CHAPTER 10

Striatal and Frontal Pathology: Parkinson’s Disease and Patients with Lesions of the Basal Ganglia and Frontal Cortex

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1 Introduction

Interval timing is the timing of perceptual or motor events in the millisecond and seconds-range. Everyday examples of perceptual timing are keeping track of elapsed time so that you can estimate that your kettle has boiled, or judging that your favorite television program is due to start. In the laboratory, perceptual timing has been investigated using a wide variety of tasks, including duration discrimination, time estimation, time production and time reproduction. Motor timing is employed in everyday life when we find ourselves clapping in time with music or dancing to the beat. In the laboratory, the more prosaic activity of tapping in time with a regularly paced tone and continuing to do so after cessation of the tone (synchronization-continuation task; S-C) has been used. It has been proposed that at the core of our ability to efficiently time movements and events is a brain-based ‘internal clock’ that enables precise calculations (see Merchant et al., 2013 for a recent review). However, successful temporal processing requires more than just a working clock. Ancillary cognitive processes are an integral part of a complex neural architecture that gives rise to accurate motor and perceptual timing. As an example, any task in which two intervals are compared requires an on-line representation of the previously presented interval, alongside dynamic updating of the current interval. Therefore, simultaneous maintenance and encoding are required, placing demands on attention and working memory.

This conceptualization of timing is supported by the most dominant model of interval timing, the scalar expectancy theory (SET; Gibbon, 1977; Gibbon et al., 1984). SET conceives that our representations of time are supported in a three-stage process consisting of clock, memory, and decision-making.
components (see Figure 10.1). The clock stage is comprised of a pacemaker that emits pulses, with the pacemaker connected to an accumulator. At the onset and offset of an interval that is to be timed, pulses are gated from the pacemaker to the accumulator via a switch, which is operated by a timing signal. The accumulator therefore holds a representation of the current time value, which can be transferred to working memory. The reference memory component provides a more permanent store for important durations (i.e., a standard/reference duration). The decision process is provided by a comparator, which compares the current time in working memory to the stored time in reference memory. The 'scalar' part of the model comes from applying the observation that human (and animal) timing conforms to the scalar property, whereby the standard deviation of timed responses increases with the mean of the interval being timed. There are challenges to the SET model of interval timing, particularly regarding the biological plausibility of the model (e.g., Matell and Meck, 2000, 2004). However, the model is a salient demonstration of the widespread belief that clock processes are supported by a range of cognitive operations.

FIGURE 10.1 Scalar expectancy theory (Gibbon, 1977; Gibbon et al., 1984).