Musical communication of flutists in ensemble performance

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Background. Several empirical studies have shown that performer's musical intentions are conveyed through manipulations of acoustic parameters. Therefore, during ensemble performance, musicians need to coordinate their musical ideas, through manipulation of different parameters.

Aims. This paper aims to discuss timbre modification, due to coupling interpretation of ensemble performance. We compared the sound quality of solo performances of orchestral excerpts played by professional flutists, with their own performances when following clarinet and bassoon playing the same excerpt in unison. In this study, timbre was represented by two of the descriptors discussed by McAdams and colleagues, the logarithm of attack time and spectral centroid. Note segmentation, end of attack and beginning of release were determined using the Expan tool developed in previous studies.

Results. We were able to observe that flute players tend to modify their timbre when following clarinet and bassoon with different tendencies for each instrument.

Previous empirical studies in music performance have suggested evidence that performers manipulate different acoustic parameters, aiming at expressing and/or communicating their own ideas to the other musicians or to the audience (Davidson & King, 2004; Gabrielsson, 2003). By manipulating parameters such as note durations, intensity, pitch, timbre, and note articulation, musicians build their phrases and ideas, as well as communicate their intentions.

In instrumental ensemble performance, musicians need to adjust different acoustic parameters in order to achieve the intended interpretation of the group (Goodman, 2002). In this paper, we discuss such adjustments on the realm of timbre modification, aiming to understand how musicians communicate with each other by means of sound quality control. According to Halmrast, Guettler, Bader and Godoy (2010), small-scale feature manipulation, such as timbre fluctuations, are crucial for our experience of music, due to its expressive power. They also point out the difficulty of defining timbre due to its multidimensionality. Sound quality modification may involve a combination of features at different timescales, being manipulated simultaneously or sequentially, which form the basis for our sensations of timbre. Flutists use airflow control and shaping of the lips and mouth in order to manipulate the sound quality they produce.

In this study, we aimed at analyzing the tendency of flutists to bend their sound quality when playing with other woodwind instruments, i.e. the clarinet and the bassoon. The sound quality they produced in both conditions, playing solo and in ensemble was compared by means of two of the descriptors discussed by McAdams and colleagues (McAdams, Winsberg, Donnadieu, Soete, & Krimphoff, 1995; McAdams, 1999), the spectral centroid and the logarithm of attack time.

The use of spectral centroid, a parameter that best describes what we understand by sound brightness, is intended to focus on the percept of timbre related to spectral fluctuation during longer notes. These changes in the spectrum during the sustain part of a single note are what makes the sound interesting or "natural" to the listener, in contrast to some synthesized sounds that remain unchanged throughout its duration (Halmrast *et al*., 2010). The logarithm of attack time aims at describing timbre perception of shorter notes due to different modes of attack and articulation in all three instruments involved in the experiment. Although attack occurs before the sustain part of the note, attack features are remembered, hence influence the global timbre perception of the note. We also observed the use of vibrato as a modifier of timbre.

Methods

Eight professional musicians (6 flutists, 1 clarinetist and 1 bassoonist) performed a short excerpt of the first movement of Symphony nº 1 in G minor, op. 13 by Tchaikovsky (Figure 1), in which woodwind instruments play in unison, presenting a real duo performance situation, that requires adaptation at every single note. The experiment was done in two sessions. In the first session, each musician played the excerpt solo with his/her own interpretative intention. In the second session, flutists were asked to play the excerpt, four times each, following separately the clarinet and the bassoon recorded in the first session, through an earphone in their right ear. The only instruction given was to accompany both instruments the best they could. A total of 72 takes were recorded, 48 takes of duet and 24 takes of solo performances .

The recordings were made using a Line-6 UX2 interface at 44.100 Hz, with two omnidirectional microphones located approximately at 1 and 2.5-meter distances from the source. The final mix was made between these two channels in order to avoid energy fluctuations due to musicians' movements and phase cancelation due to the positioning of both microphones. In the second session, the previously clarinet and bassoon recorded tracks were played back through an Audio-Technica ATH-M50 headphone at the right ear, leaving the left ear free for the musician to listen to his/her own sound. The software Audacity was used for recording and playback (http://audacity.sourceforge.net/). To avoid excessive reverb that could complicate the analysis, a partially mute room with basic acoustic treatment was used. Every musician used his/her own instrument and materials during the performances.

Figure 1. First movement of Symphony nº 1 in G minor, op. 13 by Tchaikovsky, bars 533 (13 bars after letter Q) to 545 (example above shows only the three instruments in unison).

Analysis

The first step was to segment the recorded audio into musical notes. Note onset and offset, end of attack and beginning of release were detected at the energy envelope, using a combination of pitch and amplitude values. This was done automatically with the use of EXPAN, a tool developed at CEGeME for musical expressiveness analysis (Loureiro *et al*., 2008a; Loureiro, Yehia, De Paula, Campolina & Mota, 2009). A Sonic Visualizer plugin (Cannam, Landone & Sandler, 2010) developed within the EXPAN toolbox was also used for inspection and adjustment of the segmentation parameters (Figure 2).

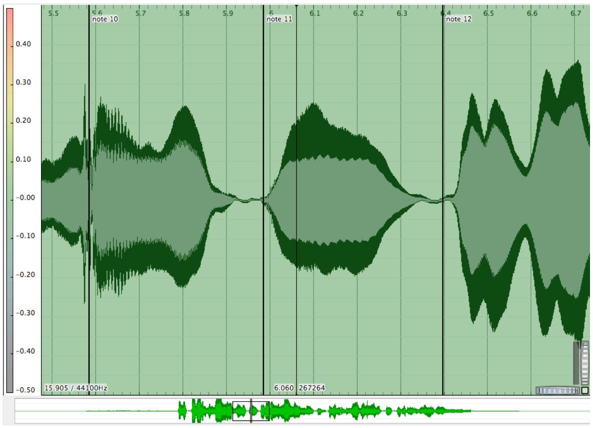

Figure 2. Note segmentation with EXPAN's Sonic Visualizer Plugin

After that, the spectral centroid curves and the logarithm of attack time of each note were estimated. A one-way Analysis Of Variance (ANOVA) was used to test differences between the three conditions to which flutists were submitted.

Results

The mean of the spectral centroid differed significantly across the three conditions, F (2, 2638) = 3.138, $p < 0.05$ (Figure 2). When following the clarinet, the flute had the highest spectral centroid value (M = 1.489, SD = 0.273), followed by the condition of playing with the bassoon (M = 1.472, SD = 0.271).

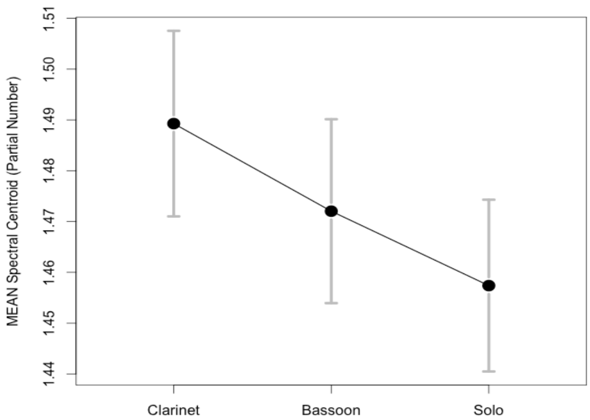

Figure 3. Mean spectral centroid, for three conditions

When playing solo, flutists presented the lowest spectral centroid (M = 1.457, SD = 0.260). As shown in Figure 3, the mean of the logarithm of attack time was also significantly different between all three conditions, F (2, 2638) = 3.484, $p < 0.05$, indicating that when playing solo, flutists tend to produce shorter attacks (M = 0.067, SD = 0.062) when compared to their ensemble performance with clarinet (M = 0.073, SD = 0.066), and bassoon (M = 0.074, SD = 0.062).

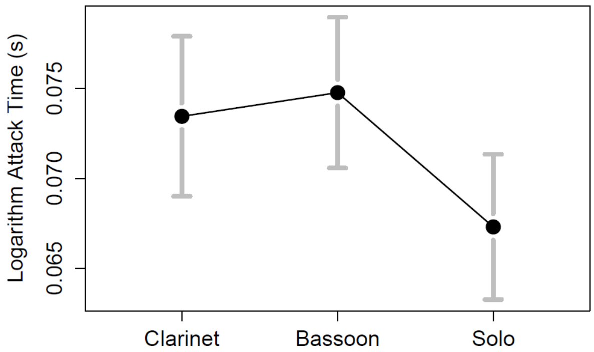

Figure 4. Mean Logarithm Attack Time, for three conditions

Discussion

This study aimed at understanding how flute players communicated with each other by means of timbre modification due to coupling of musical interpretation in ensemble practice. Our experiment suggested that flutists have the ability to perceive the timbre of different instruments in ensemble performance by reacting with sound quality manipulation of their own instrument. Loureiro *et al.* (2008b) show that the spectral centroid can vary throughout a single note, especially if there are changes in sound energy. This happens due to asynchronous variations at the energy of each partial, thus changing the position of the centroid and the timbre sensation related to it. This situation was observed when flutists manipulated the intensity when following the recordings, which resulted in spectral centroid variation.

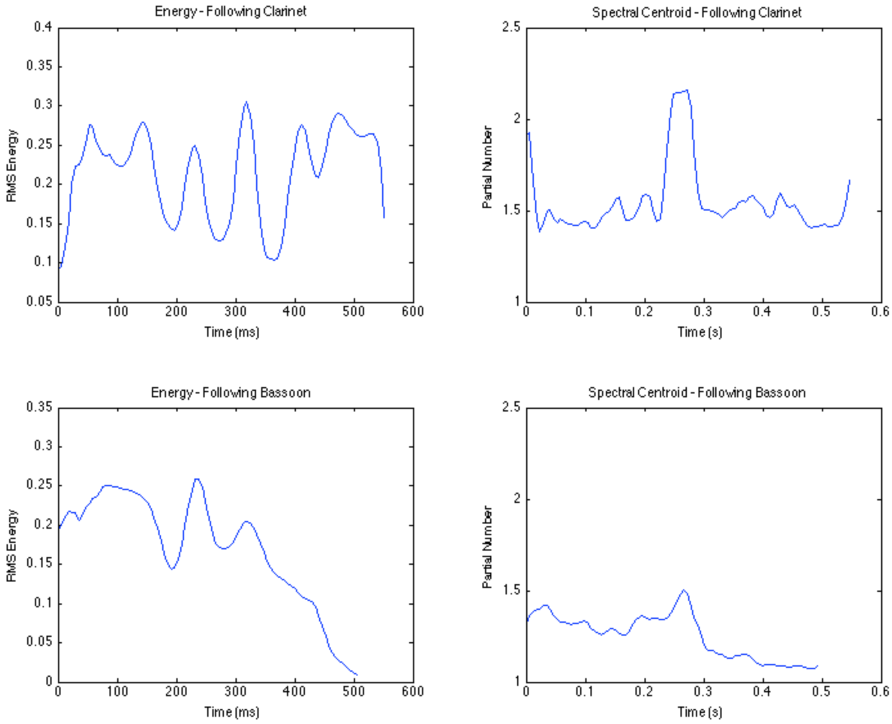

Figure 5: RMS (left side) and spectral centroid (right side) of first note bar 10, played by flutist 1, following the clarinet (upper panel) and bassoon (lower panel).

This can be illustrated with the intensity increase and decrease of the *crescendo* and *diminuendo* of bars 540 to 545. Examining one of the flutists playing the first note of bar 542 (G), correspondent to the climax of this *crescendo*, we observe stronger spectral centroid variation, reaching a high maximum value, when following the clarinet, as compared with the performance with the bassoon. Moreover, a higher value of vibrato speed was also observed on the performance with the clarinet, compared to that with the bassoon (Figure 5). It appears that they used vibrato speed variation to drive the intensity control. We argue that the simultaneous intensity and vibrato speed manipulation may have contributed to such behavior of the spectral centroid value of the two performances.

According to Fletcher (1975), most the vibrato on the flute is achieved by amplitude variation, which is largely confined into the upper partials, while little change occurs in the fundamental, hence the modification in timbre. Due to the physics of the instrument and the way the vibrato is produced, this amplitude modulation is coupled with a small oscillation in pitch. In the higher partials of the spectrum we can appreciate the corresponding frequency modulation, which is faster and more intense when flutists follow the clarinet than the bassoon (Figure 6).

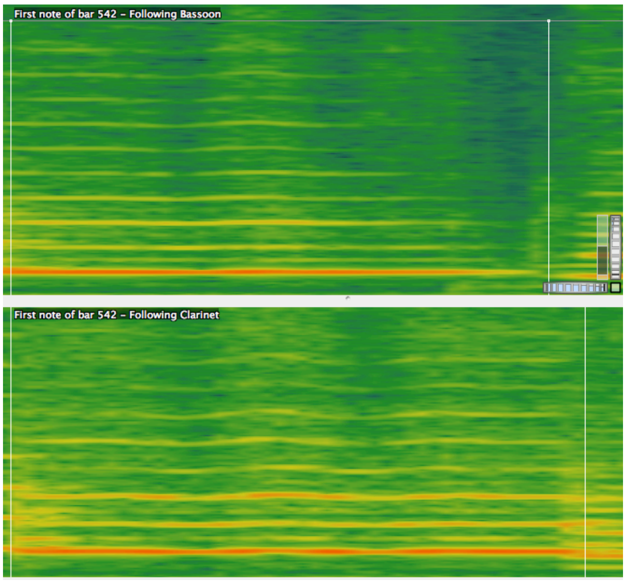

Figure 6 – Spectrogram of the first note of bar 542 (G), played by flutist 1, following the bassoon (lower panel) and the clarinet (upper panel).

Conclusion

In instrumental ensemble performance, musicians coordinate their manipulation of different acoustic parameters of what they play in order to achieve the intended interpretation of the group. We proposed to verify if flute players make use of sound quality manipulation when playing with clarinet and bassoon. We observed significant difference on two timbre descriptors measured from the sound produced by flutists between all three conditions: playing solo and following each of two instruments.

This is an indication that part of the interpretation coupling achieved by flutists in ensemble performance is done by sound quality control. The two timbre descriptors used in this study were spectral centroid and logarithm of attack time. Both descriptors exhibited significant difference between each condition, a result that also corroborates with the hypothesis that both the bassoonist and the clarinetist communicate some interpretative cues by means of dynamic manipulation of sound they produce. It is yet to be examined the dynamic behavior of such coupling, not only using additional cues, but also to inspect the time variations of intensity, vibrato, and note articulation.

The inspection of how the flutists react differently to the same expressive cues (only one recording of clarinet and bassoon was used) could also lead to some insights into how the information is received and processed by them.

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