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Short Communication

Which body for embodied cognition? Affordance and language within actual and perceived reaching space

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ABSTRACT

The mental representation of one's own body does not necessarily correspond to the physical body. For instance, a dissociation between perceived and actual reach-ability has been shown, that is, individuals perceive that they can reach objects that are out of grasp. We presented participants with 3D pictures of objects located at four different distances, namely near-reaching space, actual-reaching space, perceived-reaching space and non-reaching space. Immediately after they were presented with function, manipulation, observation or pointing verbs and were required to judge if the verb was compatible with the object.

Participants were faster with function and manipulation verbs than with observation and pointing verbs. Strikingly, with both function and manipulation verbs participants were faster when objects were presented in actual than the perceived reaching space. These findings suggest that our knowledge of the world is implicitly built online through behaviour, and is not necessarily reflected in explicit estimates or conscious representations.

1. Introduction

According to Gibson (1979), affordances are properties of the environment providing the observer with practical opportunities that he or she is able to perceive and use.

Post-Gibson literature generally assumes that affordances are dispositional properties of the environment that must be complemented by dispositional properties of individuals (Shaw, Turvey, & Mace, 1982; Turvey, 1992). According to the Blackwell dictionary of western philosophy, a dispositional property is the capacity of an object to affect or to be affected by other things. For instance, being graspable is a dispositional property of a handled mug. Recent empirical data (Cardellicchio, Sinigaglia, & Costantini, 2011; Costantini, Ambrosini, Scorolli, & Borghi, 2011; Costantini, Ambrosini, Tieri, Sinigaglia, & Committeri, 2010; Ferri, Riggio, Gallese, & Costantini, 2011; Yang & Beilock, 2011) have shown that the perception of affordance is modulated by the spatial relation between the object and the agent, that is, it is more efficient when the visually presented object falls within the reaching space of an onlooker endowed with motor abilities which allows him or her to skilfully interact with the object. But what do we really mean when talking about abilities? In this context, abilities are all the motor potentialities an individual is endowed with. To give an example: reach-ability can be construed as a motor potentiality.

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However, a distinction can be made between perceived reach-ability and actual reach-ability. A relatively common finding among studies of perceived estimates vs. actual movement is the observation of an overestimation bias in reach-ability at midline positions (Fischer, 2000; Mark et al., 1997). That is, individuals exhibit a general tendency to perceive that they can reach objects that are out of grasp. Explanations for this overestimation bias in perceived reachability have focused on two possibilities, both based on a misconception of the one's own action capabilities during the motor simulation involved in the reachability estimates. According to the whole body engagement hypothesis (Rochat & Wraga, 1997), this bias depends on the participants' engagement in a simulated reach that includes all degrees of freedom, as in their everyday experience of reaching, whereas they are generally tested in situations that prevent natural body movements. The postural stability hypothesis (Carello, Grosofsky, Reichel, Solomon, & Turvey, 1989) proposes that participants tend naturally to overestimate their reaching range as long as their body's centre of mass will be safely supported during the simulated movements required to contact the object. To date, however, none of the two hypotheses can account for the full pattern of results in reachability judgments (Delevoye-Turrell, Bartolo, & Coello, 2010; Fischer, 2000). Here we took advantage of the naturally occurring differences between perceived reach-ability and actual reach-ability in a sample of right-handed people, to investigate whether the perception of affordances (e.g. the handle of a mug) mainly depends on the individual's perceived reaching space or his/her actual reaching space. Participants were presented with 3D images of objects at four different distances, namely near reaching space (30 cm), actual reaching space (corresponding to each participant's reaching range), perceived reaching space (corresponding to each participant's estimation of her own reaching space) and non-reaching space (140 cm). Immediately after a function, manipulation, pointing or observation verb was presented. Participants had to provide a response if the verb was compatible with the previously observed object, i.e. the verb represented an action which could be performed with the object. Our interest lies in verifying the extent to which verb comprehension, which is thought to be based on a mental simulation process (e.g. Barsalou, 2008), reflects the way in which object affordances are perceived. Specifically, we aim to investigate whether comprehension of verbs referring to actions with objects reflects perceived or actual object reachability. In other words, we intend to verify whether the simulation formed during language comprehension is grounded in the conscious representation of reachable space, or whether it is grounded in the actual reachable space.

Notice that the term simulation is used also to refer to the activation of the motor system induced by observation of objects. Independently of whether we want to use the highly debated term of simulation or not (see Borghi, 2011 for a critique of the term), what counts here is to clarify the relationship between the processes (the "simulation"?) formed while observing objects and while comprehending words referring to objects. A number of behavioural and neural studies have shown that observation of objects, and particularly of tools, induces the preparation of motor actions (e.g. Tucker & Ellis, 2004; for a review on neural evidence see Martin, 2007), possibly through the mediation of the canonical neuron system (Rizzolatti & Craighero, 2004). Given that, according to embodied theories, language is grounded in perception and action system, the same tendency to prepare an action would be evoked when pronouncing, listening or reading the word corresponding to an object on which to act (e.g. Barsalou, 2008; Gallese, 2008). For this reasons many authors favouring an embodied cognition approach use in both cases the term simulation.

A variety of behavioural, brain imaging and neurophysiological studies have provided evidence that the simulation formed is rather detailed and sensitive to the different effectors implied by the sentence, to the action perspective, etc. (Barsalou, 2008; Chersi, Thill, Ziemke, & Borghi, 2010; Fischer & Zwaan, 2008; Toni, de Lange, Noordzij, & Hagoort, 2008). However, it has yet to be investigated whether the simulation built reflects the real dynamics of the actions, or whether it simply reflects the way we explicitly represent action. Our paradigm allows us to test precisely this.

If during language comprehension a simulation is built that is sensitive to object affordances and to their location with respect to the agent's body, then responses to action verbs (i.e., manipulation and function ones) should be modulated by object spatial location. Specifically, they should be faster with objects located in the peripersonal than in the extrapersonal space; this difference should not be present for observation and pointing verbs. This result would confirm the one found by Costantini, Ambrosini, Scorolli & Borghi, (2011) and extend it to pointing verbs. In addition, if the simulation built during language comprehension reflects the real dynamics of actions, then we predict that responses to action verbs should be faster when primed by objects located within the actual and not the represented reaching space. If it reflects the way actions are represented, then they should be faster with objects located within the estimated reaching space.

2. Methods

2.1. Participants

Fifteen healthy subjects (8 males, mean age 25.5 years) participated in the experiment. All participants were native Italian speakers, had normal or corrected-to-normal visual acuity and were right-handed according to self report. Participants were naïve to the hypotheses under investigation and gave their informed consent.

2.2. Materials

The experimental stimuli were images and verbs. Seven *Manipulation* Verb – *Function* Verb – Object triads were selected from our previous work (Costantini, Ambrosini, Scorolli & Borghi, 2011), in an attempt to match each object with a highly