Perceived Differences in Pitch by Musicians and Non-Musicians

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This experiment was conducted to analyze pitch perception in musicians and non-musicians. Previous researchers found that musicians had better pitch perception than non-musicians. Furthermore, violinists were found to perform best on pitch perception tests, whereas pianists and percussionists did not perform as well. Among non-musicians, music listening has been reported to affect the frequencies people are able to hear. Based on these findings, I tested three hypotheses: (1) Musicians will be able to detect small changes in frequency more accurately than non-musicians, (2) Classical musicians who play self-tunable instruments will outperform other musicians and singers, and (3) In non-musicians, the more often they listen to music, the better they will perform on this test. I conducted an in-person study with a between-subjects design to test these hypotheses. The data showed support for the first hypothesis, but not the latter two. Limitations were discovered in sample size, specificity of instructions, reported hearing ability, and design of the experiment. Still, this study was a good indicator of pitch perception, especially for musicians who were able to evaluate their personal skill levels.

An interesting aspect of the human experience is the ability to discern pitch and use this information to make a mental map of the world. In fact, a condition called congenital amusia, characterized by the inability to recognize changes in pitch, is debilitating not only for musicians, but also for communicating with others and general interaction with and perception of one's surroundings. While all humans have the ability to discern pitch, musicians seem to have honed this skill and demonstrate a greater need for proficiency in this area. Due to this finding in musicianship, there is also the question of extensive music listening and whether that affects

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perception and hearing. To explore these ideas, I decided to analyze the ability to perceive minute differences in pitch between and within musicians and non-musicians.

In general, previous research has confirmed that musicians outperform non-musicians in pitch discrimination (Akin & Belgin, 2009; Kishon-Rabin, Amir, Vexler & Zaltz, 2001; Micheyl, Delhommeau, Perrot & Oxenham, 2006; Tervaniemi, Just, Koelsch, Widmann & Schroger, 2005). Musicians are faster and more accurate at detecting changes in pitch, though non-musicians have demonstrated reliable performance. Within musicians, violinists were found to perform the best, since they tune their instruments and must play notes on fretless strings (Tervaniemi et al., 2005). Frets are bars most notably found on the necks of guitars that help the player to find the correct pitch, but violinists, as well as violists, cellists, and upright bassists, do not have the luxury of using frets to find their notes and must memorize pitches. They also work harder to discern pitch because of the high-pitched nature of the violin; subtle differences in pitch are harder to detect in higher frequencies. Tuning one's own instrument has been shown to train the ear to hear fine pitch changes. Pianists did not perform as well as other musicians on this type of test because most pianists do not tune their own piano (Micheyl et al., 2006).

Genre and style have also been shown to affect pitch perception in musicians. Classical musicians tend to outperform contemporary musicians because contemporaries tend to play more percussive and keyboard instruments that do not require tuning (Kishon-Rabin et al., 2001). Level of music education also determines accuracy of pitch discrimination; the more training, the better the performance on this type of test (Akin & Belgin, 2009). Building off this finding, non-musicians who were musicians in their childhood should perform better in this area than non-musicians who have never practiced or studied music. Interestingly, there are no studies that consider pitch discrimination in singers, who are sometimes seen as separate from musicians.

Outside of musicianship, there are age and music listening factors to consider. The ability to discern changes in frequency has been shown to decrease with age, with higher frequencies becoming more difficult to hear (Clinard, Tremblay & Krishnan, 2010). However, in musicians, this age-related decline is delayed due to enhanced cognitive reserve that musicianship promotes (Zendel & Alain, 2011). Moreover, a study comparing auditory performance between participants who regularly listened to music and those who did not found that frequent listeners had more difficulty hearing higher frequencies, but infrequent listeners had more difficulty hearing lower frequencies (Vinay & Moore, 2010). Difficulty hearing high frequencies can be attributed to outer hair cell damage in the ear and/or slowed information processing in the auditory nerve that is commonly seen in age-related decline. To compensate for hearing loss in high frequencies, the ability to hear low frequencies improves.

My experiment will test three hypotheses: (1) Musicians will be able to detect small changes in frequency more accurately than non-musicians, (2) Classical musicians who play self-tunable instruments will outperform other musicians and singers, and (3) In non-musicians, the more often they listen to music, the better they will perform on this test. With these hypotheses in mind, I performed an in-person study with musicians and non-musicians in which they listened to pairs of sound pitches and determined whether the second pitch was higher, lower, or unchanged. To ensure participant confidentiality, only non-identifying demographic information was collected.

Method

Participants

Lindenwood University students were recruited for this study by means of the Lindenwood Participant Pool as well as through classroom announcement via the professors of the music department. Students who signed up through the Lindenwood Participant Pool received extra credit for their participation, but there was no use of compensation otherwise and participation was limited to those over the age of 18 with adequate hearing. A total of 36 students participated in the experiment with a mean age of 21.15 (SD = 3.70). There were 22 musicians, including 8 participants identifying as male and 14 participants identifying as female, and 14 non-musicians, including 6 participants identifying as male and 8 participants identifying as female. Five non-musicians indicated past musical training but do not currently consider themselves musicians. Within musicians, 10 participants play one or more self-tuned instruments, 6 play percussion or piano, and 4 are vocalists. Concerning genre, 8 participants are classical musicians, 6 are contemporary musicians, and 6 play in both genres. Of the additional 2 musicians, 1 reported below average hearing and the other did not understand the instructions and redid the test, so their data were not used. Across both musicians and non-musicians, 23 participants reported listening to an average of 3 hours of music per day or less and 13 participants reported listening to an average of 4 hr of music per day or more. Participants who listen to non-Western music were also considered due to possible differences in musical culture and perception. Out of all participants, 9 reported listening to non-Western music. Regarding hearing ability, 6 participants reported above average hearing, 28 participants reported average hearing, and 2 participants reported below average hearing.

Materials

The participants listened to pairs of pitches through calibrated Genelec 8030C speakers inside the Push Records recording studio owned by the Lindenwood University Department of Music. The soundproof studio ensured pure sound quality and reliability and consistency of environment. I used 10 pairs of pitches to test the participant's perception during the experiment, which consisted of a tone followed by another tone that was either raised, lowered, or unchanged. The first five pairs of pitches were sine waves, which are tones that provide consistent amplitude (loudness), and the last five were piano tones. The audio also employs a short track of white noise that plays in the beginning to cleanse the palate of noise heard just before the experiment that may affect performance, such as music or voices. Pitch pairs were gathered and converted with the assistance of Professor Adam Donohue as well as online resources (Bird, 1998; Szynalski, n.d.). Participants used a response sheet during the experiment (see Appendix A) and filled out a demographic survey afterward (see Appendix B).

Procedure

Participants were tested one at a time within the recording studio. Each participant sat approximately 5 ft. away from the calibrated speakers inside the recording studio, so sound conditions were consistent and optimized for the experiment. Before the experiment, I went over the informed consent form and provided careful instructions for each participant. After this, the speakers, volume set to 70 dB, played 5 s of white noise to begin the experiment. Each pitch was played for 5 s, and after 5 s of silence, the second pitch in the set was also played for 5 s. This was followed by 10 s of silence for the participant to record his or her response on the response sheet. Then, the next pair of pitches would play until all five sine wave pairs were accounted for. After this, the same five pitch pairs were played in randomized order, but this time using tracks of piano to see if type of sound changed perception. The procedure was the same for these: 5 s for the first pitch, 5 s of silence, 5 s for the second pitch, and 10 s to respond. Once the test was completed, participants were asked to fill out a demographic survey and given a debriefing sheet thanking them for their participation.

Results

For the first hypothesis, I conducted an independent *t*-test to compare the test scores of musicians and non-musicians. Musicians (M = 5.25, SD = 3.46) performed significantly better on the pitch perception task than non-musicians (M = 3.57, SD = 2.26; $t(32) = 2.79$, $p = .004$ (one-tailed)). For the second hypothesis, I conducted an independent *t*-test to compare the test scores of classical musicians who play self-tuned instruments and all other musicians. Classical musicians who tune their own instruments (M = 5.5, SD = 4.3) did not perform significantly better than all other types of musicians (M = 5.14, SD = 3.36; $t(18) = .38$, $p = .35$ (one-tailed)). For the third hypothesis, I conducted a Pearson's *r* correlation to determine if test scores among non-musicians were related to the average amount of hours they listened to music per day. There was a moderately strong negative correlation between non-musicians' test scores and average amount of hours listened to music per day ($r(12) = -.51$, $p = .06$).

Discussion

In this study, I tested three hypotheses. My first hypothesis was that musicians would be able to detect small changes in frequency more accurately than non-musicians, and the data supported it, demonstrating that musicianship is associated with pitch perception. My second hypothesis was that classical musicians who play self-tunable instruments would outperform other musicians and singers, but this was not supported. Test scores between the two groups were very close and there was no statistically significant difference between musician types. My third hypothesis was that in non-musicians, the more often they listened to music, the better they performed on this test. The correlational analysis used to test this hypothesis was approaching statistical significance, but in the opposite direction. The data show that the more often non-musicians listen to music, the lower their scores on the test.

Musicians performed significantly better than non-musicians, and this was supported by a large sample size of participants in both groups. However, within musicians, there were not enough participants to draw conclusions between them based on the instrument(s) the musician studied, nor the genre(s) performed by each musician. Most musicians also played multiple instruments and in multiple genres, so it was difficult to group their data. For my third hypothesis, the data indicated that music-listening and test score are inversely related. This suggests that exposure to music does not help to develop pitch perception. The reason for this finding may be linked to hearing ability, because young adults are often exposed to loud music on a daily basis. Therefore, it is possible that the more they listen to music, the more exposure they have to loud music, which can in turn, affect their hearing, and hence their ability to discriminate slight pitch differences. Building off of this, I analyzed the data obtained from musicians, and found that men had better test scores on average than women. However, women listened to twice as much music on average per day than men. Based on this evidence, future studies in this area may want to conduct a hearing test for the participants to further analyze the relationship between hearing ability and pitch perception.

Sample sizes were not the only limitation of the study. For many participants, the instructions were not specific enough. I mentioned that the participants would be trying to detect differences between pairs of pitches, but many participants thought that the pitch would change dramatically rather than subtly. One participant thought there would be a change of notes (like C to D), so he marked all answers as “Unchanged.” He asked if he could retake the test, and once he knew how subtle the changes would be, he got a perfect score on the test. He was the only one to get a perfect score on the test, and even participants with over 10 years of musical training experienced similar confusion.

In the future, instructions for the test should be as specific as possible. It would also be interesting to repeat this study with a different design. This study may work better as mixed-factorial design in which musicians and non-musicians take multiple pitch perception tests over the course of different days or weeks. Having different tests each time and testing over different days will help to account for subject-to-order and carryover effects when completing the tests, and participants would likely need to be compensated in order to encourage them to come back for multiple trials. Additionally, having a hearing test at the beginning would help test the idea that hearing ability plays a role in pitch perception. Overall, my study and other studies in this area provide insight into how pitch perception can be trained and honed. This is particularly useful for musicians, who are always seeking to better themselves in their profession. In the future, techniques used in this study could be used to develop effective training programs for musicians to develop their pitch perception, and even non-musicians who need to train their perception.

References

Akin, O., & Belgin, E. (2009). Hearing characteristics and frequency discrimination ability in musicians and nonmusicians. *The Journal of International Advanced Otology, 5*(2), 195-202. Retrieved from http://www.advancedotology.org/

Bird, I. W. (1998). Frequency to note calculator. Retrieved from http://www.birdsoft.demon.co.uk/music/notecalc.htm

Clinard, C., Tremblay, K., & Krishnan, A. (2010). Aging alters the perception and physiological representation of frequency: Evidence from human FFR recordings. *Hearing Research, 264*(1-2), 48-55. doi:10.1016/j.heares.2009.11.010

Kishon-Rabin, L., Amir, O., Vexler, Y., & Zaltz, Y. (2001). Pitch discrimination: Are professional musicians better than non-musicians? *Journal of Basic and Clinical Physiology and Pharmacology, 12*(2), 125-143. doi:10.1515/jbcpp.2001.12.2.125

Micheyl, C., Delhommeau, K., Perrot, X., & Oxenham, A. (2006). Influence of musical and psychoacoustical training on pitch discrimination. *Hearing Research, 219,* 36-47. doi:10.1016/j.heares.2006.05.004

Szynalski, T. P. Online tone generator. Retrieved from http://www.szynalski.com/tone-generator/

Tervaniemi, M., Just, V., Koelsch, S., Widmann, A., & Schroger, E. (2005). Pitch discrimination accuracy in musicians vs nonmusicians: An event-related potential and behavioral study. *Experimental Brain Research, 161,* 1-10. doi:10.1007/s00221-004-2044-5

Vinay, S., & Moore, B. (2010). Effects of the use of personal music players on amplitude modulation detection and frequency discrimination. *Journal of the Acoustical Society of America, 128*(6), 3634-3641. doi:10.1121/1.3500679

Zendel, B., & Alain, C. (2011). Musicians experience less age-related decline in central auditory processing. *Psychology and Aging, 27*(2), 410-417. doi:10.1037/a0024816

Appendix A

Pitch Test Response Sheet

After listening to each pair of pitches, indicate on this sheet whether the second pitch is higher, lower, or unchanged.

Pitch Set A

Pitch Pair 1	Higher	Lower	Unchanged
Pitch Pair 2	Higher	Lower	Unchanged
Pitch Pair 3	Higher	Lower	Unchanged
Pitch Pair 4	Higher	Lower	Unchanged
Pitch Pair 5	Higher	Lower	Unchanged

Pitch Set B

Pitch Pair 6	Higher	Lower	Unchanged
Pitch Pair 7	Higher	Lower	Unchanged
Pitch Pair 8	Higher	Lower	Unchanged
Pitch Pair 9	Higher	Lower	Unchanged
Pitch Pair 10	Higher	Lower	Unchanged

Appendix B

Demographic Survey

1. **How old are you?**

2. **How would you rate your hearing ability?**
   Below Average Average Above Average

3. **What is your gender?** Male Female Other Prefer Not To Say

4. **Have you trained/studied in music during your lifetime?** Yes (Answer 4a) No

   a. **How long have you trained/studied (in years)?**

5. **Do you consider yourself a musician?** Yes (Answer 5a and 5b) No

   a. **(If musician) Write what instrument(s) you play or if you sing:**

   b. **(If musician) Write the genre in which you perform (such as classical, contemporary, opera, etc.):**

6. **How many hours do you listen to music on average per day?**

7. **Do you listen to any non-Western genres of music (J-pop, K-pop, Bollywood, etc)?**
   Yes (Answer 7a) No

   a. **Write the genre you listen to:**