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Good playing practice when drumming: Influence of tempo on timing and preparatory movements for healthy and dystonic players

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Four professional percussionists were recorded when playing single strokes at different tempi (50, 120, 300 beats per minute [bpm]) and dynamic levels (*p*, *mf*, *f*). All players were right handed, but two of the players had their left arm affected by focal dystonia. Audio, contact time, as well as players' arm, hand, and stick movements were recorded. The analysis indicated that the healthy players use the long inter-stroke intervals available at slow tempi to prepare the strokes. Strokes at 50 bpm were, in general, initiated from a greater height and played louder than strokes at fast tempi. As expected, variability was highest for the left arm at 300 bpm.

Keywords: drumming; timing; preparatory movement; motor control; focal dystonia

In order to control timing and sound characteristics of individual notes, musicians typically use preparatory, or anticipatory, movements. In drumming, a player can ensure sufficient striking force by creating a "runway" during which the stick increases its velocity before impact. Strokes to be played at higher dynamic levels can be initiated from a greater height, producing louder sound level at low physical cost (Dahl 2004). However, the player needs to initiate the upward movement of the hand and stick well before the actual downstroke in order for the stroke to arrive on time. With increasing tempo there is less time available for such preparatory movements, suggesting that playing loud and fast may be more of a challenge.

The aim of this work is to investigate how players' movement patterns and timing performance are affected by more extreme combinations of tempi and dynamic levels.

METHOD

Participants

Four professional, classically trained percussionists (19-24 years playing experience) participated in the study. All players were male and reported their right hand as being the preferred in playing. Two of the players had their left arm affected by focal dystonia.

Materials

A motion capture system (Selcom Selspot) sampled the position of infrared LED markers attached to the drumstick and the players' shoulder, elbow, wrist, and index finger knuckle (MPC joint) at 400 Hz. The contact between stick and drumhead was measured electrically, using copper foil at the tip of the drumstick and a thin layer of graphite sprayed at the striking area (a 5 cm diameter circle). All acoustical measures and a trigger from the motion capture system were simultaneously sampled at 16 bits, 160kHz (National Instrument PCI-6143). The signals were then lowpass filtered at a cutoff frequency of 22 kHz and downsampled to 44.1 kHz for analysis.

Procedure

When the markers had been attached, the player adjusted a drum stool to a comfortable level and was given time to try out playing. Recordings started when the player reported that none of the cables obstructed the playing. For each arm, combinations of three dynamic levels (*p*, *mf*, and *f*) and tempi (50, 120, and 300 beats per minute [bpm]) were recorded. The order was randomized, and to avoid fatigue the trials were separated into three blocks, interleaved with another task (see Dahl and Altenmüller 2008).

Analysis

The analysis focused on (1) variability in timing (inter-onset intervals [IOI]), (2) general movement organization, and (3) vertical position and acceleration of the drumstick marker (the vertical acceleration being the most important to transfer energy at impact).

For the overall timing performance, the number of unintended events (e.g. extra bounces or missing strokes) was identified. These errors were then removed and the Coefficient of Variance (standard deviation [SD]/meanIOI) across each trial was calculated.

For the movement data, the 3D movement trajectories from the six markers were checked and outliers and data gaps repaired. After some sparse filtering, the points of impact were determined from the vertical velocity of the stick marker, using an algorithm virtually identical to that used by Dahl (2004). The points of impacts were then used as landmarks when transforming the time series to functional data (Ramsay and Silverman 2005).

The transformation followed the procedure used by Goebl and Palmer (2008). Order 6 b-splines were fit to the second derivative of the position data, with a knot placed every sixth data point. Smoothing of the data was made using a roughness penalty on the fourth derivative ($\lambda=10^{-19}$). By adding extra knots at each hit, it was possible to achieve sufficient smoothing of the second derivative (acceleration) without loss of detail. Lastly, time series were sampled at a new sample frequency of 2100 Hz from the functional data, generating new time series for the vertical displacement, velocity, and acceleration. For each trial, peak acceleration at impact for ten strokes were extracted for analysis.

RESULTS

The analysis showed differences between healthy and dystonic players and also between arms used, an expected result. For the right (preferred) arm and the intermediate tempo (120 bpm) the variability in timing was small for both healthy and dystonic players. At the fast tempo, however, both groups of players displayed errors and increased variability in timing. A pronounced deterioration in movement patterns and lack of timing control in the affected (left) arm was evident for the dystonic players.

When extra bounces after strokes (frequently occurring for one patient at 300 bpm) had been removed, the timing variability was comparable between healthy and dystonic players, ranging between 0.015 and 0.065 at 300 bpm. A repeated measures ANOVA of the Coefficient of Variance for main intervals showed no difference between the two groups ($p=0.726$).

At slow tempi and medium tempo, the movement organization appeared similar for healthy and dystonic players. The top panel in Figure 1 shows how the wrist leads the preparatory movement before the stick. This preparatory “lead” was seen to decrease at medium tempo and become almost anti-phase at 300 bpm. The bottom panel in Figure 1 shows how the MPC marker still

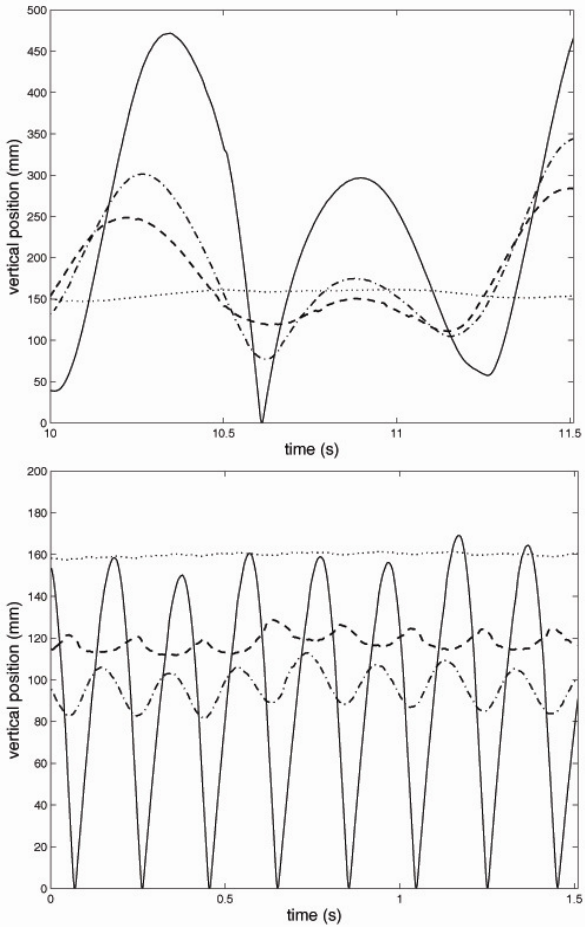

Figure 1. Vertical displacement vs. time for a healthy player at 50 bpm (top panel) and 300 bpm (bottom panel). The lines show the vertical displacements of markers at the elbow (dotted), wrist (dashed), MPC joint (dot-dashed), and stick (full line). Note the difference in magnitude for the vertical position at the two tempi.

leads briefly before the stick, whereas the wrist marker reaches its peak amplitude directly before the hit.

All players initiated strokes at 50 bpm from a greater height compared with faster tempi, but the healthy players produced higher peak acceleration. The two panels in Figure 2 show the peak acceleration at *mf* and different

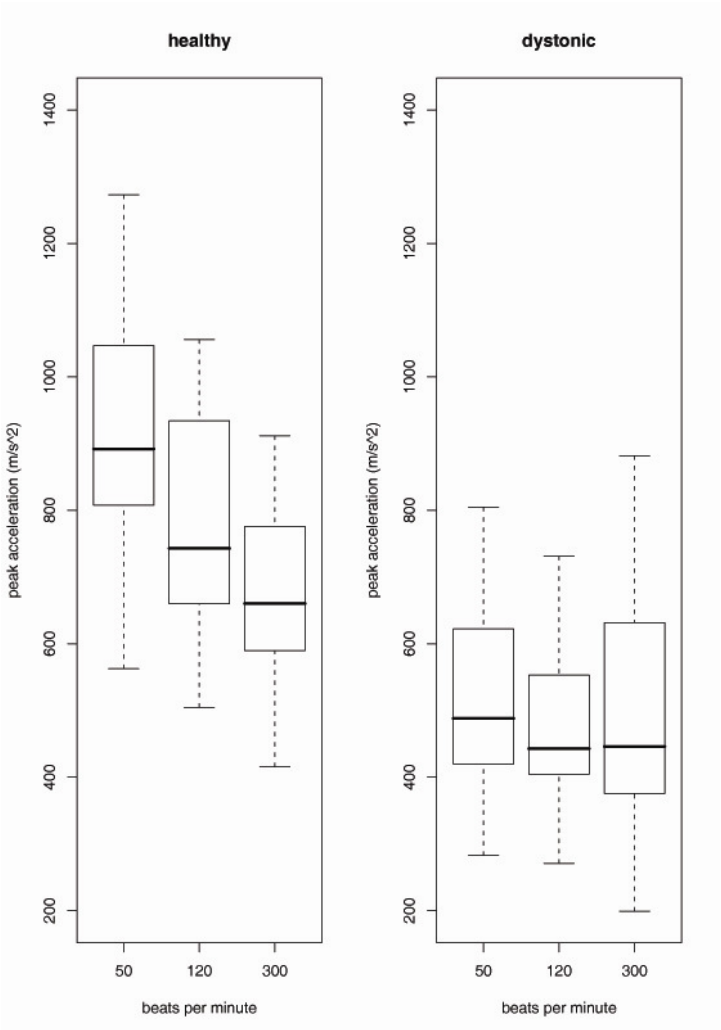

Figure 2. Peak acceleration for *mf* strokes at three different tempi as played by healthy (left panel) and dystonic (right panel) players, using both arms. The boxplots show the first and third quartile around the median (black line) with values within 1.5 times the interquartile range indicated by whiskers.

tempi for the healthy and dystonic players. In general, the two healthy players displayed more of a range in acceleration values. In particular, the healthy

players produced higher peak acceleration at 50 bpm compared with strokes at higher tempi but at the same dynamic level (*mf*). This might indicate that these players chose to use the additional time between strokes to increase their dynamic range.

DISCUSSION

The differences in performance between healthy percussionists and those suffering from focal dystonia are evident for the (affected) left arm. When unintended extra hits were removed, however, the timing variability (as measured by the Coefficient of Variance) was not significantly different between the two groups of players. The healthy players appeared to use the additional time between strokes at slower tempi to increase their dynamic range somewhat more than the dystonic players. Although the results cannot be generalized at this stage, this type of research could provide valuable insights in how players' movement strategies change in response to more demanding playing conditions. Such knowledge would have important implications for music teaching and education.

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References

Dahl S. (2004). Playing the accent: Comparing striking velocity and timing in an ostinato rhythm performed by four drummers. *Acta Acustica united with Acustica, 90,* pp. 762-776.

Dahl S. and Altenmüller E. (2008). Motor control in drumming: Influence of movement pattern on contact force and sound characteristics. In *Proceedings of Acoustics 2008* (pp. 1489-1494). Paris: European Acoustics Association.

Goebl W. and Palmer C. (2008). Tactile feedback and timing accuracy in piano performance. *Experimental Brain Research, 186,* pp. 471-479.

Ramsay J. O. and Silverman B. W. (2005). *Functional Data Analysis* (2nd ed.). New York: Springer.