Using pitch discrimination tasks to tease apart the effects of pitch height and octave equivalence in our perception

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Introduction

Notes separated by a doubling in frequency (or an "octave") sound similar, a phenomenon named "octave equivalence". While this relationship is used in musical cultures around the world, it has been remarkably difficult to demonstrate experimentally, with many past studies finding contradictory results (Burns, 1999). Hoeschele et al. (2012) were perhaps most successful in demonstrating octave equivalence in adults, using a three-range discrimination task. There, participants were trained to respond only to one of three ranges of notes of octave four. A subsequent testing phase showed that participants generalized the discrimination from octave four to octave five. Here we explored why and how this task worked, to better understand the roots and potential cross-cultural significance of octave equivalence: In particular we tested whether three ranges were crucial to showing octave equivalence by running analogous two-range tasks.

Methods

We ran two tests, a generalization test and a transfer test. Both included variations of the original paradigm by Hoeschele et al. (2012). Namely, we added two-range tasks as well as testing across three instead of two octaves. We also collected data on participants' musical training and ability to speak a tonal language.

Generalization:

In this test, participants were trained to respond only to rewarded notes from octave 4. Subsequently novel unrewarded notes from octaves 5 and 6 were added to test generalization. The rationale here is that perception of octave equivalence will make participants respond more to the octave 5 and 6 notes that correspond to rewarded octave four 4 notes. See Figure 1 for a visualization of reward contingencies used in this test.

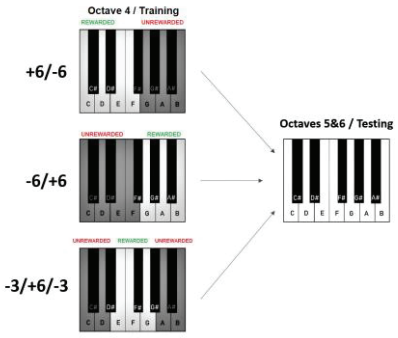

Figure 1: Pattern of rewarded and unrewarded notes in octave 4 (used for training) and subsequently tested of unrewarded octave 5 and 6 testing notes. Dark grey areas on keyboard and "unrewarded" demarcate non-rewarded notes, light grey areas and "rewarded" signify rewarded notes.

Transfer:

In this test, participants were trained with rewarded octave 4, as well as with rewarded 5 and 6 notes. For half of the participants the reward pattern was the same for all octaves, for the other half it was reversed from octave 4 to octaves 5 and 6. See Figure 2 for a visualization of reward contingencies used in this test. The rationale here is that octave equivalence should make it more difficult to learn reward patterns that reverse between octave as this means similar sounding notes need to be treated differently.

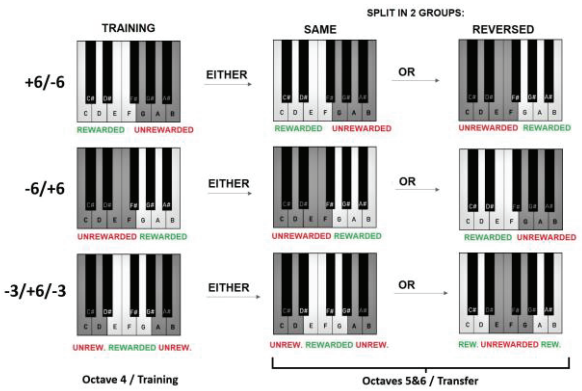

Figure 2: Rewarded and unrewarded notes for octave 4 and octaves 5 and 6 for the "same" and "reversed" groups during transfer test. Dark grey areas on keyboard and "S-" demarcate non-rewarded notes, light grey areas and "S+" demarcate rewarded notes.

Results

Generalization:

In this test, two-range groups used only pitch height to solve the task. The response pattern simply increased or decreased across octaves. Three-range group participants maintained the response pattern from training to the neighbouring octave but not across two octaves. See Figure 3 for a visualization of these results:

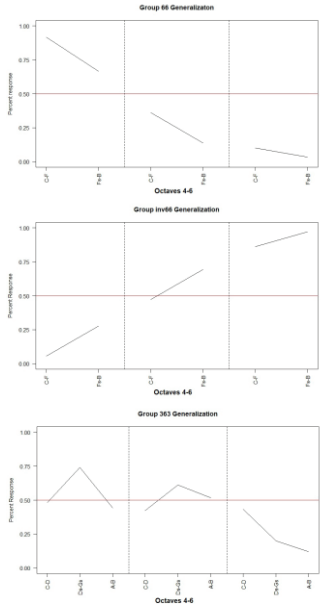

Figure 3: Median responses to note ranges for all groups for all octaves (4-6, left to right) for generalization testing. The red line demarcates chance level.

Transfer:

In this test, the reversed transfer pattern especially affected the three-range group, making participants respond almost at chance level for octaves 4 and 5. This constitutes more evidence, that only the three-range group used octave equivalence to solve the task. See Figure 4 for a visualization of these results:

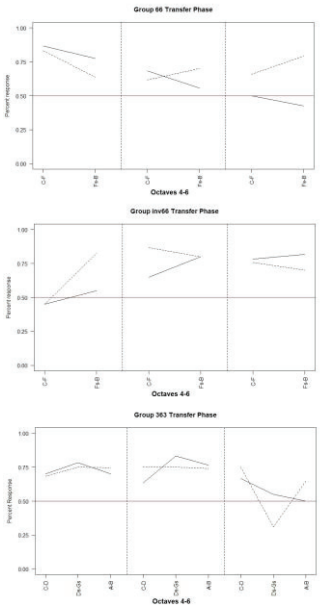

Figure 4: Median responses to note ranges for all groups for all octaves (4-6, left to right) for transfer testing. Reversed group is in dotted line. Red line demarcates chance level.

Conclusion:

Results showed octave equivalence only in participants in the three- but not in two-range tasks. As such three or more ranges indeed seem to be crucial to showing octave equivalence as otherwise pitch-height perception is dominant over octave equivalence – which may be limited to neighbouring octaves. Additionally, analysis of the questionnaire answers suggested that tonal language and musical training have a positive effect on discrimination abilities but not on perception of octave equivalence as such.

References:

[1] Burns, E. M. (1999). Intervals, scales, and tuning. In D. Deutsch (Ed.), The psychology of music (2nd ed., pp. 215–264). San Diego, CA: Academic Press.

[2] Hoeschele, M., Weisman, R.G. & Sturdy, C.B. (2012). Pitch chroma discrimination, generalization and transfer tests of octave equivalence in humans. Attention, Perception, & Psychophysics, 74. https://doi.org/1742-1760. 10.3758/s13414-012-0364-2