21M.542 FINAL PROJECT

A PRESENTATION OF CURRENT RESEARCH ON MUSIC & THE BRAIN

ANONYMOUS MIT STUDENT

BRAIN SPECIALIZATION FOR MUSIC

- Vissarion- Aphasia (language disorder) without Amusia (musical disorder)
  - Spared music-specific circuitries
- Isabelle- Amusia without Aphasia
  - Damaged music-specific circuitries

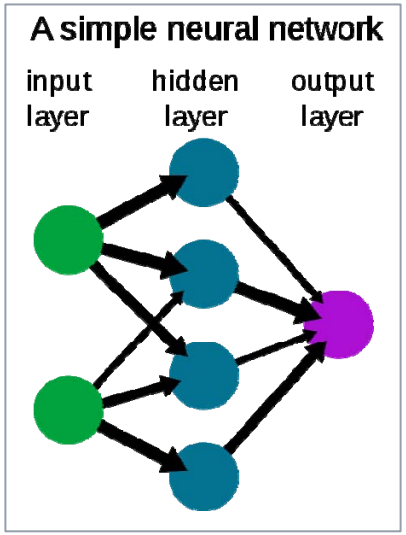

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Image of neurons removed due to copyright restrictions.

OUTLINE OF BRAIN SPECIALIZATION PAPER

- 1) Specify circumstances under which brain specialization for music can be observed
- 2) Describe nature and function of specialized mechanisms that are sub-served
- 3) Provide reasons why human brain is equipped with musical modules

CIRCUMSTANCES UNDER WHICH BRAIN SPECIALIZATION FOR MUSIC OBSERVED

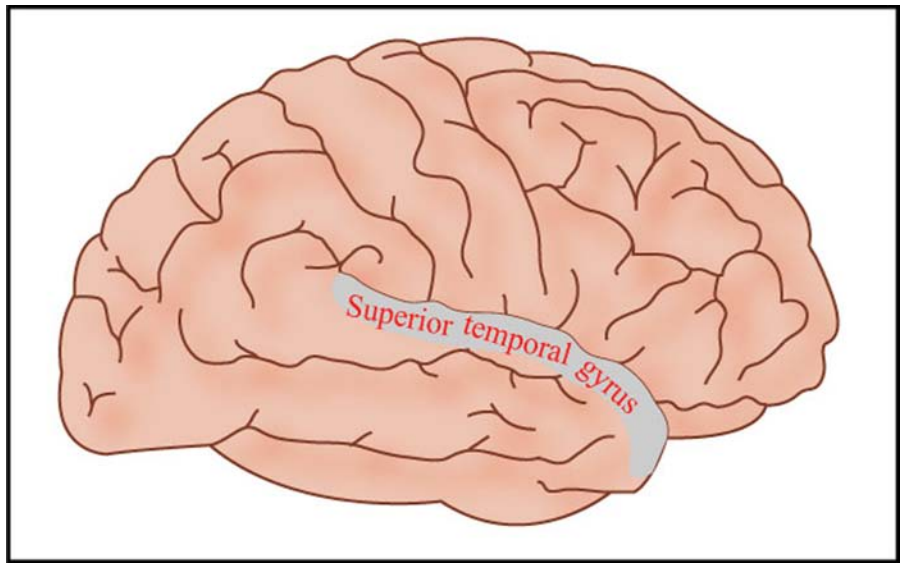
- 1) Lesions
- 2) Pathological contexts- autism, epilepsy, brain damage in adults
- 3) Amusic adults- learning disability for music
- 4) Brain imaging and electrophysiological techniques in normal adults
- Autism
  - Pauline- music ability is an isolated area of normal functioning
    - Intellectual deficiency with an IQ of 70 but able to harmonize, improvise and possesses absolute pitch

CIRCUMSTANCES UNDER WHICH BRAIN SPECIALIZATION FOR MUSIC OBSERVED

- Epilepsy
  - Musicogenic Epilepsy- music is sometimes exclusive trigger of pathological firing of neurons that underlies seizures
    - Shows epileptogenic tissue lies in neural region tied to music processing
  - Musical trigger can be highly selective, such as in a patient whose seizures were only triggered by “classical” music
  - During epileptic seizures, abnormalities observed at temporal lobes with slight bias towards right one
  - Direct electric stimulation of brain can trigger musicogenic epilepsy

CIRCUMSTANCES UNDER WHICH BRAIN SPECIALIZATION FOR MUSIC OBSERVED

- Brain damage in adults
  - Neuronal networks close to superior temporal gyrus (auditory cortex) participate in music perception & memory
  - Isabelle & CN- chance performance in melody recognition test; normal performance in songs with spoken lyrics and environmental sounds
    - Able to recognize the lyrics but not the melodies



CIRCUMSTANCES UNDER WHICH BRAIN SPECIALIZATION FOR MUSIC OBSERVED

- Congenital Amusia (Tone Deaf)
  - Speech- variations in pitch larger than half an octave
  - Melodies- small pitch intervals on the order of 1/12 or 1/16 of an octave
  - Inability to detect anomalous pitch
- Normal Adults
  - Semantic incongruity- activation of left inferior frontal cortex (Brodmann's areas 44 and 45)
  - Harmonic incongruity- activation of Brodmann's area 44
  - Thus, left inferior frontal cortex might reflect general intervention in detecting rule violations

MUSIC ESSENTIAL MECHANISMS

- Encoding of pitch along musical scales
  - Listeners sensitive to hierarchy of pitches
  - Probe-Tone task
    - Normal individuals prefer scale tones making up major triad
    - Brain-damaged individuals prefer using pitch direction and proximity to determine conclusion to melody
- Acribing of a regular beat to incoming events
  - Need for synchronicity

BRAIN LOCALIZATION & EMOTIONS

- Only consensus is pitch contour is processed in superior temporal gyrus and frontal regions on right side of brain
- Evidence music utilizes multiple brain regions in both hemispheres
- Importance may also lie in the dynamics and interactions of the music-specific neural networks
- Emotional appreciation of music consistent across individuals
- Remains to be determined how musical emotions are unique

SOCIOBIOLOGICAL FOUNDATIONS FOR MUSIC

- Music…
  - attracts mates
  - promotes group cohesion
- Personal and group identity

Image courtesy of junipaire on Flickr

Photo courtesy of tracy out west on Flickr.

SEMANTIC AND EPISODIC MEMORY OF MUSIC SUBSERVED BY DISTINCT NEURAL NETWORKS

- Tools: functional neuroimaging
- Aim: determine neural substrates responsible for semantic and episodic components of music memory
- Episodic memory- life events
  - Musical episodic memory- recognition of musical excerpt and its spatiotemporal context
    - Neural substrates uncertain
- Semantic memory- concepts
  - Musical semantic memory- strong feeling of knowing for familiar songs and melodies
    - Neural substrates uncertain

MATERIALS & METHODS

- Subjects: 9 young, healthy right-handed men with normal performance in pitch perception and not inclined to a particular music genre
- Musical material- 128 short (5s) melodies with same timbre (flute)
  - 64 familiar and 64 non-familiar tunes

PARADIGM

- 5 tasks- 1 semantic, 2 episodic, 2 control for a total of 12 PET scans (10 activation tasks, 2 rest measurements)
- 1 semantic task- familiar vs. nonfamiliar melody
- 2 control tasks- for familiar and nonfamiliar, indicate if last two notes of each sequence had same pitch
- 2 episodic tasks- for familiar and nonfamiliar, recognize among distractors, if melodies were heard during semantic task

DATA ACQUISITION & ANALYSIS

- PET scans reconstruct 63 planes
- Nonlinear transformation of images into standard space
- Analysis of covariance- global activity as confounding covariate
- Anatomical localization of activations based on SPM99 MRI template and Talairach's coordinates

PET Scanner: Public domain image (Wikipedia)

RESULTS- BEHAVIORAL DATA

- Performance for episodic task with nonfamiliar melodies lower than that for familiar melodies
- False alarms for episodic tasks more common with nonfamiliar melodies
- No subject expressed awareness tasks were based on familiarity vs. nonfamiliarity

RESULTS- PET DATA

- Semantic vs. control (NF + F)
- Episodic (NF + F) vs. control (NF + F)
- Episodic (NF + F) vs. semantic
- Semantic vs. episodic (NF + F)
- Control (NF + F) vs. rest
- Control (F) vs. control (NF)
- Episodic (F) vs. control (F)
- Episodic (NF) vs. control (NF)

DISCUSSION

- Activation patterns observed for semantic and episodic tasks were independent
- Semantic memory- medial frontal region (BA 10/11), left hemisphere including middle temporal gyrus (BA 21) up to inferior frontal gyrus (BA 47)
- Episodic memory- predominantly involves right hemisphere including frontal areas (BA 9/10) and precuneus (BA 7)
- Agreement with Tulving's findings
- Musical semantic/episodic memory consistent with verbal/visuospatial memory

WHAT DOES MUSIC MEAN TO YOU?

- “Music expresses that which cannot be put into words and cannot remain silent” –Victor Hugo
- “When people hear good music, it makes them homesick for something they never had, and never will have” –Edgar Watson Howe
- “Without music, life would be an error” –Friedrich Nietzsche
- “Music is God’s gift to man, the only art of Heaven given to earth, the only art of earth we take to Heaven” –Walter Savage Landor
- “Music and silence combine strongly because music is done with silence, and silence is full of music” –Marcel Marceau

RESEARCH PAPERS BIBLIOGRAPHY

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- Platel, Herve, Jean-Claude Baron, Beatrice Desgranges, Frederic Bernard, and Francis Eustache. Semantic and episodic memory of music are subserved by distinct neural networks. NeuroImage 20 (2003) 244-256.

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