The effect of discontinuity on timing processes

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Timing has been considered for a long time as a single ability shared between all rhythmic tasks. However, Robertson et al. (1999), comparing variability in continuous and discontinuous tasks, evidenced the exploitation of different timing processes according to task conditions. Schöner (2002) pleaded for the distinction between event-based timers, which are supposed to work on the basis of cognitive events produced by central internal clocks, and dynamical timers, which are considered as peripheral and using the properties of limb motion to define time intervals.

Zelaznik et al. (2002) suggested that the use of event-based or dynamical timing control could be related to the continuous vs discontinuous nature of the task. Nevertheless, some studies have evidenced that in some cases participants don’t used the expected timer (Delignières et al., 2004; Lemoine et al., in prep). The aim of this study was then to test the effect of motion discontinuity on timers’ exploitation.

Delignières et al. (2004) showed that this distinction could be revealed through the examination of bi-logarithmic power spectra. They collected interval time series in tapping and forearm oscillations, two tasks supposed to elicit the exploitation of an event-based timer for the former, and a dynamical timer for the latter. They showed that event-based timers were characterized by a positive slope in high frequencies, and dynamical timers by a slight flattening.

![Figure 1: Power spectra in log-log coordinates from tapping series (left panel) and oscillation series (right panel).](image)

This method, nevertheless, requires the collection of lengthy (e.g. 512 data points) time series. We recently proposed a new method, based on the analysis of windowed autocorrelation functions, that allows an efficient discrimination between event-based and dynamical timers, with shorter series (Lemoine et al. 2006).

**Method**

Ten participants practiced two discontinuous tasks (tapping and intermittent circle drawing) and two continuous tasks (circle drawing and forearm oscillations). Each task was performed following two frequency conditions (2 and 1.25Hz), twice per frequency condition in two separate sessions. We used the mean lag one value of the Detrended Windowed Autocorrelation Function (DWAF), denoted \( \hat{\gamma}(1) \), to determine the nature of the exploited
timer (Lemoine et al., 2006). $\gamma(t)$ is supposed to be negative for event-based timers, and positive for dynamical timers.

**Results**

As reported in figure 2, we obtained on average negative $\gamma(t)$ values in discontinuous tasks and positive values in continuous tasks. A repeated-measure ANOVA 2(Session) x 4(Task) x 2(Frequency) revealed significant effects for Task and Frequency. Moreover, $\gamma(t)$ was significantly correlated between sessions ($r = 0.91$). Nevertheless, as indicated in figure 2, right panel, in some cases participants didn’t use the expected timing process.

![Figure 2](image-url)

Figure 2 : Left panel: Mean $\gamma(t)$ indices for each task. Right panel: Mean number of occurrences of the non predicted timer per frequency condition for each session (right panel).

**Discussion**

Results evidenced a clear effect of discontinuity on the preferentially used timing process. The two discontinuous tasks (tapping and intermittent drawing) are characterized by negative $\gamma$ indices while the two continuous tasks (oscillation and circle drawing) are characterized by positive $\gamma$ indices. The effect of discontinuity on the preferential use of event-based timers could be considered as reliable. This effect is stable over sessions with reproducible $\gamma$ indices from one session to the other (no session effect, and significant correlation between sessions). In some cases participants didn’t exploit the predicted timing process. Task difficulty and practice could explain the observed differences between frequency conditions.

**References**


Lemoine, L., Torre, K., Delignières, D. (in preparation). Fractal and spectral indices in rhythmic tasks: could they be used for timers’ exploitation distinction?


