Effects of musical training on pitch discrimination of resolved and unresolved complex tones

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Introduction
Musicians typically show enhanced pitch-discrimination ability compared to non-musicians, consistent with the hypothesis that musicians are more sensitive to some acoustic features critical for both speech and music processing (see 1, 2, 3, 4). It has been debated whether this perceptual enhancement, so far mainly observed for complex tones containing resolved harmonics (1), can be ascribed to higher peripheral frequency selectivity (5), increased sensitivity to spectro-temporal features due to finer representations at a cortical level (6, 7), or an enhanced ability to attend to and extract such features. The present study investigated whether musical training enhances pitch-discrimination performance for complex tones containing resolved vs. unresolved harmonics to the same extent (experiment 1), and whether this enhancement can be ascribed to increased frequency selectivity (experiment 1) or to a greater effort in performing the task indicated by task-evoked pupil dilations (experiment 2).

Method

Experiment I: Pitch discrimination

- Pitch discrimination of complex tones was measured via fundamental frequency (F0) detection task.
- Participants: 14 listeners (6 musicians, 8 non-musicians).
- Stimuli: complex tones filtered in either a LF (80–1500 Hz) or a HF (1500–3000 Hz) frequency region to vary the resolvability of the harmonics.
- Paradigm: 3 AFC, two intervals contained a reference complex tone with a fixed F0, and one interval contained a deviant complex tone with a larger F0.
- Measured the smallest detectable ΔF0.3

“Which tone has the highest pitch?”

Experiment II: Pupillometry

- Task-evoked pupil dilation was measured during a pitch-discrimination task.
- Participants: 6 musicians (4 from Experiment I), 5 non-musicians (4 from Experiment I).
- Variation of task difficulty: ΔF0 was adjusted to be below, at and above the individual pitch-discrimination threshold from experiment I.
- Variation of harmonic resolvability: three different F0s (100, 200, and 500 Hz) were tested, filtered in LF and HF regions.

Discussion

- Musically-trained listeners obtained smaller (better) behavioral pitch-discrimination thresholds than non-musicians by a factor of about 2 in both resolved and unresolved conditions, indicating that the presence of resolved harmonics is not necessary for enhanced pitch discrimination following musical training.
- Possible factors enhancing performance:
  - higher peripheral frequency selectivity
  - higher task-induced effort for unresolved tones and high task difficulty
  - finer spectro-temporal cues at higher levels

Perspectives

- Confound of the current paradigm: all resolved conditions are tested with an easy task, unresolved with a difficult task
- New paradigm: test higher levels of difficulty and resolvability
- Disentangle resolvability and task difficulty
- Measure pupil dilations (pupilometry experiment) and, additionally, cortical activation (functional magnetic resonance imaging, fMRI)

Conclusions

- Our behavioral findings indicate a similar perceptual benefit for pitch-discrimination of resolved and unresolved complex tones in musicians.
- This benefit seems not to be ascribed to sharper peripheral filtering.
- Higher task-induced effort may partly explain the enhanced performance of musicians for unresolved complex tones.
- Future work may clarify whether increased pupil dilation can be explained as an effect of stimulus resolvability or task difficulty.
- Future work on fMRI may clarify whether musicians show a higher sensitivity to fine spectro-temporal cues at a cortical level.

References