perception
Studying Binaural Perception

Lateralization Index = \( \frac{R-L}{R+L} \)

*Wong et al. IEEE (2010)*
Reorganization of Auditory Cortex

- Long Delay (> 2 years)
- Short Delay (< 1.5 years)
- Simultaneous
- Normal

Reorganization of Auditory Cortex

Lateralization of auditory activity (%)

- Long Delay (> 2 years)
- Short Delay (< 1.5 years)
- Simultaneous
- Normal

* P<0.05

Spatial Unmasking

(noise at 0°) vs. (noise at 90°)
Spatial Unmasking

(noise at 0°) vs. (noise at 90°)
Spatial Unmasking

Noise moved to 1st implanted ear
Noise moved to 2nd implanted ear

P=0.001
P>0.05

Chadha et al., *Otol NeuroOtol*, 2011
Inter-Aural/Implant Level & Timing Differences

Normal

Sequential

Simultaneous

Intra-Aural/Implant Loudness Difference Condition

Intra-Aural/Implant Timing Difference Condition
Inter-Aural/Implant Level & Timing Differences

**Normal**

**Sequential**

**Simultaneous**

Intra-Aural/Implant Loudness Difference Condition

Intra-Aural/Implant Timing Difference Condition
Inter-Aural/Implant Level & Timing Differences

Sequential

Month 9, n=29

CI2 weighted
CI1 weighted

Interaural Level Difference (CU)

0 20 40 60 80 100
CI2 20 10 0 -10 -20 CI1

Simultaneous

Sequential

Simultaneous (n=20)
Sequential R CI1 only (n=10)
Normal (n=16)

Rate of Right/CI1 Responses

-1000 0 +1000

0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0

Correlation

left leading right leading

Interaural/implant Timing Difference (µs)

Gordon, Abbasalipour et al., in press
Binaural Fusion

Steel et. al., *in press*

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Inter-Aural/Implant Level & Timing Differences and “Fusion”

**Level Cues**

- L/CI-2 Level Changing (dB/CU)
- ITD = 0 ms
- Electrode = 20

**Timing Cues**

- Proportion of 1 Response vs ITD (ms)
- p<0.0001
- (Mean ILD = -0.34 ± 0.9 dB)

Unilateral control

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Increased Effort & Increased P2 Amplitude


Additional Resources Recruited

Right Stimulation
CI Experienced – Normal Hearing Dipole Differences

Jiwani et al., Submitted

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Plasticity/Novel Process?

- the “auditory system” makes full use of sensory data
- novel methods of data processing are employed….
- …precisely because assembling correctly promotes survival