We thank Drs. Solopchuk et al. for their careful reading of our manuscript. Here we provide some clarification about points raised in their comments. First, we believe that it is important to emphasize the value of using cebus monkeys for this experiment. In this species, the PMd and most of M1 are located on the surface of the brain and are easily accessible for stimulation and recording. This makes it possible to perform detailed mapping of motor representations using intracortical stimulation and define the border between M1 and the PMd with considerable precision. This precise localization ensured that our experimental manipulations targeted a single cortical area without involving adjacent ones through spread of pharmacological agents, for instance. This critical component of our experiments is not as readily accomplished in human studies using TMS. It may contribute to the different outcomes of our inactivation experiments and those of some TMS studies.

We also wish to note that our findings are consistent with previous observations in monkeys. Mushiake et al. (1991) recorded the activity of single neurons in premotor cortex while monkeys performed visually-guided and internally-determined sequential movements. Like we did, they found that some premotor neurons, especially those in a region later identified as the PMd, showed enhanced activity during performance of memory-guided sequential movements compared with visually-guided movements. In addition, Kurata and Hoffman (1994) reported that PMd inactivation with muscimol disrupted the performance of conditional movements instructed by an arbitrary color cue, but not the performance of movements instructed by a spatial cue. These results support our conclusion that the PMd is critical for the performance of movements that are based on arbitrary associations either between movements (e.g., an internally generated sequence) or between sensory and motor elements (e.g., conditional motor tasks).

Solopchuk et al. presented an alternative interpretation of our results based on the involvement of the PMd in the control of kinematics. According to their view, effects on kinematic planning after inactivation would be minimized in the Random task by the presence of the visual cue allowing for the quick correction of initial kinematic errors. We recorded the monkey's performance with high-speed video in each experiment (space constraints prevented inclusion of this information in our Rapid Communication). A preliminary analysis suggested that the monkeys' arm trajectories were not affected by PMd inactivation, other than the errors noted in our article. The findings of Kurata and Hoffman (1994) also do not support a "kinematic" explanation of the results.

Finally, we would like to clarify that our experiments were carried out after 50-150 days of training. At these times, the monkeys' performance had reached a plateau (see also Matsuzaka et al., 2007). More recently, we found that PMd inactivation significantly disrupted the performance of the Repeating task after 300 days of training. These observations suggest that the PMd is involved in the maintenance of motor-motor associations even after long-term training.

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References

Kurata K, Hoffman DS (1994) Differential effects of muscimol microinjection into dorsal and ventral aspects of the premotor cortex of monkeys. J Neurophysiol 71:1151–1164.

Matsuzaka, Y, Picard N, Strick PL (2007) Skill representation in the primary motor cortex after long-term practice. J Neurophysiol 97: 1819-1832.

Mushiake H, Inase M, Tanji J (1991) Neuronal activity in the primate premotor, supplementary, and precentral motor cortex during visually guided and internally determined sequential movements. J Neurophysiol 66:705–718.