Environmental Acoustic Enrichment Promotes Recovery from Developmentally Degraded Auditory Cortical Processing

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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 neurotophic factor (BDNF):
  - Protein important for neural and synaptic growth
- NE: Normal Environment
- AEE: Acoustic-Enriched Environment

Research Question

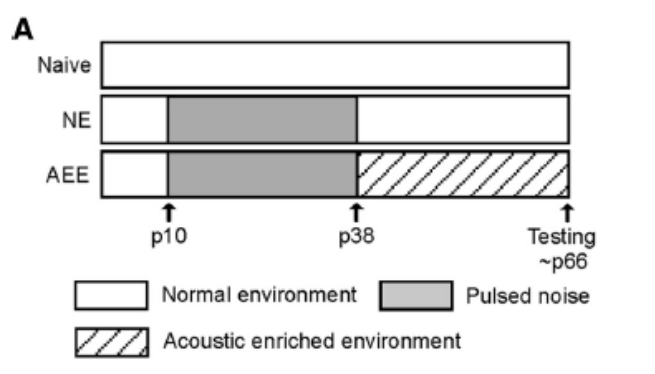
- **Can enriched auditory environments remedy poor auditory processing?**
- Aside from an example of plasticity, ***why do we care?***
- Impaired auditory processing implicated in several disorders:
  - Language Disorders
  - Dyslexia
  - (C)APD (Possibly.)
- Rich auditory experience as treatment / intervention

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)

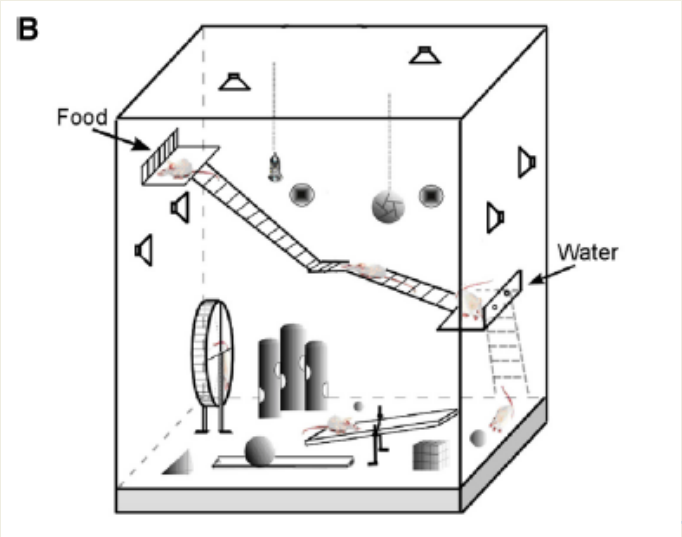


Methods: Phase 1

- **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

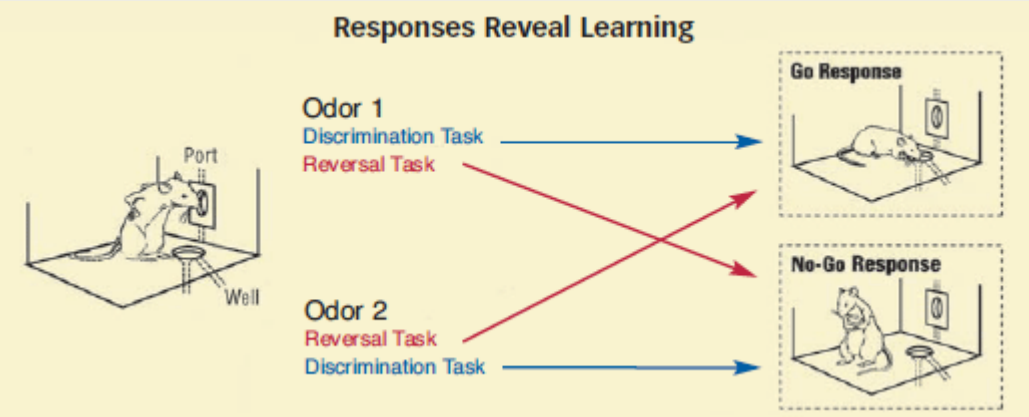
Methods: Phase 2

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



Methods: Phase 3

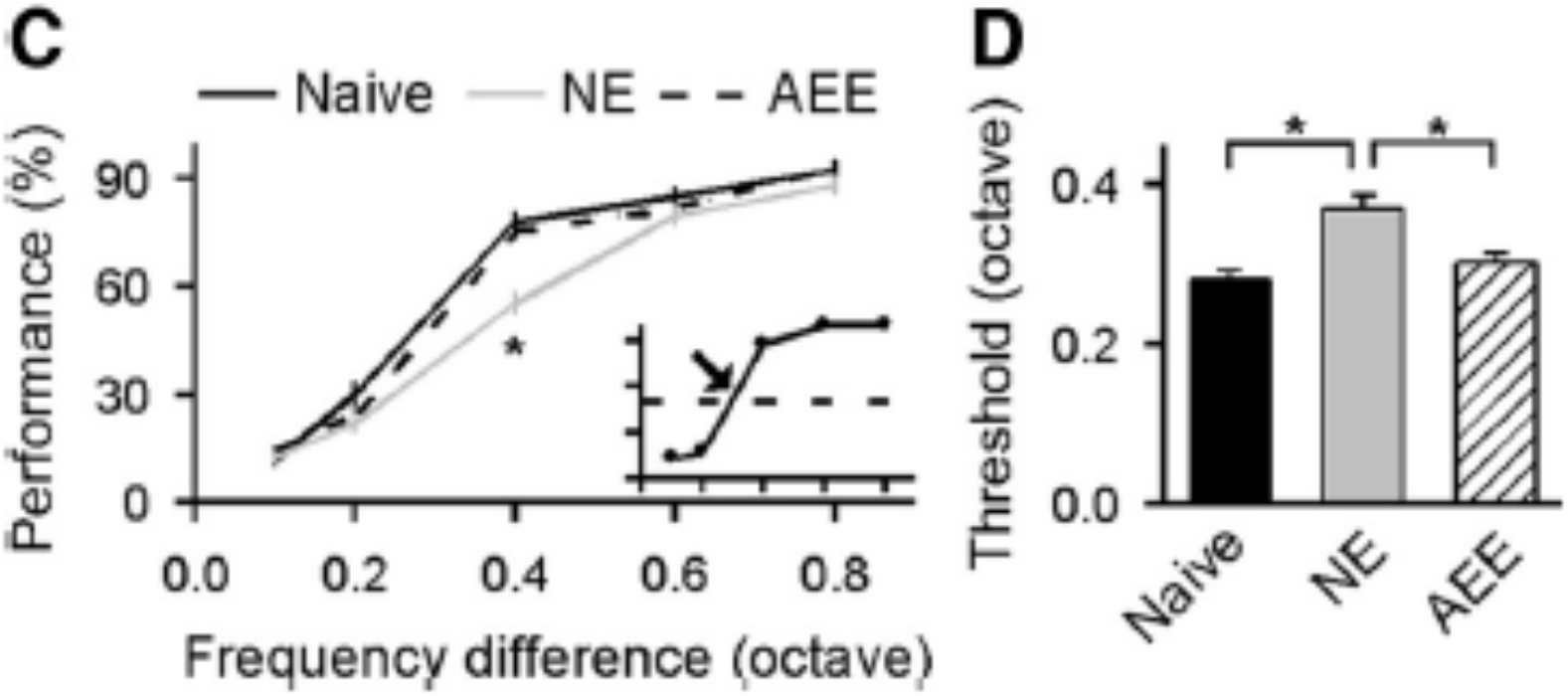
- **Frequency Discrimination:**
  - Go/No-Go Task
  - Discrimination training: target and non-target pure tones that differed in frequency (0.8 octaves)
  - Test frequencies increased by 0.1, 0.2, 0.4, 0.6 & 0.8 octaves



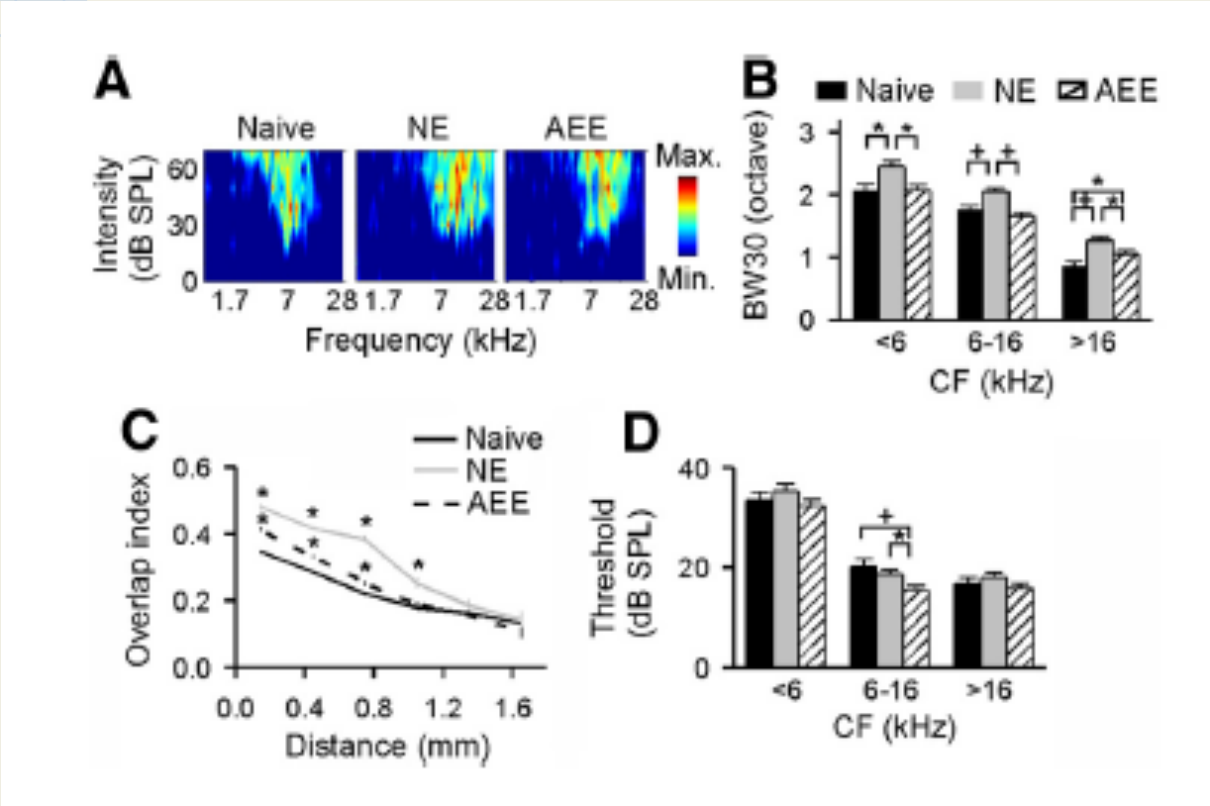
Methods: Phase 4

- **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

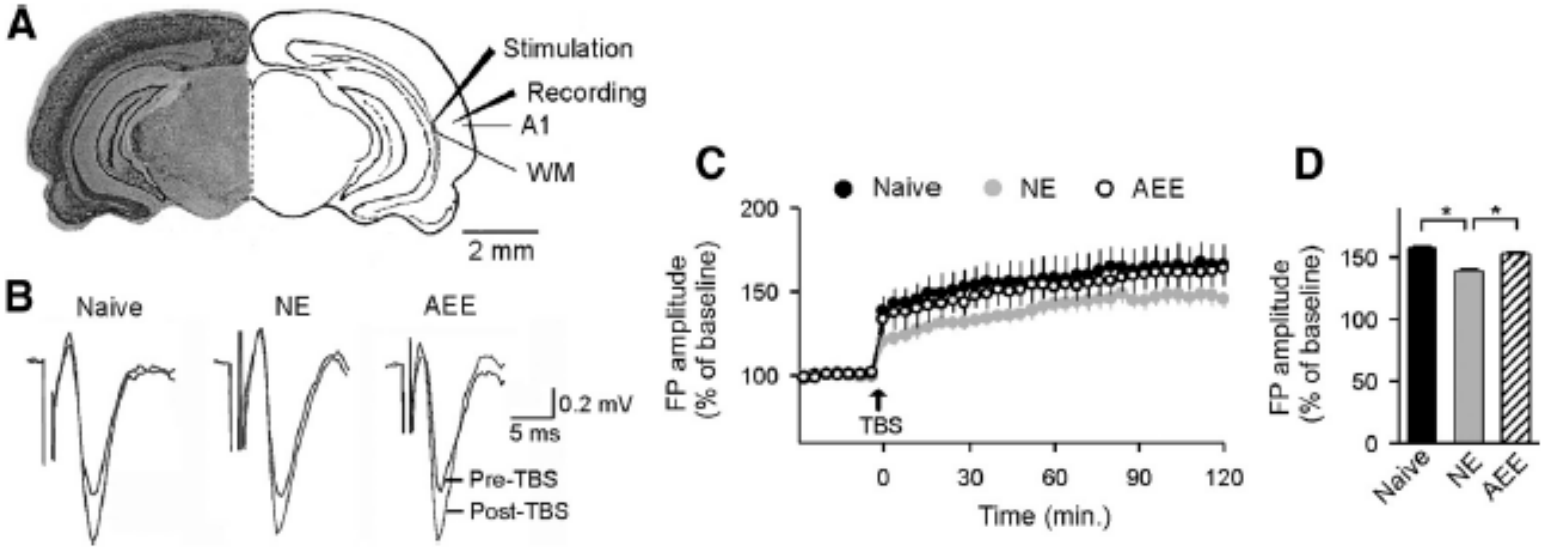
Results: Frequency Discrimination



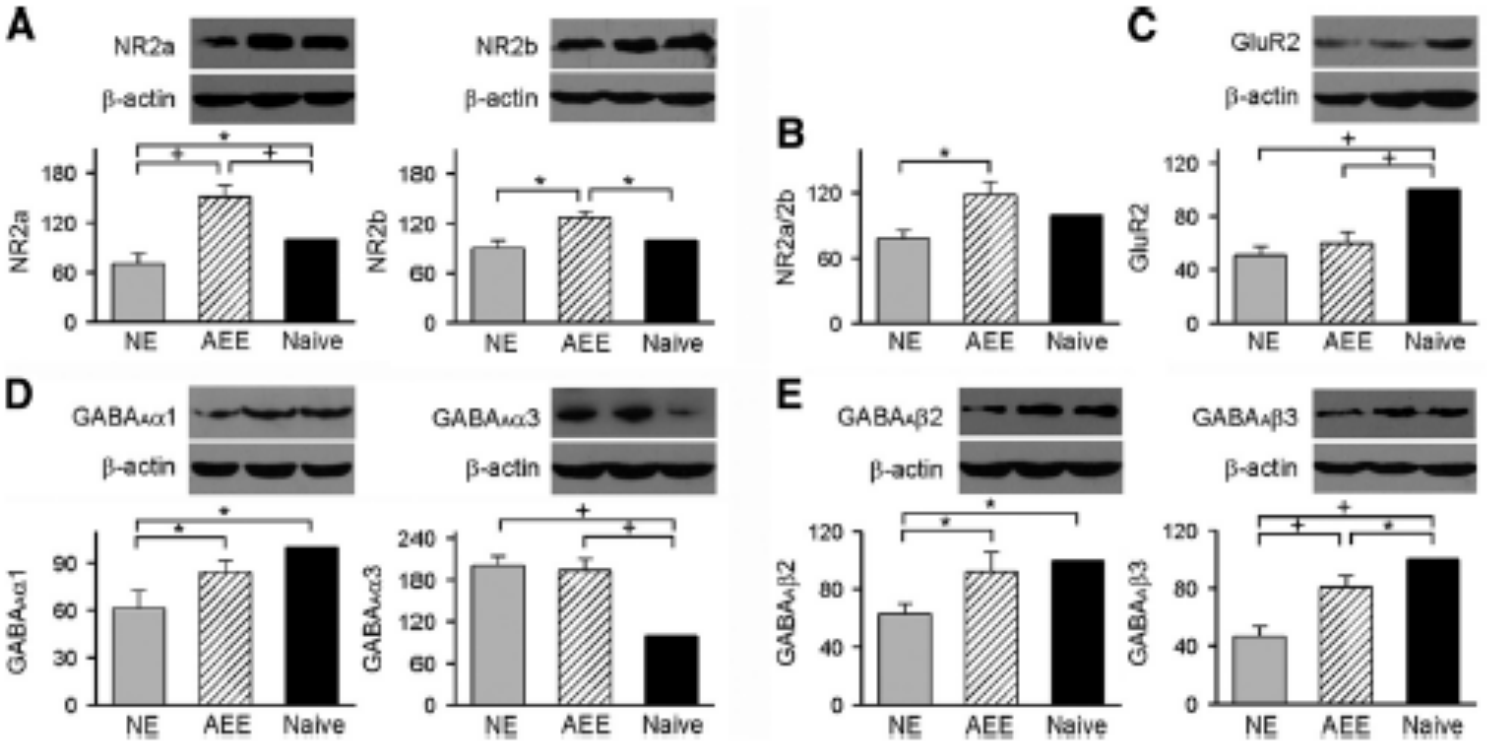
Results: Cortical Recording



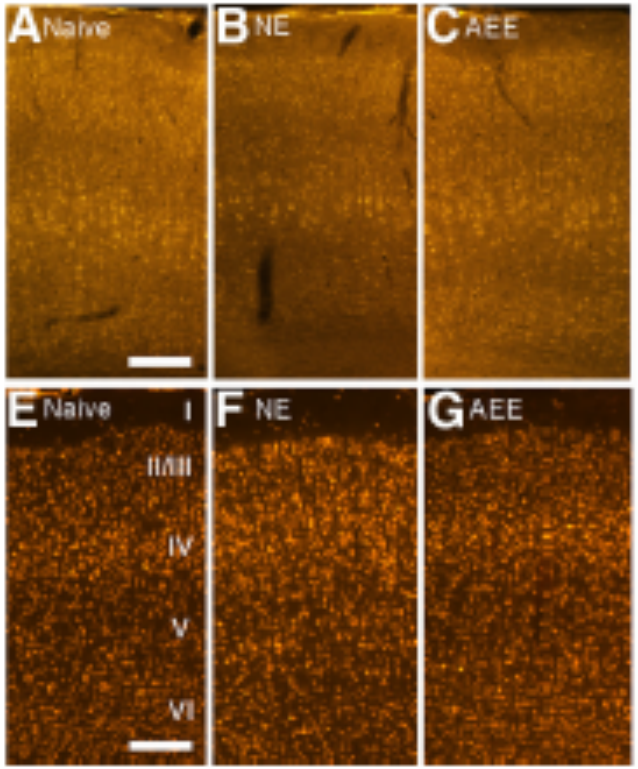
Results: LTP Induction

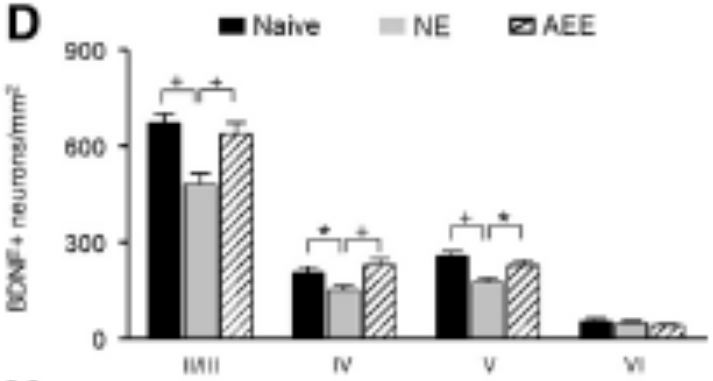


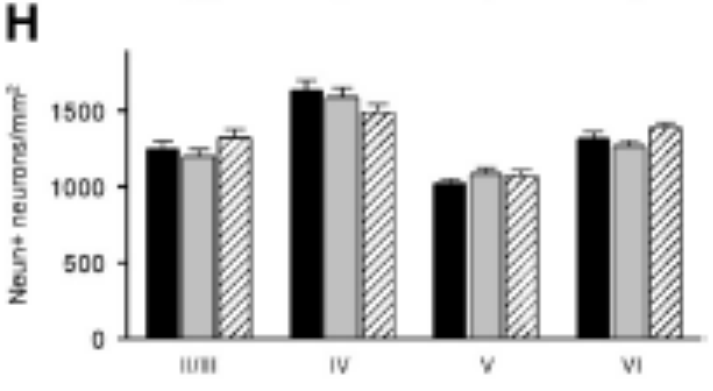
Results: Immunoblotting



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 $GABA_A$ a1, B2, 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?***