HST.723 Final Exam
May 18, 2009

1. **Answer each of the 10 questions on a separate sheet of paper. Please use these pages. Write on both sides if necessary.**
2. **Write your code and Question # on every page you turn in. The pages will be split between instructors for grading.**
3. **All 10 questions will be weighted equally.**

Code: ______________________________ **Question 1**

Psychophysical tests are done using a 20 ms long, 1000 Hz probe tone at 15 dB SPL (which is 10 dB above the subjects threshold at 1000 Hz). A 300 ms long tone masker is timed so that it ends just before the start of the probe tone. Both masker and probe have 5 ms rise-fall times.

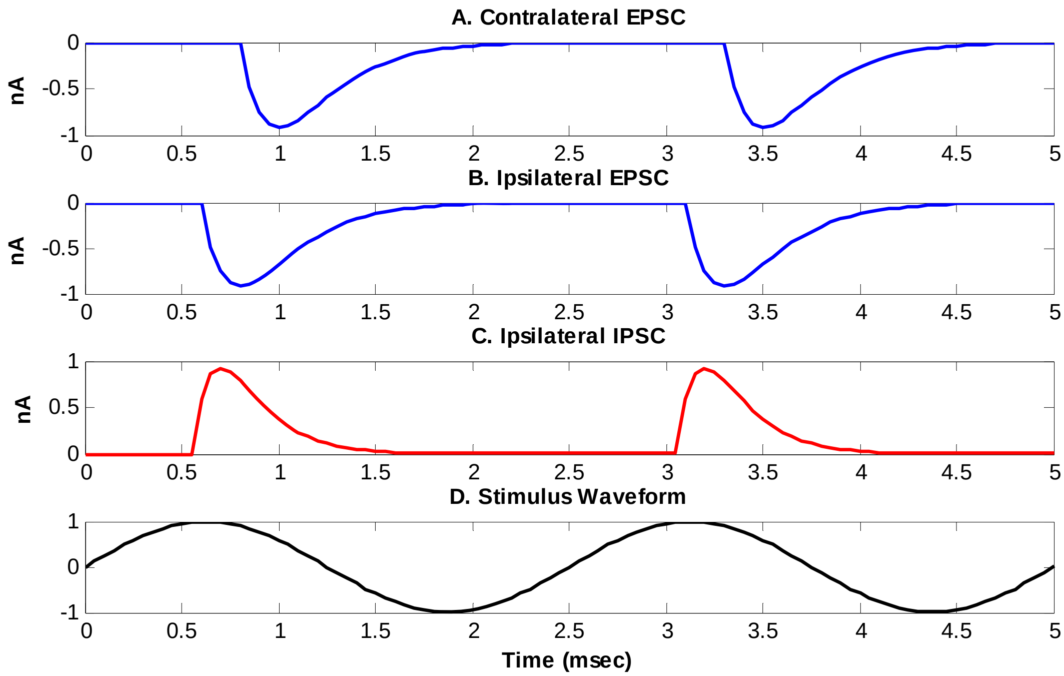
a) A first set of tests are done to obtain the masker tone levels needed to just produce masking when the masker is at 800 Hz and then at 1050 Hz. A second set of tests are done in the same way with the maskers at 790 Hz and then at 1060 Hz.
Describe and contrast the difference in the change in masker levels obtained in Set 1 versus Set 2 for the below-probe maskers versus the above-probe maskers.
(Remember this asks for the masker levels, the probe level stays at 15 dB SPL).

b) A third set of tests are done with the same masker frequencies as for Set 1, but the probe level is raised by 10 dB to 25 dB SPL.
Describe and contrast the difference in the change in masker levels obtained in Set 1 versus Set 3 for the below-probe maskers versus the above-probe maskers.

c) A fourth set of tests are done with the same probe level (25 dB SPL) and masker frequencies (800 Hz and 1050 Hz) as in Set 3, but the timing of the tones is changed so that the masker and probe *end at the same time*.
Describe and contrast the difference in the change in masker levels obtained in Set 3 versus Set 4 for the below-probe maskers versus the above-probe maskers.

***Code:*____________________________ **Question 2**

The figure shows excitatory and inhibitory postsynaptic currents (EPSC and IPSC) recorded from a neuron in the gerbil superior olivary complex using the whole-cell, patch clamp recording technique in response to acoustic stimulation by a pure tone. Two cycles of the tone waveform are shown in D. The tone was presented monaurally either to the contralateral ear (A) or to the ipsilateral ear (B and C). IPSC and EPSC were isolated by applying selective channel blockers intracellularly. For contralateral stimulation, no IPSC was detected. The inhibition is known to be glycinergic.



a) Would you use voltage clamp or current clamp to measure EPSCs and IPSCs? Explain.

b) Now the same pure tone is presented binaurally. Sketch the neuron's firing rate as a function of interaural time difference (ITD) **under application of strychnine**. Pay particular attention to the location of the best ITD. Sketch the response for ITD varying from -5 to +5 msec (positive ITDs represent stimuli leading at the contralateral ear).

c) On the same axes, sketch the neuron's response as a function of ITD in the normal condition when there is no strychnine.

d) Now the pure tone is presented through a movable loudspeaker in an anechoic room. Sketch the neuron's response as a function of source azimuth from -90° to +90°.

Code: ________________________________ **Question 3**

Auditory cortex and cochlear nucleus both have tonotopic organizations. Compare and contrast their tonotopic organization in terms of the categories below, using a couple of sentences and/or a sketch for each answer. Use the cat or another animal model in your answer:

a) Anatomical orientation of the tonotopic axis:

Cochlear Nucleus:

Auditory Cortex:

b) Anatomical structure (be as precise as possible) providing the tonotopic inputs:

Cochlear Nucleus:

Auditory Cortex:

c) Known plasticity of tonotopic organization after peripheral hearing loss

Cochlear Nucleus:

Auditory Cortex:

d) Give an example of how tonotopic organization in auditory cortex might change over the course of a few minutes:

Code: ______________________________ **Question 4**

a) A patient wears a monolateral cochlear implant that includes 100 electrodes (numbered 1 to 100 from apex to base) uniformly distributed along the total length of the right scala tympani. Using today's conventional stimulation techniques, your task is to design a sound processor for optimal speech reception. How many analysis channels (band-pass filters) would you use? Specify the number and explain why you selected it. Sketch their magnitude responses on a single plot. How would you map the N analysis channels to the array of 100 electrodes?

b) The patient returns with the same right-ear system you designed and also with a 100-electrode array (same interelectrode spacing as the right) partially inserted in the left cochlea. Only Electrodes 1 to 70 are properly inserted in the left ear. Answer the same three questions asked in (a).

Code:_______________________________ **Question 5**

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 why. If you're not sure, briefly state what you know that's relevant.

a) Summing localization in the precedence effect does not occur when the leading and lagging sound sources are both located in the horizontal plane in the back of the listener.
   T **F**, reason:

b) Inferior colliculus (IC) neurons with build-up temporal response patterns have more robust directional responses than onset neurons in reverberation because they integrate binaural cues over longer periods of time.
   T **F**, reason:

c) According to Joris et al. (*PNAS* 103:12917-222, 2006), the range of best ITDs tends to be wider in IC neurons with low best frequencies (BF) than in high-BF IC neurons because the cochlear traveling wave slows down as it progresses from the base to the apex.
   T **F**, reason:

d) Tone languages such as Mandarin Chinese are harder to understand than English in large halls because the temporal envelope pitch cues available from unresolved harmonics are severely degraded by reverberation.
   T **F**, reason:

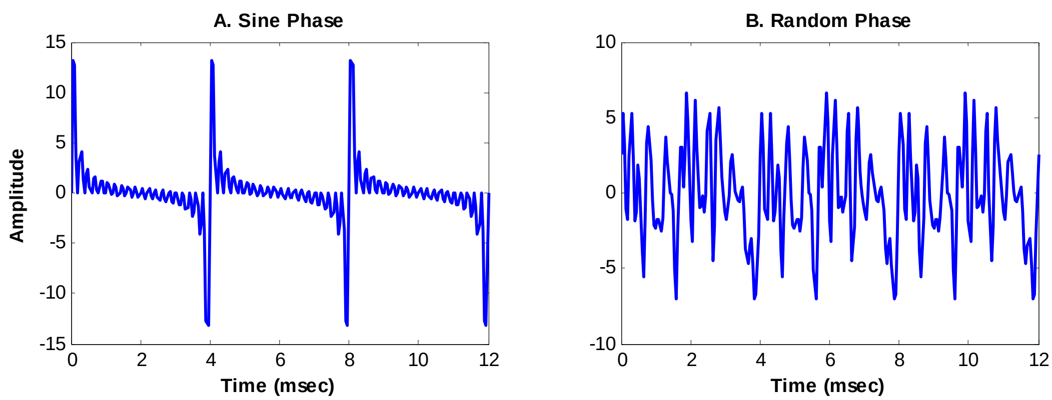
e) Human subjects wearing cochlear implants bilaterally are unable to use envelope ITD cues for sound localization because their sound processors eliminate these cues.
   T **F**, reason:

a) A tone complex consists of the following components, all of equal amplitude and in cosine phase: 400, 600, 1000, 1400, and 1600 Hz. What is the frequency of the perceived pitch?

b) Another tone complex consists of the following components: 620, 820, and 1020 Hz. What is the approximate frequency of the perceived pitch?

c) Give one class of pitch models that predicts the pitch of the sound in (b). Give one class of models that does **not** predict the pitch. Briefly explain why each model works or does not work.

The figure shows the waveforms of two harmonic complex tones that have the same power spectrum, but differ in the phase relationships among their components.



d) Would you expect the pitch strength of Sound A to be stronger, weaker, or about the same as that of Sound B? Explain.

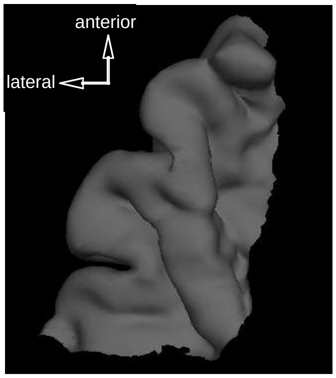
e) How would your answer change if the two sounds were highpass filtered at 2600 Hz? Explain.

_Code:_________________________________ **Question 7**

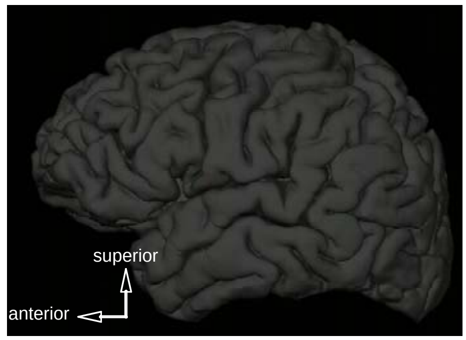
a) (1 pt) Primary auditory cortex in humans mainly overlaps which of the following structures (circle one):

Superior temporal sulcus   Heschl's gyrus   Planum temporale

b) (3 pts) Label each of the structures listed above on one or, if appropriate, both figures below:

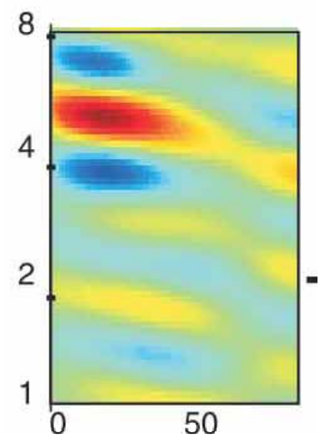


Superior temporal lobe viewed from above



Side view of brain

c) Auditory cortical neurons are commonly characterized by a spectro-temporal response field (STRF).



i. (2 pts) At right is an STRF from Fritz et al. (Nat. Neurosci. 6: 1216-1223, 2003). Label the horizontal and vertical axes as clearly as possible (perhaps more clearly than Fritz et al did).

ii. (4 pts) Describe how an STRF is derived from neural response measurements. Keep your answer brief and focus on the most essential aspects of the derivation.

***Code:*______________________________ **Question 8**

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 why it is false. (READ CAREFULLY!).

a) In forward masking, increasing the level of a tone in the masker either does nothing or decreases the audibility of the following probe sound.
T **F**, reason:

b) For certain operating points, as a low-frequency, simultaneous masker tone (a "bias tone") is increased in level, the masking of the basilar-membrane response to a high-frequency probe tone first appears as a reduction of the probe tone response at two phases of the bias tone, 180 degrees apart, and when the bias tone becomes very large, there is only one phase of suppression and this shows a very large suppression.
T **F**, reason:

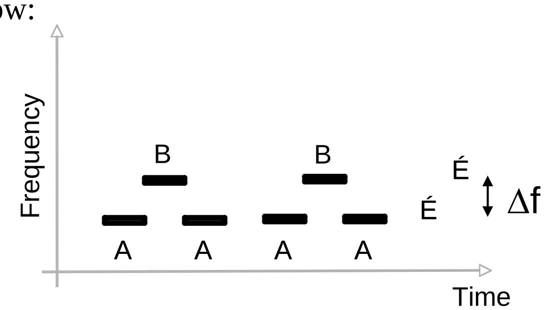
c) Measurements of SFOAE phase versus frequency were done on a previously untested mammalian species and the results showed phase-vs.-frequency functions that yielded group delays that were shorter than those in cats and guinea pigs. This suggests that this species has sharper cochlear tuning than cats and guinea pigs.
T **F**, reason:

d) The main cause of excitatory masking observed in auditory nerve fibers is refractoriness in the fibers.
T **F**, reason:

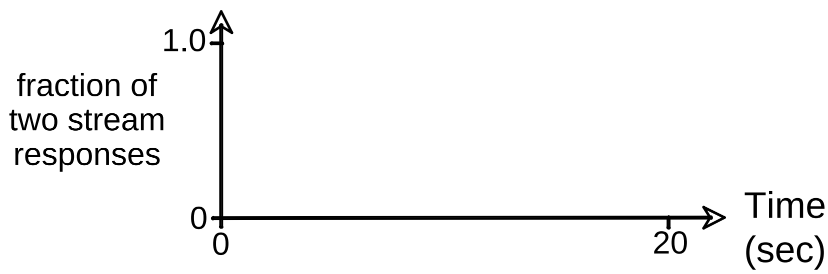
e) Suppressive masking comes only from basilar-membrane motion bending outer-hair-cell stereocilia into lower slope regions of the stereocilia-angle versus receptor-current function.
T **F**, reason:

Code:________________________________ **Question 9**

a) (4 pts) You perform an experiment in which subjects listen to sequences of tones like the one illustrated below:



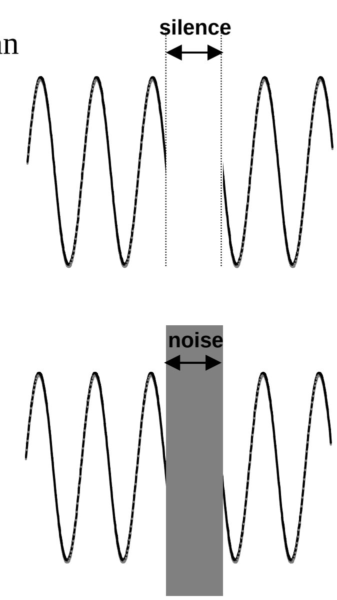
During each trial of the experiment, subjects listen to a tone sequence for 20 seconds while continuously reporting whether they hear one stream or two.* You conduct many trials in many subjects and vary Δf, the frequency separation between the A and B tones, from trial to trial. You then calculate the fraction of "two stream" responses for each Δf as a function of time. On the axes below, plot this fraction vs. time for three Δf 's: large, intermediate, and zero.



* If you're concerned about details, the subjects are pressing one of two buttons depending on whether they hear one stream or two.

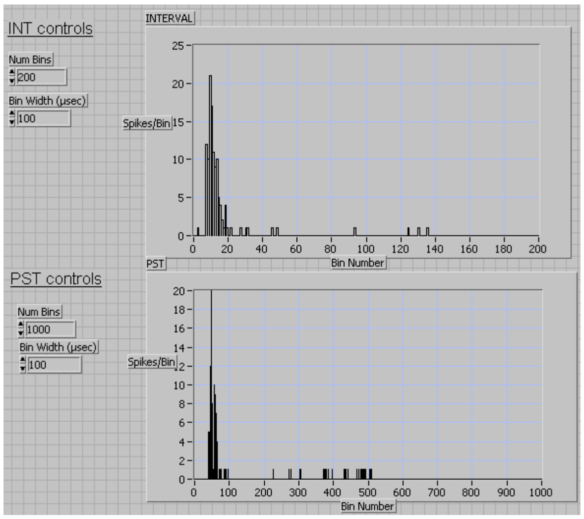
b) (3 pts) A harmonic complex is typically heard as a single, complex tone. However, if one harmonic is sufficiently mistuned, it "pops out" and is heard separately from the complex. In 1 - 2 sentences, explain which grouping cues determine this phenomenon.

c) (3 pts) When a prolonged 500 Hz tone is briefly silenced (right, top), an interruption of an otherwise continuous tone is heard. Predict what would be heard if the brief silence were filled with broadband noise (bandwidth: 50 - 5000 Hz) (right, bottom). Explain your answer in 1 - 2 sentences.



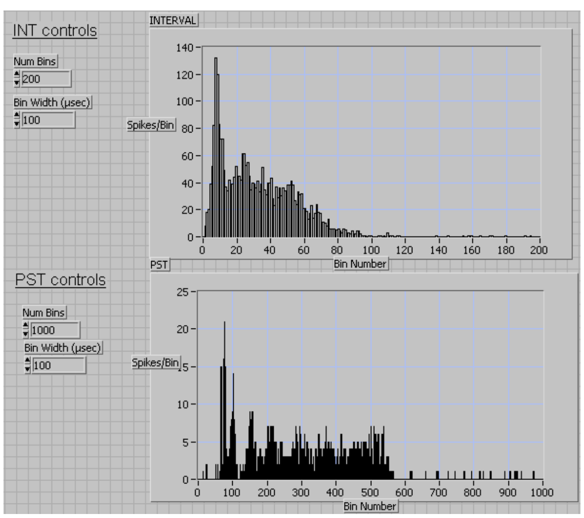
***Code:*_______________________________** **Question 10**

The following histograms were obtained from cochlear nucleus units. In each example, the upper histogram is the interspike interval histogram (INT) and its time scale is 0.1 ms/bin (20 ms for the total x axis), whereas the lower histogram is the poststimulus time histogram (PST) and its time scale is 0.1 ms/bin (100 ms for the total x axis). The sound stimuli were CF tone bursts of 50 ms duration. Please answer the questions beside each histogram.



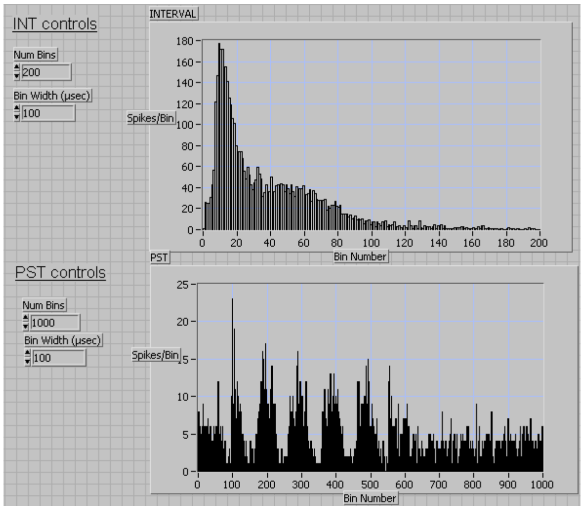
Unit 1. State the physiological type of this unit:

In the INT, explain the peak at around 1 ms:



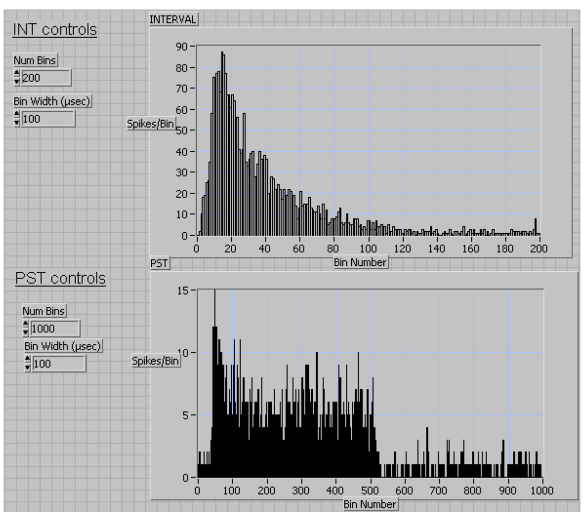
Unit 2. These data may be a recording from two units at once. What two physiological types of units could they be?

Using standard recording equipment, state an easy way to check the idea that it is a recording from two units:



Unit 3. There are several possibilities for the physiological type of this single unit. State them:

Using data in the histograms, how would you estimate the sound frequency used for the stimulus:



Unit 4. State the physiological type of this unit:

In the PST, give a likely explanation for spikes in the first few bins: