Environmental Acoustic Enrichment Promotes Recovery from Developmentally Degraded Auditory Cortical Processing

Xiaoquing Zhu, Fang Wang, Huifang Hu, Xinde Sun, Michael P. Hilgard, Michael M. Merzenich, & Xiaoming Zhou, 2014
Definitions

- **GABA\(_A\) (a1, B2, B3):**
  - inhibitory neurotransmitter
- **N-methyl-D-aspartate (NMDA) receptors:**
  - Controls synaptic plasticity and memory function
  - NR2a/2b subunits
- **Brain-derived neurotrophic factor (BDNF):**
  - Protein important for neural and synaptic growth
- **NE: Normal Environment**
- **AEE: Acoustic-Enriched Environment**
Research Question

● Can enriched auditory environments remedy poor auditory processing?
● Aside from an example of plasticity, why do we care?
● Impaired auditory processing implicated in several disorders:
  ○ Language Disorders
  ○ Dyslexia
  ○ (C)APD (Possibly.)
● Rich auditory experience as treatment / intervention
Previous Findings

- Enriched auditory environments induce auditory plasticity in animals
- These studies used typical animals
- What about *atypical* animals?
Rodent Model

1. Expose rat pups to noise during an early stage of development
2. Raise half in an enhanced environment, half in a standard environment
3. Test rats behaviorally (e.g., frequency discrimination)
4. Investigate mechanisms underlying enrichment-induced cortical plasticity (e.g., synaptic and molecular)
Methods: Phase 1

- **Subjects:** Female rats pup (Sprague Dawley) and their mothers (n = ?)
- **Phase 1: Noise Exposure**
  - P10-38 exposed to noise
  - 50ms noise pulses played at five pulses per second at 1s intervals
  - Sound-shielded test chamber
Methods: Phase 2

- Phase 2: Post-Noise Environments
  - Standard housing environment (NE): 4 weeks
  - Acoustic-enriched environment (AEE): 4 weeks
Methods: Phase 3

- **Frequency Discrimination:**
  - Go/No-Go Task
  - Discrimination training: target and non-target pure tones that differed in frequency (0.8 octaves)
  - Test frequencies increased by 0.1, 0.2, 0.4, 0.6 & 0.8 octaves
Methods: Phase 4

- **Cortical Recording:**
  - Frequency tuning curves of the A1 to 50 frequencies

- **LTP Induction:**
  - Persistent increase in synaptic strength following high-frequency stimulation of a chemical synapse

- **Quantitative Immunoblotting:**
  - Use antibody to target proteins of interest

- **Immunohistochemistry:**
  - Detect antigens through antibody binding
Results: Frequency Discrimination

Graph C shows the performance (%) of Naive, NE, and AEE groups as a function of frequency difference (octave). Graph D displays the threshold (octave) for Naive, NE, and AEE groups, with asterisks indicating significant differences.
Results: Cortical Recording
Results: LTP Induction
Results: Immunoblotting
Results: Immunohistochemistry
Final Conclusions:

- Early noise exposure degrades frequency selectivity of neurons in the cortical field
  - AEE reverses the effects of noise exposure
- How?
- Decreased NR2a/2b ratio from noise exposure
  - AEE restored NR2a/2b to normal levels
- Noise exposure induced down-regulation of GABA_\text{A}_\text{a1}, \text{B2}, \text{B3}.
  - AEE reversed down-regulation
- “The current results, thus, indicate that enriched conditions re-establish cortical frequency selectivity presumably through restoring the proper expression profile of certain excitatory and inhibitory neurotransmitter receptors.”
Questions

● Could AEE also improve subcortical auditory processing?
● Implications for clinicians?