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Toward You: The Social Side of Actions

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Abstract

Humans spend most of their time interacting with other people. It is the motor organization subtending these social interactions that forms the main theme of this article. We review recent experimental studies testing whether it is possible to differentiate the kinematics of an action performed by an agent acting in isolation from the kinematics of the very same action performed within a social context. The results indicate that social context shapes action planning and that in the context of a social interaction, flexible online adjustments take place between partners. These observations provide novel insights on the social dimension of motor planning and control.

Keywords

social interaction, kinematics, cooperation, competition, communication, motor control

For many years, cognitive psychology and cognitive neuroscience have focused on individual cognition, developing paradigms suited to investigating individual minds in isolation. Yet when applied to social interaction, this "isolation paradigm" has led to the irony of studies in which social interaction is investigated by examining individuals who are physically isolated in separate compartments that do not allow face-to-face interaction. Neuroimaging experiments on social interaction have adopted this approach by testing single participants playing a game with a real or fictitious partner outside the scanner (e.g., Decety, Jackson, Sommerville, Chaminade, & Meltzoff, 2004; Gallagher, Jack, Roepstorff, & Frith, 2002; but see Schilbach et al., in press, for a different approach). These isolation experiments reflect the underlying assumption that social interaction is ultimately reducible to the understanding of those mental states that people entertain when they interact—or at least, believe to interact—with other agents (e.g., Jacob & Jeannerod, 2005).

Recent findings challenge this perspective by positing that social interaction is deeply rooted in the actions of agents interacting together (e.g., Knoblich & Sebanz, 2008). Here we review findings from a novel line of research suggesting that social context shapes action kinematics. We begin by briefly introducing the basic experimental model employed by the studies reviewed in this article. We then consider how acting with a partner might influence action planning and control in different social contexts. We end by offering suggestions for future research.

The Experimental Window: The Reach-to-Grasp Movement

The reach-to-grasp movement is performed normally and routinely within the familiar context of living. It is also a movement that has been well characterized experimentally in terms of two functionally coupled components: a *transport* component, the aim of which is to move the hand into the vicinity of the object to be grasped, and a *grip formation* component, responsible for preparing the hand to capture the object (for review, see Castiello & Pierno, 2008). Both components have been shown to be sensitive to different aspects of object processing (e.g., object size and spatial location; Jakobson & Goodale, 1991), as well as to the agent's end-goal in grasping the object (e.g., grasping a bottle for pouring versus for throwing; Ansuini, Giosa, Turella, Altoè & Castiello, 2008).

If social context influences action planning and control, then differences in kinematics should be evident when comparing reach-to-grasp movements preparing a subsequent social interaction with similar movements executed in isolation. Furthermore, as acting with a partner requires adjusting one's action depending on what the partner is doing, changes in the reach-to-grasp kinematics in response to sudden changes occurring

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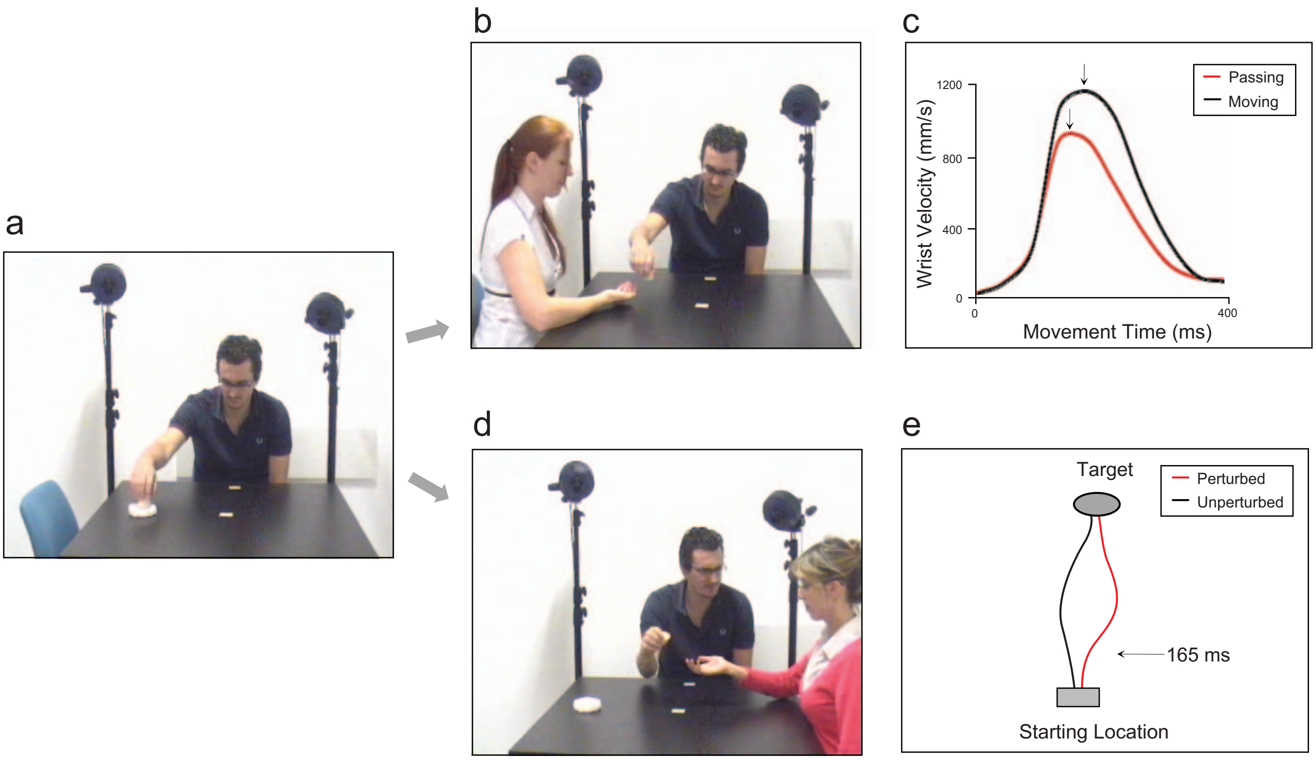

Fig. 1. Reach-to-grasp movement task used to test whether action kinematics are sensitive to the social end goal of passing an object to another person, and experimental results. Panel (a) represents the individual condition, in which the participants reached toward the object, grasped it, and placed it within a concave base. Panel (b) represents the social condition, in which, following the action of grasping, the object was handed to a partner. Panel (c) depicts the velocity profiles of participants' wrist speed in the individual condition (black line) and the social condition (red line). In the social condition, the amplitude of peak velocity was lower and it occurred earlier in time than it did in the individual condition. Panel (d) represents a social perturbation condition. Although the instruction for the participant was to place the object within the concave base located to his or her right, the sudden and unexpected "give me the object'" request by a partner produced a dramatic deviation of the arm's spatial trajectory toward the partner (Panel e).

within the social environment might be expected. Such findings would contradict the often tacitly accepted assumption that actions can be conceived as independent from the social context in which they take place (Jacob & Jeannerod, 2005).

Helping and Requesting Help From One Another

Human beings help one another and request help from one another in many situations. Passing an object represents a basic helping gesture that humans perform in a variety of contexts. In an initial test of the hypothesis that social context influences action planning, Becchio, Sartori, Bulgheroni, and Castiello (2008a) sought to determine whether reach-to-grasp kinematics is sensitive to the social end goal of passing an object to another person. For the individual condition, participants were requested to reach toward an object, grasp it, and move it from one spatial location to another (Fig. 1a). This condition was contrasted with a social condition, in which participants were requested to reach toward and grasp the same object and pass it to a partner (Fig. 1b). Results revealed that both the reach-to-grasp and the placing phase of the movement were sensitive to the social manipulation (see Fig. 1c). Critically, no significant differences were found when comparing the individual condition with a condition in which a passive observer witnessed the action.

The same task context—passing an object to a partner—was used by Meulenbroek, Bosga, Hulstijin, and Miedl (2007) to assess the extent to which transfer of kinematic patterns takes place between coactors involved in transferring objects. First, one of the two actors picked up a cylinder from a nearby location on the table and put it in the middle of the table. Subsequently, the other actor fetched the cylinder and repositioned it in a nearby target area. The authors varied both the size and the weight of the transferred cylinder. Time series analysis of the lifting heights revealed that the actor who fetched the object first showed a systematically larger surprise effect compared with the actor who was asked to subsequently transport the object. These findings indicate that, in the context of a social interaction, kinematic parameters may be picked up during movement observation and integrated into a subsequent motor plan (see also Mason & Mackenzie, 2005).

Surprisingly, the influence of other people's actions is evident even when it would be more effective for task performance to ignore others' actions (e.g. Sebanz, Knoblich, & Prinz, 2005). Using a perturbation paradigm, Sartori, Becchio, Bulgheroni, and Castiello (2009) investigated how much an unexpected social request might influence the kinematics of a preplanned action. Participants were instructed to reach toward an object, grasp it, and put it in a container. On 20% of the trials, a perturbation occurred. Specifically, at the moment the participant started the action toward the object, a coexperimenter unexpectedly stretched out her right arm and unfolded her hand as to ask for the object (Fig. 1d). Analysis of spatial trajectories revealed a significant veering in the arm trajectory occurring 165 milliseconds following the perturbation (see Fig. 1e). Strikingly, in some trials, participants totally disregarded the instruction to place the target on the platform and instead handed the object to the coexperimenter. No perturbation effect was observed when the human coexperimenter was replaced by a robotic agent or when the perturbation consisted of a human arm movement conveying no communicative intention. These results suggest that, in contrast to a robotic or generic human arm movement, processing a social request had the power to override the agent's initial motor plan. In line with an ecological perspective to social interaction (Marsh, Richardson, & Schmidt, 2009), it is tempting to interpret these findings as evidence that socially motivated actions (e.g., a request gesture) may act as social affordances that activate appropriate motor responses. Once a social request has been processed, the activation of the appropriate response is almost automatic.

Cooperating and Competing

Cooperation and competition are two basic modes of social interaction that involve specific and often different cognitive processes. For example, whereas both cooperation and competition necessitate predicting the action of coactors, incorporating the action plan of a coactor with one's own action plan might be beneficial for cooperative situations but not for competitive ones. In cooperative contexts, this process would allow individuals to adjust the timing of their actions as to achieve a common outcome in real time (Sebanz & Knoblich, 2009). In contrast, in competitive contexts it might be more beneficial not to incorporate the action plan of an opponent, as this would slow down responses and, consequently, competitive performance (De Brunijn, Mield, & Bekkering, 2008).

To test the influence on action that cooperative and competitive contexts might have, Georgiou, Becchio, Glover, and Castiello (2007) analyzed the kinematics of reach-to-grasp movements toward a wooden block in four different conditions: natural individual, fast individual, cooperative, and competitive. For the natural individual condition, participants reached toward, grasped, and moved the stimulus to the center of the working surface at a natural speed comparable to the speed of a cooperative movement. For the individual fast condition, participants performed the same action, but as fast as possible, therefore, at a speed comparable to that characterizing a competitive interaction (Fig. 2a). For the cooperative and competitive conditions, participants were assigned in pairs. The cooperation task required them to reach and grasp their respective objects and to cooperate in building a tower by putting one object on top of the other in the middle of the working surface (Fig. 2b). The competition task was similar, except that they had to compete to place their own object in the middle of the working surface first (Fig. 2d). Results revealed specific kinematic patterns for cooperation and competition, which were distinct from similar actions performed by each participant in isolation (Figs. 2c–e). As predicted, for the cooperation task, but not for the competition task, a high level of correlation between key kinematical parameters of the two participants was found.

In these experiments, the attitude of the actor always matched the attitude of the partner. In real-life social interaction, however, this is not always the case. Imagine being asked to cooperate with a partner who clearly displays the intention to compete or, vice versa, to have to compete with an opponent who displays the intention to cooperate. Would the incongruent attitude of the partner influence the implementation of your action?

To answer this question, Becchio, Sartori, Bulgheroni, and Castiello (2008b) manipulated the attitude of the partner during the reach-to-grasp phase of a social interaction. Participants were requested to reach for their respective objects and then either to cooperate or to compete with a partner. The participants were not aware that the partner was a semiprofessional stage actor. For the congruent trials, the partner assumed an attitude (facial expression and body posture) congruent with the task instructions: cooperative for the cooperative task, competitive for the competitive task. For the incongruent trials, her attitude was manifestly in contrast with the instruction: competitive for the cooperative task, cooperative for the competitive task. Results revealed a significant "mismatch effect" on the agent kinematics: Cooperating with a partner displaying the intention to compete rendered the agent's action more competitive. The opposite effect emerged when competing with a partner displaying the intention to cooperate: The kinematic pattern of the agent became similar to a cooperative pattern.

These findings point to the importance of social cues in face-to-face interaction. Facial expression and body posture represent powerful cues for intention that can either support or compromise cooperation. Reversal of kinematic patterning during incongruent trials might indicate that participants used these cues to infer the partner's attitude and this led to a change in their kinematics. In this interpretation, the changes in an agent's kinematics would be mediated by the representation of the partner's attitude. Alternatively, reversal in kinematic patterning might be interpreted as the result of nonintentional interpersonal alignment, by which individuals acting together tend to automatically coordinate their goal-directed actions (Marsh et al., 2009). In this scenario, the cooperative and competitive patterns would emerge via such dynamic coupling rather than through a cognitively mediated process such as mental-state attribution.

Communicating With Others

Whereas speech is the most obvious signal humans use to communicate, many other signals are also used. For example, the

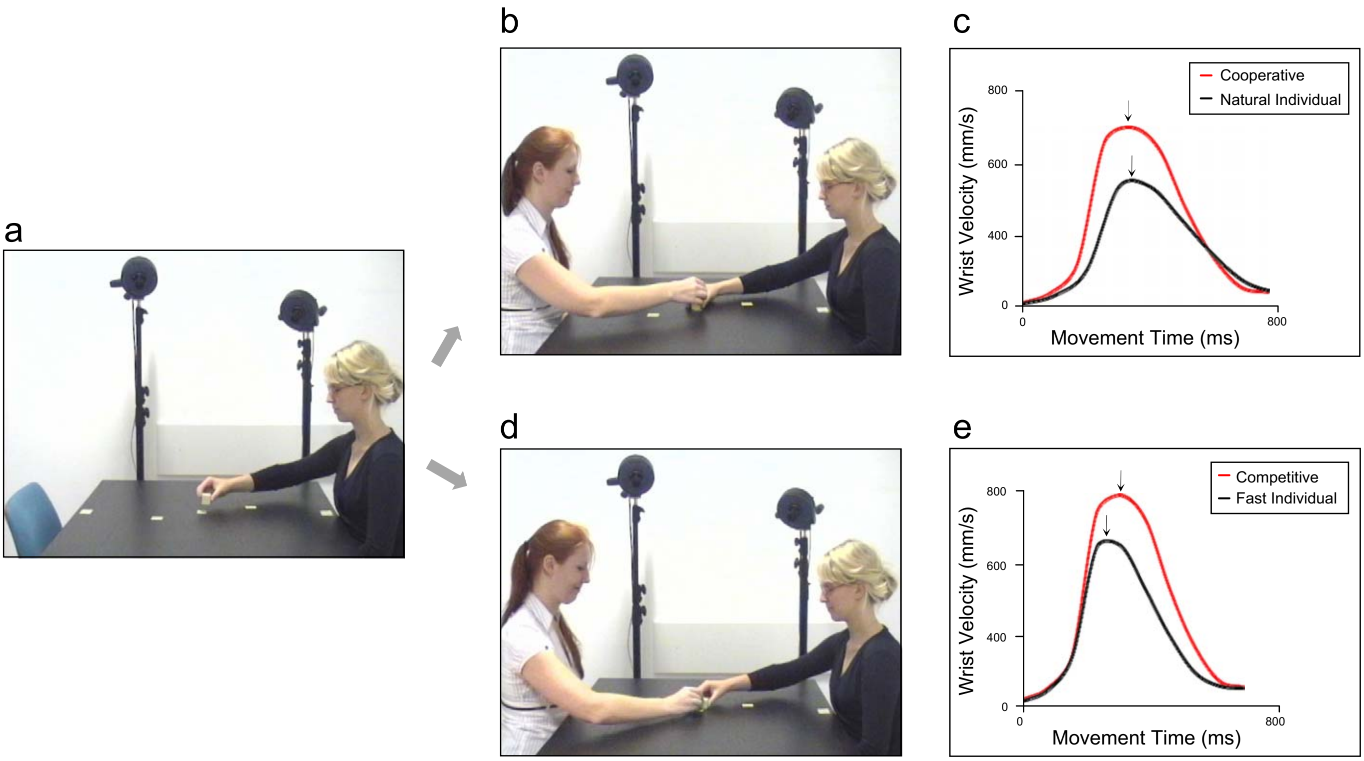

Fig. 2. Experimental setup used for the studies considering cooperative and competitive behaviors, and results. Panel (a) represents the individual (both the natural individual and the fast individual) conditions, in which participants were requested to reach toward a stimulus, grasp it, and place it in the middle of the working surface. Panel (b) represents the cooperative task, in which the two participants were requested to grasp the object in front of them and form a tower in the middle of the table. The photograph represents the point at which the two participants tend to synchronize the action as to fulfill the task. Panel (c) represents the velocity profiles obtained for the cooperative and the natural individual tasks. Note that deceleration time was longer for the cooperative than for the natural individual condition. Panel (d) represents the competition task, in which participants competed to put their object in the bottom of the tower first (middle of the table). Panel (e) represents profiles of the participants' wrist velocity in the competitive and the fast individual tasks. Note that the amplitude of peak velocity was higher and deceleration time was shorter for the competitive than for the fast individual condition.

action of touching one's earlobe—which is not communicative in most contexts—could become a communicative signal in the context of a Bridge game, when two players agree that touching the earlobe means ''Fold the current hand.'' Sartori, Becchio, Bara, and Castiello (2009) employed kinematic methods to investigate whether acting in a communicative context places special demands on action planning. To answer this question, they asked participants to perform the same goal-directed action in an individual task and a communicative task. In the individual condition, participants were requested to reach toward either a blue or a green spherical object, grasp it, and lift it, according to one of five predetermined sequences. The communicative task was identical to the individual task, except that participants executed the sequence with a communicative intent. Each of the sequences of blue and green spheres represented a different meaning in a sort of simplified Morse code. Participants were asked to select a meaning (and thus a sequence) and to communicate it to a partner by lifting the spheres in the predetermined order. Based on a conversion table, the partner had to interpret the meaning of the communicated sequence. Results revealed how the imposition of a communicative meaning was not neutral with respect to action kinematics: Although the to-be-grasped object remained the same, approach movements to the object in the communicative condition were more careful than were those in the individual condition. This finding might be regarded as indicative of an adaptation to a partner: When lifting the object was executed with a purely individual intention, the participant could grasp the object in whatever orientation without compromising the goal of the action. When the lifting action was performed to show the object to another person, then a more careful determination of contact points might be desirable as to optimize the viewing of the object by the partner. Results obtained for a second experiment in which the partner was blindfolded confirmed this hypothesis. When the partner was blindfolded and adaptation to the partner was therefore pointless, no communicative effect on movement kinematics was observed.

In this connection, Newman-Norlund et al. (2009) have recently demonstrated that in the context of tacit communication games, adaptation of communicative behavior is partner specific. In their experiment, participants could not see each other, and the mere belief that one was communicating with a child versus with an adult influenced the way the communicative message was generated. An interesting task for future research is to determine whether, during a face-to-face interaction, adaptation of communicative behavior to a specific addressee extends to motor parameterization—that is, whether in planning a communicative action, participants take into account specific information regarding the partner, such as eye level or head orientation.

Conclusions and Future Directions

A range of behavioral and neuroscientific studies has provided evidence that processes related to motor organization are influenced by the mere observation of another person's action (Blakemore & Frith, 2005). By replacing the usual observer/actor context with an interactive setting in which participants act with others, the studies discussed in this paper critically advance our understanding of the social nature of action planning and control. First, studies using this paradigm demonstrate that social context shapes action planning in such a way that, although the to-be-grasped object remains the same, different kinematical patterns for individual actions and actions preparing to a subsequent social interaction are observed. Second, they provide evidence that in the context of a social interaction, flexible online adjustments take place between partners. One main challenge for future work is to understand to which extent these adjustments are grounded within sensorimotor processes and to which extent they require cognitively mediated processes such as mental-state attribution. This question is related to the ongoing debate regarding the role of low- and high-level processes in social interaction (Galantucci & Sebanz, 2009). How is coordination in social interaction achieved? To which extent and under which circumstances do different kinds of processes work together to enable individuals to interact with others in a flexible manner?

A second challenge is to provide a model of motor control that incorporates the influence of social context (Wolpert, Doya, & Kawato, 2003). Current models postulate a vertical hierarchy in the organization of movements, with higher levels representing goals and intentions and lower levels representing kinematics and muscle-group selection. Future research should clarify how behaviors of interacting individuals may be horizontally integrated at different levels.

Recommended Reading

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Declaration of Conflicting Interests

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