Available online at www.sciencedirect.com
SCIENCE DIRECT
COGNITION
Cognition 88 (2003) B11–B21
www.elsevier.com/locate/cognit

Brief article

Representing others' actions: just like one's own?

Natalie Sebanz*, Günther Knoblich, Wolfgang Prinz

Max Planck Institute for Psychological Research, Amalienstrasse 33, 80799 Munich, Germany

Received 9 December 2002; accepted 13 February 2003

Abstract

Previous research has shown that observing others' actions can affect individual performance of the same actions. In the present study, we developed a new paradigm to investigate whether and how complementary actions at the disposal of another agent are represented and influence one's own actions. A spatial compatibility task was distributed among two people so that each participant took care of one of two responses. The identical task was performed alone and alongside another participant. There was a spatial compatibility effect in the group setting only. It was similar to the effect obtained when one person took care of both responses. This result suggests that one's own actions and others' actions are represented in a functionally equivalent way.

Keywords: Action representation; Joint action; Preception-action link; Social cognition; Ideomotor theory; Spatial compatibility

1. Introduction

Many of our actions are not carried out in isolation, but are influenced by the social context and, in particular, by the actions performed by others. Two main areas of research that deal with the issue of how others influence our actions can be identified. On the one hand, research on social facilitation investigates how the presence of others or co-acting with others affects performance in a general way. On the other hand, ideomotor approaches deal with the question of how observing others' actions induces in us specific tendencies to engage in these actions ourselves. Although these two lines of research seem quite diverse, both investigate situations in which two or more agents carry out the same actions.

However, in many situations, people do not perform identical actions, but carry out complementary actions as they take care of different aspects of a task. Our aim in the

* Corresponding author. Tel.: +49-89-38602-243; fax: +49-89-38602-190.
E-mail address: sebanz@psy.mpg.de (N. Sebanz).

0010-0277/03/$ - see front matter © 2003 Elsevier Science B.V. All rights reserved.
doi:10.1016/S0010-0277(03)00043-X

present study was to investigate whether and how complementary actions at the disposal of another agent are represented and influence one's own actions. A way to test this assumption is to distribute a task with two action alternatives among two individuals and compare task performance when they act alongside each other and when each individual is alone. Before reporting two experiments addressing this issue, we will briefly review earlier research on social facilitation and ideomotor action and derive predictions for situations in which two agents perform complementary actions.

1.1. Social context and individual action

Social facilitation demonstrates that the presence of others can affect individual performance. The typical finding is that simple task performance is facilitated, whereas complex task performance is impaired (Aiello & Douthitt, 2001; Guerin, 1993). The traditional explanation has been that the mere presence of others elevates drive levels (Zajonc, 1965). Other accounts have focused on social comparison processes (Carver & Scheier, 1981), or shifts in cognitive processing caused by the distracting presence of others (Baron, 1986). All of these accounts imply that social facilitation effects are not moderated by the specific actions carried out by others. Rather, the mere presence of others often leads to similar effects as when a group of individuals engages in the same actions (Bond & Titus, 1983).

In contrast, ideomotor theories (Greenwald, 1970; James, 1890; Jeannerod, 1999; Prinz, 1997) predict that the specific actions of others can selectively affect one's own actions, as observed in mimicry (Chartrand & Bargh, 1999), priming (Wegner & Bargh, 1998), and imitation (Brass, Bekkering, & Prinz, 1999; Iacoboni et al., 1999; Prinz & Meltzoff, 2002). According to these theories, actions are coded in terms of the perceptual events resulting from them. Observing an event that regularly resulted from one of one's own actions induces a tendency to carry out this action. Thus, perceiving events produced by others' actions should activate the same representational structures that govern one's own planning and control of these actions (Jordan & Knoblich, in press; Knoblich & Jordan, 2002, in press).

1.2. The current study

Both theories of social facilitation and ideomotor theories suggest that others' actions affect one's own. Whereas the former predict general effects that should occur independently of the similarity of the two actions performed, the latter predict specific effects when the same actions are performed. It has not been investigated so far what happens when one acts alongside another person performing not the same, but a complementary action. For this situation, theories of social facilitation suggest that performance in a group will be better than individual performance given that the task is easy. Ideomotor theories suggest that actions at the other's disposal might become represented and have a specific impact on one's own acting. The reason is that observing or knowing about the actions somebody else can perform might activate event representations that are functionally equivalent to the event representations used in one's own control of these actions.

To test these assumptions we used a variant of a spatial compatibility RT task (Craft & Simon, 1970; Simon, 1990). In this task, one carries out a spatial two-choice response to a relevant stimulus feature (e.g. color) that is presented along with an irrelevant spatial stimulus feature. The basic finding is that responses are faster when there is an overlap between the irrelevant stimulus dimension and the response, and slower when the two conflict.

There is wide agreement that this compatibility effect has its basis primarily on a response level. According to the Kornblum, Hasbroucq, and Osman (1990) dimensional overlap model, this effect emerges because the irrelevant spatial dimension of the stimulus overlaps with the spatial dimension of the responses. Thus, the response corresponding to the spatial information provided by the stimulus will be automatically activated. Responses are speeded when the response is the same as the one indicated by the relevant stimulus dimension, but slowed when the two conflict (see also Hommel & Prinz, 1997). Normally, spatial compatibility effects are only observed in two-choice and not in go-nogo RT tasks, in which only one stimulus requires a response (for an exception, see Hommel, 1996).

2. Experiment 1

To address our question of whether observing or knowing about others' actions might affect one's own actions we compared performance on the Simon task in three different conditions. Participants always responded to one color with a right and to the other with a left button press. The irrelevant spatial dimension was provided by a pointing stimulus. In the two-choice condition, a single individual took care of both responses. In the joint go-nogo condition, the task was distributed among two individuals. Each person responded to only one of the two colors (see Fig. 1a). In the individual go-nogo condition, the identical go-nogo task was performed alone (see Fig. 1b).

The following predictions can be derived for the three different conditions. For the two-choice condition, the findings should be the same as in any standard Simon task. RTs should be faster on compatible trials, where the irrelevant spatial dimension corresponds to the response, compared to incompatible trials, where there is no such correspondence. For the critical joint go-nogo condition, there are three possible outcomes. First, the other's actions might not be represented at all and will therefore not affect one's own actions. Thus, performance should be the same as in the individual go-nogo condition. Second, social facilitation predicts a general effect of the other's presence: the simple go-nogo response should be faster in groups. Finally, ideomotor theory predicts a specific effect of the other's presence: if the other's actions are represented in a functionally similar way as one's own, performance in the joint go-nogo condition should be similar to the two-choice condition where both responses are at one's own disposal. Thus, in the group setting, there should be a spatial compatibility effect. This effect should not appear when one performs the identical go-nogo task alone, because in that case the other action alternative is not expected to be automatically activated.

2.1. Method

2.1.1. Participants

Forty participants (27 female) recruited by advertising at the University of Munich, Germany took part in Experiment 1. They ranged in age from 18 to 35 years. All had normal or corrected-to-normal vision. Half of the participants were assigned to the two-choice condition. The other half performed both the individual and the joint go-nogo condition.

2.1.2. Materials and procedure

Participants assigned to the go-nogo conditions carried out exactly the same go-nogo task alone and together with a partner. The order of condition (joint go-nogo vs. individual go-nogo) was counter-balanced across pairs of participants. In the two-choice condition, participants sat centrally in front of the screen. In the joint go-nogo condition, they sat side-by-side in front of a monitor. In the individual go-nogo condition, an empty chair remained beside each participant.

Participants responded to digital photographs of a right hand pointing to the left, to the right or straight. On the index finger there was a ring colored red or green (see Fig. 1). The stimuli were presented centrally and the ring always appeared at the same location. Picture size was about 15×13 visual degrees horizontally and vertically. In the two-choice

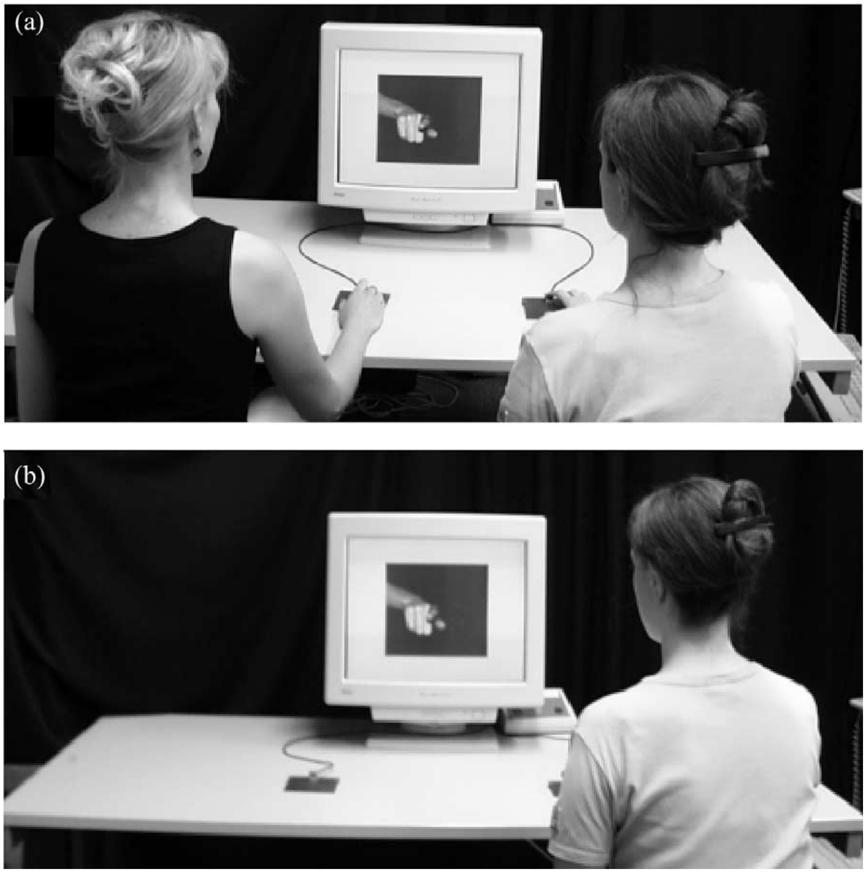

Fig. 1. Setting in the joint go-nogo task (a), and in the individual go-nogo task (b).

condition, participants were instructed to respond to one ring color with a left and to the other with a right button press. In the go-nogo conditions, each participant was instructed to respond to one of the two colors by pushing a single button. In each condition, participants completed four blocks of 126 trials presented in random order.

Stimulus presentation and data collection were controlled by an Apple Power PC. The pictures were presented on an Apple 21 inch monitor (resolution 1024×768 pixels). Button presses were recorded with a PsyScope button box (Cohen, Mac Whinney, Flatt, & Provost, 1993).

2.2. Results and discussion

Responses were coded as compatible (finger points towards the button that should be pressed), incompatible (finger points towards the button that should not be pressed), and neutral (finger points straight). The error rate in the two-choice condition was 2.9%, in the joint go-nogo condition 1.7%, and in the individual go-nogo condition 1.6%. Error trials were excluded from further analyses.

Fig. 2 shows the results. A within-subjects ANOVA with the factor Compatibility revealed a significant main effect for Compatibility for the two-choice condition ($F(2, 30) = 4.3$, $P < 0.05$). In order to assess the statistical significance of the RT differences observed for the go-nogo conditions, a within-subjects 2×3 ANOVA with the factors Condition (individual go-nogo and joint go-nogo), and Compatibility (compatible, neutral, and incompatible) was conducted. There was no significant difference in RTs between the individual and the joint condition ($F(1, 19) = 0.6$, $P = 0.45$). The main effect for Compatibility was significant ($F(2, 38) = 13.4$, $P < 0.001$). There was also a significant interaction between the factors Condition and Compatibility ($F(2, 38) = 8.3$, $P < 0.001$).

To compare the compatibility effects in the joint go-nogo with the two-choice condition, we conducted a mixed 2×3 ANOVA with the between factor Condition (joint go-nogo vs. two-choice) and the within factor Compatibility. There was a significant main effect for Condition ($F(1, 38) = 112.2$, $P < 0.001$). RTs were faster in the joint go-nogo condition. Furthermore, there was a significant main effect for Compatibility ($F(2, 76) = 15.2$, $P < 0.001$). The interaction was not significant ($F(2, 76) = 0.47$, $P = 0.63$).

In conclusion, Experiment 1 showed that one and the same go-nogo task is performed differently depending on whether one acts alone or alongside another agent performing a complementary action. The predictions from social facilitation theory were not confirmed. However, the results provide first evidence supporting the predictions of ideomotor theory. The result that RTs in the joint go-nogo condition were faster on compatible than on incompatible trials, just as in the two-choice condition, can be explained by the assumption that the action at the other's disposal was represented and subject to automatic response activation by the irrelevant stimulus dimension.

3. Experiment 2

However, another way to account for the joint compatibility effect is to assume that differences in RTs were caused by socially modulated changes in the processing of the stimuli without the other’s actions being represented. In Experiment 2 we addressed this issue by varying the context in the joint go-nogo task in two ways, and comparing performance to the corresponding individual go-nogo task. There were two groups. Participants in the presence group carried out the joint go-nogo task alongside a confederate who merely sat beside them. If the joint compatibility effect is due to socially modulated stimulus processing in the presence of another person, it should still be observed in this situation. If the action at the other’s disposal is represented and subject to automatic response activation by the irrelevant stimulus dimension one would not expect a joint compatibility effect.

Participants in the no-feedback group carried out the joint go-nogo task alongside each other but received neither visual nor auditory feedback about the other’s actions. If the action at the other’s disposal is represented right from the start (following the instruction) one would expect a joint compatibility effect to occur. If the action at the other’s disposal

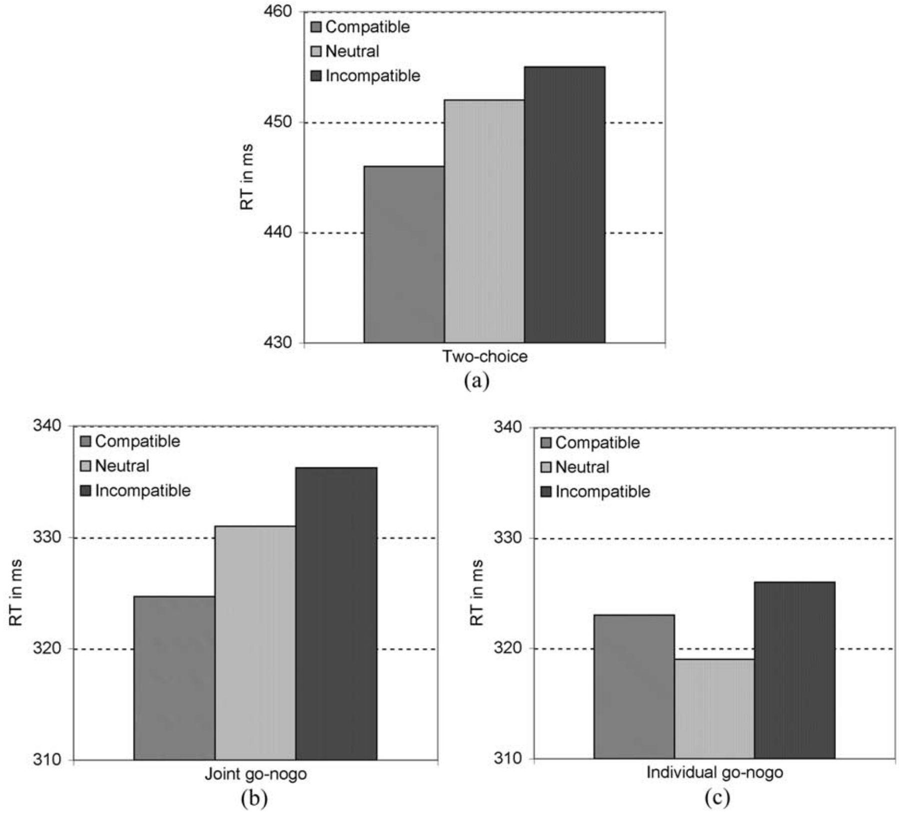

Fig. 2. Mean RTs on compatible, neutral, and incompatible trials in the two-choice condition (a), the joint go-nogo condition (b), and the individual go-nogo condition (c). Mean RTs in the two-choice condition were 446 ms (SD = 40 ms), 452 ms (SD = 40 ms), and 455 ms (SD = 43 ms), in the joint go-nogo condition 325 ms (SD = 32 ms), 331 ms (SD = 32 ms), and 336 ms (SD = 32 ms), and in the individual go-nogo condition 323 ms (SD = 32 ms), 319 ms (SD = 30 ms), and 326 ms (SD = 28 ms).

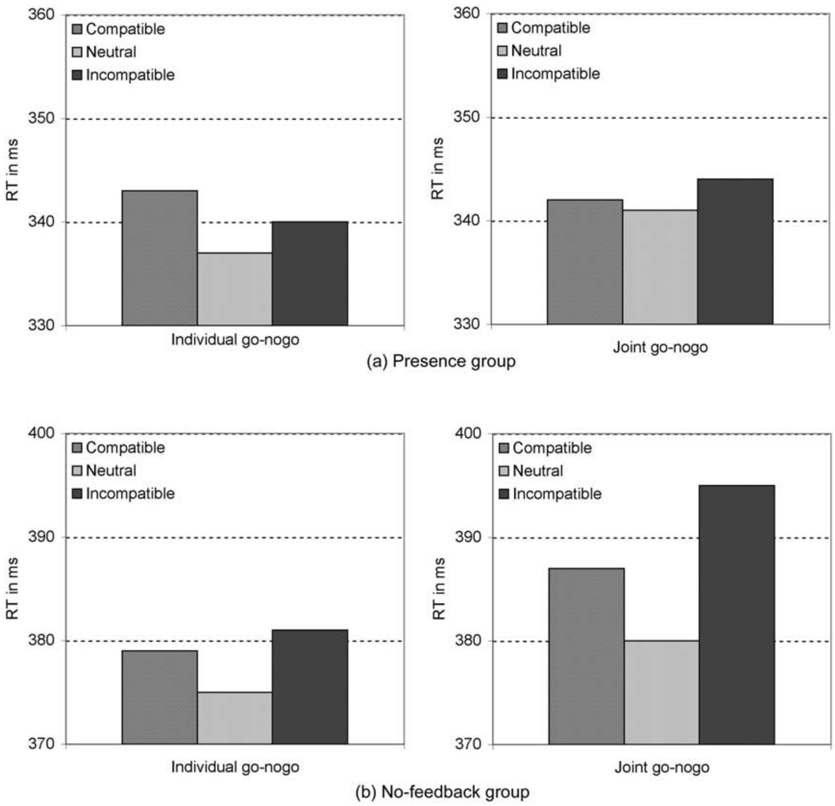

Fig. 3. Mean RTs on compatible, neutral, and incompatible trials in the presence group (a), and the no-feedback group (b). The mean RTs for the individual go-nogo condition in the presence group were 343 ms (SD = 66 ms), 337 ms (SD = 68 ms), and 340 ms (SD = 63 ms). In the joint go-nogo condition, they were 342 ms (SD = 56 ms), 341 ms (SD = 53 ms), and 344 ms (SD = 51 ms). The mean RTs for the no-feedback group were 379 ms (SD = 36 ms), 375 ms (SD = 34 ms), and 381 ms (SD = 31 ms) in the individual go-nogo condition. In the joint go-nogo condition, they were 387 ms (SD = 34 ms), 380 ms (SD = 30 ms), and 395 ms (SD = 34 ms).

is represented because continuous feedback about the other's actions is received the effect should not be present. Neither in the presence nor in the no-feedback group was a compatibility effect in the individual go-nogo task expected.

3.1. Method

3.1.1. Participants

Thirty-six participants (26 female) took part in Experiment 2. They ranged in age from 17 to 31 years. All had normal or corrected-to-normal vision. Twenty were assigned to the presence group, and 16 to the no-feedback group.

3.1.2. Material and procedure

These were the same as in the go-nogo conditions in Experiment 1 with the following exceptions. Participants in the presence group carried out their part of the joint go-nogo task while a confederate sat beside without acting. The individual condition was exactly the same as in Experiment 1. Participants in the no-feedback group wore ear-plugs and headphones to make button presses inaudible. The hand used to respond rested in a box and was invisible. The picture containing the color cue automatically disappeared after 500 ms. The individual go-nogo condition was exactly the same as the joint go-nogo condition except for the presence of the other participant.

3.2. Results and discussion

The error rate for the presence group was 1.1% in the individual condition, and 1.6% in the joint condition. For the no-feedback group, it was 1.8% in the individual condition, and 1.1% in the joint condition.

Fig. 3 shows the results of Experiment 2. A mixed $2 \times 2 \times 3$ ANOVA with the factors Group (presence vs. no-feedback), Condition (individual go-nogo and joint go-nogo), and Compatibility (compatible, neutral, and incompatible) revealed a significant main effect for the factor Group ($F(1,34) = 6.7$, $P < 0.05$). RTs in the no-feedback group were slower than in the presence group. The main effect for Compatibility was significant ($F(2,68) = 19.5$, $P < 0.001$). There was no significant main effect for Condition ($F(1,34) = 2.6$, $P = 0.12$). There were no significant two-way interactions, but there was a significant three-way interaction between Group, Condition, and Compatibility ($F(2,68) = 3.4$, $P < 0.05$). Post-hoc tests (Newman–Keuls) confirmed that the only significant difference between compatible and incompatible trials was present in the joint go-nogo condition of the no-feedback group.

The pattern of results suggests that the mere presence of another is not enough to obtain a joint compatibility effect. However, continuous feedback about the other's actions is not necessary. It seems that the other's actions become part of one's action plan right from the start. In other words, the way the task is implemented seems to be a consequence of the instructions rather than of continuous feedback.[1]

4. General discussion

Our results provide evidence that actions at the disposal of another agent are represented and have an impact on one's own actions, even when the task at hand does not require taking the actions of another person into account. In our view, the finding of a spatial compatibility effect in a joint go-nogo task similar to the effect usually observed in a two-choice RT task can best be explained as follows: given that the action alternative at the

[1] Unexpectedly, there was a general RT advantage for the neutral stimulus. Given that this advantage was present in all conditions this does not seem to pose a problem for our interpretation that a joint compatibility effect was selectively present in the joint condition of the no-feedback group. A possible ad-hoc explanation for the fast RTs on neutral trials is that there is no (middle) action or (middle) person the neutral stimulus refers to and hence, no relation is processed.

other's disposal is represented, the spatial dimension of the two responses is also represented and thus overlaps with the irrelevant spatial dimension of the stimulus. Hence, just as in a normal Simon task, the response corresponding to the spatial information provided by the stimulus is automatically activated. For instance, when the finger points left, the left response is activated, no matter whether it is at one's own disposal or at the other's. When the response is the same as the one indicated by the relevant stimulus dimension, there is no response conflict. In this case, the person the finger points at is also the person to respond. However, when the irrelevant spatial information conflicts with the spatial response to be given, response conflict arises (Wallace, 1971). For this reason, people take longer to respond when the stimulus points at the other person and are faster when the stimulus points at themselves.

One open question is whether the joint compatibility effect observed in our experiments is specific to pointing stimuli, which usually appear in social contexts (Butterworth, 1997; Moore & D'Entremont, 2001), or whether it generalizes to more abstract spatial stimuli. Pilot studies indicate that joint compatibility effects can also be obtained for arrows, supporting the second alternative. Further experiments are needed to determine additional boundary conditions for joint spatial compatibility effects to occur, especially on the stimulus side.

Our results add evidence to an expanding literature suggesting that social interactions depend on a close link between perception and action systems (Barresi & Moore, 1996; Jordan & Knoblich, in press; Knoblich & Jordan, 2002, in press). One way to conceptualize this link is the postulate of ideomotor theory that at a certain representational level the actions planned and the actions observed are functionally equivalent (Knoblich & Flach, 2001). Direct evidence for this assumption is provided by recent functional magnetic resonance imaging (fMRI) studies and positron emission tomography (PET) studies. Several areas, such as premotor cortex (Gallese, Fadiga, Fogassi, & Rizzolatti, 1996; Iacoboni et al., 1999; Rizzolatti, Fogassi, & Gallese, 2001), posterior parietal cortex (Ruby & Decety, 2001) and the cerebellum (Grossman et al., 2000), are activated when an action is imagined or carried out as well as when the same action is observed in others (Blakemore & Decety, 2001; Grèzes & Decety, 2001). Thus, it is tempting to speculate that the joint compatibility effect observed in our experiments arises on a level at which one's own actions and others' actions are represented in a functionally equivalent way. It seems worthwhile to conduct neurophysiological studies involving groups to investigate whether this speculation is justified.

Acknowledgements

We thank Irmgard Hagen, Jana Hiller, Birte Kröger, Veronika Schradi, and Charlotte Trenk-Hinterberger for their help in collecting the data.

References

Aiello, J. R., & Douthitt, E. A. (2001). Social facilitation from Triplett to electronic performance monitoring. *Group Dynamics: Theory, Research, and Practice*, *5*, 163–180.

Baron, R. S. (1986). Distraction-conflict theory: progress and problems. *Advances in Experimental Social Psychology*, *19*, 1–36.

Barresi, J., & Moore, C. (1996). Intentional relations and social understanding. *Behavioral & Brain Sciences*, *19*, 107–154.

Blakemore, S. -J., & Decety, J. (2001). From the perception of action to the understanding of intention. *Nature Reviews Neuroscience*, *2*, 561–567.

Bond, C. F., & Titus, L. J. (1983). Social facilitation: a meta analysis of 241 studies. *Psychological Bulletin*, *94*, 265–292.

Brass, M., Bekkering, H., & Prinz, W. (1999). Movement observation affects movement execution in a simple response task. *Acta Psychologica*, *106*, 3–22.

Butterworth, G. E. (1997). What is special about pointing? In F. Simion & G. E. Butterworth (Eds.), *The development of sensory motor and cognitive capacities in early infancy: from perception to cognition* (pp. 171–187). Hove: Psychology Press.

Carver, C. S., & Scheier, M. F. (1981). The self attention induced feedback loop and social facilitation. *Journal of Experimental Social Psychology*, *17*, 545–568.

Chartrand, T. L., & Bargh, J. A. (1999). The chameleon effect: the perception-behavior link and social interaction. *Journal of Personality and Social Psychology*, *76*, 893–910.

Cohen, J. D., Mac Whinney, B., Flatt, M., & Provost, J. (1993). PsyScope: an interactive graphic system for designing and controlling experiments in the psychology laboratory using Macintosh computers. *Behavior Research Methods, Instruments, & Computers*, *25*, 257–271.

Craft, J. L., & Simon, J. R. (1970). Processing symbolic information from a visual display: interference from an irrelevant directional cue. *Journal of Experimental Psychology*, *83*, 415–420.

Gallese, V., Fadiga, L., Fogassi, L., & Rizzolatti, G. (1996). Action recognition in the premotor cortex. *Brain*, *119*, 593–609.

Greenwald, A. G. (1970). Sensory feedback mechanisms in performance control: with special reference to the ideo-motor mechanism. *Psychological Review*, *77*, 73–99.

Grèzes, J., & Decety, J. (2001). Functional anatomy of execution, mental simulation, observation, and verb generation of actions: a meta-analysis. *Human Brain Mapping*, *12*, 1–19.

Grossman, E., Donnelly, M., Price, R., Pickens, D., Morgan, V., Neighbor, G., & Blake, R. (2000). Brain areas involved in perception of biological motion. *Journal of Cognitive Neuroscience*, *12*, 711–720.

Guerin, B. (1993). *Social facilitation*. Cambridge: Cambridge University Press.

Hommel, B. (1996). S-R compatibility effects without response uncertainty. *The Quarterly Journal of Experimental Psychology*, *49A*, 546–571.

Hommel, B., & Prinz, W. (1997). Theoretical issues in stimulus-response compatibility: editors' introduction. In B. Hommel & W. Prinz (Eds.), *Theoretical issues in stimulus-response compatibility* (pp. 3–11). Amsterdam: Elsevier.

Iacoboni, M., Woods, R. P., Brass, M., Bekkering, H., Mazziotta, J. C., & Rizzolatti, G. (1999). Cortical mechanisms of human imitation. *Science*, *286*, 2526–2528.

James, W. (1890). *The principles of psychology (2 vols.)*, New York: Holt.

Jeannerod, M. (1999). The 25th Bartlett Lecture: to act or not to act: perspectives on the representation of actions. *The Quarterly Journal of Experimental Psychology, Human Experimental Psychology*, *52A*, 1–29.

Jordan, J. S., & Knoblich, G. (in press). Spatial perception and control. *Psychonomic Bulletin & Review*.

Knoblich, G., & Flach, R. (2001). Predicting action effects: interactions between perception and action. *Psychological Science*, *12*, 467–472.

Knoblich, G., & Jordan, S. (2002). The mirror system and joint action. In M. Stamenov & V. Gallese (Eds.), *Mirror neurons and the evolution of brain and language* (pp. 115–124). Amsterdam: John Benjamins.

Knoblich, G., & Jordan, S. (in press). Action coordination in groups and individuals: learning anticipatory control. *Journal of Experimental Psychology: Learning, Memory, and Cognition*.

Kornblum, S., Hasbroucq, T., & Osman, A. (1990). Dimensional overlap: cognitive basis for stimulus-response compatibility: a model and taxonomy. *Psychological Review*, *97*, 253–270.

Moore, C., & D'Entremont, B. (2001). Developmental changes in pointing as a function of attentional focus. *Journal of Cognition and Development*, *2*, 109–129.

Prinz, W. (1997). Perception and action planning. *European Journal of Cognitive Psychology*, *9*, 129–154.

Prinz, W., & Meltzoff, A. N. (2002). An introduction to the imitative mind and brain. In W. Prinz & A. N.

Meltzoff (Eds.), *The imitative mind: development, evolution, and brain bases* (pp. 1–15). New York: Cambridge University Press.

Rizzolatti, G., Fogassi, L., & Gallese, V. (2001). Neurophysiological mechanisms underlying the understanding and imitation of action. *Nature Reviews Neuroscience*, *2*, 661–670.

Ruby, P., & Decety, J. (2001). Effect of subjective perspective taking during simulation of action: a PET investigation of agency. *Nature Neuroscience*, *4*, 546–550.

Simon, J. R. (1990). The effects of an irrelevant directional cue on human information processing. In R. W. Proctor & T. G. Reeve (Eds.), *Stimulus-response compatibility: an integrated perspective* (pp. 31–86). Amsterdam: North-Holland.

Wallace, R. J. (1971). S-R compatibility and the idea of a response code. *Journal of Experimental Psychology*, *88*, 354–360.

Wegner, D. M., & Bargh, J. A. (1998). Control and automaticity in social life. In D. T. Gilbert, S. T. Fiske & G. Lindzey (Eds.), *The handbook of social psychology* (pp. 446–496). Boston, MA: McGraw-Hill.

Zajonc, R. B. (1965). Social facilitation. *Science*, *149*, 269–274.