HST.723 Final Exam
May 19, 2008

1. **Answer each of the 11 questions on a separate sheet of paper. Please use these pages.**
2. **Write your name and Question # on every page you turn in. The pages will be split between instructors for grading.**
3. **All questions will be weighted equally.**

Solve Question 5 to help Bert improve Ernie's cochlear implant

Why have chipmunks been neglected in auditory research?
Find out by solving Question 2.

Name: _____ **Question 1**

An experiment is performed in which current is passed between two electrodes placed in the anteroventral cochlear nucleus (AVCN) of a cat. Assume the current results in a lesion that extends throughout almost all of the AVCN, but not outside it.

a) Indicate which of the following would be damaged by the lesion and which would not. Explain each response in one sentence.

   i. auditory nerve fibers

   ii. pyramidal/fusiform cells

   iii. spherical bushy cells

   iv. multipolar cells

b) After the lesion is created, the animal is allowed to recover while the damaged neurons degenerate. Name two nuclei outside the AVCN in which you would expect to find degenerated or missing terminals. Explain each answer in one sentence.

c) Indicate whether each of the following is true or false. Explain any false response in one sentence.

   i. In humans, primary auditory cortex at least partially overlaps Heschl's gyrus.

   ii. Within the gray matter of primary auditory cortex, layer II receives more direct inputs from the medial geniculate body than any other layer.

d) In 3 - 4 sentences, explain what is meant by "tonotopic organization".

Name: _____ **Question 2**

In spite of their excellent singing abilities, chipmunks have been ignored in auditory research. On the basis of what you have learned in class for other species, sketch the expected plots of CF vs. distance along the tonotopic axis of the primary auditory cortex (A1) for the adult chipmunk. Assume that the normal hearing range for a chipmunk extends from 1 to 50 kHz, and that the total distance along A1 is 2.5 mm. Also assume that chipmunks mature from infancy with a time course similar to that of the better-studied rat. Label any important points on the CF axis. Sketch a graph for each of the following four chipmunk auditory cortices:

a) a normal adult chipmunk

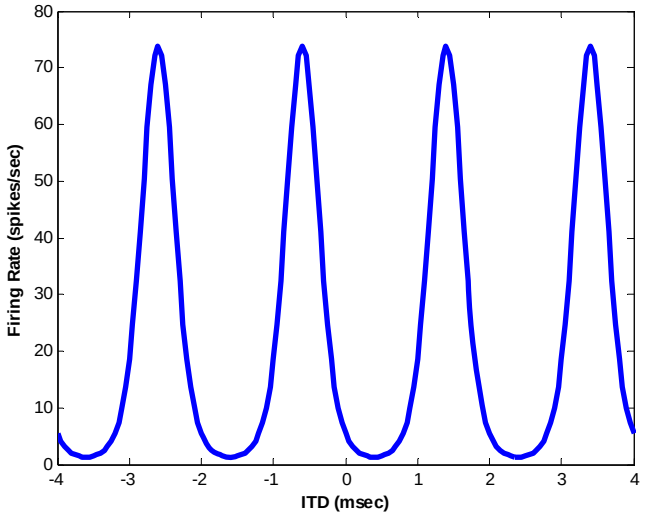
b) a chipmunk with normal hearing below 10 kHz but that has had a complete peripheral hearing loss above 10 kHz for the past several weeks

c) a chipmunk that listened to modulated 10 kHz tone bursts for its first two weeks of life

d) a chipmunk that listened to modulated 10 kHz tone bursts for two weeks as an adult

Name: _____ **Question 3**

The figure below shows the average firing rate of a neuron in gerbil medial superior olive (MSO) as a function of interaural time differences (ITD) of a pure tone. Positive ITDs mean stimuli leading at the right ear.



a) What is the tone frequency? Explain.

b) Is this neuron more likely to be located in the left MSO or in the right MSO? Explain.

c) Draw the period histogram for this neuron's response to binaural pure tones with an ITD of (1) –0.6msec, (2) +0.4 msec. Label the horizontal axes in msec.

d) Now the same neuron is stimulated with broadband noise. Sketch the average firing rate as a function of ITD over the same range as in the figure. Assume the neuron's best frequency is 800 Hz. Clearly label the horizontal axis.

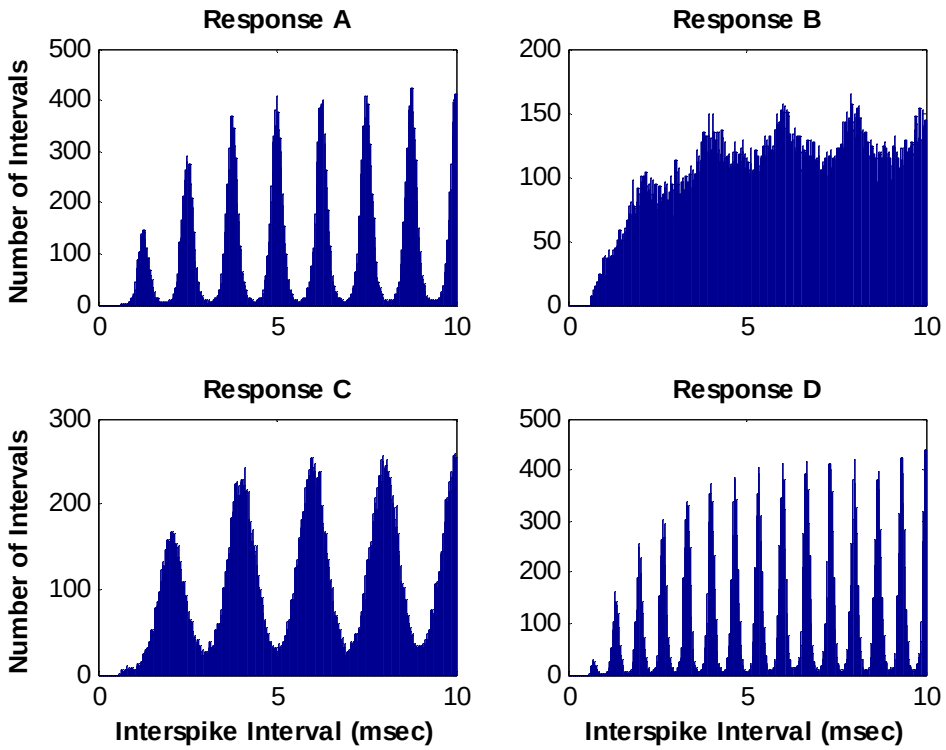
Name: _____ **Question 4**

The figure below shows all-order interspike-interval distributions measured from cat auditory-nerve fibers in response to pure and complex tone stimuli. Specifically recordings were made from two fibers with characteristic frequencies (CF) of 1500 Hz and 5000 Hz, respectively. Three different stimuli were presented:

S1: A 800 Hz pure tone.

S2: A harmonic complex tone (F0 = 500 Hz) with 20 equal-amplitude harmonics all in cosine phase.

S3: A harmonic complex tone (F0 = 500 Hz) with 20 equal-amplitude harmonics in random phase.



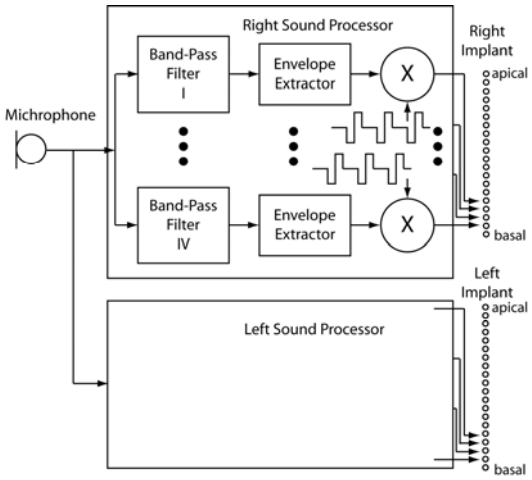
a) For each of the 4 responses shown in the figure, circle the stimulus and the CF of the fiber from which the recording was made. In some cases, more than one answer is possible.

A.	Stimulus:	S1	S2	S3	CF:	1500	5000
B.	Stimulus:	S1	S2	S3	CF:	1500	5000
C.	Stimulus:	S1	S2	S3	CF:	1500	5000
D.	Stimulus:	S1	S2	S3	CF:	1500	5000

b) How would you expect Responses A-D to differ in a hearing impaired animal with a three-fold reduction in cochlear frequency selectivity (i.e. the bandwidths of the cochlear filters are 3 times wider than normal)?

Name: _____ **Question 5**

Bert's friend Ernie is deaf and has bilateral cochlear implants (see diagram). Each ear is implanted with a 20-electrode array. Each implant is controlled by a sound processor that splits the spectrum into 4 equal (in log(freq)) bands by band-pass filtering. The envelope of each filter's output modulates a pulse train. Each of the four pulse trains stimulates one of the 20 electrodes. Each processor is capable of stimulating any and all electrodes. The left and right sound-processors are identical and receive input from the same single microphone.



Bert asks you how he might modify the sound processors to provide more information for Ernie. You have complete flexibility in redesigning the two sound processors (but not the implants). Describe at least two changes you would make. For each change, describe the specific added or improved auditory information you are attempting to provide for Ernie.

Name: _____ **Question 6**

In a two-interval, two-alternative forced-choice masking experiment with a normal-hearing human listener, a 100 ms masker tone was timed so that it ended 1 ms *after* a 1,000 Hz tone-pip target (which had a 2-cycle rise, no plateau, and a 2-cycle fall). The masker level was adjusted so that the listener heard the target 75% of the time. Four different masker frequencies were used (700, 900, 1,050 and 1,150 Hz), and 2 different target levels (10 and 20 dB SPL) i.e., eight sets of data were obtained. The table below shows the threshold masker level for each of the 8 combinations of masker frequency and target level, but the masker frequencies are only labeled only as A, B, C, D.

Masker Frequency	**Masker Level for 10 dB SPL target**	**Masker Level for 20 dB SPL target**
A	60 dB SPL	65 dB SPL
B	40 dB SPL	55 dB SPL
C	40 dB SPL	49 dB SPL
D	30 dB SPL	40 dB SPL

a) For each case, state which of the four masker frequencies was used and give a justification for this choice.

Masker Frequency (**700**, **900**, **1,050** or **1,150** Hz) Reason

A: _____ _____

B: _____ _____

C: _____ _____

D: _____ _____

b) The experiment is changed so that the 1,000 Hz tone-pip target now starts 1 ms *after* the end of the masker. Is the masker level required to produce 75% suppression of the 10 dB SPL target HIGHER or LOWER than before for masker frequency "A"? State your reasoning.

Circle one: HIGHER LOWER

Reason:

Name: _____ **Question 7**

This question is about the "pitch neurons" found by Bendor and Wang (2005) in the auditory cortex of awake marmosets. For each item, circle TRUE or FALSE, and give a reason if FALSE.

a) Pitch neurons respond to harmonic complex tones with missing fundamentals, but not to pure tones.

TRUE FALSE, Reason:

b) Pitch neurons are found in a circumscribed area located rostral and medial to the primary auditory cortex (A1).

TRUE FALSE, Reason:

c) On the average, pitch neurons better respond to iterative ripple noise (IRN) generated with 16 iterations than to IRN with 4 iterations.

TRUE FALSE, Reason:

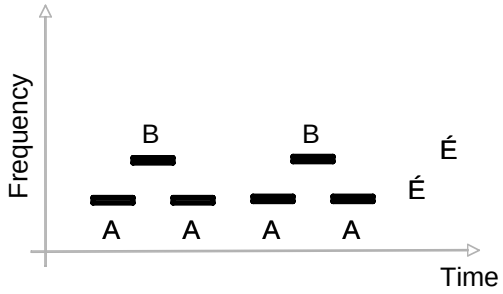
d) A pitch neuron tuned to F0 responds to individual harmonics of F0 presented in isolation if these harmonics are resolved but not if they are unresolved.

TRUE FALSE, Reason:

e) A key issue in the Bendor and Wang study was to rule out the possibility that responses of pitch neurons might be due to *combination tones*. Explain what combination tones are and why they could generate neural responses meeting the criteria for pitch neurons. Feel free to use sketches.

Name: _____ **Question 8**

Consider an "ABA_" sequence of pure tones:



a) How does a normal listener's perception of this sequence change as the frequency separation between A and B is increased from zero. Limit your answer to five sentences or less.

Suppose A and B are each replaced by a complex tone comprising 60 harmonics of 100 Hz (both odd and even) in cosine phase. The tone complexes are filtered to remove all resolved harmonics.

b) Should the filter be (1) high-pass or (2) low-pass to remove the resolved harmonics? How would you choose the filter cut-off frequency? Explain your answer in 1 -2 sentences.

c) Name one feature of the complex tones which, if sufficiently different between A and B, will cause A and B to perceptually split into separate streams. Assume A and B have been filtered to remove all resolved harmonics and further filtered to ensure that the range of frequencies comprising each tone is the same. Explain your answer in one sentence.

Name: _____ **Question 9**

For each of the following, circle **T** if the statement is TRUE, and **F** if the statement is FALSE. If the statement is false, give a reason. (READ CAREFULLY!).

a) A forward masking experiment uses a 1 kHz, 10 dB SPL tone-pip target and 1.1 and 1.3 kHz maskers. The 1.1 kHz tone masks the target (to 75% correct) at 60 dB SPL but the 1.3 kHz tone produces no masking at the highest level available (80 dB SPL). Therefore, if a 1.3 kHz, 80 dB SPL tone is presented simultaneously with the 1.1 kHz masker, the level of the 1.1 kHz tone needed to produce 75% correct masking will remain at 60 dB SPL.
T F, reason:

b) According to the Cai and Geisler (1996) model for the origin of low-side two-tone suppression, maximum suppression is produced at the peak of basilar-membrane velocity toward scala media and/or toward scala tympani.
T F, reason:

c) If OHC and IHC stereocilia are both included, simultaneous masking is completely explained by the bending of these stereocilia into their nonlinear region reducing cochlear amplification and IHC responses.
T F, reason:

d) There has been controversy over the sharpness of human cochlear tuning because all measures of human cochlear tuning require subjective human responses and there are no independent physiologic measurements in humans that shed light on this issue.
T F, reason:

Name: _____ **Question 10**

The Seeber & Fastl (2008) paper discussed in class showed that wearers of bilateral cochlear implant (BiCI) have good sensitivity to interaural level differences, but are unable to use interaural time differences (ITD) for sound localization. This problem explores the consequences of this poor ITD sensitivity for speech reception in noise.

a) Describe two factors that contribute to spatial unmasking of speech in noise *for normal-hearing (NH) listeners*. Briefly explain how they contribute and in which frequency region they are the most effective. [Use the back to answer]

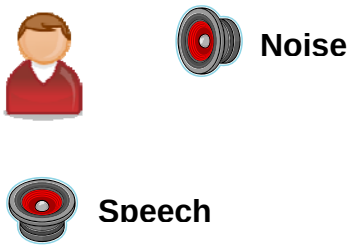
b) Speech reception in noise is measured in an anechoic room for both NH and BiCI listeners using the stimulus configurations shown below. For each configuration and type of listener, state whether you expect to observe masking release relative to the reference configuration. For BiCI subjects, assume that monaural speech reception performance is the same with both implants.

Reference: Speech and noise in front

i. Speech in front, noise to the side

NH Subjects: RELEASE NO RELEASE

BiCI Subjects: RELEASE NO RELEASE



ii. Speech in front, noise in back

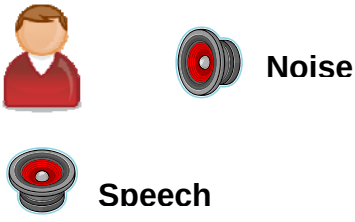
NH Subjects: RELEASE NO RELEASE

BiCI Subjects: RELEASE NO RELEASE

iii. Speech in front, two **uncorrelated** noise sources on opposite sides

NH Subjects: RELEASE NO RELEASE

BiCI Subjects: RELEASE NO RELEASE



Name: _____ **Question 11**

This question considers data from recordings of single units in the cochlear nucleus. Below are 6 interspike interval histograms (A – F). On the following page, there are 6 PST histograms (1 – 6). Next to each PST histogram, fill in the letter of the corresponding interspike interval histogram. Also for each histogram, write the unit type and write an explanation (1 or 2 sentences) of why you chose that unit type. "Phase locked" is an acceptable unit type in the case when phase locking prevents classification.