Targeting Timbral Recognition Abilities of Musical Participants: When Musicians Hear What Isn't There

Stephan Bonfield and Elzbieta Slawinski
Department of Psychology, University of Calgary, 2500 University Dr. NW., Calgary, Alberta, T2N 1N4
Correspondences to be sent to spbonfie@ucalgary.ca

1. Introduction

The area of timbral studies in music perception is under-represented. Although part of the reason for this is owing to the difficulty of measuring timbre relative to ones perception, (Handel and Erickson, 2001), the focus of this study is geared toward simultaneous presentation of timbres and the difficulties listeners encounter with their perceptions, which often result in the misidentification of the instruments generating the timbres in question (Bregman, 1990). In spite of the fact that identifying a single timbre of any instrument (given reasonable range, onset, duration constraints and critical bandwidth) falls well within the purview of competent perceptual skill levels of musicians and non-musicians (Bregman, 1990), it is the discernment of instruments in combination that create perceptual problems for listeners, and that remains an important issue requiring investigation. Here, in this introductory study, we hypothesize that participants will have difficulty discerning the identity of four orchestral instruments presented from a passage taken from the first movement of Igor Stravinsky's *Ebony Concerto*.

2. Methods

A passage of 1300 ms in length consisting of 17 combined tones over 8 beats of measure 43 of Stravinsky's *Ebony Concerto* was played in three conditions to 22 participants. Condition 1 consisted of the measure in question, condition 2 provided 10 s of the musical material preceding measure 43 (approximately measure 37 ff.,) and condition three consisted of condition 2 material with 3000 ms of musical material after the targeted stimulus. Condition 3 was created so as to permit the participants to contextualize the stimulus window of condition 1, by hearing what follows the target stimulus in the piece itself. Trial Version 1: Participants (N=13) were presented with the targeted stimulus (bar 43) first, so that they knew what the target would be in advance. They were told that there would be three conditions, but that the order of the conditions would be randomized and that they could have up to ten voluntary iterations of each condition (such as condition order 2-1-3, to name one example).

Trial Version 2: In this version of the experiment, nine (N=9) participants were played the three conditions in any order over eight compulsory iterations. The recording chosen was that of *Ensemble Intercontemporain*, directed by Pierre Boulez. Participants were also told the orchestration of the piece in advance of the trials, and that they were expected to choose instruments from the list provided.

3. Results

None of the participants were able to correctly name all four instruments (harp, tom-tom, clarinet, trombone). All participants named piano as an instrument even though no piano is found in the target stimulus passage. 45% of respondents (N=10) scored three correctly (the so-called "three-group"), and 45% scored two correctly (the so-called "two-group"). The remaining two respondents scored only 1 correctly. The three-group and the two-group misidentified trumpet equally, (four times each) but the two-group misidentified more instruments more often than the three-group overall, including french horn three times to one time in the three-group.

Overall, there were 2 opportunities for participants to score higher when moving from one block of iterations to the next, and when multiplied by 13 participants, this created an aggregate total of 26 potential differences for scores between blocks. Of these 26 potential differences, only 8 blocks registered improvement in accuracy (32.5%), indicating a low percentage overall for learning effects across conditions consistent in this case with a mild saturation effect. In the second trial version, 5 participants (N=9) answered with at least two correct identifications, 4 of whom accurately increased their correct scores. One participant answered initially with one correct answer and increased the score subsequently, and 3 answered with 0 but increased their score by the second iteration (N=2) or third iteration. It appeared that participants who were satisfied with their answers felt that what they were hearing was reflected accurately with what they were perceiving. No participants listened to fewer than three iterations per condition in Trial Version 1.

4. Discussion

Given the hypothesis as stated at the outset, it was not surprising that no one named all four instruments correctly. The two main groups, the two-group and three-group, showed one significant difference in the types of errors they made, namely that the three-group identified the clarinet more successfully. Both groups almost equally failed to identify the trombone. The most significant response however was the unanimous belief that piano was part of the target stimulus. Regardless of condition-order presentation, or number of iterations, 'piano' was responded by all participants. Such a widespread confusion was not anticipated. A variety of possible answers present themselves. The fundamental tone of the final 300 ms of condition 2 is G (98 Hz). The fundamental tone of both harp and tom-tom at 360 ms is also 98 Hz and thus is the same as the lowest tone of the final four eighth-note grouping of the piano in measure 42. The similarity of pitches from measures 42 to 43 is not surprising given Stravinsky's propensity to use pitch-class sets.

The close comparison of both fundamental frequency and super-imposed tones, with the exception of the C natural in measure 42, and the change of f natural to F sharp in bar 43 in harp, creates qualitatively very similar spectrographic conditions in the frequency domain, thereby making it possible that listeners could perceive a melodic and harmonic continuity from piano to harp. Furthermore, the spectral energy of both piano in measure 42, and harp/tom-tom in measure 43 appear similar enough in the upper harmonics to cause confusion.

One other possible explanation for the confusion may involve onset times. Onset forms the critical perceptual determinant of instrumental timbres and it is known that the deletion of the first few milliseconds of onset of a piano will result in a timbre closely approximating a harp (Sundberg, 1991). While the reverse certainly is not true, it raises the question of whether the combination of the harp/tom-tom timbre results in a peculiar perception, namely, the additive qualities of one percussion family instrument (tom-tom) plus one plucked-string family instrument (harp) equaling roughly the timbral quality of an instrument that is often regarded to be from both families (piano). Given this possibility, it could be that the harp, struck with the nail, (as indicated in Stravinsky's score) plus the tom-tom played with a felt stick could combine to create a characteristic onset quality and thus, a similar spectral quality that explains how participants could confuse the harp/tom-tom combined timbre with piano.

The task was also implicitly asking whether each participant could identify the combined timbre at the 975 ms point (beat 8) of the target stimulus, and whether they could deduce that the two timbres were clarinet and trombone. Participants reported that the combination of clarinet and trombone seemed to be played perfectly in tune, which is unusual when both instruments are orchestrated very high relative to their respective ranges. The clarinet plays the second harmonic of the trombone's fundamental, a challenge for performers in tuning the two notes doubled at the octave, and for participants in discerning the qualitative difference between the two instruments. The placement of both clarinet and trombone in a high acoustical range together likely creates vibrational complications for the performers resulting in fractional intonational differences (similar to when two french horns play together in their upper register). In this case, it may be surmised that intonational , and thereby, timbral differences are driven by the acoustical properties of the oscillators controlling pulsating airflow, namely the clarinet reed and the brass player's lips, resulting in perceptual problems for participants in identifying the two instruments.

5. Conclusions

Perception of combined tones is a difficult task that requires multiple iterations before discernment of individual instruments may be accomplished. Misidentified timbres tended to run along instrumental family lines (trumpet or french horn for trombone; piano for harp, or piano and harp for harp's differing timbres). However, the preliminary data suggest that errors may move along lines of instrumental familiarity, i.e. participants make errors by identifying the sounds of instruments they think they know best. These examples further illustrate the on-going experimental challenges involved in testing timbral perception.

6. Selected References

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