APC

Interactions of Pitch and Timbre: How Changes in One Dimension Affect Perception of the Other

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Introduction

In music, timbre differences allow us to distinguish between instruments, while pitch carries melody and harmony. In speech, timbre allows us to distinguish between speech sounds, while pitch carries important prosodic information. Pitch and timbre are two of the most fundamental attributes of auditory perception, yet the perceptual interactions of pitch and timbre are not well understood.

The **primary hypothesis** for this experiment is that timbre and pitch, despite often being treated as separable dimensions, are not perceptually independent. The **secondary hypothesis** is that non-musicians and musicians will show perceptual differences on pitch and timbre discrimination tasks.

Method

Participants

16 normal-hearing subjects recruited from the University of Minnesota community: eight musicians (six female), with at least eight years of musical training, and eight non-musicians (six female), with two or less years of musical training.

Materials and Procedure

Experiment time: average of 3 two-hour sessions.

Subjects instructed to listen to two sequential tones over headphones.

Task: to determine which tone in each pair had the higher pitch (or higher timbre).

Differential thresholds obtained using standard adaptive two-alternative forced-choice procedures.

Boxes were displayed on the computer screen, which lit up with the corresponding tone. Subjects were instructed to click on the box associated with the higher pitch. Immediate feedback was given. Both correct and wrong answers were expected in order to gauge the listener's threshold. 12 conditions for pitch and 12 conditions for timbre were run, and averaged, in order to obtain the subject's difference limens for each task. The main experiments were customized for each listener's unique thresholds.

Main Experiments: as subjects listened for the higher pitch, the timbre of the tones changed through random permutation. Likewise, for the task in which subjects listened for the higher timbre, the pitch of each tone changed.

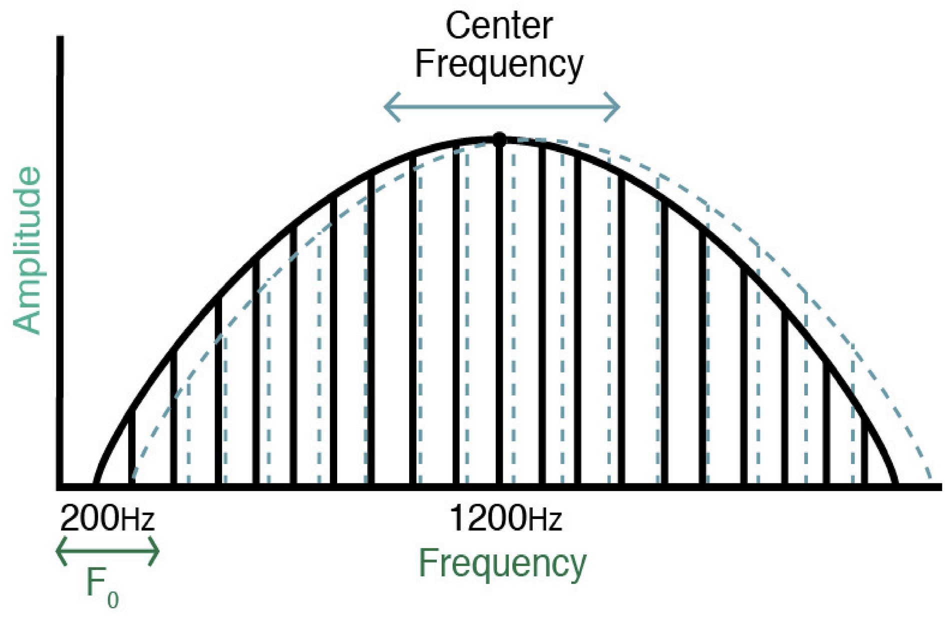
Roving parameters were based upon multiples of the difference limen: 0, 2, 5, 10, 25, 50, and 100, with zero indicating a lack of roving.

Pitch baseline: was centered around the fundamental frequency of 200 Hz.

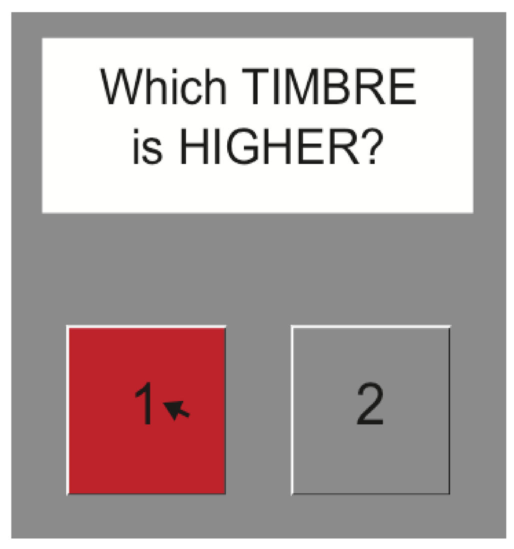
Timbre baseline: was centered around the spectral peak of 1200 Hz.

Experiment Conditions: 28 conditions for pitch, 28 for timbre.

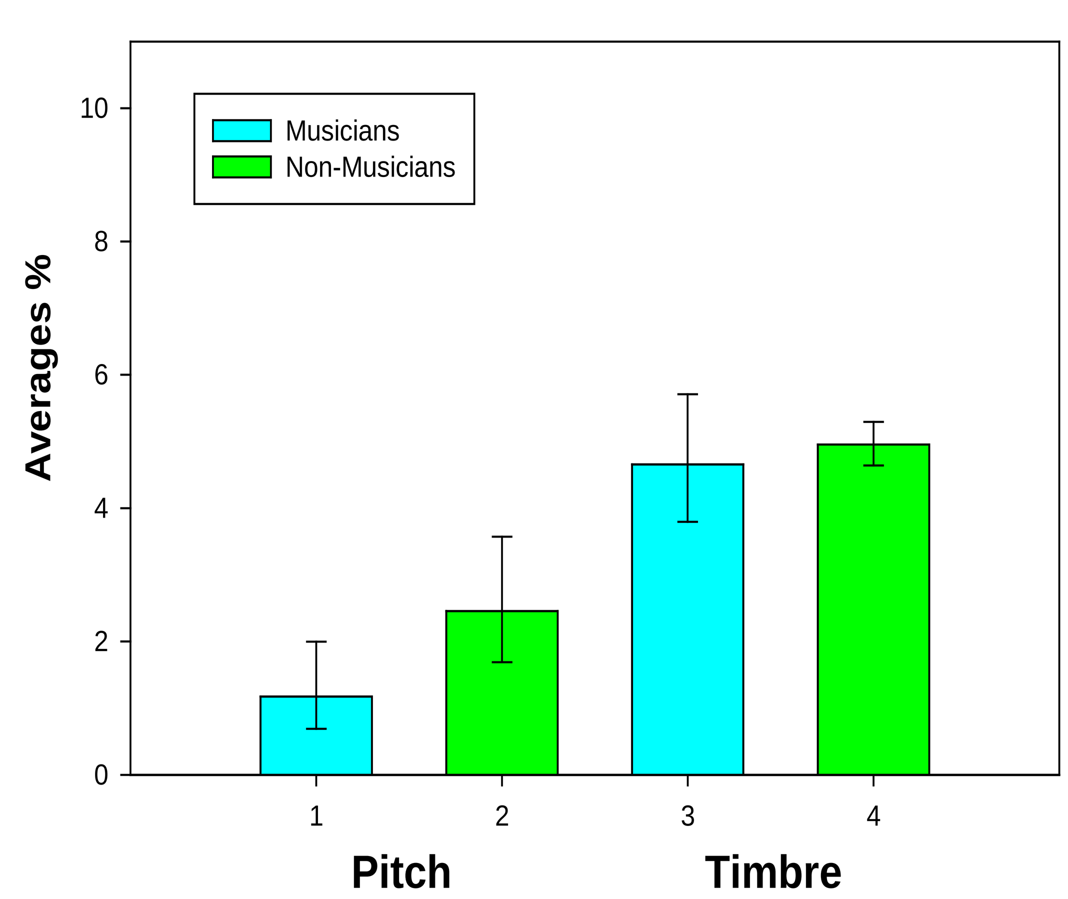
All tasks, including control tasks, were performed in counterbalanced order.



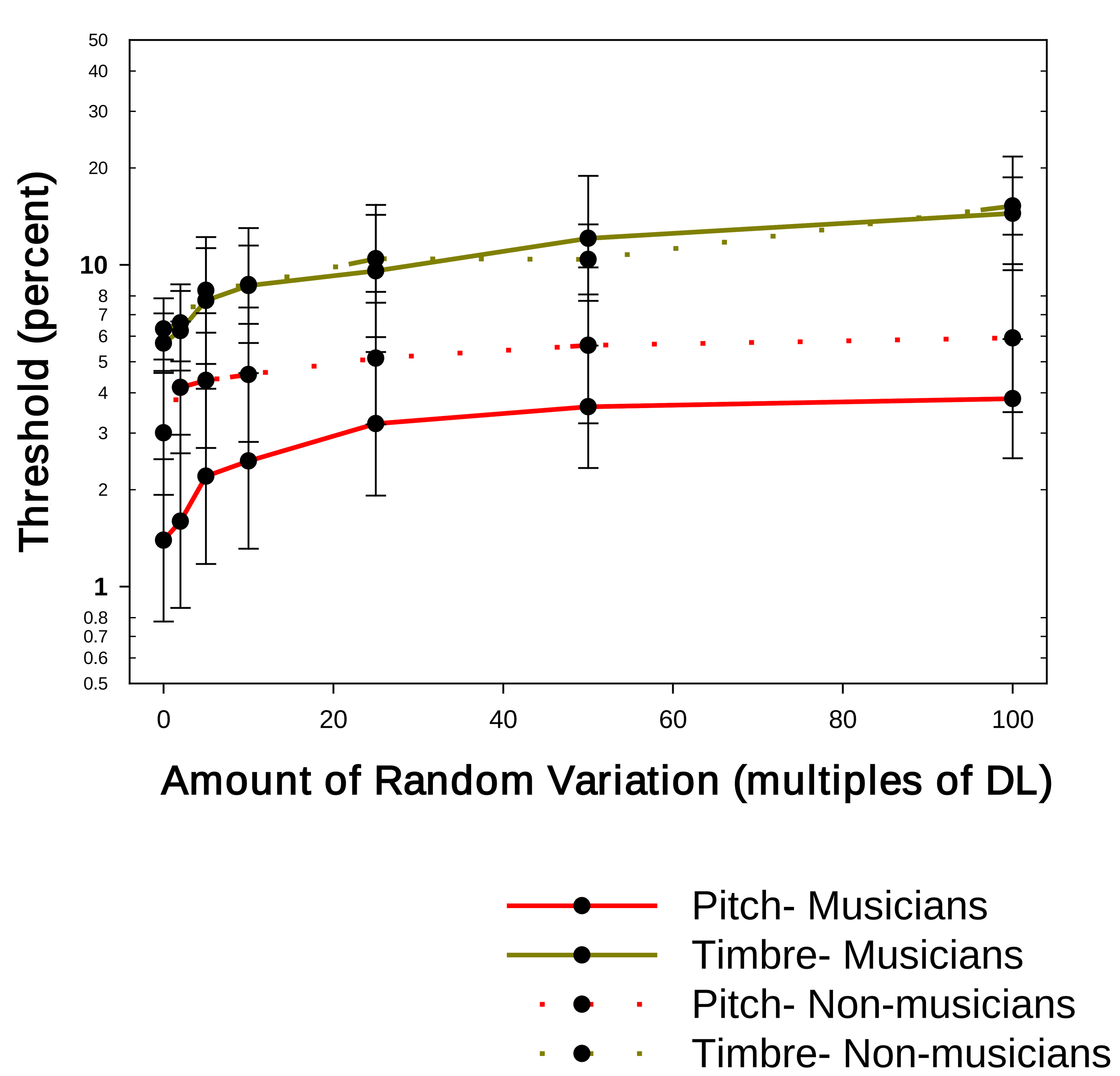
Changing the spectral shape through filtering changes the perceived timbre of the tone, while shifting the fundamental frequency (F_0), by changing the periodicity of the pulse train, changes the perceived pitch of the tone.



Here's what showed up on the computer screen. Boxes lit up for each tone. The subjects clicked on the box with the higher timbre (or higher pitch, depending on which test they were running). Immediate feedback was given telling them if they were correct or wrong.The better they did, the more difficult the task became.



These are the average just noticable differences (DL) for musicians and non-musicians in the pitch and timbre pilot studies. No significant differences were found in their pitch or timbre thresholds.



Comparison of musicians and non-musicians on pitch and timbre tasks, with standard error bars, showing a clear roving effect in both groups. No interaction effects were found between pitch and timbre dimensions.

Results

Results of the repeated measures one-way ANOVA showed the amount of roving in the opposing parameter significantly affected subjects' ability to discriminate small differences in pitch and timbre ($p<0.001$).

Overall, subjects performed significantly better on the pitch task compared to the timbre task ($p<0.001$).

Between-group variability for both the pitch and timbre tasks, however, was not significant.

In the control conditions, significant practice effects were found within subjects when comparing the first six conditions with the last six conditions on a repeated measures ANOVA (for pitch $p=.003$, for timbre $p=.008$).

Discussion

Greater variation in the opposing parameter for each experiment led to greater difficulty in performing the task for both musicians and non-musicians, indicating that detecting very fine differences in one dimension is increasingly difficult with larger and larger differences in the opposing dimension.

This confirms the primary hypothesis that pitch and timbre are not perceptually independent.

No interaction effects found between the pitch and timbre tasks, suggesting that pitch and timbre have similar effects on each other .

The secondary hypothesis was not supported, as there was not a significant difference between musicians' and non-musicians' performance on the pitch and timbre tasks.

Significant practice effects in the control condition could have resulted in smaller differences between the musicians' and non-musicians' main experiment results. On the other hand, had we extended the control conditions to last even longer, it may have led to smaller standard errors in the main experiment.

Possible caveats: subjects' inattentiveness to the tasks and potential tone deafness amongst subjects. This is unlikely, however, since only about four percent of the population is considered tone deaf. Additionally, describing timbre sounds as being "higher" or "lower" is somewhat of a misnomer, as timbre is more commonly described in terms of brightness or dullness. This may have led to some confusion for the subjects. Finally, there could have been gender effects, given the fact that the majority of the participants in both the musician and non-musician categories were female.

Suggestion for future research:
using a larger sample size, in order to get a more accurate representation of musicians and non-musicians.

Related Studies

Beal, A.L. (1985). The skill of recognizing musical structures. *Memory & Cognition, 13*, 405-412.

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Micheyl, C., Delhommeau, K., Perrot, X, & Oxenham, A. J. (2006). Influence of musical and psychoacoustical training on pitch discrimination. *Hearing Research, 219*, 36-47.

Warrier, C. M., & Zatorre, R. J. (2002). Influence of tonal context and timbral variation on perception of pitch. *Perception & Psychophysics, 64*, 198-207.