

# How sensory anticipations in the human brain control motor action

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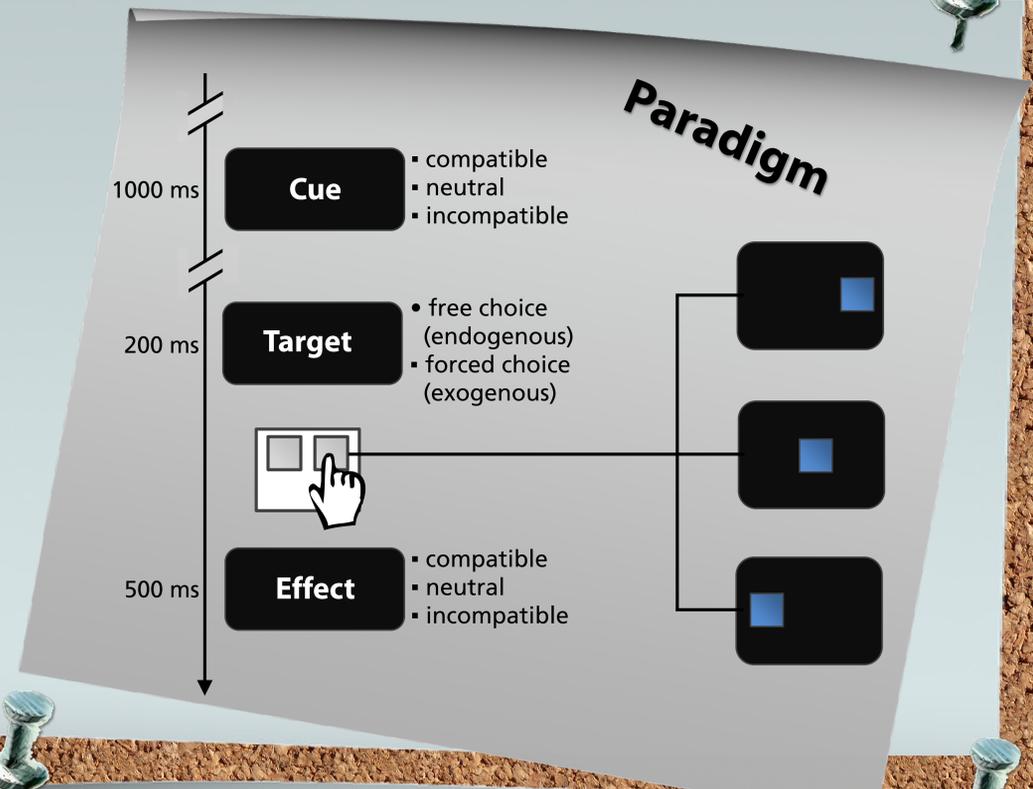


## Background

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

Adopting a philosophical approach, the **ideomotor principle** postulates that actions can be triggered by anticipating their sensory consequences (i.e., action effects). We used a **response-effect (R-E) compatibility** paradigm (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, 2011), we used free and forced choice actions to create conditions with more and less pronounced effect anticipations (Pfister, Kiesel, & Melcher, 2010). The participants' individual R-E-compatibility effects allowed us to identify neural centers that process ideomotor effect anticipations by means of regression analysis.



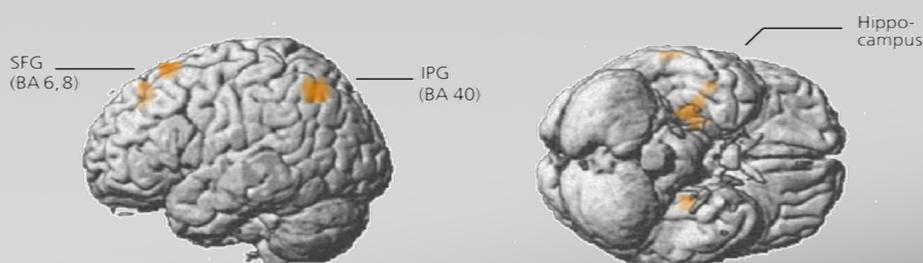
## fMRI Results I: Free vs. Forced Choice

The t-contrast identified a 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,  $k = 20^*$ :

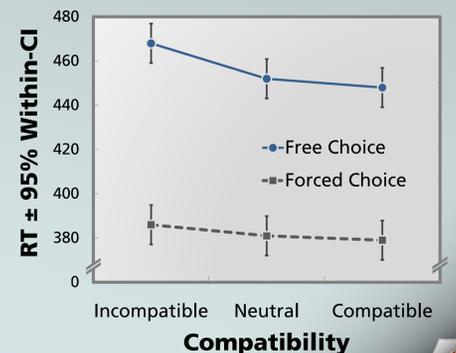


## Behavioral Results

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 at least some activations resembling effect anticipations.

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



## 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. Future experiments 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. (2011). Learning at any rate: Action-effect learning for stimulus-based actions. *Psychological Research*, 75(1), 61-65.

Pfister, R., Kiesel, A., & Melcher, T. (2010). Adaptive control of ideomotor effect anticipations. *Acta Psychologica*, 135(3), 316-322.

\*) Scanner stats: 3T Siemens Trio, TR = 2000 ms, TE = 30 ms, 33 slices (ascending), voxel size =  $3 \times 3 \times 3 \text{ mm}^3$ , 18 participants, 378 trials / participant.