



# Shared representations of actions and action attribution

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Our everyday experience suggests that our body builds an entity independent from other bodies.

We normally attribute body states and actions to the self or to another agent without difficulty or conscious effort.

The privileged access to our bodily sensations forms a sense of self.





From a scientific point of view, the ability to recognize one's own body and actions appears problematic and poorly understood:

Discovery of shared representations of actions (DE VIGNEMONT & HAGGARD, 2008), based on mirror neurons, suggests that action attribution is a key computational problem for the sensorimotor system of the brain!





### **Human Mirror Neuron System**



Others' and one's own actions are mapped onto one and the same representation Parietal and ventrolateral premotor cortices are involved in both the execution and perception of action





### Shared representations of self and other

If the brain represents others' actions in the same way as it represents one's own, the questions arise:

How do we attribute actions to self or to another?

How do we generally distinguish self and other?

Shared representations should lead to attribution errors, especially in perceptually ambiguous situations (cf. DAPRATI ET AL., 1997; VAN DEN BOS ET AL., 2002; TSAKIRIS ET AL., 2005)





### Attribution errors: just an artifact?

Lab experiments create just artificial situations; self/other distinction normally based on e.g., visual cues and intentions

But! Ambiguities between self and other must happen during development; self-schema as a function of sensorimotor experience:



Detection of sensorimotor contingencies: A 3-month-old infant looking at delayed or not delayed on-line projection of his own legs (ROCHAT & STRIANO, 2002)

Mirror self-recognition as a major cognitive hallmark of self-consciousness





### Shared representations of self and other

Mirror matching system is intrinsically social: Representing/mirroring others in order to e.g. understand their actions.

But it also implies social equivalence or matching between self and other because the same neural representation is activated for actions made by either agent.

Does this mean that the representation of the other and the self are equivalent?

Is the other not represented *qua* other but only as a derivate of ourselves?





### Self and Other in the Human Motor System



# Agent neutral representation in the human motor system?

Comparing corticomotor excitability during observation of another's actions vs. actions linked to the self (as induced by the *Rubber Hand Illusion*, BOTVINICK & COHEN, 1998)

SCHÜTZ-BOSBACH, MANCINI, AGLIOTI, & HAGGARD (2006), Curr Biol, 16(18), 1830-1834.













### Interaction between body ownership x hand action:







Observed actions of others and one's own actions have different effects on cortical representation:

Motor resonance effects are stronger for others' actions than for putative own actions.



### Cortical suppression for self-observation?

Reduced facilitation for "one's own" actions due to cortical suppression/inhibition?

Inhibition is difficult to study because it does not produce a measurable output

Dependent measurement: **Silent Period** (SP) which is an indicator of cortical inhibitory mechanisms

SCHÜTZ-BOSBACH, AVENANTI, AGLIOTI, & HAGGARD (under revision), J Cog Neurosci



# Silent Period

In tonically (pre)activated muscles, TMS over M1 induces a short-latency MEP in the EMG as an excitatory effect followed by a transitory suppression of EMG activity (= Silent Period)









#### same paradigm as before

to elicit a silent period during a TMS trial subjects maintained an isometric tonic contraction (20% of maximal force) of FDI muscle







Significant interaction between hand ownership and hand action:









Viewing another's actions reduced intracortical inhibition, while viewing actions linked to the self increased intracortical inhibition.

Observation-evoked inhibition for "one's own actions" as a functional response: It might involve a motor parallel to sensory suppression to prevent inapproriate perseveration or entrainment of the motor system.





Agent **specific** representation in the primary motor cortex: Observing others' actions: **motor facilitation** Observing "one's own" actions: **motor suppression** 

Contrary to mirror theories: Social sensitivity, not social equivalence in the motor system

Mirror matching mechanism is intrinsically social: It maps the actions of others to corresponding actions of one's own body but does not simply represent the other agent as a derivative of, or even equal to the self

A sense of self might be embedded in primary sensorimotor representations (i.e., embodied self-representation)



## Open Questions and Future Directions

Ownership can certainly not be reduced to a single neural basis and is likely to extend far beyond the primary motor cortex.

Where does the information processed in M1 propagate or where does it come from?

Is and how is the embodied self-representation used to build up the conscious sense of agency and the sense of self? Many thanks to: Patrick Haggard Benedetta Mancini Alessio Avenanti Salvatore M. Aglioti