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Neural basis of working memory for time intervals

Sundeep Teki[1,2,*], Timothy D. Griffiths[1,2]

[1]*Wellcome Trust Centre for Neuroimaging, University College London, 12 Queen Square, London WC1N 3BG, UK*
[2]*Institute of Neuroscience, Newcastle University, Framlington Place, Newcastle upon Tyne NE2 4HH, UK*

Abstract

The brain can hold information about multiple environmental objects in working memory. It is not known, however, whether time intervals can be treated similarly as “sensory objects” and stored in memory as distinct items. Here, we designed a new paradigm to measure the precision of memory for time intervals. Listeners were required to remember and match the duration of a probed interval from a sequence of intervals and the precision of the response was evaluated as an index of memory (Bays & Husain, 2008). Behavioural data indicated that memory for a single sub-second time interval was significantly modulated by temporal regularity and the number of intervals in the sequence (Teki & Griffiths, 2013).

In this functional magnetic resonance imaging study, we specifically aimed to examine the brain areas that encode memory for time as a function of rhythmic context and memory load. Based on previous work, we hypothesized a role for both striatum and cerebellum in encoding time in a beat-based and duration-based manner respectively (Teki et al., 2011, 2012) and a role for the parietal and prefrontal cortex in encoding the memory load. Four different levels of temporal regularity (5-10%, 20-25%, 35-40%, and 50-55% jitter) and working memory load (1-4 intervals) were used in an orthogonal design where jitter was varied across sequences with fixed number of intervals (4) and number of intervals were varied across sequences with a fixed jitter (20-25%). Functional imaging data were acquired using a sparse sampling protocol in a 3T Siemens Trio scanner whilst participants were performing the task.

Parametric analysis of data from 12 participants so far revealed activation in both striatum and cerebellum, with stronger striatal and cerebellar activity as a function of decreasing and increasing jitter respectively. Analysis of brain areas that parametrically encode increasing number of time intervals revealed significant clusters in the parietal cortex and cerebellum. Our data go beyond previous work examining memory during single interval discrimination tasks and reveal context-dependent correlates of memory for time intervals (Merchant et al., 2013) that vary as a function of the rhythmic context and the working memory load of the sequences. The data suggests a critical role for subcortical timing networks in the basal ganglia and the cerebellum in mediating rhythmic timing and the parietal cortex in representing the memory load.

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[*] Corresponding author. *E-mail address*: sundeep.teki@gmail.com

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