Pitch Discrimination Threshold Perception

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Introduction

The study done previously by Micheyl et al. (2006) regarding pitch discrimination threshold compares the auditory differentiation of pitch between musicians and non-musicians. The psychoacoustic study was done in two experiments; the first one was done on 30 musicians and 30 non-musicians and the second one was done on only 8 non-musicians. The main goal of the study was to find out the amount of training the non-musicians need to reach the level of pitch discrimination of musicians, and the number of trials the musicians need to reach optimal performance. The reason for having a second experiment where the subjects were only non-musicians is that during the first experiment, the non-musicians did not have enough time/trials to reach the optimal pitch discrimination threshold (Micheyl et al. 2006). The musicians selected needed to fall under the following criteria: they need to have at least 10 years of experience playing a classical instrument, and to be full-time musicians which means they practice their instrument for hours on a daily basis. Non-musicians need to be individuals with no musical training background. The study did not include musicians and/or non-musicians who had psychoacoustical experience to ensure accurate results that convey improvement in thresholds (Micheyl et al. 2006). The authors also gave the musicians practice trials to familiarize themselves with psychoacoustical tasks.

The main questions the authors addressed in their study were how much psychoacoustical training would it take for musicians and non-musicians to reach optimal thresholds, and how much does classical music training benefit in pitch discrimination. Now the answer to the second question was answered by studies before Micheyl et al's. However, there were many factors that could have affected the accuracy of the results. In the study done by Spiegel and Watson (1984), some of the non-musicians actually had experience in musical or psychoacoustical tasks (Spiegel and Watson, 1984, p.1692). In the study done by Kishon-Robin et al. (2001), the number of musicians who had contemporary musical experience rather than classical exceeded 50% of the number of musicians included in the study (Kishon-Robin et al. 2001). Thus, Micheyl et al. made sure to avoid such variants in their study. They also used pure tones as well as complex tones to better determine the advantage of a musical training experience since complex tones contains harmonics that could play in favor of the musicians' musical training background.

During the study, the subject was exposed to two tones separated by an interval (two tones, one higher in frequency than the other) (Micheyl et al. 2006). The subjects were required to select the higher frequency tone perceived within each tone type (pure tones and complex harmonic tones). The study followed the rule of two-down/one up; when the subject chooses the correct higher pitch tone twice in a row, the interval between the frequencies of the tones gets smaller. And once the subject makes one incorrect choice, the interval pitch gets wider once, and so on (Micheyl et al. 2006). What Micheyl et al.'s study stand out from previous studies is the addition of noise masking to compare pitch discrimination between left and right ear (Micheyl at al. 2006).

Based on the result plots from Micheyl et al's study, the musicians did a better job overall in pitch discrimination than the non-musicians. The results also showed that the mean frequencies (FDTs) of the musicians group were much closer to each other than of the non-musicians group. The plots conveyed that the non-musicians have shown more improvement in the influence of short-term practice on FDTs and F0DTs (F0 discrimination thresholds) than the musicians. The musicians seem to do better with complex tones than with pure tones overall, and that strings and winds instrumentalists did better than keyboard/piano players.

What I found interesting was the rapid initial improvement in the non-musicians' performance. It could mean that the musicians did not need many trials to adjust to the psychoacoustical experiment. Thus, the initial decrease in threshold for the non-musicians' shows the adaptability of human learning skills rather than pitch discrimination in particular. The study is also only showing short-term adaptability skills, and might not necessarily mean that if the non-musicians did the experiment weeks or even months after that, they'd be able to reach the smallest threshold which they have reached in the first time. This is where 10 years and more musical experience would play a role, since the results would relatively not differ much. Again, further research regarding this topic would be needed.

Our study compares the results of the pitch discrimination experiment of two subjects JAA and

LS. Each subject had done the experiment individually under different circumstances and did not go under noise masking between left and right ears.

Methods

Participants

The first subject is a 25-year-old female who's a singer-songwriter, played the guitar, and sang both solo and in choir for 12 years. The subject is also a music producer and sound engineer exposed to loud volumes on a daily basis for 4 years.

The second subject is a 27-year-old female who played the violin and the guitar for 3 years. The subject also sang in choir for two years and in a band (contemporary music) for two years as well.

Procedures

During each block, the subject would hear two tones of different frequencies. The subjects have to select the tone that they perceive as higher in pitch. If they get two correct, the interval between the two tones becomes smaller and moves forward. If they get one incorrect, the interval goes wider again and so on (two-down /one-up). Unlike in the study by Micheyl et al. (2006), each subject performed the test in different conditions in their homes from a computer device and not in an isolated noise cancelation environment. This study mainly compares the performance of two different individuals rather than compares the results between musicians and non-musicians since both subjects have different musical backgrounds. However, this experiment still studies how long it takes for subjects to reach an optimal threshold. This study is approximately 30 minutes, thus, is a more simplified and less accurate version of the study by Micheyl et al. (2006).

Results

The obtained threshold data are illustrated in the Table 1.

Table 1. Pitch discrimination threshold results.

Subject	Conditions	Pure Tone		Complex Tone	
		Threshold (Hz)	Number of Trials	Threshold (Hz)	Number of Trials
JAA	1st block	1.1743757795928373	49	1.0769073381282697	47
	2nd block	2.2491721986220923	48	0.987528383220431	44
LS	1st block	6.091907852000432	34	1.8111350403849638	53
	2nd block	4.1249999999999997	54	3.7826416782192664	53

The overview of the numbers above show that subject JAA was closer to the optimal threshold than subject LS. We notice that both subjects performed proportionally better with complex tones than with pure tones.

The detailed time course of the stimulus level changes in the staircase procedure is illustrated in Figure 1 for the pure tone condition, and Figure 2 for the complex tone condition.

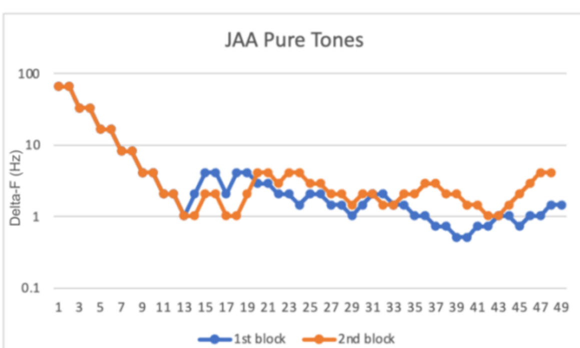

Fig 1a – JAA Pure Tones

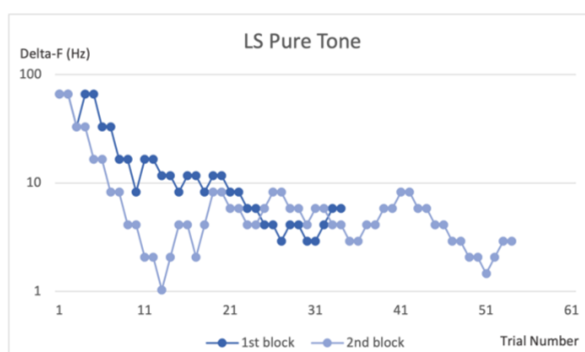

Fig 1b – LS Pure Tones

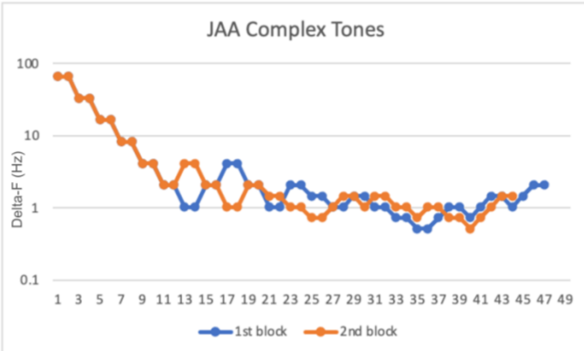

Fig 2a – JAA Complex Tones

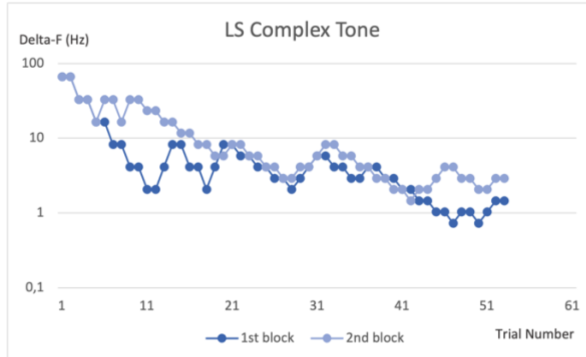

Fig 2b – LS Complex Tones

What seemed interestingly noticeable was that both subjects did better during their first trial/block. Additionally, both subjects showed a very quick initial improvement in threshold. We see that subject JAA's initial improvement is relatively consistent with both pure and complex tones during both blocks. However, LS's initial improvement threshold with pure tones was better in the second block while it was the opposite with complex tone.

Discussion

The subjects had done one trial run with pure and one trial run with complex tones to get familiar with the test, and two runs for each tone (two with pure tones and two with complex tones) that were documented for the study. Both subjects did not have psychoacoustical experience before this study. The test runs were done about a week before the actual runs were documented.

The first subject, JAA performed the test using studio headphones, in a quiet room with minimal outside sounds. The subject's hearing is normal and sensitive to high volume and frequencies; thus, the volume was adjusted accordingly. JAA's test was done in the morning. The subject LS performed the test using Apple AirPods at home. The test was done in a quiet setting at 10:00pm. It was noted by LS that the subject was a bit tired after a long day. This is particularly interesting because even if both subjects performed the test under the same conditions but at different times of the day, results would not be very accurate. Additionally, the difference in results from the same subject doing the experiment under the same conditions but at different times of the day (tired at the end of the day and refreshed at the beginning of the day) would already be comparable and very interesting.

This could pause the question: is this why subject JAA did better than LS in general? Could the level of fatigue of the subject affect pitch discrimination?

According to the study done by Jain & Nataraja (2019), auditory memory gets affected due to fatigue. Despite the positive impact musical training has on working memory and speech perception, fatigue still affects auditory memory and perception for musicians as well as non-musicians (Jain & Nataraja, 2019).

On the other hand, if we compare the results of LS between the 1st and 2nd block, we can notice that their performance has worsened by the second trial with both pure and complex tones. This could lead us to the hypothesis that the subjects got even more tired as the experiment went on and their attention to the intervals of the pitches has declined. Now it's important to mention that subject JAA had also similar results between 1st and 2nd blocks despite them performing the task in the morning. In addition to fatigue being a factor affecting the results of pitch perception and memory, the difference in results between blocks poses the question of how long does it take for the subject to get familiar with the test. Would the results be different if the two blocks were separated by a longer period of rest?

Tsaliach, Amel, & Banai (2010) studied the effects of global and local stimuli context on auditory frequency discrimination. A global context is the repetition of stimuli across trials and local context is stimuli repetition within the same trial (Tsaliach, Amel, & Banai, 2010). The assumed expected results of our study are that the subjects would get familiar with the psychoacoustical exercise and eventually perform better in the second trial. However, that was not necessarily what we found in our results. It was very interesting to find such contradicting results to what was expected. Based on Tsaliach, Amel, & Banai's study, subjects have shown better results when given a global context than to when given a local context. Overall, both global and local contexts have improved the subjects' performance in frequency discrimination, however, the study suggests that local and global contexts are stored in different parts of the brain (Tsaliach, Amel, & Banai, 2010). Local contexts conditions are stored in a section with very fast storage decay where the information (in this case stimulus) did not have enough time to be processed, while global context information was stored in a different section where it's also stored temporarily but with a longer short-term buffer (Tsaliach, Amel, & Banai, 2010). Tsaliach, Amel, & Banai's study results coincide very well with our study results. Seeing the performance of the 1st block for both subjects, considering that they have had a test run a week or a few days before, compared to the results of the 2nd block that was done a few minutes after the first block proves that familiarity with the psychoacoustical tasks takes time to be processed even within the short memory temporary storage time.

It would be interesting to find further research that connects the factor of fatigue on short-term memory of auditory perception and pitch discrimination for both musicians and non-musicians.

References

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