Encoding Time: Temporal Objects and Temporal Arithmetic.

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Temporal processing on the scale of tens to hundreds of milliseconds is a fundamental component of many sensory tasks, including speech perception. However, little is known about the neural mechanisms underlying even simple temporal tasks such as interval discrimination. Two general classes of models proposed to underlie timing include Internal Clocks and State-Dependent Networks (SDN). In the later models recurrent networks generate high-dimensional representations of temporal and/or spatial-temporal stimuli, as a result of accumulative changes in network state. The dynamic changes in the state of the network are a product of the interaction between network dynamics and time-dependent neural properties such as short-term synaptic plasticity. SDN models make an explicit prediction regarding the encoding of time: if an interval T is embedded within a sequence, information regarding its absolute interval will be lost, rather it will be encoded in the context of the global stimulus as a 'temporal object'.

To examine this prediction we developed a Reset Task in which subjects perform interval discrimination on stimuli composed of two (2T) or three tones (3T). In the 3T condition, the target interval is between the 2nd and 3rd tones (T2-T3). Both stimuli are randomly interleaved, thus for any trial T2 could be the 2T stop signal or the start signal of the 3T discrimination. Two 3T conditions were examined: in the FIX condition the T1-T2 'distractor' interval was always the same, in the VAR condition it varied across trials. Our results establish that performance on a 100 ms task in the VAR condition was very poor, indeed it was comparable to that of a simple 200 ms interval. However, in experiments using a 1 s target interval, there was no significant difference between the 3T-FIX and 3T-VAR conditions. These data suggest that when processing rapid sequences, the temporal information is not encoded in absolute time, but as a temporal object. In contrast, for longer intervals, our results are consistent with absolute encoding, which allows for 'temporal arithmetic'. Together our results confirm the prediction of the SDN model for sub-second intervals.