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Synchronization of motion and timing in clarinet performance

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We examined the effect of expressive intent on timing and movement in clarinet performance. Clarinetists' performances were recorded with motion capture while they performed with three expressive intents: expressive (normal) performance, exaggerated performance, and inexpressive performance. Acoustic measures (intensity, pitch height, duration) were compared with ancillary gestures (bell movement). The more expressive performances contained larger expressive timing measures and bell movement. Clarinetists marked phrase boundaries with increases in both expressive timing and clarinet motion. Neither pitch height nor sound intensity accounted for bell movements beyond expressive timing. These findings suggest that ancillary bell gestures are rule-governed and correlate with some acoustic features of musical expression.

Keywords: expressive timing; clarinet performance; motion capture; movement analysis; ancillary gestures

How do performing musicians express a range of musical intentions? Patterns of expressive timing have been linked to performers' expressive intentions (Palmer 1989), and various auditory cues provide sufficient information for listeners to distinguish between levels of expressive intent (Kendall and Carterette 1990). Visual cues resulting from pianists' head and upper torso movements have been shown to be more effective than auditory cues in conveying performers' intended expressivity, suggesting that movement best conveys expression (Davidson 1995). In piano performance (on which most research is conducted), expressive movement is limited to the hands and the upper torso/head region (Davidson 2007); a larger variety of movements may be found in the performance of wind instruments, including the clarinet

(Wanderley 2002). Limited research to date combines acoustic and movement features of expressive performance. The current study examines the effect of expressive intent on both timing and movement in clarinet performance.

Expressive rubato timing in music performance is characterized by increased tone durations as performers approach cadences or phrase endings (Gabrielsson 1987, Palmer 1989), and additional lengthening of tones notated with long durations and shortening of tones notated with shorter durations (Sundberg *et al.* 1991). Inexpressive performances tend to exhibit less range of rubato timing than expressive performances (Gabrielsson 1987, Palmer 1989). These studies, however, did not investigate performers' movements or their relation to musical intent.

Wanderley (2002) analyzed clarinetists' movement gestures while they performed the same music in expressive and inexpressive ways. Following Delalande's (1988) classification of musicians' ancillary gestures as those visible body movements that are not directly linked to sound production, Wanderley (2002) recorded the ancillary movements of the clarinet bell with a motion tracker system. Surprisingly, clarinetists' vertical and horizontal bell movements were highly consistent across their repeated expressive performances. However, Wanderley's instructions to clarinetists to move the clarinet as little as possible in the inexpressive condition precluded comparisons of expressive timing with movement.

The current study examines the relationship of clarinetists' ancillary movements to their expressive goals by combining Palmer's (1989) expressive performance conditions with Wanderley's (2002) measures of bell motion in clarinet performance. Skilled clarinetists performed the same musical piece under three different expressive instructions: normal expressive, exaggerated, and inexpressive performance. No instructions were given concerning movement. We tested the hypotheses that increased expressive intent results in both increased variation in timing (Palmer 1989) and larger amplitudes of ancillary movement (Davidson 2007, Wanderley *et al.* 2005).

METHOD

Participants

Eight adult clarinetists from the Montreal community participated in this study (with 8-20 years of performing experience, mean=12 years).

Materials

The first eight measures of Mozart's *Clarinet Concerto in A Major* (K. 622), second movement, were used. The excerpt (Figure 1) was chosen for its high expressive content and the fact that it is well known. All clarinetists performed on an A clarinet. All clarinetists were familiar with the excerpt before participating. An active motion capture system (NDI Optotrak Certus) measured the clarinetists' movements at a 250 Hz sampling rate. Markers were placed on each fingernail tip of the clarinetists' hands and on the clarinet: one marker on the barrel (below the mouthpiece), one centered just above the bell, and two on the bell. These markers provided information about the orientation of the clarinet. An AKG C414 B-XLS standing microphone, as well as a microphone integrated into the clarinet barrel, recorded the audio at 44.1 kHz. The clarinet movements are reported only up to the notated ornament in measure seven, which permitted a variety of temporal interpretations and was therefore excluded.

Procedure

The clarinetists were instructed to perform the melody as they would in a normal concert setting (normal), with an exaggerated version of their interpretation (exaggerated), and with a flat and inexpressive interpretation (inexpressive). The orientation of the clarinet was computed from the marker data in spherical coordinates, eliminating translational position differences that arise between participants of different heights and standing positions. Clarinet elevation (vertical rotation) was measured as degrees of rotation around the mouthpiece marker, relative to a rest position perpendicular to the floor. Tone onsets were detected by identifying large negative peaks in the first derivative of sound intensity, taken from the integrated barrel microphone. Audio and motion data were smoothed using *functional data analysis* (Ramsay and Silverman 2005) and registered by tone onsets.

RESULTS

Figure 1 shows the mean clarinet elevation in each expressive condition; positive values indicate the bell was raised relative to the mouthpiece. A functional Analysis of Variance (ANOVA) on the continuous elevation data indicated significantly lower elevations at the beginnings of phrases as clarinetists performed more expressively (significant regions are shown in horizontal lines at the bottom of Figure 1). Overall, clarinetists were more variable

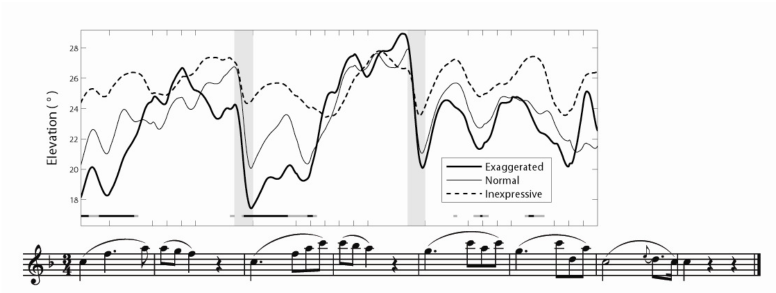

Figure 1. Mean clarinet bell elevation (degrees) in each expressive condition. Horizontal lines indicate significance regions (grey and black indicate p<0.05 and p<0.01, respectively); vertical shaded bars indicate locations of rests at phrase boundaries.

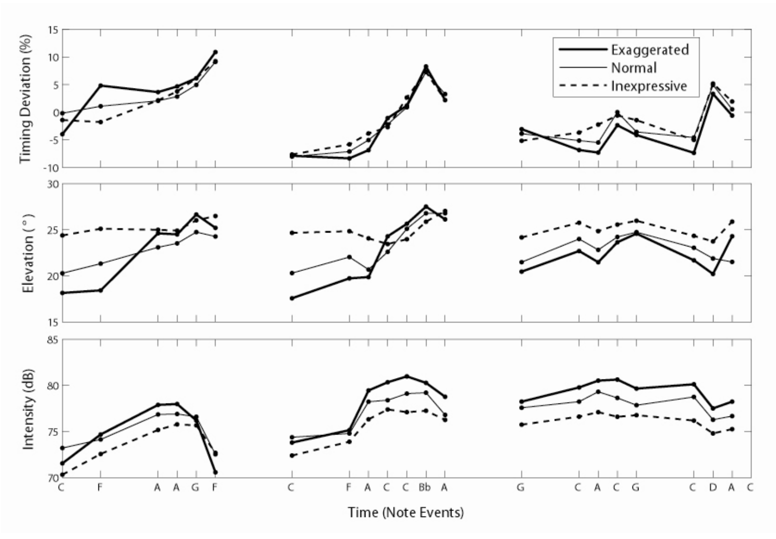

Figure 2. Mean timing deviation, bell elevation, and intensity (from standing mic) for each expressive condition. Gaps indicate locations of ends of phrases.

in clarinet elevation (measured by standard deviation) from inexpressive to exaggerated conditions ($F_{2,14}$=33.04, $p<0.01$).

Next we measured expressive timing, in terms of the difference between observed and expected interonset intervals (in %) relative to the notated durations in the score ([observed-expected]/expected); positive values indicate lengthened tones. Figure 2 shows clarinetists' mean expressive timing deviations, which indicated slowing from the beginnings to the ends of each phrase. Furthermore, the variability of timing deviations (measured in standard deviation) increased with expressive intent ($F_{2,14}=5.3$, $p<0.01$). Figure 2 (bottom) shows the peak intensity for each tone, which reflected the phrase structure, but in a different pattern (inverted U-shape) than that of the elevation and timing deviation measures.

To examine whether the ancillary gestures were related to the acoustic features of performance, regression analyses were conducted to predict the bell elevations for each tone from expressive factors: timing deviations, sound intensity (correlated with loudness), and sounded pitch (as measured by modal frequency). Individual correlations among variables indicated that sound intensity and pitch correlated with each other (mean $r=0.82$, $p<0.01$). In addition, sounded pitch correlated with elevation in expressive performances (mean $r=0.51$, $p<0.05$); however, only expressive timing predicted elevation significantly when other acoustic features were controlled in each expressive condition [semipartial correlations: standardized regression coefficient (β) for timing=0.65 in exaggerated condition, $p<0.01$; $\beta=0.58$, $p<0.01$ in expressive condition; $\beta=0.44$, $p=0.06$ in inexpressive condition].

DISCUSSION

Expressive timing and clarinet bell motion increased across each phrase with clarinetists' expressive intent: performers used more bell motion and more expressive timing when performing with greater expressive intent. Clarinetists may use the bell's elevation to help shape phrases, by physically representing change in musical features such as tension/relaxation. Together with previous findings that documented performers' reduced expressive timing when musicians were asked to perform without moving (Wanderley *et al.* 2005), these findings suggest a bi-directional relationship between expression and movement in performance. The clarinet elevations and the expressive use of rubato increased from phrase beginnings to endings. Clarinet tone intensities instead showed an inverted U-shape throughout each phrase.

This study extended several findings on expressive performance to the study of ancillary gestures in a wind instrument that permits considerable degrees of motion. Our findings suggest that ancillary bell gestures are rule-governed; they correlate with some but not all acoustic features of musical expression, and in particular with phrase structure. Future research may derive musical variables from performers' movements by creating a taxonomy of gestures that correspond to specific musical intentions.

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