Role of the PPC in vestibular information processing during goal-directed movements tested with TMS

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Introduction:

fMRI and TMS studies have shown that visual and proprioceptive information for motor control are integrated in the posterior parietal cortex (PPC) (e.g. Culham and Valyear, 2006; Filimon et al., 2009; Reichenbach et al., 2010). When the head is moving in space during a goal-directed movement, vestibular signals have to be integrated into the motor processing as well. The neural correlates of these integration processes during motor control have not been investigated thus far. However, fMRI studies about vestibular stimulation have shown that the PPC is also processing vestibular information (Suzuki et al., 2001; Dieterich et al., 2003; Stephan et al., 2005). Furthermore, Seemungal et al. (2008) demonstrated that the administration of TMS over the PPC disturbs the perception of the position in space when the body is rotated. For the TMS study presented here, we used the behavioral paradigm of Bresciani et al. (2002) where subjects performed a goal-directed reaching task while suddenly being rotated. In order to assess the neural correlates of vestibular information processing for movement control, we probed with TMS the necessity of several sites on the PPC for this motor task.

Methods:

In pitch black, subjects (n=4) were seated comfortably in a wheelchair with a chin and forehead rest. The head was additionally fixated by backings on the side of the head and the TMS coil. Subjects' task was to constantly fixate a LED straight ahead of them and reach from a starting lever to an earth fixed red LED target as soon as this target was extinguished (memory guided reaching). At the onset of the reaching movement, the wheelchair rotated 30° to the right or left in 2/3 of the trials. At half of the trials, a train of 4 TMS pulses was delivered 30 ms after movement onset. The TMS stimulation sites were derived from previous studies (Dieterich et al., 2003; Della-Maggiore et al., 2004; Stephan et al., 2005, Seemungal et al., 2008; Reichenbach et al., 2010). They included the temporo-parietal junction and covered the cortical area around the left and right intraparietal sulcus (IPS), respectively (see Fig.1 for the stimulation sites on the left hemisphere, the sites on the right hemisphere are mirrored).

Results:

When TMS was delivered over the medial IPS (see circled site in Fig 1.), the end points of the reaching movements showed less correction for the vestibular perturbation than the corresponding end points without TMS stimulation. This pattern was consistent across subjects. Furthermore, the trajectories of these two conditions deviated clearly from each other already from an early time point on. However, the results are still preliminary and need to be confirmed in a larger group of subjects.

Conclusions:

The results suggest that the medial IPS might be causally involved in vestibular information processing during goal-directed reaching movements when the vestibular signals arise from a rotation. This cortical area is most likely distinct from the cortical area which processes vestibular signals for the perception of one's own position in space (Seemungal et al., 2008). The TMS site derived from the aforementioned study is located approximately 1.5cm posterior from the site where the TMS effect in the present study emerged and TMS over this site did not elicit behavioral effects. This finding confirms on a neural level the conclusions of Bresciani et al. (2002) who deduced from a behavioral study that the processing of vestibular information during online motor control does not resemble spatial perception of vestibular information. However, this conclusion has to be regarded with care as the results are based on a small group of subjects and have to be confirmed with additional tests.

Motor Behavior:

Motor-Premotor Cortical Functions

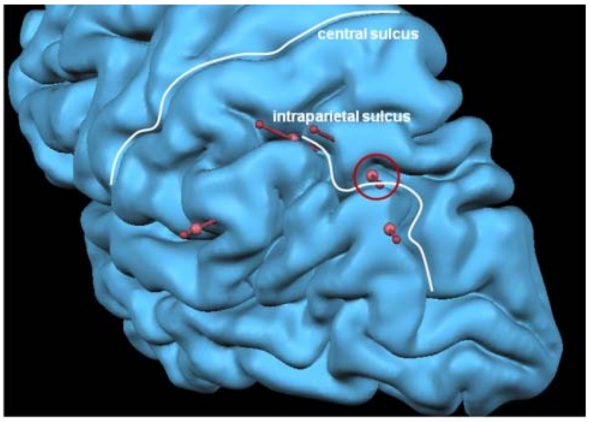

Figure 1 Poster-lateral view on the rendered left hemisphere of an exemplary subject. The red needles indicate the TMS stimulation sites with their head being located just in the center of the TMS coil on the subjects head. The distance between adjacent stimulation sites around the IPS is approximately 1.5cm. The red-circled highlights the site where TMS stimulation affected the correction for the vestibular perturbation.

Abstract Information

References

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