MEMORY: Measuring the relationship between perception of space and time

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Time and space are normally considered to be independent, and are studied typically separately by neuroscientists. However, evidence is beginning to emerge that they are in fact strongly interconnected in the brain [1, 2]. Experiments in our laboratory, using standard techniques of adaptation, show that neural units sensing the time of events are spatially selective [3]. In these experiments observers adapted to a grating drifting within a 12° diameter patch while fixating on a spot to its lower left; once the adaptation period elapsed, they changed their gaze to a target that appeared 15° right of fixation. Eight hundred ms after the display of the target, a test grating was presented for 600 ms in one of three randomly chosen positions: the same retinotopic position, the same spatiotopic position or in one that was neither (control condition). Perceived duration in the control and the retinotopic locations were near 600 ms, the actual duration of the test. On the other hand events in the spatiotopic location were affected by adaptation and were perceived on average as 456 ms. These results imply that there are multiple timing mechanisms for visual events; these units are selective in real-world coordinates, taking into account the position of gaze.

Eye movements themselves also affect the perception of time. At the time of saccades, temporal intervals marked by two brief visual stimuli are strongly underestimated. A test interval of 100 ms is judged veridically as long as it is presented far from an eye movement [2]. However, if the test interval is presented perisaccadically, its duration is compressed down to 50ms. The effect occurs for intervals presented from 150 ms before a saccade to 150 ms after the onset of the eye movement. The temporal compression parallels closely perisaccadic mislocalization, a phenomenon which is thought to be the by-product of the remapping of retinal information which compensates for gaze shifts. Not only: under some conditions the perceived temporal order of two bars flashed just before a saccade can even be reversed [2, 4]. The moment at which temporal order inversion is most prominent coincides with the beginning of spatial remapping. These results suggest a strong correlation between the mechanisms mediating perception of space and perception of time [2, 5].

More recent experiments show that it is not actually necessary to move the eyes for the perception of time to be compressed: it suffices to transfer attention from one object to another [6]. Notably, also in this case the effects are spatially selective. In this paradigm subjects were asked to perform concurrently a visual discrimination task (primary task) and a duration discrimination task (secondary task). We tested various positions both tasks. In one condition the two bars marking the duration, were flashed in two separate locations, in a second condition the two bars were flashed in the same spatial location. We found that shifting attention to perform the primary task can induce a strong compression of temporal intervals. However, this compression of perceived time occurs only if the subject needs to integrate temporal information signalled in two separate locations. Intervals marked in the same spatial position were not subject to such a strong temporal compression and were not affected by attentional deprivation. This indicates that location where the events take place is crucial in determining perceived duration.

Taken together, these experiments show that neural representations of space and time are strongly inter-dependent.

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