PITCH DISCRIMINATION: ARE PROFESSIONAL MUSICIANS BETTER THAN NON-MUSICIANS?

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ABSTRACT

Musicians are typically considered to exhibit exceptional auditory skills. Only few studies, however, have substantiated this in basic psychoacoustic tasks. The purpose of the present investigation was to expand our knowledge on basic auditory abilities of musicians compared to non-musicians. Specific goals were: (1) to compare frequency discrimination thresholds (difference limen for frequency [DLF]) of non-musical pure tones in controlled groups of professional musicians and non-musicians; (2) to relate DLF performance to musical background; and (3) to compare DLF thresholds obtained with two threshold estimation procedures: 2- and 3- interval forced choice procedures (2IFC and 3IFC). Subjects were 16 professional musicians and 14 non-musicians. DLFs were obtained for three frequencies (0.25, 1 and 1.5 kHz) using the 3IFC adaptive procedure, and for one frequency (1 kHz) also using the 2IFC. Three threshold estimates were obtained for each frequency, procedure and subject. The results of the present study support five major findings: (a) mean DLFs for musicians were approximately half the values of the non-musicians; (b) significant learning for both groups during the three threshold estimations; (c) classical musicians performed better than those with contemporary musical background; (d) performance was

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influenced by years of musical experience; and (e) both groups showed better DLF in a 2IFC paradigm compared to the 3IFC. These data highlight the importance of short-term training on an auditory task, auditory memory and factors related to musical background (such as musical genre and years of experience) on auditory performance.

KEYWORDS

frequency discrimination, frequency difference limen, DLF, musicians

INTRODUCTION

Auditory performance in musicians is of interest because of the mystique associated with the listening abilities of many well-known performers, conductors and composers of classical music /1/. These exceptional listening skills are typically extended to the entire group of musicians. This inference is made despite the fact that little is actually known about the relative acuteness of hearing of highly trained musicians, in comparison with those of the general adult population /1, 2/.

Superior auditory performance of musicians has been reported primarily on tests that reflect specific facets of music, such as timbre and rhythm /3/, mistuned harmonics /4, 5/ and the identification (labeling) of musical intervals (frequency ratio) /5-7/. Only a few studies, however, have attempted to compare the auditory abilities of musicians and non-musicians in simple basic psychoacoustic tasks /1, 2/. Results of such tests in highly trained professional musicians may serve as a 'benchmark' reference for the limits of the human auditory system. Relating performance to musical background may provide insight into underlying factors that affect auditory abilities, such as age of initial exposure to music and years of musical training /1, 8/.

Frequency discrimination, that is, the ability to detect changes in frequency over time, is one of the less investigated psychoacoustic abilities in musicians /9/. To our knowledge, only two studies reported simple frequency discrimination results with professional musicians and non-musicians /1, 10/. The first was conducted by Stucker in 1908 /10, p.73/ who used tuning forks, monochords and Galton whistles to test members of the Royal Opera in Vienna. He found great diversity in the results, some of which was attributed to methodological issues. Seventy-five years later, Spiegel and Watson reported frequency discrimination thresholds in professional musicians using musical-scale frequencies /1/. The *relative* DLF (difference limen for frequency) thresholds (in $\Delta f/f$, i.e., the smallest detectable frequency difference relative to the tested frequency) for this group were between 0.001 and 0.0045. Half of the non-musicians had thresholds in the same range as the musicians, while in the remainder, the thresholds were up to five times greater. Spiegel and Watson raised the possibility that the overlap in results between the musicians and non-musicians may be related to their high degree of musical or psychoacoustic experience, which was not detected through the questionnaires on musical background prior to testing.

Examinations of frequency difference limen for pure tones in the general hearing adult population are more extensive /2, 11-18/. The different methodologies used in these studies, however, contribute to great variability in the results. Differences exist in (a) stimulus configurations (pure tones differing in frequency and pure tones that may or may not be frequency modulated), (b) threshold estimation procedures [yes/no, same/different, 2-interval forced choice (2IFC) stating the higher pitch of two tones, or 3-interval forced choice (3IFC) stating the "odd" pitch of the three tones], (c) experience and/or training on psychoacoustic tasks, (d) duration of the signals, and (e) level of presentation.

Although normative values of DLF in the general population are difficult to establish, some trends have been observed. One such trend is the smaller DLF values obtained in pure-tone procedures compared to frequency-modulated procedures. Average DLF values using 2IFC approach 1-1.5% in the general adult population for frequencies 0.5-2 kHz /13, p.164/. Another trend is the smaller variability in results when using the 2IFC threshold estimation procedure compared to yes/no procedures. This has been explained by the important role that *memory* factors play in frequency discrimination tasks and was confirmed in the one study that compared different threshold estimation paradigms of frequency discrimination (2IFC, yes/no, same/different) /16/.

The most commonly used method in frequency discrimination tests is the two-interval forced choice procedure. Moore and Peters /2/ argued, however, that because the 2IFC requires that a decision be made as to whether a pitch went up or down, it may be a difficult task for naïve listeners. They hypothesized that the 3-interval forced choice procedure may be an easier task because it only requires picking the "odd" pitch of a three-tone sequence without identifying the direction of the change. They did not consider in their arguments, however, that the 3IFC task might involve greater memory demands because the listener would have to store an immediate memory representation of all three pitches before reaching a decision /19/. Whether Moore and Peters were correct in their assumptions or, alternatively, memory plays an important role in frequency discrimination tasks, as was previously suggested, was not investigated and as yet not resolved.

Very few studies have been conducted to substantiate simple frequency discrimination abilities in highly controlled groups of trained professional musicians and non-musicians. Furthermore, the existing frequency discrimination data on the general population varies greatly, mainly due to differences in methodology.

Therefore, the goals of the present investigation were: (1) to compare frequency discrimination of non-musical pure tones in controlled groups of professional musicians and non-musicians; (2) to relate frequency discrimination performance to musical background, and (3) to compare DLF thresholds using two threshold estimation procedures: 2IFC and 3IFC.

METHODS

Subjects

A total of 30 male subjects participated in the study: 16 were professional musicians and 14 non-musicians, approximately matched in age and education. The musicians were 20-33 years of age (average 25 years old), played at least one musical instrument for 6-24 years (average of 13 years). All of them were members of a formal musical group (orchestra or a band). Individual background information is outlined in Table 1. The non-musicians were 23-34 years of age (average 27 years old). These subjects had no previous musical training (less then 1 year) or experience in psychoacoustic testing. All subjects had pure-tone air-conduction thresholds less then 15 dB HL bilaterally at octave frequencies from 250-4,000 Hz /20/.

TABLE 1

Individual musical background information

Subject	Musical style	Years of training	Major instrument	Additional instrument
1	Contemporary	24	Keyboard	Guitar, percussion
2	Classical	10	French horn	Piano, flute
3	Classical	14	Bassoon	Piano, flute
4	Contemporary	7	Percussion	Piano, keyboard
5	Classical	10	Viola	Violin
6	Classical	13	French horn	Flute
7	Contemporary	13	Guitar	Bass guitar
8	Contemporary	8	Guitar	Accordion
9	Contemporary	10	Percussion	Guitar, electric guitar
10	Contemporary	14	Guitar	Bass guitar, keyboard
11	Classical	20	Violin	N/A
12	Contemporary	6	Percussion	Bass guitar
13	Contemporary	15	Saxophone	Clarinet, piano
14	Classical	18	Violin	Piano
15	Classical	14	Violin	N/A
16	Contemporary	18	Keyboard	Percussion, guitar

Stimuli

All stimuli were digitally generated at a sampling rate of 22,050 Hz and 16-bit using a sound-editing program (Sound Forge 4.5), and were stored on the hard disk of the microcomputer. The auditory stimuli consisted of three different sets of non-musical pure tones. Each of these three sets contained one reference tone and 20 different comparison tones. The reference tones were 250, 1000 and 1500 Hz.

The comparison tones varied from 250.5 to 260 Hz in 0.5 Hz steps for reference tone 250 Hz, and between 1001-1020 Hz and 1501-1520 Hz in 1 Hz steps for the 1000 and 1500 Hz reference tones, respectively. All signals had 25 msec raise-cosine ramps and a steady state portion of 250 msec.

Procedure

For each reference tone 250, 1000 and 1500 Hz, frequency discrimination threshold was estimated using a three-interval, three-alternative forced-choice adaptive procedure. Each presentation (trial) consisted of three stimuli: two identical reference tones and one comparison tone. The comparison tone was presented randomly as either first, second or third in the sequence. A visual marker on the computer monitor accompanied each audio presentation. The subjects were required to select the different stimulus among the three. A two-down one-up rule was used to estimate the frequency difference corresponding to 71% correct point on the psychometric function /21/. The first trial consisted of the reference and comparison tones differing by the largest step size. An example of a possible sequence in the first trial for 1000 Hz reference tone would be: 1000, 1000, 1020 Hz. In this example Δf, that is the difference between the reference and the comparison tones, was equal to 20 Hz. After two consecutive correct responses, Δf decreased, while after one incorrect response, Δf increased. In each turning point the decrease/increase in Δf was reduced until a minimal step-size was reached (0.5 Hz for 250 Hz and 1 Hz for 1000, 1500 Hz). Threshold was calculated as the geometric mean of the Δfs of eight turn-points at minimal step size. A total of three threshold estimates was obtained for each reference tone.

For the purpose of comparing the effect of threshold estimation paradigm on frequency discrimination threshold, a second threshold estimation procedure was conducted for the 1000 Hz reference tone only. This was an adaptive two-interval, two-alternative forced-choice method. Each trial consisted of two observation intervals: a reference tone and a comparison tone. The subjects were required to select the higher of the two tones. The same two-down one-up rule described above was used.

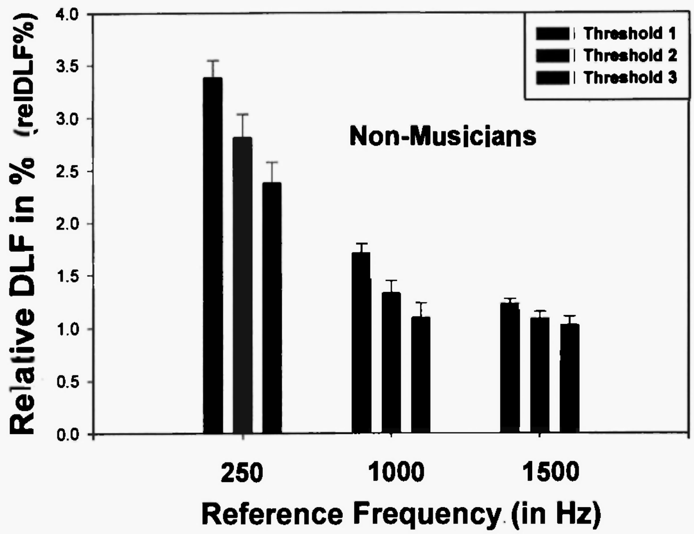
Each subject sat in a sound-treated room and listened to stimuli presented binaurally through headphones (MDR-CD270) at 80-85 dB

SPL /22/. Signal presentation, subject response, feedback and scoring were under software control. For the 3IFC threshold estimation, a Latin square design was utilized to minimize order effect. The 2IFC estimation procedure was interleaved among the 3IFC estimates but never appeared in first place. For each subject, testing lasted for approximately 1 hour.

RESULTS

The results in Δf were transformed to *relative* DLF thresholds in percent (*rel*DLF% = Δf/f × 100). Individual data obtained using 3IFC and 2IFC procedures are shown in Appendices A and B, respectively. The mean *rel*DLF% for each tested group, reference tone and repetition obtained with 3IFC are illustrated in Figure 1. Analysis of variance with repeated measures separating the effect of Group (musicians and non-musicians), reference Frequency (250, 1000 and 1500 Hz), and Repetition (1, 2 and 3), as well as interactions was conducted on the transformed data. A significant main effect of Group [$F(1,28) = 26.97$; $p < 0.0001$] confirmed smaller *rel*DLF% for the musicians (0.907) compared to the non-musicians (1.783). The analysis also revealed a significant main effect of Frequency [$F(2,27) = 100.37$; $p < 0.0001$]. Contrast analysis confirmed ($p < 0.01$) smallest *rel*DLF% for 1500 Hz (0.893), significantly larger *rel*DLF% for 1000 Hz (1.002) and the largest *rel*DLF% for 250 Hz (2.143). Note, however, that a significant Group × Frequency interaction [$F(2,27) = 12.18$, $p < 0.0001$] was found. Specifically, the difference in *rel*DLF% between the groups was smallest at 1500 Hz (0.44), increased significantly at 1000 Hz (0.753) and was greatest at 250 Hz (1.429).

Main effect of Repetition was also found to be significant [$F(2,27) = 38.05$, $p < 0.0001$]. Contrast analysis revealed that the threshold decreased significantly with repetition ($p < 0.001$). That is, mean *rel*DLF% values decreased significantly from 1.63, 1.29 to 1.13 for repetitions 1 to 3, respectively. The effect of repetition was found to be dependent on the tested frequency [$F(4,25) = 6.92$, $p < 0.001$]. For frequencies 250 and 1000 Hz, a significant reduction of *rel*DLF% occurred from the first to the second repetition and from the second to the third ($p < 0.01$). At 1500 Hz, however, the decrease in *rel*DLF% between consecutive repetitions was significantly smaller. These



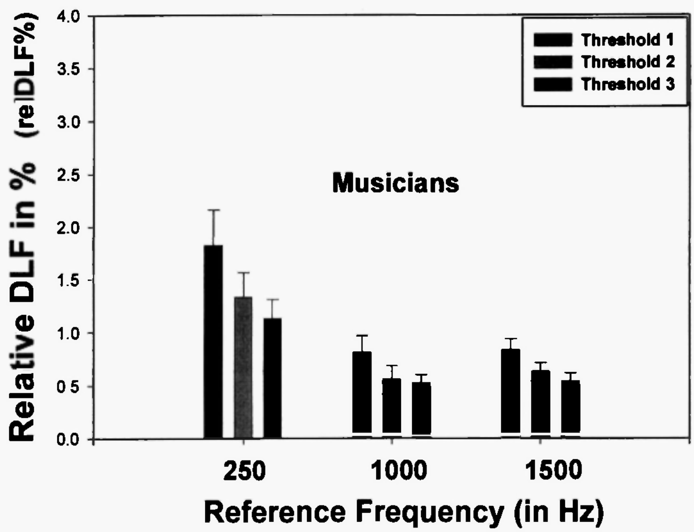


Fig. 1: Mean group frequency discrimination thresholds in *rel*DLF% ($\Delta f/f \times 100$) for each reference frequency and repetition, for the non-musicians (above) and the professional musicians (below) using the 3IFC adaptive procedure.

results demonstrate a general significant learning effect not influenced by musical training, particularly for 250 and 1000 Hz.

The unexpected learning effect, observable for both groups, led us to consider the possibility that non-musicians, after short training on the task, would perform as well as musicians when tested on the task for the first time. Statistical analysis on the *rel*DLF% values comparing the third estimate of the non-musicians to the first of the musicians showed that the group means (1.5 and 1.158, respectively) were not significantly different ($p > 0.05$). This was also the case for each frequency, although a trend for smaller *rel*DLF% values was still observed for the musicians.

In order to examine the effect of threshold estimation paradigm on *rel*DLF%, an ANOVA with repeated measures was conducted separating the effect of Paradigm (3IFC and 2IFC), Group and Repetition on thresholds in *rel*DLF% obtained at 1000 Hz. The results revealed significant main effects of Paradigm, Group and Repetition [$F(1,28) = 15.45$, $p < 0.001$; $F(1,28) = 19.63$, $p < 0.001$; $F(2,27) = 18.68$, $p < 0.0001$]. Thus, the 2IFC paradigm yielded smaller mean *rel*DLF% thresholds than the 3IFC for both musicians (0.509 vs 0.625) and non-musicians (1.153 vs 1.37). Overall, musicians showed smaller *rel*DLF% than the non-musicians, and all showed smallest values at the third repetition.

In order to evaluate the effect of musical training on DLF thresholds, we analyzed the musicians' data according to the number of years they had trained and to their musical genre (classical versus contemporary). Figure 2 shows decrease in *rel*DLF% values with years of musical training for each frequency. It can be seen that with fewer years of musical training the variability in results is large. This variability is reduced after more than 15 years of musical experience. Figure 3 shows the effect of musical background on *rel*DLF%. It can be seen that the classical musicians obtained *rel*DLF% values that are half those obtained by the contemporary musicians for all three frequencies (0.771, 0.278, 0.319 and 1.411, 0.673, 0.719 for 250, 1000 and 1500 Hz, for the two groups, respectively). Non-parametric Wilcoxon rank test confirmed significant differences between the classical and contemporary musicians ($p < 0.001$).

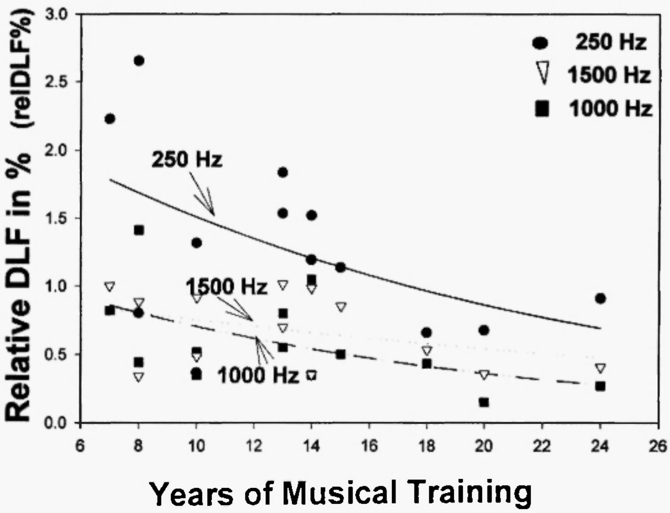


Fig. 2: Individual frequency discrimination thresholds in *rel*DLF% ($\Delta f/f \times 100$) of each musician as a function of years of musical training and reference frequency. Empirical data are indicated by the symbols whereas the lines are best fitting exponential curves. Each data point is the average of three threshold estimates.

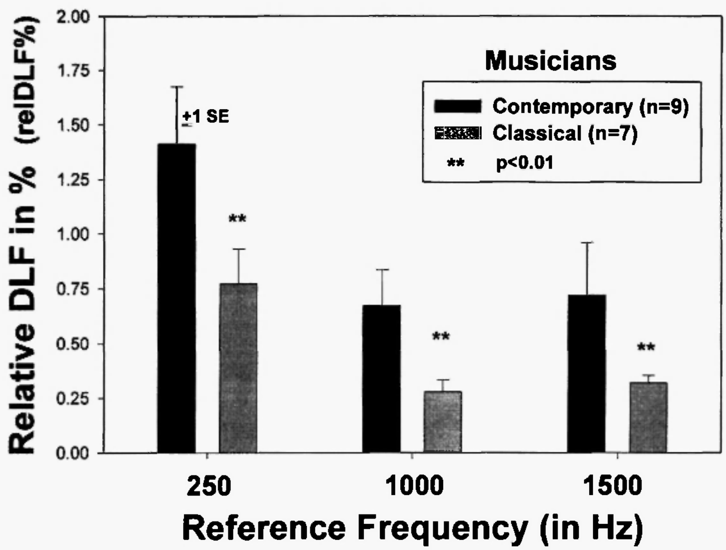


Fig. 3: Mean frequency discrimination thresholds in *rel*DLF% ($\Delta f/f \times 100$) of musicians of contemporary (n=9) and classical (n=6) musical training. Also shown are ± 1 standard error.

DISCUSSION

The primary goal of the present investigation was to examine whether professional musicians perform better than non-musicians on a frequency discrimination task that uses non-musical pure-tones. We will answer this question in light of the six major findings of the present study: (a) significantly smaller values of *rel*DLF% for musicians compared to non-musicians; (b) significant threshold improvements for both groups during the three threshold estimations; (c) no significant difference between the first threshold estimation of the musicians and the third estimation of the non-musicians; (d) musicians' performance was affected by their musical genre and (e) years of musical experience; and (f) both groups showed better frequency discrimination thresholds in a 2IFC paradigm compared to the 3IFC.

The finding that, as a group, professional musicians perform better than non-professionals on a frequency discrimination task is in keeping with the results reported by Watson and Spiegel /1/. Thirteen of our 16 professional musicians (82%) fall within the range of DLF% performance of the musicians reported in that study /1/. Only 29% of our non-musicians performed within that range compared to 50% of the non-musicians in the same 1984 study. These results suggest that our inclusion criteria for the subjects in each group were stricter, thus allowing for better group separation between musicians and non-musicians than previously reported. The similar ranges of performance of the musicians in the two studies suggest that with the provision of musical training, frequency discrimination abilities approach *rel*DLF% of 0.1. However, in light of the strong repetition effect, these data should not be interpreted as reflecting the limit of auditory human performance. Thus, future training of professional musicians on the frequency discrimination task may help define this upper limit.

The second of our findings, i.e. significant learning evident for both musicians and non-musicians, suggests that training unique to the task is effective regardless of previous musical experience. If auditory training specific to a task were more effective than general musical experience, we would expect thresholds of the non-musicians in the third threshold estimate not to differ from those of musicians on the first threshold estimation. Results confirmed no significant differences between these measurements, although smaller *rel*DLF% values were observed for the musicians group on their first threshold estimate.

Spiegel and Watson reported on three non-musicians who had at least 30 hours of frequency discrimination training and obtained thresholds 5 times smaller than the musicians' thresholds /1/. They concluded that specific training on an auditory task is more beneficial than previous musical experience. They also stated that as experimental stimuli more closely resemble music, previous musical training would be more likely to transfer to the new task. Menning *et al.* trained 10 normal-hearing adults on an auditory frequency discrimination task for 15 sessions over a 3-week period /23/. They found that frequency discrimination improved rapidly in the first week (or after 5 sessions) and was followed by small but constant improvements thereafter. The mean group *rel*DLF% at 1000 Hz was 0.2 while one subject obtained a *rel*DLF% value of less than 0.1. The resemblance between the data in the musicians and highly trained non-musicians raises the possibility that similar mechanisms underlie musical and frequency discrimination training. Support for this possibility can be found in neurophysiological studies /4, 8, 23/. These studies in both musicians and highly trained non-musicians provided evidence of enlarged cortical representation and increased total strength of cortical activation at frequencies that were either used during training or associated with musical tones.

The results of the present study emphasizes the need to consider factors related to the musical background of the subjects: musical genre, instrument and years of musical training. Of the musicians, nine had contemporary musical background (jazz, modern) and 7 classical. Results showed that classical musicians performed significantly better than contemporary. Re-examination of the data by musical genre suggests that contemporary musicians obtained similar *rel*DLF% as the non-musicians on their third threshold estimation (e.g., 1.13 vs 1.1 at 1000 Hz). The classical musicians obtained significantly lower *rel*DLF% (e.g., 0.4 at 1000 Hz) on their first threshold estimates. If this trend were replicated in studies with a larger number of subjects, it would suggest that there is a group of musicians who outperform the general population in their auditory skills regardless of specific auditory training.

The hypothesis that musicians who tune their own instruments (violin vs piano, for example) might be able to detect small frequency changes was not supported by us or others /1/. In our study, musicians who tune their instruments were distributed relatively equally in both genres of music. We argue, therefore, that frequency discrimination performance is related to musical genre. The present data also show that musicians' performance is closely related to years of musical experience, thus supporting the notion that years of musical experience contribute to general auditory non-musical skills. Others suggested, however, that it is not the total number of years of musical exposure that is important but rather the age at which it commences /8/. Our data are too few to accurately account for these factors. Clearly these issues require further investigation.

Finally, comparing two different threshold estimates 2IFC and 3IFC yielded small but significant results in favor of the 2IFC. These results are similar to the finding that there is no difference in DLF between 2IFC and the same/different task /24/. Thus the assumption of Moore and Peter, that frequency discrimination using 3IFC is an easier task, is not supported /2/. Furthermore, these data suggest that auditory memory plays an important role in frequency discrimination tasks, possibly more than identification of pitch direction. The fact that no Group × Method interaction was found suggests that both groups cope similarly with the cognitive demands imposed by the tasks. It is assumed that as long as cognitive thresholds prevail, there is a possibility of improvement by practice to the extent that the cognitive surpasses the physiological limit /10/.

In summary, the present study's major finding was that musicians obtained better frequency discrimination thresholds than non-musicians. The reasons that underlie these differences remain unclear. On the one hand, *rel*DLF% values of the non-musicians after 3 threshold estimates approached those of the musicians on their first threshold estimate, emphasizing the benefit of short-term training on a specific auditory task. On the other hand, musical genre and years of musical experience were predictive of performance. Classical musicians (not necessarily string players) appear to comprise a subgroup of individuals with exceptional frequency discrimination ability. Intensive training of these individuals may shed light on the boundaries of human psychoacoustic abilities.

An additional interesting outcome of this study was the immediate DLF improvement after very short training for musicians and non-musicians. Improvements in threshold are commonly attributed to both cognitive and sensory factors. We hypothesize that the immediate dramatic improvements are probably due to cognitive factors. The present results suggest that the frequency discrimination task is susceptible to training. The relative contribution of the different factors to the threshold improvements on this task requires further investigation.

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APPENDIX A

Relative DLF in % (*rel*DLF% = Δf/f × 100) for each frequency and repetition, for each musician (a) and non-musician (b) using the 3IFC threshold estimate procedure. Also shown are group means and standard deviations.

a. Musicians

Subject	250 Hz			1000 Hz			1500 Hz		
	Repetition			Repetition			Repetition		
	1	2	3	1	2	3	1	2	3
1	.97	.80	.95	.33	.22	.26	.53	.36	.34
2	.35	.38	.37	.55	.21	.29	.67	.53	.26
3	1.52	.28	.60	.36	.60	.36	.46	.30	.27
4	3.55	1.72	1.40	1.49	.54	.44	1.31	.90	.80
5	1.65	2.30	.82	.29	.24	.22	.38	.39	.38
6	1.75	1.20	1.65	.80	.29	.56	1.05	.57	.48
7	2.32	1.48	1.70	.76	.50	1.14	1.09	.90	1.05
8	3.82	2.32	1.80	1.95	1.59	.70	1.03	.90	.73
9	1.77	1.32	.85	.65	.45	.45	1.29	.87	.59
10	1.40	1.85	1.30	1.66	.88	.61	1.24	1.10	.62
11	.75	.80	.47	.14	.21	.10	.34	.41	.33
12	3.75	3.88	3.20	1.99	1.94	1.75	1.33	1.32	1.33
13	1.50	.98	.92	.83	.41	.26	1.28	.61	.67
14	1.25	.65	.60	.24	.22	.19	.19	.22	.21
15	1.67	1.02	.87	.48	.35	.22	.36	.39	.31
16	1.12	.28	.57	.51	.34	.45	.83	.43	.34
Mean	1.82	1.33	1.13	.81	.56	.50	.84	.64	.54
SD	1.04	.94	.71	.61	.51	.42	.41	.32	.31

b. Non-Musicians

Subject	250Hz			1000Hz			1500Hz		
	Repetition			Repetition			Repetition		
	1	2	3	1	2	3	1	2	3
1	2.92	3.30	2.30	2.00	1.71	1.09	1.33	.91	1.19
2	4.00	3.40	2.97	2.00	1.94	1.68	1.28	1.23	1.12
3	2.57	1.68	1.05	.76	.46	.61	.68	.59	.31
4	3.87	3.78	3.77	1.95	1.74	1.96	1.33	1.33	1.32
5	3.80	2.30	2.05	1.63	1.01	1.00	1.33	1.08	1.02
6	2.33	1.00	2.20	1.68	1.00	.34	1.06	.68	.45
7	3.87	3.90	1.77	1.21	1.01	1.05	1.26	.90	1.11
8	3.92	2.75	3.42	1.91	1.80	1.58	1.23	1.32	1.23
9	3.27	2.20	2.02	1.91	1.58	.69	1.26	1.23	1.04
10	2.42	3.25	2.15	1.79	1.59	1.46	1.28	1.33	.83
11	3.52	3.05	2.27	1.71	1.60	.90	1.33	1.28	1.18
12	4.00	3.38	2.30	1.66	1.19	.63	1.33	1.32	1.30
13	3.00	2.28	1.67	1.75	.84	.57	1.14	.87	1.03
14	3.80	3.12	3.32	1.93	1.14	1.83	1.33	1.13	1.25
Mean	3.38	2.81	2.38	1.71	1.33	1.10	1.23	1.09	1.03
SD	.62	.83	.75	.34	.44	.52	.18	.25	.30

APPENDIX B

Relative DLF in % (*rel*DLF% = Δf/f × 100) at 1000 Hz for each repetition, and for each musician and non-musician using the 2IFC threshold estimate procedures. Also shown are group means and standard deviations.

Subject	Musicians			Non-Musicians		
	Repetition			Repetition		
	1	2	3	1	2	3
1	.38	.19	.27	.96	1.79	1.04
2	.26	.16	.14	1.85	1.10	1.71
3	.54	.15	.16	.29	.16	.29
4	.68	.43	.25	1.88	1.89	1.63
5	.20	.27	.46	1.41	1.30	.38
6	.64	.57	.30	.26	.19	.33
7	1.10	.41	1.08	1.41	.81	1.20
8	1.35	1.03	.48	1.73	1.86	1.83
9	.76	.70	.24	1.90	1.98	.93
10	.76	1.18	.66	1.91	.95	.48
11	.11	.10	.10	1.41	1.90	1.56
12	1.48	1.70	1.98	1.91	1.18	.30
13	.30	.33	.22	1.05	.25	.49
14	.34	.15	.25	1.26	.76	.94
15	.38	.44	.16			
16	.15	.22	.24			
Mean	.59	.50	.44	1.37	1.15	.94
SD	.42	.45	.48	.57	.67	.57

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