Octave bias in an absolute pitch identification task

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Abstract

Octave errors are common within musicians, even among absolute pitch possessors. Overall, evidence shows pitch class and octave to be perceived in a different way, even if they are highly connected. We investigated whether pitch class perception, in an absolute pitch identification task, can be influenced by the octave context, examined among two consecutive octaves. Participants, all musicians with formal musical education, showed different response patterns in the two octaves even if the octave context was explicitly told to be task irrelevant. The direction of errors revealed a consistent tendency to underestimate pitch height in the lowest octave and to overestimate pitch height in the highest octave. Thus, pitch class identification showed to be biased by the octave context. These results are discussed in terms of polarity and pitch enhancement.

Keywords: absolute pitch identification; octave bias; underestimation; overestimation; music psychology.

Introduction

Absolute pitch (AP) abilities have mostly been investigated through identification tasks. Namely, participants had to identify the pitch class of a tone by its name or by other response typologies. For a review on AP abilities and tasks used to investigate it see Levitin & Rogers (2005) and Takeuchi & Hulse (1993). However, most of studies considered response accuracy simply as correct and incorrect, without deeply investigating the "direction" and the "amount" of the errors committed by AP and non AP possessors. As error amount we considered the interval distance between the response and the target tone (e.g., if the target tone is A and the response is B, it is considered a 1 tone error). As the error direction we considered the positive or negative value of the error interval (e.g., if the target tone is A and the response is B, it is considered a positive +1 tone error; while, whether the response is G it is considered a negative -1 tone error). A similar approach to pitch errors was previously used by Levitin (1994) for analyzing participants' errors during a singing production task. This study showed that non AP possessors are perfectly able to retain in long term memory and, consequently, to reproduce a specific pitch frequency, without using any type of external reference, when singing a well known popular song. These results strongly argue in favor of the so called "residual AP abilities" claiming that even non AP possessors are in some way able to process the absolute frequency of a pitch.

An interesting point to this debate is the difference between "pitch class" and "pitch register". Indeed, both are due to the frequency of a sound but the "pitch class" is defined by precise categories with proper names (e.g., C, C#, D) while the "pitch register" refers to the extension of these categories through different octaves. Indeed, pitch classes are repeated among different octaves and the specific octave can be identified by a number following the pitch class name (e.g., E2, E3, E4). Piano has one of the largest octave range in western music, consisting in 7 complete octaves. However, the most used are the middle octaves while extreme sounds are more rarely played (Miyazaki, 1989; Owen, 2000). Although identifying an octave should be theoretically easier than identifying a specific pitch class, octave errors are very common among musicians. Surprisingly, even AP possessors - who are highly accurate in identifying the class of a target pitch - often commit octave errors (Miyazaki, 1989; Takeuchi & Hulse, 1993). This evidence seems paradoxical but underlines the existence of separate processes in the identification of these two characteristics of tones. Indeed, pitch classes seem to be perceived as well defined categories, while octaves are more likely to be perceived as a continuum. Moreover, it is known that the pitch register strongly influences the identification of a specific pitch, making the identification more difficult and prone to errors in the extreme ranges (Takeuchi & Hulse, 1993).

The aim of our work was to verify the existence of constant errors in the identification of pitch classes by musicians lacking a formally ascertained AP. Given that the octave context has a strong influence on the accuracy of pitch classes identifications, we aimed to investigate the direction and the amount of the interval errors among two consecutive octaves. Participants responded both verbally and by pressing the correct key on a electric piano keyboard. The use of two response conditions aimed to deeply investigate the role of response modality on identification errors.

Method

Participants

Only experienced students or graduated students from the State Conservatory of Music "G. Tartini" took part in the experiment.

Apparatus and stimuli

The administration of the stimuli was programmed and controlled by the E-Prime 2.0 software, running on a Dell notebook. Stimuli were 14 piano tones with a duration of 3000 ms each, previously recorded with a professional digital piano, and consisted in the C major scale repeated in two consecutive octaves. Participants listened to the stimuli through a pair of professional headphones. The volume was set on a comfortable fixed level for all the participants. Responses were recorded with an electric piano keyboard in the "motor response condition" and with a voice microphone in the "verbal response condition". Both response devices were connected on a external audio device connected to a MacBook Pro. The experiment took place in a quiet room of the State Conservatory of Music "G. Tartini" without environmental distractions.

Procedure

All the participants were required to identify the pitch class of the stimuli in two conditions. In the "motor response condition", they had to press the correct key of the electric piano corresponding to the listened pitch. The electric piano was muted, thus no external pitch reference was provided to participants during the identification task. In the "verbal response condition", they had to identify the target pitch by naming its pitch class. In both conditions they were told to ignore the pitch register of the tone and to respond exclusively by identifying its pitch class. The order of the conditions were counterbalanced among participants, thus half of them started with the verbal one while the other half started with the motor one. Each condition was set up by 5 repetitions of the entire stimulus set, resulting in a total of 140 experimental trials. Moreover, each session was preceded by 7 training trials. Stimuli were in random order in both training and experimental blocks. In addition to the 3000 ms of the stimuli duration, participants had additional 2000 ms of silence for performing a response. Thus, they had globally 5000 ms to respond after each stimulus started. Responses after 5000 ms were not accepted. After this time interval a drum sequence of 2000 ms started. The aim of this distracting sound sequence was to "clean" the participants' echoic memory and, therefore, to avoid that participants used previous stimuli as reference for next trials. Indeed, we meant to investigate participants' errors in AP judgments, thus we had to prevent the retention in memory of previous stimuli. For additional information about memory for pitches and other musical attributes see Levitin (2002).

Participants had the possibility to take a short break after completing the first response condition. Both response times and accuracy were stressed in the instructions.

Interval errors were calculated as follows. Correct responses were considered 0 and, therefore, not taken into account. Errors could be positive (+) or negative (-). We considered positive errors as an overestimation of pitch height (e.g., if the target tone is A and a participant responds B, C or D), while negative errors as an underestimation of pitch height (e.g., if the target tone is A and a participant responds G, F or E). As the error amount we considered the interval error, namely, the distance in tones (1 unit) and semitones (0.5 unit) between the response and the target note. Finally, for each target tone we calculated the sum of the interval errors for both the octaves. Therefore, positive (+) values indicated an overestimation, while negative (-) values indicated an underestimation.

Data analysis and results

A repeated-measures ANOVA was ran for the Interval Errors, with a 2×2×7 design (Response Condition × Octave × Pitch). There was a significant main effect of the octave, indicating differences in the interval errors committed in the two octaves. Additionally, a t-test was run confirming the interval error differences in the relatively low and high octaves. Conversely, the main effect of response condition was not significant, as well as the main effect of the pitch classes. Moreover, the interaction between the response condition and the octave was not significant, while the interaction between the note and the octave was significant.

Discussion

Our findings confirmed the role of the octave in affecting the AP identification abilities of single tones. Moreover, we discovered an intriguing "bias" in the interval errors of a pitch class identification task. Indeed, when requested to identify the pitch class of target tones among two consecutive octaves, participants tended to overestimate the pitch of the upper octave and to underestimate the pitch of the lower octave. Therefore, musicians judged as higher than they actually are pitches in the highest octave, while they judged as lower than they actually are pitches in the lowest octave. Moreover, this phenomenon seems not to be linked to the response modality, as there were no differences between verbal and motor response conditions. Conversely, it can be due solely to different stimuli perception across the octaves. Indeed, the target tones in the highest octave have clearly highest frequencies than those in the lowest octave, and vice versa. Thus, this perceptual artifact, that we called "pitch enhancement", can be the cause of the octave bias in the present experiment.

Future investigations have to ascertain the existence of this bias also in non consecutive octaves and, moreover, across multiple octaves. Indeed, such phenomenon could be simply an artifact due to the use of dichotomous octave categories. In fact, in our study, stimuli were repeated across two consecutive octaves producing a bipolar coding of tones as high and low. Thus, the same tone (e.g., G) could be coded as high (e.g., high/+ G) or low (low/- G). Therefore, for instance, G3 was judged to be lower than it actually is leading to underestimation errors while, in the case of G4, it was judged to be higher than it actually is leading to overestimation errors. We can dare in speculations and find some similarities with the Polarity Correspondence Theory (Proctor and Cho, 2006), which refers to binary choice tasks. Since in our case a binary coding was possible for the stimuli, this could be a plausible explanation of the obtained data, even if responses were not coded on a bipolar dimension. Otherwise, if data are attributable not to a polarity coding artifact but to a more extended octave bias, we should find this constant error among different octaves. Indeed, using an odd number of octaves (e.g., three octaves), we should expect a non biased identification in the central octave, while an under- and overestimation in the lower and upper octaves respectively. Moreover, the size of the bias should be expected to grow as the distance between the octaves become larger. We called this account "pitch enhancement", as the octave context plays an important role in enhancing the perceptual height of a pitched tone. However, this phenomenon remains largely unexplained and no indications seem to come from previous literature. Therefore, this is probably the first report of this octave bias and, thus, more investigations are needed to deeply understand its nature.

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