

## 05: What Is the Mark That Distinguishes Actions?

s.butterfill@warwick.ac.uk

1. Philosophical Methods
2. Intentions and Goals
3. Motor Representation

Markers of motor representation

1. are unaffected by variations in kinematic features but not goals (e.g. Cattaneo et al. 2010; Umiltà et al. 2008; Cattaneo et al. 2009; Rochat et al. 2010)
2. are affected by variations in goals but not kinematic features (e.g. Fogassi et al. 2005; Bonini et al. 2010; Cattaneo et al. 2007; Umiltà et al. 2001; Villiger et al. 2010; Koch et al. 2010)

So:

3. carry information about goals (from 1,2)

Also

4. Information about outcomes guides planning-like processes (consider Grafton & Hamilton 2007; Jeannerod 1998; Wolpert et al. 1995; Miall & Wolpert 1996; Arbib

1985; Mason et al. 2001; Santello et al. 2002).

‘a given motor act may change both as a function of what motor act will follow it—a sign of planning—and as a function of what motor act preceded it—a sign of memory’ (Cohen & Rosenbaum 2004, p. 294).

### 4. Motor Representations Ground the Directedness of Actions to Goals

#### References

- Arbib, M. A. (1985). Coordinated control programs for movements of the hand. *Hand Function and the Neocortex. Experimental Brain Research*, 10, 111–129.
- Bonini, L., Rozzi, S., Serventi, F. U., Simone, L., Ferrari, P. F., & Fogassi, L. (2010). Ventral premotor and inferior parietal cortices make distinct contribution to action organization and intention understanding. *Cerebral Cortex*, 20(6), 1372–1385.
- Cattaneo, L., Caruana, F., Jezzini, A., & Rizzolatti, G. (2009). Representation of goal and movements without overt motor behavior in the human motor cortex: A transcranial magnetic stimulation study. *The Journal of Neuroscience*, 29(36), 11134–11138.
- Cattaneo, L., Fabbri-Destro, M., Boria, S., Pieraccini, C., Monti, A., Cossu, G., & Rizzolatti, G. (2007). Impairment of actions chains in autism and its possible role in intention understanding. *Proceedings of the National Academy of Sciences*, 104(45), 17825–17830.
- Cattaneo, L., Sandrini, M., & Schwarzbach, J. (2010). State-Dependent TMS reveals a hierarchical representation of

observed acts in the temporal, parietal, and premotor cortices. *Cerebral Cortex*, 20(9), 2252–2258.

Cohen, R. G. & Rosenbaum, D. A. (2004). Where grasps are made reveals how grasps are planned: generation and recall of motor plans. *Experimental Brain Research*, 157(4), 486–495.

Fogassi, L., Ferrari, P. F., Gesierich, B., Rozzi, S., Chersi, F., & Rizzolatti, G. (2005). Parietal lobe: From action organization to intention understanding. *Science*, 308(5722), 662–667.

Grafton, S. T. & Hamilton, A. (2007). Evidence for a distributed hierarchy of action representation in the brain. *Human Movement Science*, 26(4), 590–616.

Jeannerod, M. (1998). *The Neural and Behavioural Organization of Goal-Directed Movements*. Oxford: Oxford University Press.

Koch, G., Versace, V., Bonni, S., Lupo, F., Gerfo, E. L., Oliveri, M., & Caltagirone, C. (2010). Resonance of cortico-cortical connections of the motor system with the observation of goal directed grasping movements. *Neuropsychologia*, 48(12), 3513–3520.

Mason, C. R., Gomez, J. E., & Ebner, T. J. (2001). Hand synergies during reach-to-grasp. *Journal of Neurophysiology*, 86(6), 2896–2910.

Miall, R. C. & Wolpert, D. M. (1996). Forward models for physiological motor control. *Neural Networks*, 9(8), 1265–1279.

Rochat, M. J., Caruana, F., Jezzini, A., Escola, L., Intskirveli, I., Grammont, F., Gallese, V., Rizzolatti, G., & Umiltà, M. A. (2010). Responses of mirror neurons in area f5 to hand and tool grasping observation. *Experimental Brain Research*, 204(4), 605–616.

Santello, M., Flanders, M., & Soechting, J. F. (2002). Patterns of hand motion during grasping and the influence of sensory guidance. *The Journal of Neuroscience*, 22(4), 1426–1435.

Umiltà, M. A., Escola, L., Intskirveli, I., Grammont, F., Rochat, M., Caruana, F., Jezzini, A., Gallese, V., & Rizzolatti, G. (2008). When pliers become fingers in the monkey motor system. *Proceedings of the National Academy of Sciences*, 105(6), 2209–2213.

Umiltà, M. A., Kohler, E., Gallese, V., Fogassi, L., Fadiga, L., Keysers, C., & Rizzolatti, G. (2001). I know what you are doing: A neurophysiological study. *Neuron*, 31(1), 155–165.

Villiger, M., Chandrasekharan, S., & Welsh, T. N. (2010). Activity of human motor system during action observation is modulated by object presence. *Experimental Brain Research*, 209, 85–93.

Wolpert, D. M., Ghahramani, Z., & Jordan, M. (1995). An internal model for sensorimotor integration. *Science*, 269(5232), 1880–1882.