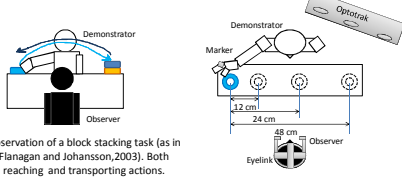


Motor resonance, which can be defined as the automatic activation of motor control systems during action perception, is a central phenomenon in understanding social behaviors (Chaminade and Cheng 2009) and seems to have a physiological basis in the mirror neurons, cells which are activated both during action execution and action observation (Rizzolatti et al. 1996). A common behavior which is thought to be associated with motor resonance is proactive gaze. When subjects observe an object manipulation task, their gaze predicts forthcoming events rather than reactively tracking actor's motion (Flanagan and Johansson 2003). Interestingly, when an object performs the same predictable movement by itself the gaze tends to exhibit much less prediction (Falck-Ytter et al. 2006). In our study we investigated whether goal-oriented robotic actions can induce motor resonance, by measuring the appearance of proactive gaze during action observation.

## Can uncommon motion characteristics reduce gaze predictivity?

### Setup and procedure

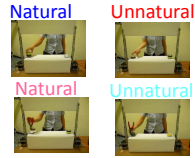


### Kinematics manipulations

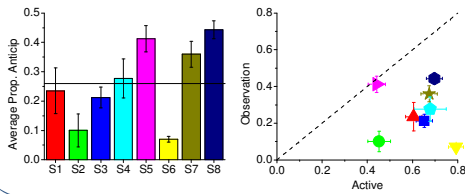


and Fast/ Natural/ Slow Pace

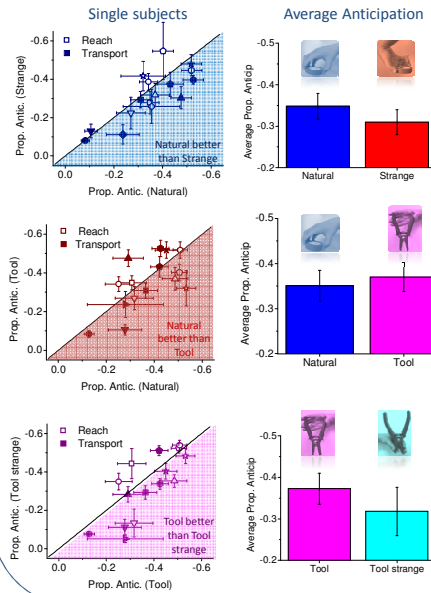
### Naturalness manipulations



### Anticipation is present both during action and action observation



### Anticipation is robust to manipulations of the naturalness of the observed action



An imperfect mapping between the observed action and our own motor repertoire can induce resonance.

### Short bibliography

Flanagan, J. R. & Johansson, R. S. *Nature*, 2003, 424, 769-771  
 Falck-Ytter, T., Gredeback, G. & von Hofsten, C. *Nat Neurosci*, 2006, 9, 878-879  
 Rizzolatti G, Fadiga L, Gallese V & Fogassi L. *Cogn Brain Res*, 1996, 3, 131-141  
 Gredeback, G. & Kochukhova, O. *Exp Brain Res*, 2010, 202, 493-497  
 Chaminade, T. & Cheng, G. *J. Physiol*, 2009, 103, 286-295

## Can a robot evoke motor resonance?

### YES

Gazzola V, Rizzolatti G, Wicker B, Keysers C *Neuroimage*, 2007, 35, 1674-1684

Press C, Bird G, Flach R, Heyes C, *Cogn Brain Res*, 2005, 25, 632-640

Oztop E, Franklin D, Chaminade T, Cheng G, *Int J Humanoid Robot*, 2005, 2, 537-559

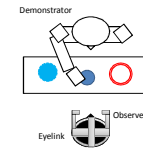
### neurophysiological

Tai YF, Scherfler C, Brooks DJ, Sawamoto N, Castiello U *Curr Biol*, 2004, 14, 117-120

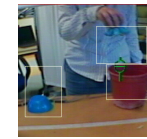
### behavioral studies

Kilner JM, Paulignan Y, Blakemore SJ, *Curr Biol*, 2003, 13, 522-525

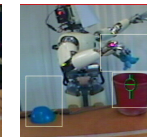
### Setup and procedure



### Human



### Robot



### Protocol

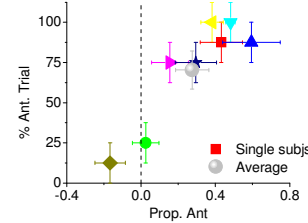
Replica of Falck-Ytter et al. 2006

8 presentations – robot actor  
 8 presentations – human actor

Robot motion: Biological motion recorded from human trials

Recorded subject's gaze during simple observation.

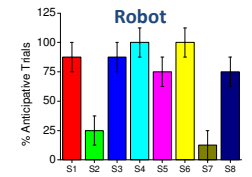
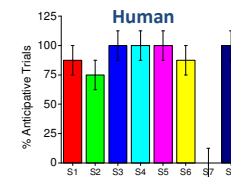
### Anticipation is present for robotic agents ...



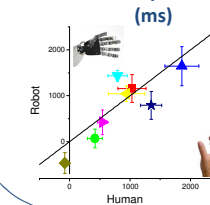
Motor resonance can be evoked also by goal-oriented actions realized by human-oriented robots, at least in the case of the adoption of biological speed profiles

### ... and is quantitatively comparable with the one for human subjects

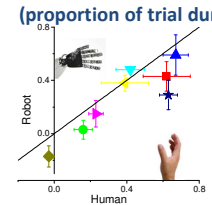
#### Percentage of anticipative trials



#### Anticipation (ms)



#### Anticipation (proportion of trial duration)



## Gaze proactivity can be also extended to the observation of robotic devices.

Robots can become useful tools to study motion resonance :  
 -Understanding of the brain (wide range of possible manipulations)  
 -- Better future human-robot interactions.