

Spectral analysis of time interval production :
from cognitive to dynamical timers

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Timing has been for a long time conceived as a unitary mechanism. The most popular model was proposed by Wing and Kristofferson (1973), suggesting that time control was based on the production, by an internal clock, of a series of discrete events triggering the execution of behavioral responses.

Robertson et al. (1999), nevertheless, evidenced that temporal precision in tapping was not related to temporal precision in continuous drawing. Zelaznik, Spencer and Ivry (2002) showed that tapping or intermittent circle drawing was governed by an explicit timing process, based on explicit temporal representations. Conversely, timing in continuous circle appeared as an emergent property (implicit control). Spencer, Zelaznik, Diedrichsen, and Ivry (2003) showed that cerebellar patients had specific deficits on discrete rhythmic tasks, but not on continuous tasks.

Schöner (2002) proposed to distinguish two kinds of timers: event-based timers, controlling rhythmic motion by the production of discrete cognitive events; and dynamic timers, supposing that the oscillatory dynamics of effectors could per se act as time controller.

Gilden, Thornton et Mallon (1995) performed a spectral analysis of time intervals series produced in tapping and evidenced first that the internal clock exhibits a $1/f$ behavior supposing that it can't be considered as an isolated cognitive process but rather as the superposition of multiple components running at different frequencies and resulting in a complex dynamical behavior. Secondly they evidenced a typical signature for event-based timers: plotted in log-log coordinates, the power spectrum exhibits a positive linear trend at high frequencies, indicative of the presence of a differenced white noise process within the series. Such process was indeed postulated in the Wing and Kristofferson's model.

According to Schöner (2002)'s assumptions, one could suppose that time intervals series produced dynamically should not contain such differenced white noise process. Delignières, Lemoine, and Torre (2004) tested this hypothesis by comparing the log-log spectra obtained from time interval series produced in tapping or by the continuous oscillation of the forearm. Their results replicated those of Gilden et al. (1995) for tapping, and evidenced a typical spectrum, contaminated by a single white noise process, for the oscillatory condition.