Hemispheric specialization during planning and execution of tool-use with the dominant and the non-dominant hand: an event-related fMRI-study

Joachim Hermsdörfer[$], Guido Terlinden*, Mark Mühlau*,
Georg Goldenberg[$], A.M. Wohlschläger*

[$] *Clinical Neuropsychology Research Group (EKN), Department of Neuropsychology, Hospital München-Bogenhausen, Germany*

[*] *Departments of Neurology, Nuclear Medicine and Neuroradiology, TU Munich, Germany*

1. Introduction: It is a common experience that we are much faster and much more precise when using the dominant hand to manipulate tools as opposed to using the non-dominant hand. This study contrasts the neural correlates of skilled use of both hands. In particular, the spread and the changes of the neural activations from the instruction to the actual executing of tool use actions were investigated.

2. Methods: 32 different tool-use actions were selected according to fMRI compatibility. All actions involved mainly finger and hand movements, with some lower-arm but no upper-arm contributions (Fig: 1). A 2x2-factorial design was introduced comprising the factors “hand” (dominant vs. non-dominant) and “mode of execution” (pantomime vs. actual execution). In the present study, results for pantomime and real execution were combined (see poster 52 TH-PM for a differential analysis). Three events in a row occurring after an instructive cue were defined: Viewing of the object (event1), pause (event2), and execution of object-related movements (event3) (Fig. 2).

Fig.1: Tools and Objects used

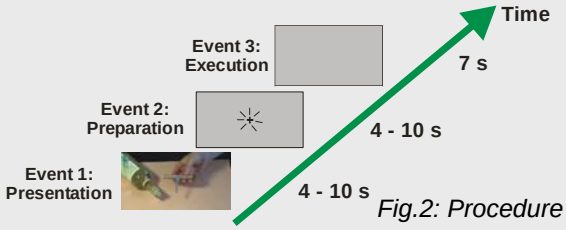

Fig.2: Procedure

24 right-handed healthy subjects participated in the experiment. Statistical analysis was performed using spmj and SPM2. Results are reported at $p<0.05$ (corrected for multiple comparisons) in the coordinate space of the Montreal Neurological Institute (MNI).

3. Results: Bilateral visual areas and the left parietal cortex were activated during event 1 irrespective of the hand that had to be used during the subsequent execution (Fig. 4). During event 2 parietal activation was weak, slightly more anterior and mainly contralateral to the instructed hand. Actual execution was associated with strong contralateral activation of sensory-motor areas, with substantial contribution of the ipsilateral brain particularly if the non-dominant hand was used.

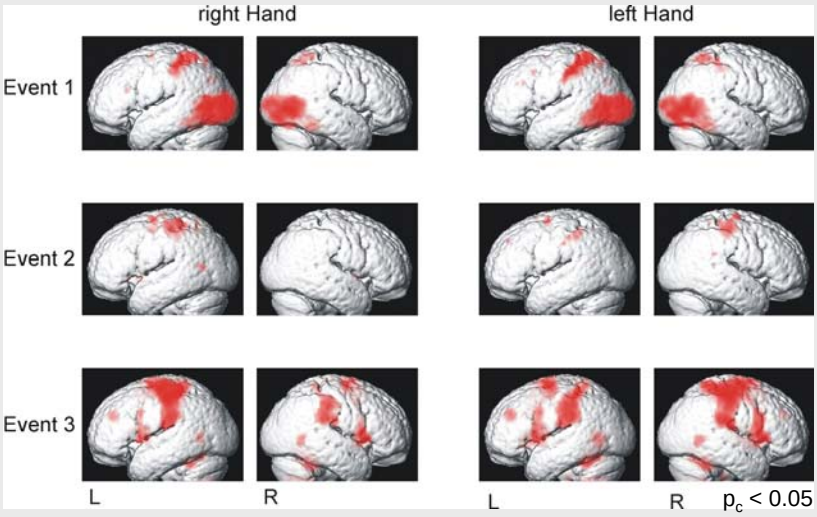

Fig.3: Activations during three successive events (event 1: viewing the tool, event 2: pause, event 3: execution) of tool-use actions versus baseline (rest between items) in dependency of the hand to be used during event 3.

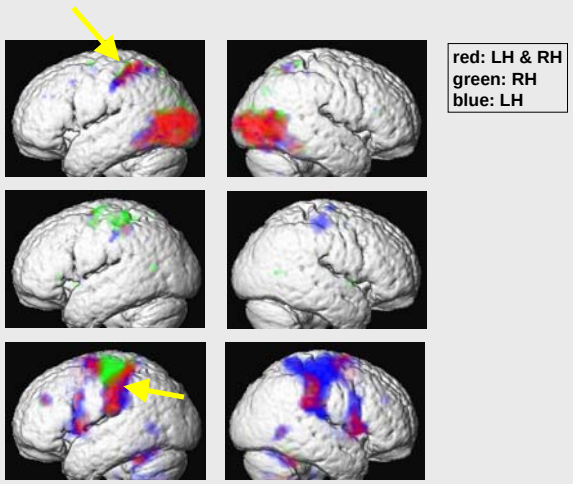

Fig.4: Brain areas associated with left, right, or both-sided hand movements. Yellow arrow: putative representations of left brain motor-dominance during event 1 and 3 ($p_c < 0.05$)

6. Conclusion: During the time course of planning (event 1), maintaining (event 2) and executing a tool-use action (event 3) motor-related peak brain activity subsequently involved left parietal, contralateral anterior parietal, and contralateral sensory-motor brain areas. Motor-dominance of the left brain is reflected by left parietal dominance during planning and ipsilateral sensory-motor contributions during movements of the non-dominant hand. Representations of motor dominance during planning and execution differ topographically according to different functional demands.