Rhythmic oscillations of visual contrast sensitivity triggered by voluntary action and their link to perceived time compression

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Abstract

Spontaneous oscillations of brain activity can be synchronized by external stimuli, or by allocation of attention, and this can lead to small synchronous modulation of visual perceptual performance over time (Busch et al., 2009, Landau & Fries, 2012; Thut et al., 2012). Increasing evidence shows that motor processing affects perception in many ways and that planning an action triggers an internal signal (corollary discharge) that can strongly influence many aspects of perception, particularly the perception of time (Morrone et al., 2005; Tomassini et al., 2012; Yarrow et al., 2001). Here we investigated whether performing an action can generate rhythmic oscillations of visual contrast sensitivity, a property that is determined at very early levels of cortical visual analysis, probably V1. We measured visual contrast sensitivity for orientation discrimination of briefly (33 ms) displayed grating patches (spatial frequency 1 c/deg; eccentricity 7.5 deg to the left or right of fixation) tilted at ±45 degrees and embedded within dynamic noise (refreshed every frame) that lasted more than 3 s. Participants were asked to execute reaching movements towards the display behind an occluder (which hid the movement: open loop) in the same direction of the position of the right visual target. The visual stimuli were randomly presented at different times with respect to the movement (from ~500 ms before to ~300 ms after movement onset). For each subject more than 2000 trials were collected to obtain stable psychometric functions densely sampled over time. Visual contrast sensitivity for both eccentricities varied by about 0.2 log-units, oscillating in the theta range (~5Hz). Interestingly, the synchronized oscillations in visual sensitivity began before movement onset, suggesting that a motor preparatory signal might be responsible for synchronizing activity in primary visual areas. In a second series of experiments to control that the oscillations were not initiated by sensory cues related to the start of the trial, such as the start of the visual noise display or the sound go-signal for the start of the reaching movements, we let the subject perform a self-paced action within an interval of 2 s. Also in these conditions we observed oscillations in the theta range when data were aligned to the

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start of the movements that started 300-500 ms before movement onset. The present results reinforce growing evidence that sensory and motor functions are strongly interconnected, demonstrating that motor processing can modulate very early sensory function, such as sensitivity to visual contrast. The results suggest that sensory-motor integration might be, at least partly, mediated by phase modulations of brain rhythmic activity. We postulate that the synchronized oscillatory performance may be instrumental in aligning temporally the many sensory inputs that reach perception with multiple and varying delays due to the property of the various sensory receptors and pathways. That motor signals can govern the alignment reinforces the idea of the leading role of the motor system in the brain time-keeping mechanism (Ivry & Spencer, 2004).

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**References**


