Pinpointing ideomotor effect anticipations in the human brain

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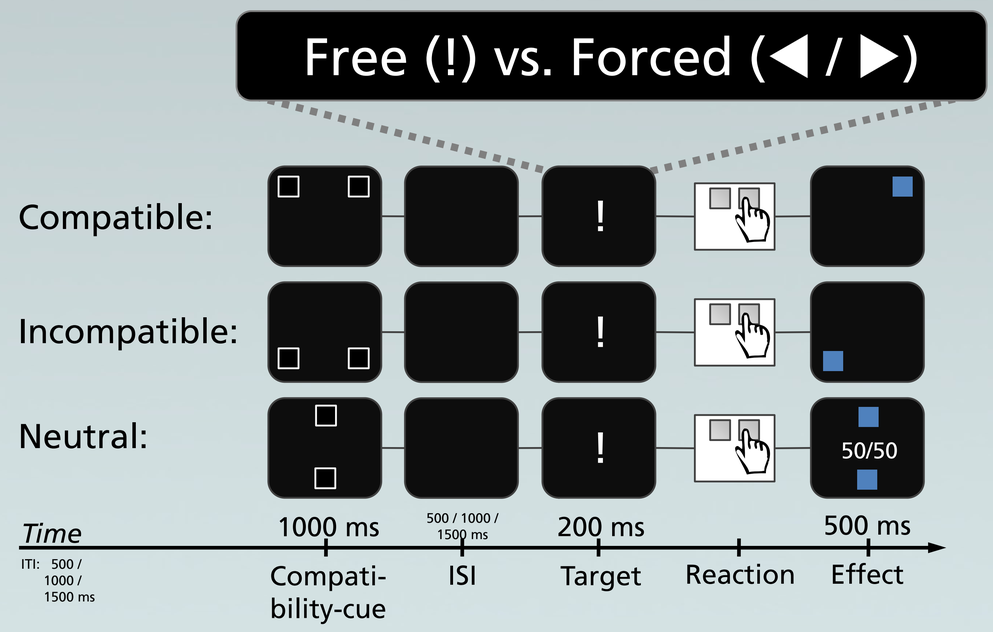
Background & Paradigm

How does our brain translate subjective states of mind into overt action of our body? How can a psychological state result in physical behaviour?

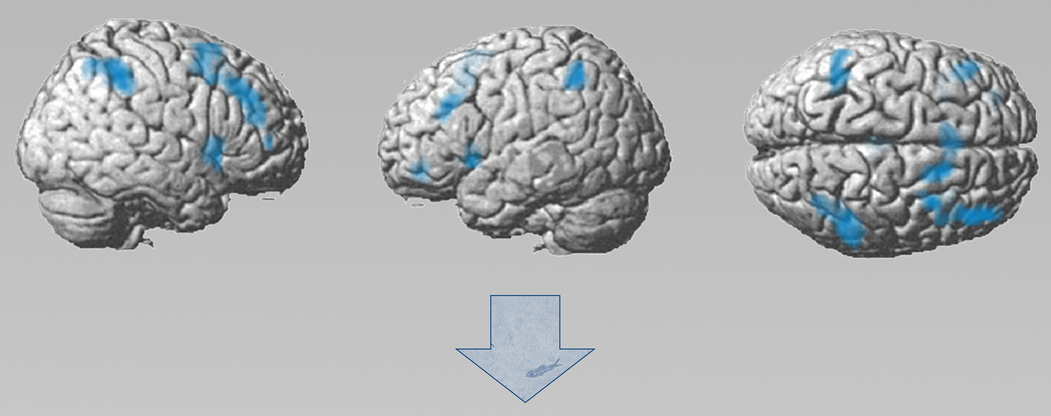
Adopting a philosophical approach, the **ideomotor principle** of action postulates that actions can be triggered by anticipating their sensory consequences (i.e. action effects). We used a **response-effect (R-E) compatibility** design (e.g. Kunde, 2001) in combination with event-related fMRI to investigate the neural correlates of such processes.

In accordance with the theory of **action control modes** (Herwig, Prinz, & Waszak, 2007; Pfister, Kiesel, & Hoffmann, in press), we used free and forced choice actions to create conditions with more and less pronounced effect anticipations (Pfister, Kiesel, & Melcher, submitted). The participants' individual R-E-compatibility effects allowed us to identify neural centres of ideomotor effect anticipations with regression analysis.



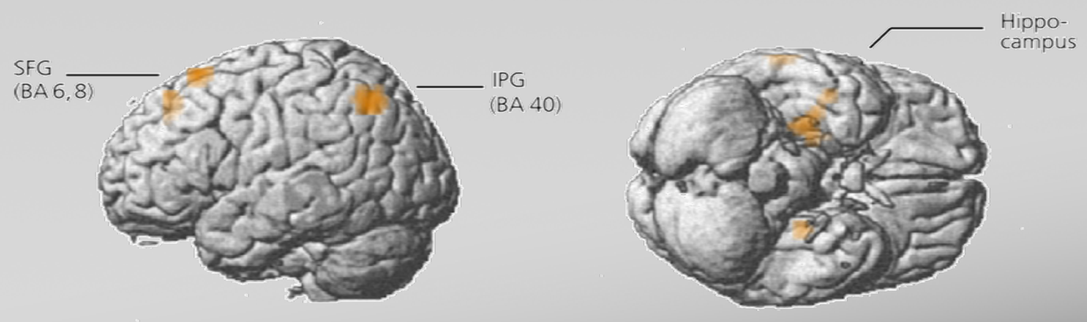
fMRI Results I: Free vs. Forced Choice

The t-contrast showed the bilateral fronto-parietal network that is commonly associated with voluntary action (Haggard, 2008), $p < .050$, FWE-corrected, k = 20*:



fMRI Results II: Regression with individual R-E compatibility effects

Most importantly, activity of the left inferior parietal gyrus (BA 40) was correlated with individual R-E-compatibility effects as a measure of ideomotor effect anticipations; $p < .005$, uncorrected, k = 20*:



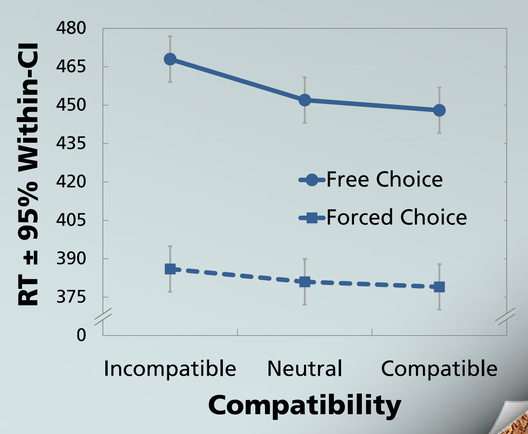
*) Scanner stats: 3T Siemens Trio, TR = 2000 ms, TE = 30 ms, 33 slices (ascending), voxel size = 3 x 3 x 3 mm³, 18 participants, 378 trials / participant.

Behavioural Results

We found stronger R-E-compatibility effects for free choice than for forced choice actions, resulting in a significant interaction, $F(2, 16) = 3.74$, $p = .047$, $\eta_p^2 = 0.32$.

Conclusions: An fMRI contrast of free vs. forced choice actions will contain some activations that are due to effect anticipations.

These should correlate with individual R-E-compatibility effects (= $RT_{free/incompatible} - RT_{free/compatible}$).



Summary

The present experiment provides the first neurophysiological evidence for ideomotor effect anticipations. The results indicate that inferior parietal circuits play a more important role in the initiation of voluntary actions than most contemporary theories of action control assume. The next steps will target fronto-parietal interactions to capture the dynamics of ideomotor action control.

Haggard, P. (2008). Human volition: Towards a neuroscience of will. *Nature Reviews Neuroscience*, *9*(12), 934-946.

Herwig, A., Prinz, W., & Waszak, F. (2007). Two modes of sensorimotor integration in intention-based and stimulus-based actions. *Quarterly Journal of Experimental Psychology*, *60*(11), 1540-1554.

Kunde, W. (2001). Response-effect compatibility in manual choice reaction tasks. *Journal of Experimental Psychology: Human Perception and Performance*, *27*(2), 387-394.

Pfister, R., Kiesel, A., & Hoffmann, J. (in press). Learning at any rate: Action-effect learning for stimulus-based actions. *Psychological Research*.

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