
Name

Date

FINAL EXAMINATION
MUSIC MIND & BRAIN

MUSIC INDUSTRY 103

DUE FRIDAY JUNE 15, 2012

UCLA HERB ALPERT SCHOOL OF MUSIC
2011-2012 ACADEMIC YEAR, SPRING QUARTER

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Email: _____

I. Conceptual Approaches to Understanding Mind-Brain Correlates.

In class, we discussed several concepts that:

- form the foundation of modern scientific inquiry; and
- guide experimental approaches to research on mind-brain correlates.

1. Write the letter of the concept on the line preceding the corresponding paragraph. Use each letter once. (10 pts)

- A. Verificationism
- B. Falsificationism
- C. Existence Proof
- D. Neuroanatomically-Dissociable Musical Functions
- E. Top-Down Processing

_____ Introspection is not an acceptable scientific method for answering questions about how the brain perceives, performs, remembers, feels, and creates music. Nor are anecdotes an acceptable means of understanding the potential health benefits of “music therapy”. One must formulate *testable hypotheses* whose truth value can be tested via well-controlled

experiments. Propositions whose truth value cannot be tested through empirical observation lie outside the realm of science. (2 pts)

_____ Three split-brain patients were tested in a Cognitive Neuroscience Laboratory on two timbre perception tasks. The first task employed a one-interval, two-alternative, forced-choice, match-to-sample, go-go paradigm that required each isolated hemisphere to match familiar, well-known musical instrument timbres (e.g., trumpet, piano) to one of two pictures of musical instruments. The second task employed a two-interval, two-alternative, forced-choice, go-go paradigm that required patients to determine whether two unfamiliar timbres were the same or different. On the first task, both the Left and Right Hemispheres were competent – i.e., each performed above chance at a significance level of 95%. On the second task, only the Right Hemisphere was competent. Conclusion: In these patients, music-related functions mediating the recognition of familiar timbres are carried out by different parts of the brain than music-related functions mediating the discrimination of unfamiliar timbres. (2 pts)

_____ How you perceive the world is not solely determined by the information sent to your brain by sense organs in your ears, eyes, skin, and other body parts. What you know about the world influences how you perceive the world. (2 pts)

_____ We really can't prove any hypothesis is true beyond doubt using scientific methods. What scientists *can* do is exclude what is *not* true. By ruling out hypotheses using rigorous empirical methods, scientists can refute or refine a theory, even if they can't prove beyond a doubt the theory is true. Scientific theories advance and evolve over time by this process. (2 pts)

_____ One case, known as "SC", suffered damage the Orbitofrontal Gyri in the Left and Right Frontal Lobes due to a Stroke. Subsequently, this conductor/cellist couldn't control his emotional and visceral responses to music, especially his lifelong favorites. Conclusion: one's ability to control emotional and visceral responses to music *can* be lost following lesions of the Left and Right Orbitofrontal Gyri, but we don't know if that's true for most people, especially since SC had extraordinary talent in music. (2 pts)

2. Hans-Lucas Teuber, who co-founded MIT's Brain & Cognitive Science Department, coined the term *double dissociation* in 1955 to refer to dissociations between two anatomical structures and two mental functions that were in opposite directions. Write the letter of the lesion effect on the line preceding the corresponding hemisphere (note: the answer applies to >95% right-handers but <70% of left-handers) (4 pts):

- A. Deficit in Speech Production and Comprehension (Aphasia) with relative sparing of Spatial Cognition
- B. Deficit in Spatial Cognition with relative sparing of Speech Production and Comprehension

_____ Right Hemisphere (2 pts)

_____ Left Hemisphere (2 pts)

II. Methodological Approaches to Understanding Music & the Brain

In lectures and seminar presentations of professional journal publications, we discussed the handful of methods presently available to neuroscientists who want to study how we experience and make music. Limitations in these methods inherently limit the questions neuroscientists can answer experimentally. For example, much is known about the gross physiology of human cerebral cortex but next to nothing is known about its cellular neurophysiology and microcircuitry dynamics.

3. Below is a list of methods used to study brain anatomy, brain pathology, and brain physiology at the gross anatomical and gross physiological levels in humans and other animals. Write the letter of the method on the line preceding the corresponding description, then spell out what the abbreviation stands for. Use each letter once. (15 pts)

- A. MRI
- B. PET
- C. EEG
- D. MEG
- E. fMRI

_____ Measures electrical field potentials generated by millions of neurons in different regions of the brain with high temporal resolution and low spatial resolution. Can be used to do event-related potential (ERP) experiments

examining stimulus-evoked brain responses (e.g., responses to congruous vs. incongruous chords at the close of a musical phrase). (2 pts)

What does the abbreviation stand for? (1 pt)

_____ Measures blood flow, glucose consumption, and/or oxygen consumption in the working brain using radioactive chemicals. Fair spatial resolution and poor temporal resolution. Measurements are almost always averaged across subjects, whose brains are warped to fit a standard, 3D brain template. (2 pts)

What does the abbreviation stand for? (1 pt)

_____ Great for studying brain anatomy and pathology (lesions) with high spatial resolution. For example, we can use T1-weighted images to measure the volume of the superior temporal gyrus in each hemisphere and test “bigger is better” hypotheses (e.g., the hypothesis that the superior temporal gyrus in the left hemisphere is bigger in musicians than in non-musicians). But it doesn’t show the working brain. (High spatial resolution; zero temporal resolution.) (2 pts)

What does the abbreviation stand for? (1 pt)

_____ Measures magnetic field potentials generated by millions of neurons in the brain with high temporal resolution and poor spatial resolution. Can be used to do ERP experiments examining stimulus-evoked brain responses. (2 pts)

What does the abbreviation stand for? (1 pt)

_____ Measures blood oxygen-level dependent changes – an index of brain oxygen consumption. Does not use radioactive chemicals. Spatial resolution and temporal resolution are good but not great. In most experiments, measurements are averaged across subjects, whose brains are warped to fit a standard, 3D brain template. (2 pts)

What does the abbreviation stand for? (1 pt)

4. There is no “music center” in the brain. Different networks of neurons are involved in different aspects of music perception, performance, and cognition. The networks take the form of nodes located in different parts of the brain that are connected directly and indirectly with Auditory Cortex, which is necessary for normal music (and language) acquisition, learning, and competence. Some of the direct connections between modality-specific auditory association cortex and supra-modal cortex span inches. Microanatomical studies using special histological staining techniques have been used to map these connections in great detail in Old World monkeys, whose auditory cortex shares some gross, cytoarchitectonic, and myeloarchitectonic features with ours. (4 pts)

Which of the two main types of neurons in the cerebral cortex have axons that project from the Belt and Parabelt Areas of Auditory Association Cortex to Supra-Modal Areas in Anterior Frontal Cortex and Medial Temporal Cortex. (Put an X next to your answer.) (2 pts)

- Pyramidal cells
- Granule cells

Are the cells in your answer above excitatory, inhibitory, or both? (Put an X next to your answer.) (2 pts)

- Excitatory
- Inhibitory
- Both

5. The ascending auditory system shows remarkable divergence in cell numbers and types. Answer each question by putting the correct number in the space. (6 pts)

_____ The approximate number of inner hair cells (the primary sensory receptor in the ascending auditory system) in the organ of Corti of the cochlea in *each* of your inner ears. (2 pts)

_____ The approximate number of type I spiral ganglion cells (the first true “neuron” in the ascending auditory system) in *each* temporal bone of your skull. These neurons send one (peripheral) axon to an

inner hair cell and one (central) axon to the brainstem (specifically, the cochlear nucleus in the medulla). (2 pts)

_____ The approximate number of neurons in the Primary Auditory Cortex of *each* of your cerebral hemispheres. (2 pts)

6. Give one basic physiological characteristic – e.g., a receptive field property – of primary auditory cortex neurons. Write your answer below. (4 pts)

• Extra Credit:

Below is a list of methods used to study psychological functions. Match the method to its description below. Use each letter once. (Please put the letter of the concept on the line preceding the definition/example.)

- A. Method of Constant Stimuli
- B. Method of Adjustment
- C. Adaptive Method

_____ Violinists, guitarists and other string players use this method to tune each string on their instruments. (1 pt)

_____ Stimulus variables are “canned” and the results depend on how you set those variables before doing the experiment. Not well-suited to defining Weber fractions for pitch discrimination. (1 pt)

_____ Stimulus variables change depending on how well the subject does. Well-suited to defining Weber fractions for pitch discrimination. (1 pt)

III. Pictures of Sound & Psychoacoustics

Humans are compulsively visual. One symptom of this trait is that we have words for all sorts of visual objects and their features but relatively few for those of other senses. Is there any vocabulary more esoteric to the uninitiated

or cumbersome to the new student than that of acoustics and psychoacoustics? To understand neuroscientific approaches to music-related functions, especially those related to acoustic feature extraction and auditory percept formation, it is helpful to picture sounds graphically in two dimensions (e.g., acoustic waveforms; amplitude spectra) and three dimensions (e.g., spectrograms) in addition to learning the names of auditory objects and features used in the “language games” played by psychoacousticians and musicians.

7. Psychoacoustics is a discipline of Psychology that is concerned with the relationships between physical (acoustical) features of sound and perceptual attributes of sound. Write the letter of the acoustical feature on the line preceding the percept it most strongly determines. Use each letter once. (6 pts)

- A. Sound Pressure Amplitude (related to Intensity, Power, Sound Pressure Level)
- B. Frequency
- C. Duration

_____ Loudness (2 pts)

_____ Pitch (2 pts)

_____ Duration (2 pts)

8. For homework, you drew representations of sound in the Time Domain and Spectral Domain. Write the letter of the domain on the line preceding the corresponding description below. *Each letter may be used more than once.* (8 pts)

- A. Time Domain
- B. Spectral Domain

_____ x axis = frequency (usually Hz); y axis = amplitude of sound pressure fluctuations at the corresponding frequency (usually dB SPL re: 20 microPascals). (2 pts)

_____ x axis = time (usually milliseconds); y axis = amplitude of sound pressure fluctuations at the corresponding time (usually dB SPL re: 20 microPascals). (2 pts)

_____ Acoustic Waveform (2 pts)

_____ Amplitude Spectrum, a.k.a. Power Spectrum, Magnitude Spectrum (2 pts)

9. For homework, you drew idealized line amplitude spectra of a pure tone, a complex tone with harmonic and inharmonic partials, and a harmonic complex tone.

What are the frequencies of the first 6 harmonics of a harmonic complex tone whose fundamental frequency (a.k.a. first harmonic) is at A_4 ? Write the 6 frequencies on the line below. (3 pts)

Extra credit (1 pt): Which 3 of these 6 frequencies correspond to an A major triad in root position?

10. How is the period (T) of a sine wave or complex periodic wave related to the frequency (F) of wave vibrations? Put an X on the line preceding the correct answer. (2 pts)

- T = 2 x F
- T = F/2
- T = F²
- T = 1/F
- none of the above

11. In class, we played with two sine-wave generators in order to hear tonal “roughness”, a term introduced by Hermann Helmholtz in his monumental 19th century work, “On the Sensation of Tone as a Physiological Basis for the Theory of Music.” We also looked at post-stimulus time histograms of auditory-nerve fiber (ANF) responses to musical (harmonic) intervals to understand how roughness is encoded in ANF action potential discharge patterns.

True or False? - Place a T or F on the line preceding the statements below. (6 pts)

The harmony of simultaneous pitches comprising a musical chord decreases as the roughness (wR) generated by unresolved frequencies increases. (2 pts)

The harmony of simultaneous pitches comprising a musical chord increases as the strength of the fundamental pitch (wF0) increases. (The fundamental pitch is related to the “fundamental bass” of Rameau in his seminal 18th century work, “Treatise on Harmony.”) (2 pts)

The harmony of a chord sequence depends on the harmonic relationships between successive chords over time as well as the wR and wF0 of each chord. (2 pts)

IV. Functional Brain Organization & Music

12. In class, we discussed an experiment on harmony perception by the Left versus Right Hemispheres of split-brain patients. We also looked at an

experiment that measured Weber fractions for detection of chord mistuning in a music teacher with a stroke and normal controls. Which hemisphere is better at perceiving the harmony of simultaneous pitches (a.k.a. “vertical” harmony, the harmony of isolated chords)? Write an X on the line preceding your choice. (2 pts)

- _____ Left Hemisphere
- _____ Right Hemisphere
- _____ Neither Hemisphere – i.e., they are equal

13. Write the letter of the gross anatomical term on the line corresponding to the type of physiologically- and functionally-defined type of cortex: (6 pts)

Gross Anatomy

- A. Transverse Gyrus of Heschl
- B. Superior Temporal Gyrus
- C. Uncus/Amygdala

Physiology/Function

- ___ Auditory Association Cortex (2 pts)
- ___ Primary Auditory Cortex (A1) (2 pts)
- ___ Supra-modal Cortex (2 pts)

14. Brain waves oscillate during auditory stimulation with different rhythms. Write the letter of the brain rhythm on the line corresponding to the frequency of its oscillations: (6 pts)

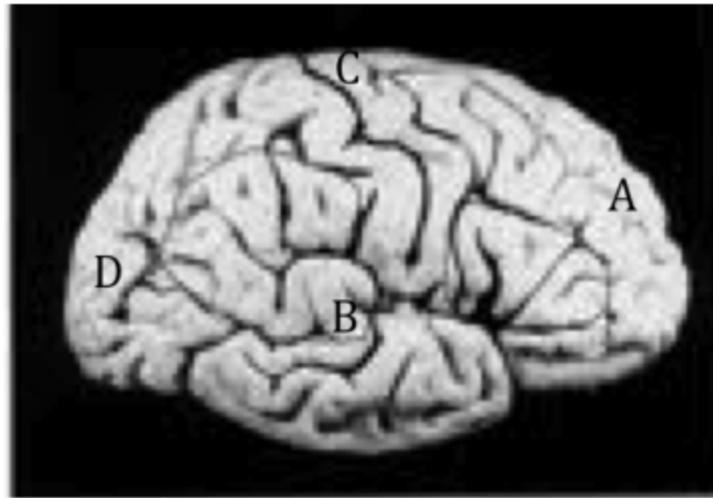
- A. Gamma Band
- B. Beta Band

- _____ 20-30 Hz (2 pts)
- _____ 30-50 Hz (2 pts)

In which Band has a neural representation of rhythm been found? Write your answer on the line below. (2 pts)

_____.

15. Match the Music-Related Function to its *Anatomical Location* (see the *letter* on the Lateral View of the Right Hemisphere below) and its corresponding *Functional Subsystem of the Cerebral Cortex* (see the corresponding *Roman numeral* in the list below the brain). Write the letter/ numeral on the line following the description. Use each letter and numeral once. (28 pts)



- I. Modality-Specific System (Auditory)
- II. Modality-Specific System (Motor/Somatosensory)
- III. Modality-Specific System (Visual)
- IV. Supra-Modal System (Future-Supramodal Subsystem)

Auditory Analysis & Representation (e.g., perception of melody, harmony, rhythm, timbre, voice):

Corresponding Anatomical Structure: Letter = _____ . (5 pts)

Corresponding Functional Cortical Subsystem: Roman Numeral = _____ . (2 pts)

Expectancy Generation, Violation, & Satisfaction (e.g., repetition, return, appoggiatura):

Corresponding Anatomical Structure: Letter = _____ . (5 pts)

Corresponding Functional Cortical Subsystem: Roman Numeral = _____ . (2 pts)

Visual Perception (e.g., stage lighting, scene design, facial expression, body language):

Corresponding Anatomical Structure: Letter = _____. (5 pts)
Corresponding Functional Cortical Subsystem: Roman Numeral
= _____. (2 pts)

Kinetics & Kinesthetics (e.g., dancing, singing, foot-tapping – moving):
Corresponding Anatomical Structure: Letter = _____. (5 pts)
Corresponding Functional Cortical Subsystem: Roman Numeral
= _____. (2 pts)

16. Match the following brain structures with their corresponding musical functions. Write the letter on the line preceding the match. Use each letter once. (20 pts)

- A. Right Transverse Gyrus of Heschl
- B. Auditory Brainstem
- C. Right Medial Temporal Lobe, including the Amygdala
- D. Basal Forebrain/Median Forebrain Bundle/Midbrain Ventral Tegmental Area
- E. Bilateral Motor Association Cortex

_____ Perceiving the beat in a metrical rhythm. (4 pts)

_____ Judging the direction of a pitch change between two pure-tones that differ in frequency by less than a semitone (Weber Fraction < 6%). (4 pts)

_____ Judging the direction of a pitch change between two pure-tones that differ in frequency by more than an octave. (4 pts)

_____ Feeling fear when you hear scary music. (4 pts)

_____ Feeling pleasure when you hear music you like. (4 pts)

END