# ASSOCIATIONS BETWEEN MUSICAL EXPERIENCE AND AUDITORY DISCRIMINATION

**Cory McKenzie [*1], Amberley V. Ostevik [†2], Bill Hodgetts [‡2,3], Jacqueline Cummine [♦2,4]. Daniel Aalto [♯2,3]**
[1]Faculty of Science, University of Alberta,
[2]Faculty of Rehabilitation Medicine, University of Alberta,
[3]Institute for Reconstructive Sciences in Medicine, Covenant Health,
[4]Neuroscience and Mental Health Institute, University of Alberta,

## 1 Introduction

Auditory processing is affected by both musical experience and native language. However, there is uncertainty as to which aspects of auditory perception are influenced by musical experience and whether this varies as a function of native language. Auditory discrimination (the ability to tell apart similar sounds) is an important part of auditory perception. Better pitch discrimination has a consistent relationship with more musical experience, regardless of native language. However, duration discrimination is positively related to musical experience only in some language groups. A previous study with Finnish speakers found no relationship between duration discrimination and musical experience [1], while another study found Mandarin musicians had enhanced duration discrimination when compared to non-musicians [2].

Here, we set out to study the relationship between musical experience and various aspects of auditory discrimination in a sample of English-speaking participants. The first objective was to determine if musical experience was related to auditory discrimination. Second was to determine if individual performance differences between simple and complex duration discrimination, were related to musical experience. Then finally to assess if the degree of modulation of frequency and intensity, on duration perception, is related to musical experience.

## 2 Methods

### 2.1 Participants

Eighty-two participants completed the experiment, all were right-handed, 18-33 years old (49% female, mean age of 22 years old), and undergraduate students. They self-reported speaking English natively. 78 participants reported normal hearing and four participants were unsure. This experiment was conducted according to the ethical guidelines of the Declaration of Helsinki and was approved by the Human Research Ethics Board at the University of Alberta (Pro00082110).

[*] ccmckenz@ualberta.ca
[†] aostevik@gmail.com
[‡] bill.hodgetts@ualberta.ca
[♦] jcummine@ualberta.ca
[♯] aalto@ualberta.ca

### 2.2 Procedure

Musical sophistication was scored using the self-report questionnaire of the Goldsmiths Musical Sophistication Index (Gold-MSI) [3]. The questionnaire evaluates musical sophistication based on active engagement, perceptual abilities, musical training, singing abilities, and emotional engagement. These five factors can be scored individually or scored together to create a generalized musical sophistication score. This index is particularly useful for comparing participants with a wide variety of both formal and casual musical experience.

The behavioural task included three tests. All three tests consisted of a forced-choice decision between two different sounds. In the first test, participants were asked which of the two sounds was a higher pitch; in the second, they were asked which sound had a longer duration; and in the third test, they were asked which of two complex sounds was longer. The complex sounds varied in pitch, duration, and intensity. White noise was included in the complex task to mask any potential distortion patterns. The behavioural task was completed on a laptop that was running custom Matlab scripts, and circumaural headphones calibrated to 73 dB were used.

#### Stimuli

All behavioural task stimuli were in the range of normal human speech. All sounds varied from a standard of 300ms long, 73 dB, and 150 Hz. In the simple pitch test, the frequency varied adaptively while the length and intensity were held constant. In the simple duration test, the length of the sound varied and the pitch and intensity did not change. In the complex task, all three features varied randomly. For duration, the sounds had a standard deviation of 75ms and were between 150ms and 450ms. The fundamental frequency of the sounds had a standard deviation of four semitones, and there was a pitch glide which also had a standard deviation of four semitones. The intensity had a standard deviation of 1 dB.

## 3 Results

Six correlations were used to compare behavioural data to Gold-MSI scores (Table 1). At a Bonferroni corrected alpha value ($\alpha$=0.0083), Gold-MSI scores are only significantly correlated with simple pitch discrimination (rs=0.297, p=0.008). At an uncorrected alpha, Gold-MSI is also correlated to complex duration discrimination (rs=0.218, p=0.049) and intensity modulation (rs=-0.283, p=0.010). Simple duration discrimination, duration ratio, and pitch

modulation have no significant relationship with Gold-MSI scores.

Musical experience is related to some aspects of auditory discrimination, but not all. Greater pitch discrimination (a more negative slope) is associated with more musical experience (Table 1). Degree of musical experience is not associated with duration discrimination ability (Table 1). Musical experience was not a factor in how much changes in frequency or intensity affected duration discrimination (Table 1). There is also not a relationship between musical experience and how much performance changed from the simple to complex duration discrimination tasks (Table 1).

**Table 1:** Correlations performed on behavioral data (Spearman's rho). Scores on the Goldsmith Musical Sophistication Index questionnaire (MSI) are correlated to various scores from behavioral discrimination tasks.

| Correlation | Spearman's Rho | p value |
|---|---|---|
| MSI & Simple Duration Discrimination | 0.185 | 0.100 |
| MSI & Pitch Discrimination | -0.297* | 0.008 |
| MSI & Complex Duration Discrimination | 0.218 | 0.049 |
| MSI & Duration Ratio | -0.054 | 0.0635 |
| MSI & Frequency Modulation | 0.014 | 0.904 |
| MSI & Intensity Modulation | -0.283 | 0.010 |

*Indicates significant p-values ($\alpha$=0.0083).

Duration, intensity, frequency, and frequency range all significantly impacted duration discrimination in the complex duration discrimination task (Table 2). This confirms that when ignoring musical experience, there are modulation effects. There is also a significant difference in performance between the simple and complex duration tasks ($t=9.303$, $p=2.22e^{-14}$).

## 4 Discussion

Musical experience was expected to have a positive relationship with both pitch and duration discrimination in a population of English speakers, however it was related only to pitch. These results support previous findings that pitch discrimination is related to musical experience regardless of language. However, the lack of a relationship between musical experience and duration discrimination suggests that there is still more research needed to determine how native language impacts if musical experience improves duration discrimination. Previously, it was proposed that speaking a quantity language (in which duration plays an important role in phonetics) increased duration discrimination to a maximum ceiling, and that musical expe-rience could not improve it further [1]. This is not supported by the present study.

This study highlights many areas of potential future study. First and foremost, in understanding how language plays a role in duration perception. The findings that musical experience was 1) not related to individual performance differences between simple and complex duration discrimination, or 2) to the degree of modulation of frequency and intensity on duration perception, require more research to properly interpret. The impact of other factors, such as bilingualism, culture, and cognitive abilities on the relationship between musical experience and auditory discrimination remains unstudied.

**Table 2:** Means of the coefficients of logistic regression models fitted to each participant's duration responses separately with frequency range difference calculated as the difference between the absolute values of the dynamic $f_0$ ranges.

| Effect | Mean | 95% CI | t value | p value | Cohen's d |
|---|---|---|---|---|---|
| intercepts | 0.23 | (0.14, 0.32) | 5.0 | $p=3e^{-6}$ | 1.411 |
| Duration Difference | 20 | (18, 22) | 21.0 | $p<2e^{-16}$ | 23.191 |
| Intensity Difference | 0.1 | (0.08, 0.12) | 11.0 | $p<2e^{-16}$ | 6.075 |
| Frequency Difference | 0.068 | (0.036, 0.100) | 4.2 | $p=6e^{-5}$ | 0.986 |
| Frequency Range Difference | 0.035 | (0.022, 0.048) | 5.4 | $p=6e^{-7}$ | 3.470 |

## 5 Conclusion

Scores from a self-report measure of both formal and casual musical experience (Gold-MSI) are correlated with pitch discrimination in a population of adult English speakers. However, 1) both simple and complex duration discrimination are not related to musical experience, 2) there is no correlation between musical experience and the degree of decrement in duration discrimination performance on a complex task, compared to a simple single-feature task, and 3) duration perception effects, as a function of changes in auditory features (i.e., frequency and intensity), are not significantly related to musical experience in English speakers. Overall, these findings suggest that musical experience does not enhance all aspects of auditory processing equally, and that any enhancements may be dependent on the particular features of the individual's language background.

## References


[1] Dawson, C., Aalto, D., Juraj, Š., Vainio, M., & Tervaniemi, M. (2017). Musical sophistication and the effect of complexity on auditory discrimination in Finnish speakers. *Frontiers in Neuroscience*, *11*(213), 1–11. https://doi.org/10.3389/fnins.2017.00213

[2] Dawson, C., Tervaniemi, M., & Aalto, D. (2018). Behavioral and subcortical signatures of musical expertise in Mandarin Chinese speakers. *PLoS ONE*, *13*(1), 1–14. https://doi.org/10.1371/journal.pone.0190793

[3] Müllensiefen, D., Gingras, B., Musil, J., & Stewart, L. (2014). The musicality of non-musicians: An index for assessing musical sophistication in the general population. PLoS ONE, 9(2). https://doi.org/10.1371/journal.pone.0089642