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Spontaneous motor tempo is the easiest pace to act upon for both the emergent and the predictive timing modes

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Abstract

Spontaneous Motor Tempo (SMT) is a self-paced regular series of movements that correspond to the preferred and natural pace to act upon. SMT is naturally observed within daily activities such as in hand clapping and walking. In experimental settings, SMT is evaluated using synchronization finger-tapping paradigms and has been estimated to correspond to time intervals of 600 ms (Fraisse, 1982). More recently, subjects have been instructed to tap at the most comfortable rate, and the SMT was found to be a little faster, with a mean SMT comprised between 450 and 500 ms of time intervals (Collyer et al., 1994; Moelants, 2002). Studies using whole body movements have also determined SMT between 100-130 bpm (500-600 ms) both during daily activities (MacDougall & Moore, 2005) and when walking in synchrony to music (Styns, van Noorden, Moelants, & Leman, 2007). Nevertheless, the most striking aspect of these findings is the variability reported, with ranges going from 190 to 950 ms of time intervals within a given group of healthy individuals.

In the present work, the objective was not to determine a global mean SMT for a group but to work at the individual level. More specifically, we questioned what the functional role of SMT might be in the production of sequences of motor actions. After developing an application on Android telephone, we measured SMT in a group of healthy young adults throughout a period of a three of weeks and tested the hypotheses that (1) the SMT is different but characteristic of a given individual and that (2) SMT corresponds to the time window in which movements are performed the best.

Thirty young adults aged from 20 to 28 years participated in the experiment. They all downloaded on their telephone the SPONT application and were required to measure their SMT at 10 am for 3 consecutive days, during a two-week period. During the third week, they were invited to come to the laboratory and they were randomly assigned to either a cycling session or a finger tapping session that lasted 30 minutes each. At the start of the session, all individuals sat silently for 5 minutes in silence before performing a 2-minute trial of cycling or of tapping at their "preferred and most comfortable pace". This pace was used to set the metronome frequency that was used during the remaining of the experimental session.

Both groups performed a sensori-motor synchronization and continuation task with the explicit instruction to perform movements

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in synchrony with a regular tone sequence and to continue even when the metronome stopped. The metronome was generated by a program written in Matlab and was played through speakers. All tones had the same pitch (640Hz) and the same duration (100 ms). For the cycling group, participants were seated on a stationary bike of which the saddle was adjusted to the height of the participant. The bike was set so that the strength applied on the pedal was minimal. A passive reflective marker was located on the right pedal of the bike and its position was recorded through a Qualisys 3D motion capture system at a sampling frequency of 200Hz. For the finger-tapping group, the task was to tap six visual targets one after the other, which were presented on a touch screen (EloTouch). In both tasks, the regular pacing of the metronome was manipulated for each individual to be ±500, ±400, ±300, ±200, ±100 ms or equal to each individual's SMT.

Results showed that the group SMT was 520 ms with differences ranging from 235 and 832 ms of SMT. These SMTs remained consistent for all individuals throughout the 6 measured sessions. The lab-based task confirmed the preferred tempo for all subjects especially in the finger-tapping task. During the synchronization-continuation task, participants were able to perform the task correctly without apparent difficulty. Subjects however reported that the "easiest" tempi to follow were those close to their own SMT. When measuring the inter-response intervals and the asynchrony during the synchronization task, results revealed an inverted U-shape with a minimal error and variance close to each individual's SMT. The fact that timing was both performed with the highest accuracy and the greatest stability within the SMT interval was observed both in the cycling and in the finger-tapping tasks. Finally, the analysis of the continuation data showed that especially for the extreme tempi (i.e., very slow and very fast) participants drifted towards their natural SMT.

Overall, the reported results confirm previous findings of best performances close to SMT (Styns et al., 2007) but go further by showing that this finding is true both in cyclic movements (that are thought to use emergent timing processes) and in sequential rhythmic movements (that are thought to use predictive timing processes). An interpretation of how spontaneous tempo and the two modes of timing can be considered within a unique theoretical framework may be considered in reference to the cognitive model of executive functions by Miake et al. (2000).

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Keywords: Timing; Spontaneous tempo; Preferred tempo; Synchronisation; Executive functions; Rhythmic production; Continuation; Drift

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