Assignment 2:
Human Haptics

PDF file due on Canvas by 11:59 pm PDT on Thursday, April 23, 2020
Please write clearly or type your responses.

1. Two-point Discrimination Test

Here you will do a simple human-participant experiment, ideally with the help of a partner in your household. (Please note in Part C if you are by yourself or do not have access to a willing partner.) The experiment, known as the **two-point discrimination test**, highlights the haptic sensing capabilities of different parts of the body.

The two-point discrimination test seeks to determine, for a specific location on the body, the distance between two contact points at the threshold of when they are perceived as a single contact point vs. two separate contact points. I chose this activity because it shows the process of developing a haptic experiment with human users, and the results are meaningful for the design of tactile haptic devices.

You will perform this experiment for two locations on the body:

- The **tip of the index finger** of the dominant hand (i.e., if your "subject" is right-handed, use the right hand)
- The **inside of the forearm** (as shown in the image below; use the same arm as the dominant hand)

Test your partner for each of these body locations. The steps to complete are as follows.

A. Develop a method for applying two point contacts to the skin. The contacts should be sufficiently blunt that they will not cause pain or injury. You can use paperclips, pencils, and the endpoints of calipers, to name a few possibilities. Ideally the contacts with the skin would be made at the same time and with the same light pressure, but for the purposes of this assignment, it doesn't need to be perfect. In your writeup, explain your method.

B. Develop a method for measuring the distance between the two contact points. A ruler, string (later measured with a ruler), markings on tape, etc. are a few possibilities. In your writeup, explain your method.

C. Decide how you will find the point at which two points start to feel like one (or one point starts to feel like two). Will you start with a large distance and move in? Or a small distance and move out? Or do both and average them? How many times will you repeat the test on each body location for each subject? (Do be respectful of your subject's time!) Come up with your own experimental protocol and be sure to keep it consistent for all your measurements. If you do not have a partner to test, test yourself. For this, you will need to develop a way to avoid advance awareness of the distance between points (or if there is a single point). One way is to create multiple stimulus tools, mix them up, and pick one without looking. In your writeup, explain your method.

D. Record data with your subject. Record the reported age (in years) and biological sex (Female, Male, or Other) of your subject. Please record your data in units of millimeters (mm). **Submit your two-point discrimination threshold for each body part by entering it in this google sheet: https://tinyurl.com/TwoPointSpring2020.** This spreadsheet will automatically compute the

average results for the entire class. Make sure to enter your name into the spreadsheet to get credit for this part.

E. Reflect. Were you surprised at the results? Which body part was the most sensitive? What mechanoreceptors do you think are involved? What are sources of experimental error (bias/accuracy and variability/ precision)? What improvements would you make to your experimental procedure, given infinite time and money?

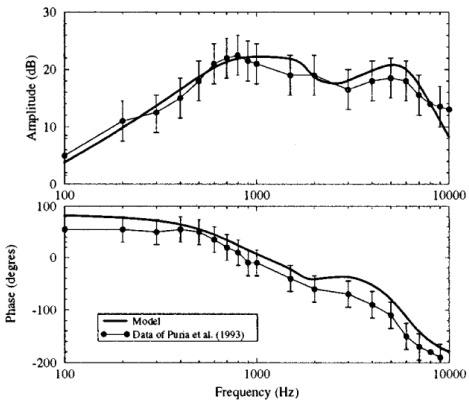
2. Frequency Response of Human Perception

In Lecture 3, we discussed how the mechanoreceptors in the skin have different frequency responses. In addition, other human sensing systems have their own frequency responses. An interesting application that exploits substitution across human sensory systems is Tadoma, a method of communication in which speech is received by placing a hand on the talker's face and monitoring actions associated with speech production (https://doi.org/10.1121/1.392266). In this question, we will explore the effects of the differing frequency responses of hearing and touch. We will also use this question to familiarize ourselves with MATLAB grader in Canvas.

A. Comparing transfer functions for hearing and vibration sensing.

Transfer function for hearing: The dynamic model of the middle ear is a 7th order system that maps the pressure at the ear drum to the pressure at the cochlea. (See Bode plot at right.) In this part of the assignment we will approximate the transfer function as a 4th order system.

Transfer function for vibration sensing: The Pacinian Corpuscles are responsible for sensing vibrations. They operate in the range of 50-500 Hz have a peak response at about 250 Hz. They can be modeled as a 2nd order system.



Frequency response of the middle ear from Pascal et al. 1998 (https://doi.org/10.1121/1.424363).

Now go to the Assignment called "Assignment 2 MATLAB Grader" on Canvas, which is a non-graded assignment (which must still be submitted) that allows you read details about the transfer functions we want you to use, view a starter Script for solving the problem, and test your code in the Assessment section. Use the information given to define the transfer functions `ear_H` and `pc_H`, and then plot the two frequency responses overlaid on the same plot. Once you have written your code in the Script section, you can click on "Run Pretest" in the Assessment section to check your transfer functions. Take a screen shot of the resulting Bode plot and paste it into your pdf solutions for Assignment 2. Then click on "Submit". (Note: If you have access to MATLAB separately, you are welcome to work in your own version of MATLAB and then paste your solution into MATLAB Grader.)

B. Now we will consider whether Tadoma can work, based on the frequency response of hearing vs. tactile vibration sense. (Note: The fundamental frequency range of human speech is approximately 100-3000Hz). Referencing the Bode plot you generated, answer the following questions in your written submission: How do the frequency responses of the auditory and tactile vibration senses compare? What do you think this means regarding the use of a tactile method for speech understanding such as Tadoma?