"Human Hearing Response To Changes In Frequency"

In general, the human ear can hear frequencies ranging from 20 Hz to 20 kHz (Szopos, Topa, Festila, and Hedesiu). However, I wanted to know if this was true for every person, and if not, what the average frequency ranges are. Additionally, I wanted to see how each person's ear reacted to different frequencies. To do so, I created two separate experiments in which I used the same group of people. I looked for the ability to hear any sound, the ability to distinguish pitch, and sensitivity in my first experiment. In my second experiment, I found out what the minimum change in frequency was for the human ear to hear a different pitch, which is also known as the just-noticeable difference (Rossing, Moore, and Wheeler 123). These two experiments helped to find out how an individual's ears react to different frequencies and changes in frequency.

For my first experiment, I used a test group of eight 18 year old students. I used Audacity to create pure tones of varying frequencies. I did the experiment in two parts. For part one, the frequencies played to the test subject were 20 Hz, 30 Hz, 40 Hz, 50 Hz, 60 Hz, 70 Hz, and 80 Hz, in that order. Each frequency was played for five seconds at the same volume. The test subjects all used the same pair of Sony stereo headphones to listen to the pure tones and there was five seconds of silence in between each frequency. I asked each test subject to tell me if and when they could hear any noise at all. Once they told me that they could hear a sound, I asked them to tell me if and when they could distinguish a pitch. In this experiment, I counted a person as being able to distinguish a pitch when they were able to

correctly match that pitch by singing it back in an octave they were comfortable in. It is important to note that I allowed my test subjects to vocally slide until they thought they landed on the right note. This could have changed my results. I used my own ear to tell if they were accurate in singing back the same pitch. I later made sure that my own ear was accurate by playing back the same note in a lower octave and making sure that that was the same pitch I thought was the same note. My ear proved to be reliable.

My results for the first part of the first experiment were only slightly varied for each individual person. One person could not hear any noise at 20 Hz, but the other seven people could. For frequencies of 30 Hz, 40 Hz, and 50 Hz, all eight out of eight people could hear a sound but could not distinguish pitch. At 60 Hz, one person could distinguish pitch but the other seven could not. At 70 Hz, seven people could distinguish pitch but one person could not. In fact, the person that could not distinguish pitch at 70 Hz was the same person that could not hear any noise at 20 Hz. This suggests that this person's ears could be damaged. At 80 Hz, every person could distinguish pitch. (See Figure 1 for a graph of the results). Overall, I validated Szopos, Topa, Festila, and Hedesiu's findings, which were that the bottom of the human hearing range is about 20 Hz. I also discovered that most people begin to distinguish pitch at about 70 Hz.

In part two of my first experiment, I played high frequencies for the same test subjects. Using Audacity, I created pure tones of 20 kHz, 19 kHz, 18 kHz, 17 kHz, 16 kHz, 15 kHz, 14 kHz, 13 kHz, 12 kHz, 11 kHz, 10 kHz, 9 kHz, 8 kHz, 7kHz, 6 kHz, 5 kHz, 4 kHz, 3 kHz, and 2 kHz, and played the frequencies in that order each for 3

seconds with 5 seconds of silence in between. I played the frequencies for a shorter period of time in this part of the experiment in order to avoid hurting my test subject's ears. As in the last part of the experiment, all frequencies were played at the same volume and all test subjects used the same pair of headphones. Again, I asked people to tell me if and when they could hear a sound and if and when they could distinguish a pitch. I also asked people to tell me if their ears hurt in order to find out what range of frequencies was most sensitive to the ears. In this part of the experiment, I had to add in another category in my results for people that thought they could distinguish a pitch but could not do so correctly.

At 20 kHz, four people could hear a sound and the other four could not. At 19 kHz, five people could hear a sound and three could not. At both 18 kHz and 17 kHz, one person could not hear a sound and the other seven could. The same person who in the last part of the experiment could not hear the 20 Hz is the same person who could not hear 18 kHz or 17 kHz, which further validates that this person may have hearing loss. By 16 kHz, everyone could hear a sound and from 16 kHz to 6 kHz, everyone could hear a sound put not distinguish a pitch. I also found that at the range from 9 kHz to 6 kHz was most sensitive to my test subject's ears. All eight people told me that their ears hurt when at least one of these frequencies was played and six out of eight people told me that their ears hurt at all frequencies played in this range (9 kHz, 8 kHz, 7 kHz, and 6 kHz). At 5 kHz, one person was able to accurately distinguish a pitch and another person thought they could distinguish a pitch but was not accurate. At 4 kHz, five people could not distinguish a pitch at all, three people could, and two people thought they could but could not do so

accurately. The people that were not accurate in distinguishing a pitch are counted in the people who could only hear a sound but could not distinguish pitch. At 3 kHz, two people could only hear a sound, and the other six could all distinguish a pitch accurately. At both 2 kHz and 1 kHz, all eight people could distinguish a pitch accurately. (See Figure 2 for a graph of the results). Through this experiment I have proved Szopos, Topa, Festila, and Hedesiu's findings that the top of the human hearing is 20 kHz to be slightly true because only half of my test subjects were able to hear a frequency of 20 kHz. It would be more accurate to say that most people are able to hear frequencies up to 18 kHz. I also discovered that most people have the ability to distinguish pitches as high as 3 kHz.

For my second experiment, I wanted to find out what the just-noticeable difference was for frequencies ranging from 440 Hz to 445 Hz. A just-noticeable difference is the minimum change in frequency needed for a person to be able to hear the difference. According to Rossing, Moore, and Wheeler, the just-noticeable difference for frequencies ranging from 1000 Hz to 4000 Hz is about 0.5% of the pure tone frequency, which is approximately equivalent to 1/12 a semitone (Rossing, Moore, and Wheeler 123). My experiment allowed me to compare the just-noticeable difference of mid-range frequencies to the higher frequencies that Rossing, Moore and Wheeler tested.

In my experiment I used the same test group as in the last experiment and I used the same pair of headphones and the same volume. I played the following sequence of frequencies: 440 Hz, 441 Hz, 440 Hz, 442 Hz, 440 Hz, 443 Hz, 440 Hz, 444 Hz, 440 Hz, 445 Hz. Each frequency was played for five seconds with no pause

in between the change in frequency. I asked my test subjects to tell me if and when

they could hear a change in pitch. Nobody could hear the difference in pitch between

440 Hz and 441 Hz. One person could hear the difference in pitch between 440 Hz

and 442 Hz. Two more people (three people in total) could hear the difference in

pitch between 440 Hz and 443 Hz. Two more people (five people in total) could hear

the difference in pitch between 440 Hz and 444 Hz. Everyone could hear a change in

pitch between 440 Hz and 445 Hz. (See Figure 3 for a graph of the results).

In order to compare my results to Rossing, Moore, and Wheeler's findings, I

calculated the semitone difference between the changes in frequency. I used the

formula n= 12 (log(f/440))/(log(2)) for my calculations. I found that there is a

0.039302 semitone difference between 440 Hz and 441 Hz, a 0.078514 semitone

difference between 440 Hz and 442 Hz, a 0.117638 semitone difference between

440 Hz and 443 Hz, a 0.156674 semitone difference between 440 Hz and 444 Hz,

and a 0.195623 semitone difference between 440 Hz and 445 Hz. Rossing, Moore,

and Wheeler's just-noticeable difference was equivalent to 1/12 a semitone, which

is equal to 0.0833. This difference is in between the semitone difference between

440 Hz and 442 Hz (0.078514) and the semitone difference between 440 Hz and

443 Hz (0.117638). Although Rossing, Moore, and Wheeler's findings were for

frequencies between 1000 Hz and 4000 Hz, my results are similar because I found

that my test subjects first started to notice a difference in pitch when frequency

increased from 440 Hz to 442 Hz, and an even larger amount of my test subjects

noticed a difference in pitch from 400 Hz to 443 Hz. Additionally, Rossing, Moore,

and Wheeler found that their just-noticeable difference was about 0.5% of a

semitone, and 0.5% of 440 Hz is 2.2 Hz, which, when added to 440 Hz, is between 442 Hz and 443 Hz. Therefore, the just-noticeable difference in my experiment is similar to Rossing, Moore, and Wheeler's findings. However, my just-noticeable difference was slightly greater. The majority of my test subjects did not hear a difference until 444 Hz. I can hypothesize, based on my results compared to Rossing, Moore, and Wheeler's findings, that the just-noticeable difference for lower frequencies is greater than the just-noticeable difference for higher frequencies.

In conclusion, the human ear's response to high and low frequencies and changes in frequency can vary from person to person. In general, most people have approximately the same hearing range of frequencies. Furthermore, most people's ability to distinguish pitch and to tell the difference between very close pitches is very similar. Although my experiment used test subjects that were not musicians, it would be interesting to discover if there is a difference in results between musicians with a trained ear and non-musicians.
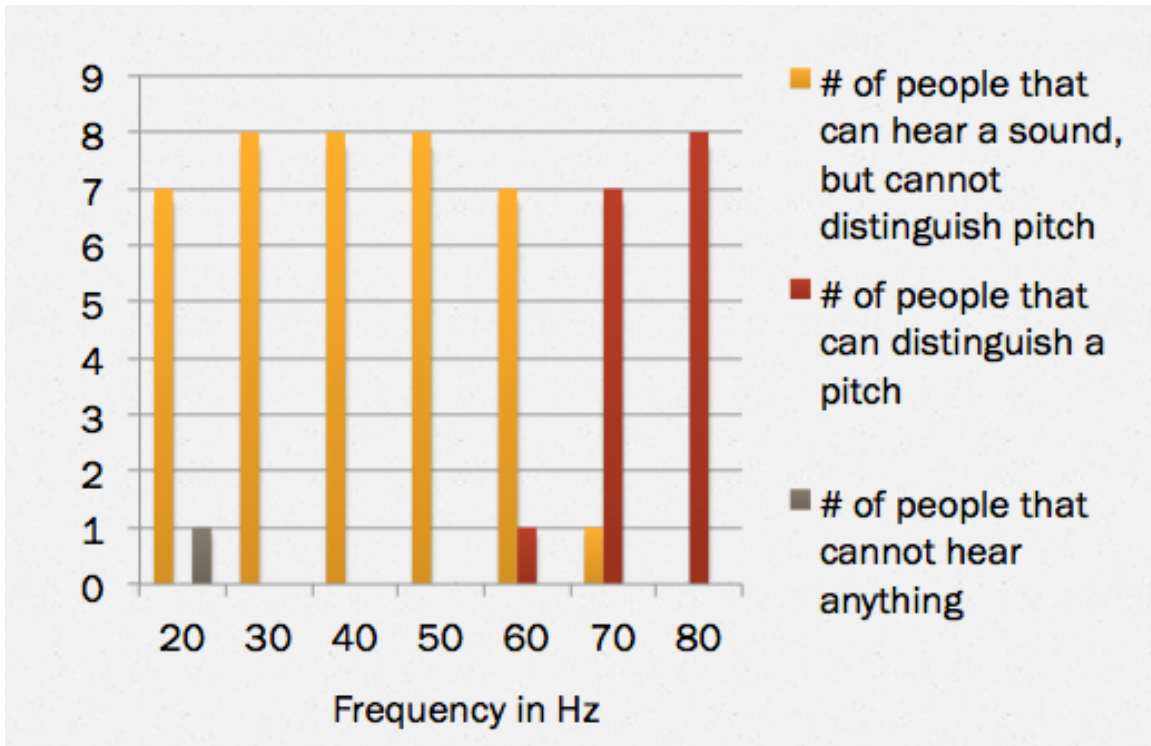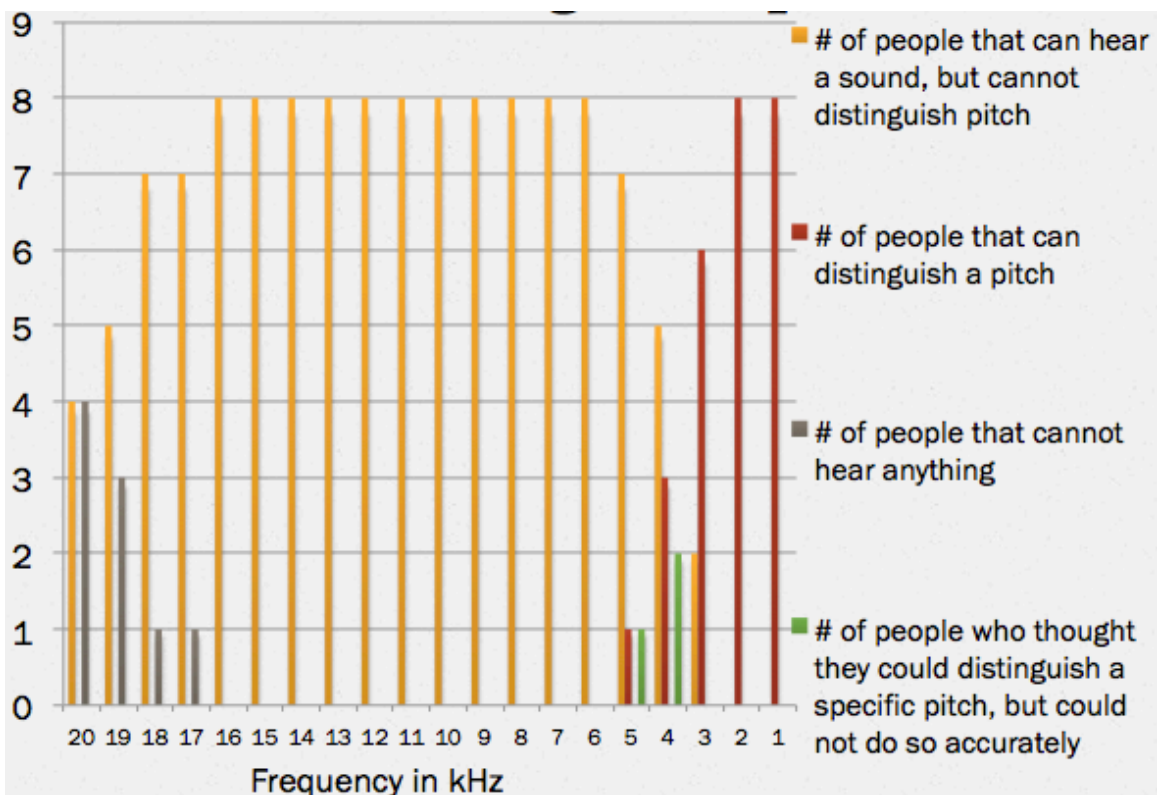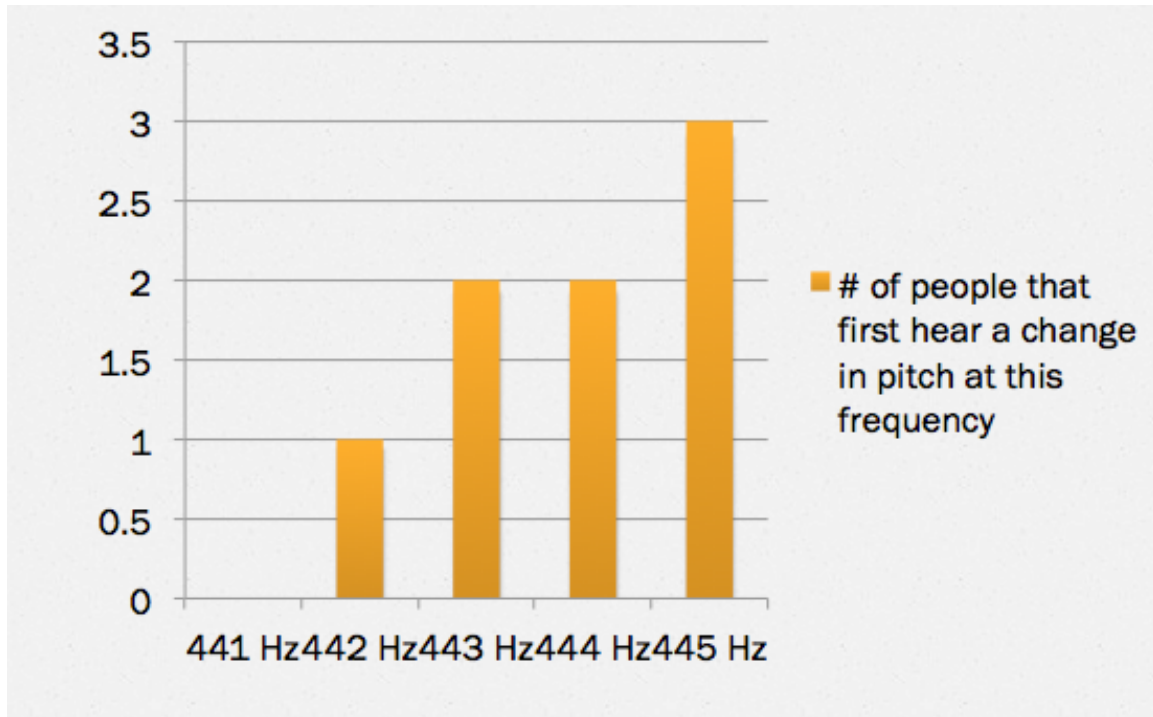
Figure 1

Figure 2

Figure 3

Works Cited

Rossing, Thomas D., Paul A. Wheeler, and F. Richard Moore. *The Science of Sound*.

3rd ed. San Francisco: Addison Wesley, 2002. Print.

Szopos, E., Topa, M., Festila, L., & Hedesiu, H.. (2010). FIR SYNTHESIS OF THE

HUMAN HEARING MECHANISM RESPONSE. *Acta Technica*

Napocensis: Electronica - Telecomunicatii, *51*(4), 41-44. Retrieved December

6, 2011, from Research Library. (Document ID: 2358645141).