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Seeing the world through another person's eyes: Simulating selective attention via action observation

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ABSTRACT

Selective attention is usually considered an egocentric mechanism, biasing sensory information based on its behavioural relevance to oneself. This study provides evidence for an equivalent allocentric mechanism that allows passive observers to selectively attend to information from the perspective of another person. In a negative priming task, participants reached for a red target stimulus whilst ignoring a green distractor. Distractors located close to their hand were inhibited strongly, consistent with an egocentric frame of reference. When participants took turns with another person, the pattern of negative priming shifted to an allocentric frame of reference: locations close to the hand of the observed agent (but far away from the participant's hand) were inhibited strongly. This suggests that witnessing another's action leads the observer to simulate the same selective attention mechanisms such that they effectively perceive their surroundings from the other person's perspective.

1. Adopting another person's selective attention by observing their actions

Understanding other people's intentions is a fundamental building block of social interactions. By observing how another person interacts with their surrounding, one may infer not only what they are doing, but also to what or who their behaviour is directed. The most straightforward way to achieve this would be to '*put oneself in their shoes*', that is, to covertly simulate how they perceive and interact with their environment.

Recent research has shown that observation of a particular action elicits the same patterns of activity in motor-planning areas of the brain that are also recruited when actually performing the same action. This link between action observation and action execution is provided by so-called 'mirror neurons', discovered in the pre-motor cortex of macaque monkeys, that discharge not only when the monkey is performing a particular action such as grasping an object, but also when it observes another individual carrying out the same action (Di Pellegrino, Fadiga, Fogassi, Gallese, & Rizzolatti, 1992; Gallese, Fadiga, Fogassi, & Rizzolatti, 1996; Rizzolatti, Fadiga, Gallese, & Fogassi, 1996). A growing number of studies indicate that a similar mirror neuron system exists in humans, showing that observation of actions elicits activation in brain areas that code for the same motor plans or movements (see Buccino, Binkofski, & Riggio, 2004; Gallese, Keysers, & Rizzolatti, 2004; Rizzolatti & Craighero, 2004, for reviews). The evidence suggests that humans encode an observed action in multiple ways, ranging from precise motoric information to information pertaining to the meaning of the action and the context in which it occurs (e.g., Calvo-Merino, Grèzes, Glaser, Passingham, & Haggard, 2006; Decety et al., 1997; Gangitano, Mottaghy, & Pascual-Leone, 2001; Grèzes, Costes, & Decety, 1998; Iacoboni et al., 2005; Maeda, Chang, Mazziotta, & Iacoboni, 2001). It has therefore been argued that the mirror system is critically involved in action imitation, action

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recognition, and discerning the intention of others' actions (e.g., Buccino et al., 2004; Gallese & Goldman, 1998; Gallese et al., 2004; Iacoboni et al., 2005; Rizzolatti & Craighero, 2004).

Behavioural demonstrations of this effect showed that observation of a particular action primes (i.e., increases the readiness for) corresponding movements or interferes with incompatible responses made by the observer (Bach, Peatfield, & Tipper, 2007; Bach & Tipper, 2007; Brass, Bekkering, Wohlschlaeger, & Prinz, 2000; Craighero, Bello, Fadiga, & Rizzolatti, 2002; Kilner, Paulignan, & Blakemore, 2003; Stürmer, Aschersleben, & Prinz, 2000). Other studies have begun to investigate more subtle tendencies in simulating other people's actions. For example, Schuch and Tipper (2007) demonstrated that observing another person successfully stopping an inappropriate response slows down the observer's subsequent response, suggesting that observing this action activates similar response inhibition processes. Welsh et al. (2005, 2007) showed that observers reflexively orient spatial attention towards the perceived target of another person's action. These studies show that some higher-level cognitive processes, such as response inhibition and spatial orienting, are mirrored along with an observed action.

Although it is clear that observing another person's action activates corresponding motor areas in the observer's brain and primes similar actions, a key issue remains. That is, to what extent are another's actions encoded and how does this influence one's own actions? Under some circumstances, actions are likely to be simulated in an egocentric frame of reference where the observer achieves their goal, such as grasping an object, more efficiently after observing someone else achieve a similar goal. However, in order to achieve a simulation of another person's actions that results in empathic understanding of them, the observer should be able to represent the world directly from the other person's point of view. This (third person) allocentric[1] representation may be quite different to the egocentric, or body-centered representations that are necessary to guide the observer's own actions. The present study engages with this issue by adapting paradigms that have been developed to study action-centred selective attention processes in order to assess whether observers represent another person's actions in an egocentric or allocentric frame of reference.

In sum, the purpose of the present study was to investigate to what extent cognitive processes are mirrored, and how they are integrated into the observer's own motor planning. From this point on we refer to the person whose actions are being observed as 'agent'. We examined (a) whether witnessing another person's goal-directed movements activates selective attention mechanisms in the observer; and (b) the possibility that the observer simulates the agent's selective attention to such an extent that an allocentric rather than an egocentric frame of reference is accessed, allowing the observer to adopt the point of view of the observed person.

2. The present paradigm

In order to obtain a sensitive measure of the simulation of selective attention, we utilized a selective reaching task in conjunction with a negative priming paradigm that allowed us to probe the observer's processing of stimuli to which the agent had *not* overtly responded. Furthermore, this allowed us to evaluate the frame of reference in which action-based selective attention is mirrored. Previous research has shown that certain actions are associated with distinctive attentional processes. Often, everyday actions such as picking up a particular item from a cluttered desk require the selection of a target from among distractors. Such selection is thought to be achieved by facilitating the processing of the goal-relevant stimulus while simultaneously inhibiting the processing of distracting stimuli, thereby reducing the interference from competing but irrelevant information. A well-known index of such inhibitory processing is negative priming, which refers to the finding that when a task requires a response towards a target object that is presented along with a to-be-ignored distractor object, subsequent responses to the previously ignored stimulus are slowed. The slowed processing of the stimulus reflects the effects of inhibition associated with it when it was a competing distractor a few seconds before (Tipper, 1985; see Fox, 1995; Tipper, 2001, for reviews). The level of inhibition the distracting input receives depends on the initial activation state of the internal representation of the distractor: the more salient a distractor, the more it competes for response and the more strongly it is inhibited. Furthermore, inhibition is associated with those aspects of the stimulus that are most relevant to the current behavioural goal.

In tasks requiring selective reaching for a target object among distractor objects, the nature of the movement rather than visuo-spatial information determines the attentional relevance of stimuli and therefore the level of inhibition that is associated with distracting stimuli (Tipper, Lortie, & Baylis, 1992). The basic finding observed in numerous studies was that irrelevant distracting objects that were closer to the starting position of the hand interfered with the reaching response to a target more, and were therefore associated with greater inhibition as measured via negative priming, than distractors that were further away from the initial starting position of the reaching hand (Tipper, Howard, & Houghton, 1998; Tipper, Meegan, & Howard, 2002). Thus, the inhibition associated with competing distractors is egocentric, based on an action-centred representation of the participant's own body.

In the present experiment, we investigated the hypothesis that witnessing another's selective reaching movements leads the observer to activate similar selective attention processes that the agent is utilizing to accomplish their goal. The logic is as follows: Witnessing a movement (such as reaching for a target stimulus) activates a corresponding action plan in the observer. Therefore, if the observed reaching movement is associated with cer-

[1] Although the term "allocentric" is often used in a general sense to refer to the spatial relationship between two external points, its original meaning pertains to being concerned with another person as opposed to oneself. In the context of this study, we use allocentric in its original sense.