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Interplay Between Action and Movement Intentions During Social Interaction

Sasha Ondobaka[1], Floris P. de Lange[1], Roger D. Newman-Norlund[2], Michael Wiemers[1], and Harold Bekkering[1]
[1]Donders Institute for Brain, Cognition and Behavior, Radboud University Nijmegen,
and [2]Department of Exercise Science, University of South Carolina

Abstract

Observing the movements of another person influences the observer's intention to execute similar movements. However, little is known about how action intentions formed prior to movement planning influence this effect. In the experiment reported here, we manipulated the congruency of movement intentions and action intentions in a pair of jointly acting individuals (i.e., a participant paired with a confederate coactor) and investigated how congruency influenced performance. Overall, participants initiated actions faster when they had the same action intention as the coactor (i.e., when participants and the coactor were pursuing the same conceptual goal). Participants' responses were also faster when their and the coactor's movement intentions were directed to the same spatial location, but only when participants had the same action intention as the coactor. These findings suggest that observers use the same representation to implement their own action intentions that they use to infer other people's action intentions and also that a dynamic, multitiered intentional mechanism is involved in the processing of other people's actions.

Keywords

movement intention, action intention, action observation, intentional interplay, action understanding, social interaction, social cognition

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Intentions are generally defined as plans or tendencies that guide actions and reactions to the environment. In the domain of action and perception, intentions form the basis for selecting and controlling the motor programs appropriate to a currently desired goal state (Bratman, 2009). Mounting evidence supports the idea that observing the movement of another agent can facilitate or hinder the observer's movement intention to subsequently produce similar movements (Brass, Bekkering, Wohlschläger, & Prinz, 2000; Chartrand & Bargh, 1999; Kilner, Paulignan, & Blakemore, 2003; Liepelt, Von Cramon, & Brass, 2008; Sebanz, Knoblich, & Prinz, 2003). This influence of observed movements on movement production is thought to be critical to fluent social interaction (Bekkering et al., 2009; Sebanz, Bekkering, & Knoblich, 2006).

Intentions can be specified at multiple levels. For example, imagine a friend washing dishes in the kitchen. As your friend moves a sponge toward a dirty plate, you might infer that he has the intention to make a rotating movement with the sponge. Obviously, this inferred *movement intention* (Desmurget & Sirigu, 2009; Mele, 1992; Rizzolatti & Sinigaglia, 2010) is predicated on the existence of a known *action intention* (Bekkering & Neggers, 2002) to do the dishes. This distinction between movement intention and action intention is directly related to the difference between *proximal* intention and *distal* intention, terms that are typically used in philosophy of action (Mele, 1992; Pacherie, 2008).

Action intentions relate to the process of action-goal attainment and encompass top-down control and selection of conceptual action goals that precede and define action as a whole (e.g., the intention to do the dishes). Action intentions are formed before the execution of a movement and persist while movement is ongoing. In contrast to action intentions, movement intentions control the selection of sensorimotor representations necessary for the more immediate execution of bodily movements (e.g., intentionally making a rotating movement). This hierarchical relationship (i.e., higher-order action intentions and lower-order movement intentions) implies that movement intentions should be influenced by preexisting factors, such as situational context, and by the action goal present at

Corresponding Author:
Sasha Ondobaka, Donders Institute for Brain, Cognition and Behavior, Radboud University, Nijmegen, 6525 RZ, The Netherlands
E-mail: s.ondobaka@donders.ru.nl

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the level of action intentions (Pacherie, 2008; Vallacher & Wegner, 1987).

The robust finding that observing particular movements can facilitate or hinder the production of similar responses is typically assumed to be due to activation of sensorimotor representations involved in the production of similar movements (Prinz, 1997). These sensorimotor activations are thought to be automatic and obligatory, and are often linked to the process of action understanding (Rizzolatti & Sinigaglia, 2010). Nevertheless, the concept of automaticity does not account for the finding that intention inference is not based solely on sensorimotor processing, but also depends on the action-prediction processes important for the inference of higher-order action intentions (de Lange, Spronk, Willems, Toni, & Bekkering, 2008). Previous research has already shown that action intentions can directly affect an actor's visual perception (Allport, 1987; Bekkering & Neggers, 2002; Witt & Proffitt, 2006; Witt, Proffitt, & Epstein, 2005).

Little is known about the influence of action intentions on the effect of movement observation on movement execution. The aim of this study was to examine the interplay between movement intentions and action intentions by evaluating how these constructs influence observation-execution coupling in a social setting. Therefore, we developed a paradigm that allowed us to manipulate the congruency of movement intentions and action intentions in jointly acting individuals while keeping all sensorimotor components of the task constant. We hypothesized that a match in action intentions between coacting individuals would lead them to respond faster than they would when their action intentions mismatched. Furthermore, if observed movements truly influence behavior in an automatic and obligatory way (Brass, Derrfuss, & Von Cramon, 2005; Gallese, 2005; Liepelt et al., 2008; van Leeuwen, van Baaren, Martin, Dijksterhuis, & Bekkering, 2009), then movement-congruency effects would be observed regardless of whether action intentions matched. If, however, observers adjust their performance according to observed movements only when their action goal matches the action goal of the person they are observing, then movement-congruency effects would be influenced by congruency in action intentions and would appear only when coactors had the same action intention.

Method

Participants and apparatus

We tested 30 healthy, right-handed (as determined by Oldfield's, 1971, handedness test) participants (age range = 17–55 years, *M* = 22.7, *SD* = 7.5) with normal or corrected-to-normal vision. Participants were seated at a custom-built table (length = 120 cm, width = 80 cm) facing a confederate coactor. Embedded in the table and level with the tabletop were a 19-in. touch screen (Elo Touch, Elo TouchSystems, Menlo Park, CA) and one start button on each long side of the screen (see Fig. 1 for an illustration of the experimental setup).

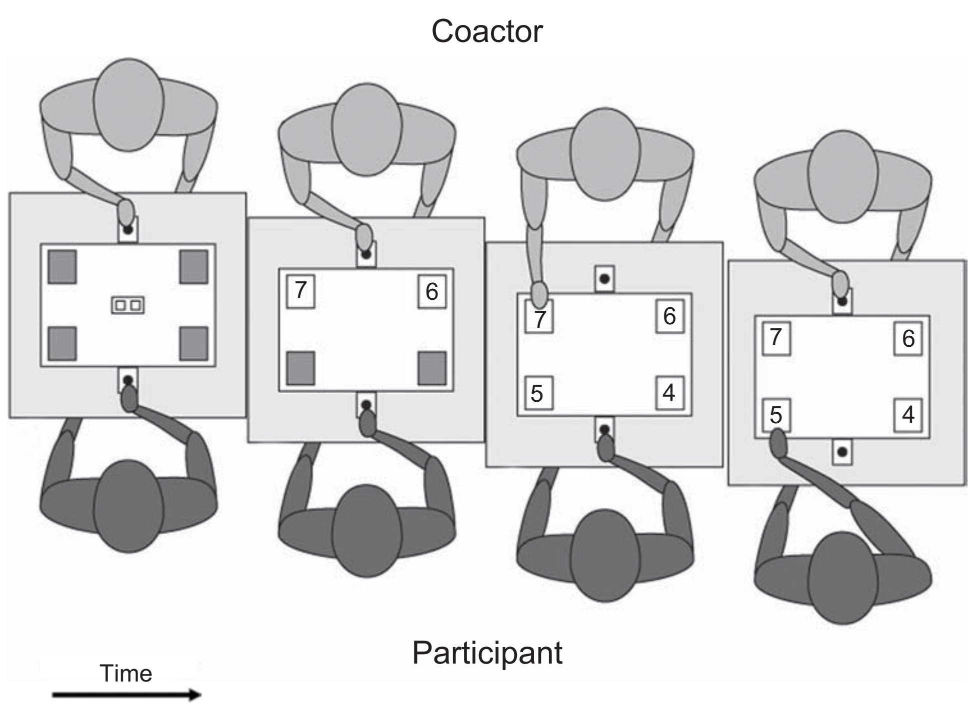

Fig. 1. Experimental setup and illustration of an action-congruent/movement-incongruent trial. Trials started with all the cards face down. After a variable delay (0.5–2.5 s), the two cards on the coactor's side were revealed. This triggered the coactor to make a selection, which caused the two cards on the participant's side to be revealed immediately; the participant then made his or her choice. The trial illustrated here is action congruent because both the coactor and the participant chose the card with the higher value; it is movement incongruent because the coactor moved to his right, whereas the participant moved to his or her left.

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Procedure, design, and stimuli

The experiment had a 2 (action congruency: congruent or incongruent) × 2 (movement congruency: congruent or incongruent) within-subjects design. Each participant performed the experimental task with a confederate coactor. On each trial, the coactor was presented with two cards and had to select the card with either the higher or the lower value. The participant also had to choose the higher or lower of two cards; this decision was based on the coactor's selection and whether the participant had been instructed to match or mismatch that selection. At the beginning of each block, we manipulated congruency of action intentions by instructing participants to adopt either the same action intention as the coactor (action-congruent condition) or the opposite action intention (action-incongruent condition). Participants had to observe the coactor's action on each trial, infer the coactor's action goal (i.e., to select the higher card or to select the lower card), and then dynamically adopt either the congruent or the incongruent action goal.

On the level of movement intentions, the responses of the coactor and the participant could be spatially congruent (movement-congruent condition; see Fig. 1) or spatially incongruent (movement-incongruent condition), as defined in an egocentric reference frame. In movement-congruent trials, the movements of the coactor and the participant were directed to the same side from the egocentric perspective (e.g., each to his or her own left), whereas in movement-incongruent trials, the coactor's movement and the participant's movement were directed to opposite sides (e.g., the coactor moved to his left, but the participant moved to his or her right).

The stimulus set consisted of 84 perceptually identical trials for each of four experimental conditions. In other words, the same combinations of card values were used in all conditions, and the only difference between conditions was the spatial alignment of the target cards (i.e., whether the target cards were presented to the same or different sides from an egocentric perspective). Participants completed 14 blocks of 16 trials each (2 practice blocks and 6 blocks for each action-congruency condition), and the trials presented in each block were randomly drawn from the pool of 84 possible trials. All trials in a block had the same action-intention congruency, and each block consisted of 8 movement-congruent trials and 8 movement-incongruent trials. The instructions that manipulated action congruency at the start of each block were presented on the screen for 10 s and were followed by the instruction to place the right index finger on the start button to begin the block. Each trial started with the presentation of four cards face down in the four corners of the screen and a cue that served as a reminder of the block type. This reminder cue was presented in the center of the screen and consisted of either two squares (action-congruent block) or a square and a circle (action-incongruent block).

So that the coactor would choose higher and lower cards at random, he was presented with an auditory cue (i.e., the word *higher* or *lower*, audible only to the coactor) at the beginning of each trial. After a variable delay (0.5–2.5 s), the reminder cue disappeared, and the cards on the coactor's side of the screen were revealed. When the coactor chose one card by using his right index finger to press it on the touch screen, the cards on the participant's side of the screen were instantaneously (see Fig. 1) revealed. At this point, the participant used his or her right index finger to select a card according to the block instruction and the coactor's choice. Immediately after selecting their cards by touching the screen, the coactor and participant placed their index fingers on their start buttons; the next trail was initiated when the coactor and then the participant had their fingers on the start buttons. For further details about the method, see the Supplemental Material available online.

Results

Trials in which participants or the coactor selected the incorrect card (4.53% of participants' responses and 0.04% of the coactor's responses) and in which response times (RTs) were more than 2.5 standard deviations above the mean (2.4% of participants' responses and 1.9% of the coactor's responses) were excluded from analysis. The analysis of the speed of the coactor's responses showed no significant effects of movement or action congruency. For a detailed analysis of error rates and the coactor's RTs, see the Supplemental Material.

Participants responded faster when they adopted the same action intention as the coactor than when they had a different action intention, as indicated by a significant main effect of action congruency, $F(1, 29) = 29.42$, $p < .001$, $\eta^2 = .50$ (see Table 1 and Fig. 2). A trend toward a main effect of movement

Table 1. Mean Response Times and Error Rates as a Function of Action Intention and Movement Intention

	Action-congruent condition		Action-incongruent condition	
Movement congruency	Response time (ms)	Errors (%)	Response time (ms)	Errors (%)
Incongruent	921.1 (34.3)	1.7 (0.2)	971.2 (39.7)	2.6 (0.3)
Congruent	890.3 (30.7)	1.8 (0.3)	976.4 (43.6)	2.1 (0.3)

Note: Standard errors of the mean are shown in parentheses. Response times in the action-congruent condition were significantly different from response times in the action-incongruent condition, $p < .001$. In the action-congruent condition, response times on movement-incongruent trials were significantly different from response times on movement-congruent trials, $p < .005$.

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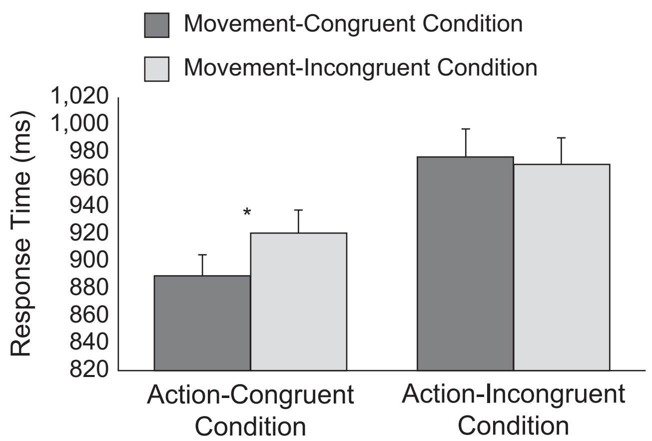

Fig. 2. Participants' mean response time as a function of action congruency and movement congruency. Error bars represent standard errors of the mean. The asterisk indicates a significant difference between conditions, $p < .005$.

congruency on RT was observed, $F(1, 29) = 3.67$, $p = .065$ $\eta^2 = .11$. Participants were faster in the movement-congruent trials than in the movement-incongruent trials. In addition, a significant two-way interaction between action congruency and movement congruency, $F(1, 29) = 4.56$, $p < .05$, $\eta^2 = .14$ (see Fig. 2), indicated a dependency between movement intention and action intention.

To further specify the effects of movement and action congruency on RT, we ran post hoc *t* tests comparing RTs in the movement-congruent and movement-incongruent trials separately for the two levels of action congruency. Analysis of action-congruent trials revealed a significant movement-congruency effect, $t(29) = 3.49$, $p < .005$, $d = 0.17$. Responses in movement-congruent trials were faster than those in movement-incongruent trials. This movement-congruency effect was not present for the action-incongruent trials, $t(29) = 0.42$, $p = .68$, $d = 0.02$. Additional distribution analysis of participants' RTs indicated that differences in task difficulty and ceiling effects did not underlie the reported movement-congruency effect (for details, see the Supplemental Material).

Discussion

The experiment reported here yielded two important findings. First, we observed a congruency effect of action intention: Participants responded more quickly when their action intention matched that of the coactor than when it did not match. Second, the previously established movement-congruency effect was present only when participants acted with the same action intention as the coactor. Taken together, these findings provide evidence for an action-congruency effect and suggest a dynamic interplay between the levels of action intention and movement intention during processing of other people's actions.

The interplay between movement and action intentions

The finding that the movement-congruency effect is dependent on the congruency of action intentions suggests that a flexible interplay between sensorimotor and inferential processes underlies the process of matching observed and executed actions. Our results show that movement production is facilitated when the produced and observed actions match at the conceptual level of action intention (i.e., that observing similar movements is not sufficient to elicit the congruency effect, as previous reports indicated; Brass et al., 2000; Kilner et al., 2003). Additionally, we have provided evidence for a dynamic interplay in intentional architecture whereby inferential levels of processing (i.e., action intentions) provide constraints on movement intentions (Jacob & Jeannerod, 2005; Kilner, Friston, & Frith, 2007; Pacherie, 2008).

Our results are in line with hierarchical models of action and intention from the fields of social and personality psychology and philosophy. For example, the findings are consistent with predictions from the theory of action identification, which proposes dynamic bidirectional links between observed behavior and the conceptual level of action representation (Vallacher & Wegner, 1987). Furthermore, according to Pacherie's (2008) multitiered dynamic framework of intention, the higher, conceptual level of action intention (distal intention) should influence the lower level of selection and control of individual movements. Our findings also extend to the domain of social interaction and support the notion that intentional processes are represented and understood on multiple levels of action representation (De Vignemont & Haggard, 2008; Pacherie, 2008; Searle, 1983; Vallacher & Wegner, 1987; Wolpert, Doya, & Kawato, 2003).

Action intentions in action observation

Existing research on action observation and action understanding has focused primarily on automatic processing of other people's movements. For example, it has been shown repeatedly that observing other people's movements leads to automatic processing of their movement intentions, as suggested by the presence of movement-congruency effects (e.g., Brass et al., 2000; Liepelt et al., 2008; Rizzolatti & Sinigaglia, 2010). Recent proposals, however, suggest that action understanding cannot rely solely on sensorimotor processing of observed movements, but also requires inference of the higher-order intentions that guide those movements (de Lange et al., 2008; Jacob & Jeannerod, 2005). Our results provide strong support for models in which action intentions (in addition to movement intentions) play a crucial role in the observation and understanding of other people's actions.

Some researchers have suggested that imitation of observed movements, as measured by the movement-congruency effect, is automatic (and therefore needs to be inhibited in contexts in

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which people do not imitate other people). Indeed, a large amount of evidence favors this idea that imitation is automatic (Brass et al., 2005; Gallese, 2005; Liepelt et al., 2008; van Leeuwen et al., 2009). However, our findings contradict this notion in the context of movements that are guided by explicit action intentions. It should be noted that the majority of evidence for the automatic imitation of observed movements comes from paradigms that involve a fixed stimulus-response coupling in which explicit information about the coactors' action goals is irrelevant and absent (e.g., Brass et al., 2000; Sebanz et al., 2003). Our data suggest that when the action goals of a coactor are relevant to the observer's actions, processing of the observed movements is influenced by a top-down mechanism related to the observer's action intentions.

Even when other people's action goals are not directly relevant to what an observer does, the observer can generally infer their goals by monitoring the specific movements they perform. It may be that movement-congruency effects occur automatically when observers have no prior knowledge about the other person's action goals, but that they cease to occur when observers become cognizant of a discrepancy between their own goals and those of a coactor. Our findings relate to a recent goal-contagion hypothesis proposing that observation of other people's behavior can lead to persuasion and to adoption of the implied motivational goals (e.g., seeking casual sex; Aarts, Gollwitzer, & Hassin, 2004). Future investigations should focus on specifying the neuronal and cognitive mechanisms that underlie both sensorimotor and inferential processing, as well as the mechanisms that underlie the processing of motivational goals that drive the observed behavior of other people.

Conclusion

In this study, we examined the influence of action intentions on movement intentions in a social setting. We found an action-congruency effect, indicating that performance is influenced by the match between the conceptual action intentions of coacting individuals. Additionally, the typically reported movement-congruency effect was present only when participants acted with the same action intention as the coactor. Overall, our findings indicate that the influence of movement observation on movement execution is neither obligatory nor automatic. Rather, the results suggest that a dynamic interplay between action and movement intentions modulates the processing of the observed actions of other people.

Declaration of Conflicting Interests

The authors declared that they had no conflicts of interest with respect to their authorship or the publication of this article.

Supplemental Material

Additional supporting information may be found at http://pss.sagepub.com/content/by/supplemental-data

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