Predictions of hand movement direction and visuomotor congruence in frontal-parietal cortices

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Background

We designed a VR-based hand movement task to examine the neuronal correlates of two kinds of visuomotor predicitions; i.e., of *movement direction* and *visuomotor congruence*. With this design, we tested for a potential shared neural substrate of these kinds of predictions within the motor system; and, secondly, whether visuomotor predictions can be generated comparably for incongruent visuomotor mappings (i.e., violating the default configuration of the multisensory body model).

Methods

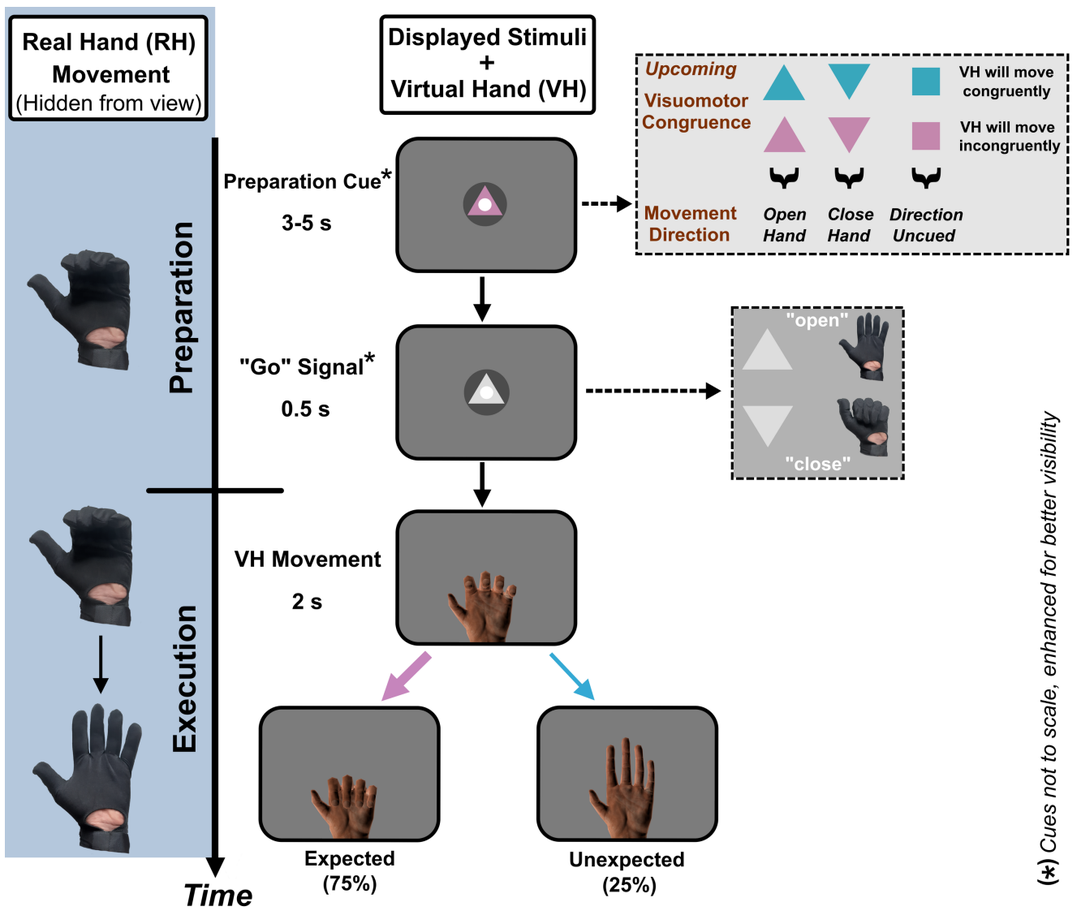

Figure 1: Design and schematic example trial. Participants (N=24, healthy, right-handed, mean age 25 years) used an MR-compatible glove to control a left virtual hand (VH) model during an fMRI scan (3 T Prisma, EPI, 3 mm³ voxel size, TR = 0.865 s). Participants had to open or close their hand from a neutral starting position following a 'Go' signal. During the movements, the VH moved either congruently or incongruently. Crucially, we included a brief 'preparatory' delay period, during which two kinds of cues were provided: (1) movement direction could be cued in advance, or left uncued until the 'Go' signal appeared; (2) the VH behaviour (congruent or incongruent) was cued, generating visuomotor expectations. A 'Go' signal then instructed the participants to either open or close their hand while observing the VH movement, which in 75% of trials met and in 25% violated the visuomotor cue prediction (surprise condition; the 'Go' signal always matched its cue). In half of the trials, participants had to indicate if the cue had correctly predicted the VH behaviour. Each subject performed 8 blocks with a total of 256 trials, which were then analysed in SPM12.

Preliminary Conclusion

Our results suggest that the dorsal premotor cortex, the anterior intraparietal sulcus, and the putative parietal reach region in the SPL generate not only predictions related to movement (direction) planning, but also about visuomotor congruence. These predictions seemed to have been similarly generated for congruent and incongruent visuomotor mappings, as activation related to surprise was observed when either prediction was violated.

Preliminary Results

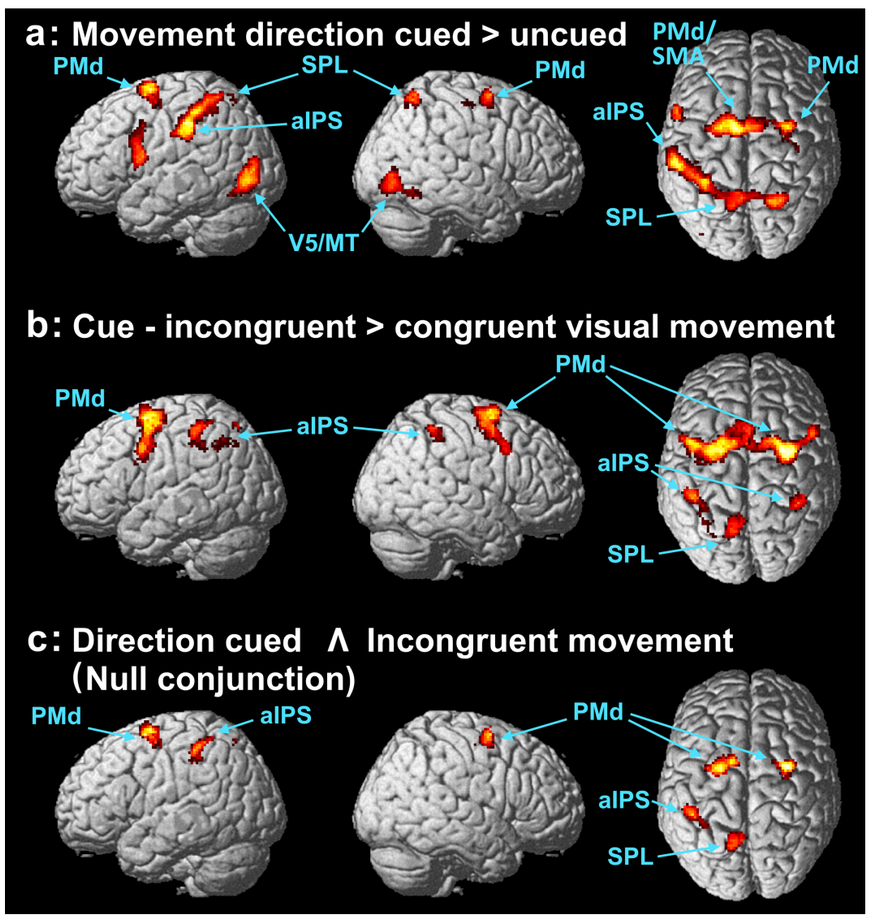

Figure 2: Significant brain activation differences during movement preparation (delay period). (a) Brain areas showing significantly ($p<0.05$ FWE) increased activation when the direction of the upcoming movement was cued > uncued. **(b)** Brain areas showing significantly ($p<0.05$ FWE) increased activation when incongruent > congruent virtual hand behaviour was cued. **(c)** Null conjunction of contrasts (a) and (b) showing significant ($p<0.05$ FWE) activations by both kinds of predictions.

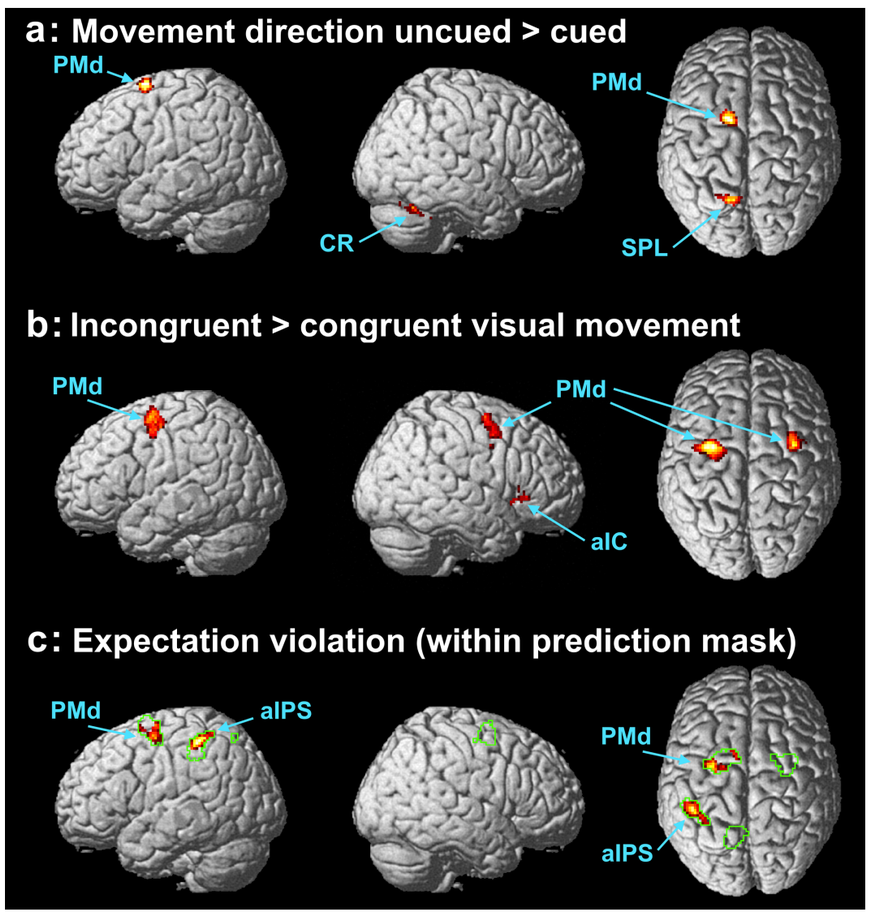

Figure 3: Significant brain activation differences during movement execution. (a) Significantly ($p<0.05$ FWE) stronger brain activations during movements after movement direction was uncued > cued in the preparatory phase. **(b)** Significantly ($p<0.05$ FWE) stronger brain activations during movements with incongruent > congruent visuomotor mapping. **(c)** Brain areas involved in predicting movement direction and visuomotor congruence (cf. Fig. 2c) showed increased ($p<0.05$ FWE) expectation violation responses (cue invalidity). There were no significant differences in the strength of this expectation violation response between congruent and incongruent movements.