## RESEARCH ARTICLE

# Contextual determinants of the social-transfer-of-learning effect

Nadia Milanese · Cristina Iani · Natalie Sebanz · Sandro Rubichi

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Abstract A recent study (Milanese et al. in Cogn 116(1):15-22, 2010) showed that performing a spatial compatibility task with incompatible S-R links (i.e., the practice task) alongside a co-actor eliminates the Simon effect in a subsequent joint Simon task (i.e., the transfer task). In the present study, we conducted three experiments to individuate which elements of the practice task need to remain constant for this social-transfer-of-learning to occur. In Experiment 1, participants performed the practice task alongside a co-actor and the Simon task with a different co-actor; in Experiment 2, they performed the practice task alongside a co-actor and the Simon task with the same co-actor after exchanging their seats. Results showed a modulation of the joint Simon effect in Experiment 1 only. In Experiment 2, we found a regular joint Simon effect. These results indicate that, while co-actor identity is not crucial, other elements of the context, such as keeping the same position across tasks, are necessary for the social-transfer-of-learning to occur. On the whole, our data suggest that the social-transfer-of-learning effect is not tuned to a specific co-actor and depends on spatial parameters of the practice and transfer tasks.

N. Milanese · C. Iani Università di Modena e Reggio Emilia, Reggio Emilia, Italy

N. Sebanz Radboud University Nijmegen, Nijmegen, The Netherlands

S. Rubichi (⊠)
Dipartimento di Comunicazione e Economia,
Università di Modena e Reggio Emilia,
Via Allegri, 9, 42100 Reggio Emilia, Italy
e-mail: rubichi@unimore.it

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#### Introduction

Human action always occurs in context (Stoutland 1998), and changes in context may fundamentally alter perception, action, and cognition. The context in which our actions take place not only is fundamental for understanding the meaning of these actions (Bratman 1999; Leist 2007) but also, at least in some cases, predicts performance. Given the relevance of this topic, many studies have focused on the role of context on learning processes (e.g., Godden and Baddeley 1975; Milanese et al. 2010; Smith 1988; Smith and Vela 2001). While some of these studies found that context plays only a small role in human learning processes (e.g., Smith 1988), other studies demonstrated that our ability to transfer new information from a task to another is strongly influenced by context (Godden and Baddeley 1975; Milanese et al. 2010). In the classic Godden and Baddeley's study, for instance, participants had to learn lists of words in two different natural contexts, either on dry land or underwater. They were then asked to remember these words either in the same or in the other context. The authors found that words were better recalled in the same context, that is, participants who had learned the lists of words underwater remembered more words underwater than on dry land, and vice versa.

Most of the studies addressing the influence of context on learning processes have focused on performance in an individual context. However, much of what we do everyday, we do by interacting with other people in various social contexts. Sometimes, these social interactions involve unintentional coordination, such as when we mimic



others' postures, mannerisms, and behaviors (Chartrand and Bargh 1999) or start moving in synchrony (Shockley et al. 2003). Other times they include intentional cooperation between partners, as when we perform a task with someone else in order to reach a common goal (e.g., Knoblich and Jordan 2003; Richardson et al. 2007).

Social interaction plays a crucial role in learning too. Indeed, very often we learn new skills and knowledge by interacting with other people, not just when we act alone. In a recent study (Milanese et al. 2010), we investigated the relationship between implicit learning and performance in individual and social contexts. To this aim, we combined two established paradigms in cognitive psychology: the social version of the Simon task developed by Sebanz and colleagues (Sebanz et al. 2003, 2005) and the transfer-of-learning paradigm in spatial stimulus—response (S–R) correspondence tasks, introduced by Proctor and Lu (1999).

In the classical Simon task (Simon and Rudell 1967; for a review see Proctor and Vu 2006), stimuli are presented on the right or on the left of a fixation cross, and single participants are instructed to press one of two lateralized keys in response to a non-spatial stimulus feature, for instance, stimulus color (e.g., press left key when stimulus is red; press right key when stimulus is green). The Simon effect refers to the finding that performance is usually better (i.e., faster and more accurate responses) when stimulus and response positions correspond (e.g., red stimulus requiring left response appearing on the left) than when they do not correspond (e.g., red stimulus requiring left response appearing on the right). Theoretical accounts of the Simon effect largely agree that a conflict emerges at the stage of response selection (e.g., Rubichi and Pellicano 2004; Rubichi et al. 2000), between two alternative response codes, one generated on the basis of task instructions, and the other automatically activated through preexisting associations linking a stimulus to its spatially corresponding response (e.g., De Jong et al. 1994; Figliozzi et al. 2010).

This effect was also observed in a social version where each participant performed a go-nogo task alongside another participant performing the complementary go-nogo task (e.g., left person responding to red stimuli and right person responding to green stimuli). The importance of this finding can be better understood if one knows that the spatial correspondence effect between S–R locations was not found when participants performed the same go-nogo task alone, without the co-actor. According to Sebanz et al. (2003, 2005), the fact that the Simon effect emerged when participants performed two complementary go-nogo tasks provides evidence that participants represented their co-actor's task, which led to the integration of their own and the other's actions in action planning.

Proctor and Lu (1999) showed that it was possible to modulate performance on the Simon task (i.e., transfer

task), by asking participants to perform a spatial compatibility task with incompatible mappings in advance (i.e., practice task; see also Iani et al. 2009; Tagliabue et al. 2000; see Pellicano et al. 2010 for the influence of real-life motor training on performance in spatial tasks). In this transfer-of-learning paradigm, participants are required to perform a Simon task after performing a spatial compatibility task with incompatible mappings in which they are instructed to press a right key when a left stimulus is presented and a left key when a right stimulus is presented. The transfer-of-learning effect refers to the finding that the Simon effect is reduced, eliminated, or even reversed after a spatial compatibility task with incompatible mappings. According to Tagliabue et al., practicing a spatially incompatible mapping defines new non-corresponding S-R associations that affect performance even when participants are performing a different task (see also Marini et al. in press).

In our previous study (Milanese et al. 2010), we used Proctor and Lu's paradigm to investigate whether it is possible to obtain transfer-of-learning effects from a social to a social context (Experiment 1), from a social to an individual context (Experiment 3), and from an individual to a social context (Experiment 4). Results showed transfer-of-learning effects across joint task performance. That is, the incompatible practice performed in a social context affected performance in the subsequent Simon transfer task when the latter was performed jointly. We also found transfer effects from the individual practice task to the joint Simon task, but not vice versa. Together, these findings suggest that individually and jointly acquired S-R associations remain functional in joint settings, whereas jointly acquired S-R associations do not transfer to individual task performance. This finding raises new questions about how a partner's actions are represented. The fact that joint practice did not affect subsequent individual performance suggests that the partner's actions may not always be represented in a functionally equivalent way as one's own (Sebanz et al. 2003).

The aim of the current study was to further investigate the mechanisms underlying transfer effects across joint task performances. Our main question was: Which elements of the context need to remain constant for transfer between a jointly performed practice task and a subsequent joint transfer task to occur? In particular, we tested whether the identity of the co-actor during the practice task and the spatial relation of the two actors are crucial aspects of the social context. To this aim, we performed two experiments in which participants carried out a joint Simon task after performing a spatial compatibility task with incompatible S–R mappings. In Experiment 1, participants performed the practice task alongside a particular co-actor and then performed the joint Simon task sitting in the same position



but with a different co-actor. In Experiment 2, participants performed the spatial compatibility task alongside a co-actor and then switched sitting position with the co-actor for the joint Simon task. These manipulations allowed us to define the contextual determinants of the social-transfer-of-learning effect. They also allowed us to cast light on the nature of joint task performance that may be at the basis of joint action (see also Atmaca et al. submitted).

More precisely, an open issue in joint action regards the constituent information used by the human brain to build up shared representations. For the joint Simon effect in particular, it is not clear whether partner's actions are represented primarily considering either the social or spatial features (or both) of the jointly performed task. As regards the spatial features, the available evidence is controversial. In the study by Welsh et al. (2007), joint performance in the Simon task was assessed when a confederate either sat besides the participants or was believed to perform her/his part of the task in another room. The social Simon effect was observed only when the co-actor sat besides the participant. A recent study (Guagnano et al. 2010) suggests that co-representation effects in spatial tasks may be due to the formation of a spatial code produced by the presence of a performing co-actor, rather than being based on the representation of the co-actor's task. In that study, a joint Simon effect was obtained when participants were presented with two right/ left stimuli and asked to perform a detection task by pressing one of two keys based on stimulus color, simultaneously with a confederate responding with the alternative key to the alternative stimulus color. Thus, participants responded in each trial independently of the other's task and, as in the Simon task, stimulus location could be corresponding or non-corresponding with the participant location. According to Guagnano et al., the joint Simon effect emerged not because the two participants shared the representation of the task, but rather because each participant used the performing co-actor acting next to her/him as a reference point for spatially coding the alternative response.

There are, however, studies supporting the view that spatial relations are not crucial. For instance, Tsai et al. (2008) compared the social Simon effect when the participant believed to co-act either with an unseen human (as in Welsh et al. 2007) or with a computer program. The social Simon effect was present with the unseen human (see also Sebanz et al. 2005) and absent with the computer program. Thus, even if a performing co-actor is a crucial condition

for the occurrence of the social Simon effect (e.g., Sebanz et al. 2003; Guagnano et al. 2010), it is not clear whether and to what extent the representation of spatial relations between the co-actors is also needed.

With regard to social features, research indicates that the relation between co-actors (Iani et al. in press; Hommel et al. 2009) and individuals' mood (Kuhbandner et al. 2010) modulates the social Simon effect. In the study by Iani and colleagues, participants only showed a social Simon effect when they acted in cooperative contexts and not in competitive contexts. It is unknown, however, whether shared representations are tied to the particular identity of a co-actor, or whether social transfer effects as observed by Milanese et al. occur even when the co-actor changes between the practice and the transfer session.

The present work investigated the contextual determinants of the social-transfer-of-learning effect by assessing the relevance of similarity between spatial and social features of the practice and transfer tasks. If spatial features are prevalent, a transfer effect should be present in Experiment 1 (manipulation of co-actor identity) and absent in Experiment 2 (manipulation of the spatial relation between the co-actors). Alternatively, if social features are prevalent, results of the present study should show a modulation of the joint Simon effect in Experiment 2 and not in Experiment 1. If both social and spatial features are critical for the formation of shared representations, then we expect no modulation of the joint Simon effect in both Experiments 1 and 2.

### **Experiment 1**

Humans are highly flexible in how they accomplish joint actions and may be able to benefit from earlier experiences with different partners. However, given that learning is to a considerable extent context-dependent, effects of practicing a task jointly with a particular co-actor may not necessarily transfer to joint performance with a different partner.

In the current experiment, we investigated whether the social-transfer-of-learning effect (Milanese et al. 2010) can be replicated when participants perform the spatial compatibility task with a particular co-actor, but then change partner in the transfer task. When we perform a novel task with someone, we often implement knowledge previously acquired by acting with someone else, without impairments in performance. Given this consideration, one could assume that S–R links during performance of the joint spatial compatibility task are established independently of the partner's identity. Hence, a social-transfer-of-learning effect should occur when the transfer task is performed with a new partner, which would be reflected in a



<sup>&</sup>lt;sup>1</sup> With respect to the Milanese et al.'s (2010) study, the present study did not test the joint Simon effect in a baseline condition because we were interested in comparing the contextual features of the practice and transfer sessions without any confounds deriving from the baseline contextual features.

modulation (i.e., reduction, elimination, or inversion) of the joint Simon effect. However, it is also possible that source memory about the individual with whom one practiced a task is instrumental in activating jointly acquired S–R links. In this case, no social-transfer-of-learning effect should occur when participants change partners, and a regular joint Simon effect should be observed in the transfer task.

## **Participants**

Sixteen right-handed students (six men; age range: 19–44 years) of the University of Modena and Reggio Emilia took part in Experiment 1 for partial fulfillment of course credit. They had normal or corrected-to-normal vision and were naïve as to purpose of the study. Once selected, they were randomly paired.

### Apparatus and stimuli

As in our previous study (Milanese et al. 2010), stimuli in the spatial compatibility task were white solid squares  $(4.5 \times 4.5 \text{ cm})$ , whereas stimuli in the Simon task were red or green solid squares  $(4.5 \times 4.5 \text{ cm})$ . All stimuli were presented on a black screen, 9.5 cm to the left or to the right of a central fixation cross  $(1 \times 1 \text{ cm})$ . Stimulus presentation was controlled by an IBM computer. In both tasks, responses were executed by pressing the "z" or "-" key of a standard Italian keyboard with the left or right index finger, respectively. Viewing distance was about 60 cm.

## Design and procedure

The experiment consisted of two consecutive sessions: a practice session and a transfer session. Two pairs of participants came into the laboratory at the same time. The two couples were led into two different rooms to perform the practice session jointly, with pairs of participants sitting side-by-side in front of the same computer screen. In the spatial compatibility task, each participant was instructed to respond to only one of the two stimulus locations by pressing the contralateral key and refraining from responding when a stimulus appeared in the alternative position. Hence, half of the participants responded to left stimuli by pressing a right key, whereas the other half responded to right stimuli by pressing a left key. After a 5-min rest, the two couples were re-mixed so that each participant changed his or her partner. In the transfer session, participants performed a joint Simon task with the new partner. Participants were instructed to respond to only one stimulus color by pressing the key at their disposal. For half of the pairs, the instructions required to press the right key to red stimuli and the left key to green stimuli, whereas the other half was instructed to respond with the opposite mapping. Each participant in the couple kept the same response position in both practice and transfer tasks. That is, for instance, the participant sitting on the left and responding with the left key in the practice session sat on the left and responded with the left key also in the transfer session, even though both partner and room changed. In both tasks, a trial began with the presentation of the fixation cross at the center of a black background. After 1 s, the stimulus appeared to the right or to the left of fixation. In the spatial compatibility task, the stimulus remained visible for 600 ms, and the maximum time allowed for a response was 1,200 ms. In the Simon task, the stimulus remained visible for 800 ms and the maximum time allowed for a response was 1 s. In both tasks, a response terminated the trial. The inter-trial interval was 1 s.

The practice session consisted of 12 practice trials and 300 experimental trials that were divided into three blocks of 100 trials each. The transfer sessions consisted of 12 practice trials and 160 experimental trials that were divided into two blocks of 80 trials each.

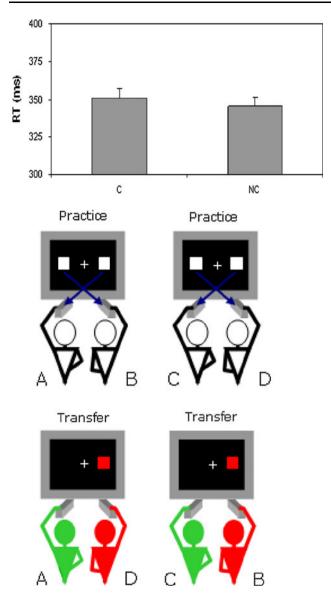
## Results and discussion

Since our predictions concern performance on the joint Simon task, for the current and the following experiments we report only the data for the Simon task (transfer session). Responses in the non-corresponding trials (345 ms) were faster than responses in corresponding trials (351 ms), F(1,15) = 4.33, P = .05,  $\eta_p^2 = .22$ . That is, there was a significant reversed joint Simon effect (see Fig. 1). Errors were comparable in corresponding (.78%) and non-corresponding (1.25%) trials, F(1,15) = .81, P = .38. RTs for correct responses and arcsin-transformed error rates were submitted to repeated-measures ANOVAs with correspondence (corresponding vs. non-corresponding) as within-subject factor.

These findings demonstrate that a spatially incompatible practice performed jointly influences subsequent performance on the joint Simon task even if the co-actor's identity changes. The observation that a spatially incompatible practice performed jointly with another person influenced performance on a subsequent joint Simon task confirms that jointly acquired S–R associations remain functional across different tasks (Milanese et al. 2010). Most importantly for the aim of the present study, these results suggest that S–R associations that are acquired during joint practice are not tied to the task partner's identity and can remain active in subsequent joint tasks performed with different co-actors.

Given that the co-actor's identity does not affect the social-transfer-of-learning effect, one might wonder





**Fig. 1** Mean reaction times (ms) for the transfer session of Experiment 1 as a function of stimulus–response correspondence. *Bars* indicate standard errors of the means. *C* corresponding, *NC* non-corresponding

whether the presence of another person performing the practice task is actually a necessary condition in order to obtain the modulation of performance on the subsequent joint Simon task. In Experiment 2 of Milanese et al.'s (2010) study, participants performed a joint Simon task before and after individually performing a spatially incompatible task, in which they responded to only one stimulus position. Results showed no modulation of the joint Simon effect in the transfer session compared to the joint Simon effect in the baseline session, suggesting that sharing the practice task with someone else who responds to the alternative stimulus position is necessary for establishing new, incompatible, S–R associations. However, the

absence of the co-actor in the practice task was highly salient in this study because participants had performed the joint Simon task just before. This may have led them to focus on their own part of the task. When performing the practice task individually without prior joint performance, it may be that participants imagine performing the whole task themselves, which may lead to a modulation of the ioint Simon effect in the transfer session. To rule out the possibility that individual practice modulates the joint Simon effect when the practice session is not preceded by a joint task, we ran a control condition with twenty new participants performing the practice alone before being paired to perform the joint transfer session with the Simon task. As expected, the social-transfer-of-learning effect did not occur when participants practiced a specific S-R link by themselves. Specifically, RTs were faster in corresponding than in non-corresponding trials (335 vs. 345 ms; F(1,19) = 6.94, P < .02,  $\eta_p^2 = .27$ ), showing a significant ioint Simon effect.

These results replicate Milanese et al.'s (2010) findings and allow us to assert that performing the practice task alongside another person is necessary for modulating performance on a subsequent joint Simon task.

## **Experiment 2**

Experiment 1 showed that the social-transfer-of-learning effect occurs even when participants perform the practice and transfer tasks with a different co-actor. This finding suggests that particular task rules may be internalized without coding for the specific identity of the co-actor acting upon these rules. The present experiment was performed to assess whether participants represent the practice task in terms of the spatial relations between themselves and the co-actor. If this is true, changing participants' spatial relation to each other should eliminate the social-transfer-of-learning effect. To test this prediction, pairs of participants in Experiment 2 performed a joint spatial compatibility task and then exchanged their positions in the transfer session. That is, the participant sitting on the left (and responding with the left key) in the practice session, carried out the joint Simon task sitting on the right (and responding with the right key), while the participant sitting on the right (and responding with the right key) in the practice session carried out the joint Simon task sitting on the left (and responding with the left key).

### **Participants**

Sixteen new students (two men; three left-handed; age range: 18–49 years) of the University of Modena and



Reggio Emilia took part in Experiment 2. They were recruited as in the previous experiment.

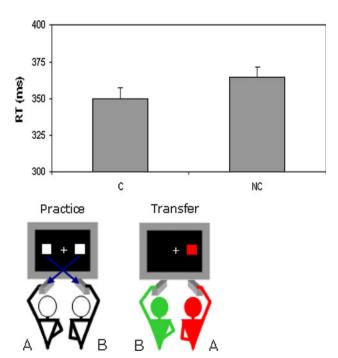
## Apparatus, stimuli, and procedure

Apparatus, stimuli, and procedure were the same as Experiment 1 with the following exceptions. Pairs of participants came into the laboratory and were asked to perform the practice session jointly, with participants sitting side-by-side in front of the same computer screen. After a 5-min rest, each participant sat again alongside his/her co-actor to perform the joint Simon task, but they exchanged positions.

#### Results and discussion

In both the ANOVAs on error rates and RTs, the main effect of correspondence was significant. Participants were more accurate in corresponding than in non-corresponding trials (.47% vs. 2.19%; F(1,15) = 5.24, P < .05). RTs were faster in corresponding than in non-corresponding trials (350 vs. 364 ms, F(1,15) = 31.251, P < .0001,  $\eta_p^2 = .68$ ), showing a significant joint Simon effect (see Fig. 2).

These results confirm the hypothesis that participants represent the joint spatial compatibility task in terms of the spatial relations between themselves and the co-actor.



**Fig. 2** Mean reaction times (ms) for the transfer session of Experiment 2 as a function of stimulus–response correspondence. *Bars* indicate standard errors of the means. *C* corresponding, *NC* non-corresponding



When participants' position changed from the practice to the transfer task, the social-transfer-of-learning effect did not occur (see the "General discussion" section for a detailed discussion of the implications of these results). To note, an alternative explanation could be considered. It is possible that changing participants' seats from the practice to the transfer task prevented the social transfer of learning because the participants' individual, rather than social, spatial relations changed. In fact, during the practice task, the participant acquires a spatially incompatible S-R association that concerns only one hand, exactly the one that, changing her/his position, she/he will not use in the transfer task. Of course, this could be an explanation for the lack of a transfer-of-learning effect found in the present experiment. There are, however, a couple of considerations that make the "individual" spatial relations explanation less likely than the "social" spatial relations explanation. The first is a general consideration: there are recent data on the social Simon effect with crossed and uncrossed limbs (Welsh 2009) which parallel earlier data on the individual Simon effect (Wallace 1971) in showing that responses in the Simon task are coded with respect to the location of the response and not in relation to the specific limb used and/or relative location of the person. The second consideration is more specific to the social-transfer-of-learning setting. Milanese et al. (2010) assessed whether shared prior practice modulates the way a single individual performs a subsequent individual Simon task (Experiment 3). Since the individual Simon effect was present, the authors concluded that shared practice does not shape individual performance. To substantiate this conclusion, RTs in the transfer session were analyzed as a function of stimulus position, response position, and practiced S-R link. Since no differences were found between the practiced and unpracticed S-R links, the conclusion was that the specific S-R link practiced by each participant during the practice session was not transferred to the Simon task. Even if in the present experiment, the experimental set-up is slightly different (because participants shared both the practice and the transfer session), this result weakens the "individual" spatial relations explanation.

## General discussion

In everyday life, we share many tasks with other people and we learn new skills and knowledge by interacting with them; very often, then, we are required to use these new abilities in subsequent joint tasks. A previous study (Milanese et al. 2010) has shown that a spatial compatibility task with an incompatible mapping performed jointly can modulate participants' performance on a subsequent Simon task, as long as the latter is performed jointly. In the present

study, we explored which elements of the context need to remain constant for the social transfer-of-learning effect to occur. This issue is not trivial, because sometimes the practice context (i.e., the context in which we implicitly acquire new knowledge) and the transfer context (i.e., the subsequent context in which we utilize the acquired knowledge) are not identical and may differ in several aspects (e.g., Godden and Baddeley 1975; Milanese et al. 2010).

To this aim, we conducted two experiments in which participants were required to share a spatial compatibility task with incompatible mappings and then to transfer to a joint Simon task. In Experiment 1, participants performed the spatial compatibility task with a particular co-actor and the Simon task with a different partner, while in Experiment 2, both tasks were executed with the same partner but participants exchanged their sitting positions in the transfer task. In Experiment 1, the joint Simon effect was reversed, indicating that the new S-R associations acquired during the practice task were not influenced by the co-actor identity and remained active in a subsequent joint task. We also ran a control condition which confirmed that sharing a practice task with a co-actor is crucial for the transfer-oflearning in social settings (see also Milanese et al. 2010). No modulation of the joint Simon effect was present in Experiment 2, suggesting that, in the present paradigm, task representations are tied to the spatial relation between the two co-actors sharing the practice task (e.g., "the person to my left responds to stimuli on the right"). Indeed, when participants switched positions to perform the Simon task, their spatial relation changed (e.g., "the person who was to my left is now to my right") and, consequently, implicit learning derived from the practice task did not transfer to the subsequent transfer task.

On the whole, the results of the present study suggest that social-transfer-of-learning is not tuned to a specific co-actor but depends on the spatial parameters of the practice and transfer tasks. The results provide insights on the way we represent another's task in particular joint action situations. On the one hand, the absence of a modulation of the joint Simon effect when participants changed their position in the transfer session (Experiment 2) speaks in favor of a crucial role of spatial information in the generation of shared task representations. On the other hand, the modulation obtained when participants performed the practice task with a particular co-actor and the transfer task with a different partner (Experiment 1) indicates that some social features (such as co-actor identity) might play a minor role for the occurrence of the social transfer-of-learning effect (note that the social relation and the valence/quality of the interactions between co-actors may, however, matter; e.g., Iani et al. in press; Hommel et al. 2009).

To conclude, the present data support the view that the constituent information used by the human brain to build shared representations at the basis of joint action in spatial tasks is primarily spatial in nature. The occurrence of the social Simon effect when the spatial relations between the co-actors are not evident (as when the co-actor is not visible, Tsai et al. 2008; Sebanz et al. 2005) urges future research to test whether co-representation in spatial tasks is based on pure spatial representations (Guagnano et al. 2010) or on shared representations which include the other's task.

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