



Grasping the other's attention: The role of animacy in action cueing of joint attention

Oliver Lindemann^{*}, Pines Nuku, Shirley-Ann Rueschemeyer, Harold Bekkering

Donders Institute for Brain, Cognition and Behaviour, Radboud University, The Netherlands

ARTICLE INFO

Article history:

Received 24 June 2010

Received in revised form 10 December 2010

Available online 5 January 2011

Keywords:

Joint spatial attention

Action observation

Grasp cueing

Social cognition

ABSTRACT

The current experiment investigates the role of animacy on grasp-cueing effects as investigated in joint attention research. In a simple detection task participants responded to the colour change of one of two objects of identical size. Before the target onset, we presented a cueing stimulus consisting of either two human hands with a small and a large grip aperture (animate condition) or two comparable U-shaped figures with small and large aperture (inanimate condition). Depending on the size of the objects and the arrangement of the apertures (i.e., large aperture to the left and small aperture to the right or vice versa), either the left or right object matched the grasping hand or U-shapes. Our data show that biological grasping actions modulate the observer's attention whereas the perception of inanimate stimuli does not result in a comparable cueing effect. This strong impact of animacy on attentional priming suggests that grasp cueing represents a marker of a joint attention mechanism that involves spontaneous simulation of the observed motor behaviour.

© 2011 Elsevier Ltd. All rights reserved.

1. Introduction

How we understand others' actions and how this knowledge affects our own behaviour are crucial issues in understanding the human capacity to observe, interpret, recognize, and react to the surrounding environment. It has been argued that social signals, such as pointing and grasping, disclose the initial stages of another's intentions, rendering these signals reliable indicators of another's attentional region of interest (Allison, Puce, & McCarthy, 2000; Tomasello, 2000). Despite the fact that the observation of motor behaviour is relevant as an attentional cue, most studies in this domain focus on how action observation affects the observer's own motor behaviour (or motor system) rather than how it affects the observer's attention. Behavioural as well as neuroimaging data suggest that the passive observation of human actions leads to activation of cognitive representations and brain areas that are involved in motor preparation and execution (Brass, Bekkering, Wohlschläger, & Prinz, 2000; Fadiga, Fogassi, Pavesi, & Rizzolatti, 1995; Iacoboni et al., 1999; Stürmer, Aschersleben, & Prinz, 2000; Vogt, Taylor, & Hopkins, 2003). Brass and colleagues (2000) showed for instance that participants are faster to initiate a finger movement when observing a person moving the same finger than when observing an actor moving a

different finger. Similarly, others have shown that the observation of grasping movements facilitates the preparation of responses that are congruent to the observed grasping (Craighero, Bello, Fadiga, & Rizzolatti, 2002). Together, these studies suggest the existence of an automatic cognitive mechanism that transforms visual inputs into motor predictions, which in turn affects motor behaviour on-line. Results showing that action observation activates motor codes in the brain have been consistently interpreted as evidence for a "direct matching" system that reflexively simulates observed motor movement (Brass et al., 2000; Gallese, Fadiga, Fogassi, & Rizzolatti, 1996).

In everyday life, we seem to build up strong associations between objects and the hand shapes typically used to interact with them. It could be shown, for instance, that these associations between objects and prototypical postures play an important role in semantic representations of action. Evidence for this has been provided by Klatzky, Pellegrino, McCloskey, and Doherty (1989); see also McCloskey, Klatzky, and Pellegrino (1992), who showed that semantic judgements about action-object phrases (e.g., "pick a grape") are performed quickly if they are preceded by a cue representing a specific associated hand shape (e.g., "pinch").

Recently, Fischer and colleagues (Fischer, Prinz, & Lotz, 2008; Fischer & Szymkowiak, 2004; Tschentscher & Fischer, 2008) investigated whether the observation of grasping actions also affects the attentional system of the observer. By using standard methods of attention research such as simple detection tasks (e.g., Posner, 1980), Fischer and colleagues provided evidence suggesting that perception of grasping postures results in obligatory shifts of

^{*} Corresponding author. Address: Donders Institute for Brain, Cognition and Behaviour P.O. Box 9104, 6500 HE Nijmegen, The Netherlands.

E-mail addresses: o.lindemann@donders.ru.nl, lindemann@donders.ru.nl (O. Lindemann).

attention to the predicted goal of the observed action (see also Girardi, Lindemann, & Bekkering, 2010). For example, Fischer et al. (2008) presented visual probes over small and large objects after the participations saw a precision or power grip posture. Although the posture cues were uninformative, stimulus detection was faster if the target appeared over the object that matched the size of the grasp aperture (i.e., if the target appeared over small object following observation of a precision grip and vice versa). The data demonstrate thus an attentional shift to the aperture-congruent object. The authors interpret their findings as evidence for a “joint attention” mechanism, which is driven by a rapid and spontaneous mental simulation of the others motor action. It remains unclear however, whether the aperture-congruency effect is indeed driven by the congruency between the action goal of an animate being (i.e., a specific hand posture) and a target object, or alternatively reflects a congruency effect between lower level perceptual cues between hand posture and object (e.g., similar size). It needs to be emphasized that stimulus animacy and the subjects belief that they are observing an intentional agent are crucial for the interpretation of a grasp-cueing effect as a marker of the social phenomenon of joint attention. This interpretation implies that biological stimuli are processed differently than non-biological stimuli and that only the perception of animate agents elicits a covered imitation or motor simulation in the observer.

It is still controversial whether motor simulation is indeed restricted to observing human agents or whether it also occurs for non-human agents (Gazzola, Rizzolatti, Wicker, & Keysers, 2007). While some studies report that animate stimuli and intentional movements of biological agents in contrast to movements of non-biological agents lead to motor priming effects (Castiello, Lusher, Mari, Edwards, & Humphreys, 2002; Kilner, Paulignan, & Blakemore, 2003; Tai, Scherfler, Brooks, Sawamoto, & Castiello, 2004), other studies report that motor priming is present, but attenuated for non-biological movements (Liepelt & Brass, 2010; Longo & Bertenthal, 2009; Press, Bird, Flach, & Heyes, 2005). For instance, Heyes, Bird, Johnson, and Haggard (2005) report that both human and robotic hands elicit motor simulation in observers but also that human stimuli had a much stronger impact on the performance of their subjects (see also Liepelt & Brass, 2010, for similar conclusions). That is, despite the debate about actual limits of the direct matching system, the different impact of biological and non-biological movements on the motor system suggests that the motor simulation is basically tuned to represent actions of animate agents. Surprisingly, however, effects of animacy have been addressed only in studies on action-observational modulation of motor responses. Animacy has been neglected entirely in studies looking at action cueing of attention.

The aim of the current experiment is therefore to compare the effects of biological and non-biological prehensile cues on the observer's visual attention (cf. Fischer et al., 2008) and to investigate whether processing of animate objects affects the observer's visual attention differently from processing of inanimate objects. We compared the responses to visual representations of configurations of grasping hands and objects matching in size with responses to visual representations of mismatching hand-object configurations. The notion of grasp aperture cueing assumes that observers are faster in aligning their attention to targets appearing at the aperture-congruent object. To test the predicted importance of animacy in joint attention, we introduced inanimate stimuli consisting of U-shaped geometrical shapes that were matched in colour, size and aperture with the animate stimuli (see Fig. 1). All cues depicted a small and a large aperture. They were presented adjacent to two lateral objects of identical size, creating an aperture-congruent configuration (i.e., object size fitting the hand/U-shape aperture) either at left or right side and an aperture-incongruent configuration at the opposite side.

If the grasp aperture cueing represents indeed a joint attention effect that is driven by the spontaneous simulation of the observed action (Fischer et al., 2008) and not by a association of two perceptually-congruent objects, we predict a cueing effect only for the animate postures but not for the inanimate U-shapes cues. If, on the other hand, grasp aperture cueing represents congruency between perceptual qualities of the observed grasp and an object, then we expect to see faster detections for congruent grasp-object pairs irrespective of animacy.

2. Methods

2.1. Participants

Twenty-six undergraduate psychology students with normal or corrected-to-normal vision, naive to the purpose of the study, took part in the study in exchange for five Euros or credit points.

2.2. Stimuli

The stimuli were presented on a computer screen placed at an approximate viewing distance of 60 cm in front of the participants. The initial stimulus consisted of a pair of objects presented laterally to a central fixation cross.

Both objects were identical and could have two different sizes. The small objects subtended a visual angle of 1°. The size of the large objects was 5°. The to-be detected target event consisted of colour change (i.e., from yellow to red) of the left or right object. The cueing stimulus consisted of either a pair of animate or inanimate cues. The animate cues consisted of two human hands, one with a large grip aperture (full grip posture, measuring a visual angle 10° horizontally and 12° vertically and inner aperture of 5°) and one with a small grip aperture (precision grip posture; measuring 8° × 12° of visual angle and an inner aperture of 1°). The inanimate cues were two U-shaped figures matching the size and apertures of the hands. One aperture (left or right) fitted the object at that side (i.e., aperture-congruent), whereas the other aperture did not fit the object.

Depending on the size of the objects and the arrangement of the apertures (i.e., large grip aperture to the left and small grip aperture to the right or vice versa), either the left or right object matched the grasping hand or U-shape. The aperture-congruent object was considered as the cued object (Fischer et al., 2008). Cueing was denoted as valid if the colour change occurred at the cued target location. Fig. 1 shows examples of the stimuli with the cued object on the left.

2.3. Procedure and design

Each trial started with the presentation of a central fixation cross along with the two lateral objects. After 700 ms, the fixation cross was replaced by the cueing stimulus (e.g., the two hands or U-shapes) which remained visible for 150 ms. Following a variable delay of 50 ms, 150 ms or 500 ms, one of the two objects changed its colour into red (target event), signalling the participants to respond. The target remained visible until a response was made or for the maximum duration of 2500 ms. Ten percentage of the trials served as catch trials, in which no target event occurred. Participants were instructed to detect the colour change and to respond as soon as possible with a button press.

Participants were randomly assigned to the animate or inanimate cueing conditions. Trials were composed of all combinations of the factors object size (small, large), aperture arrangement (large aperture to the left/small aperture to the right, large aperture to the right/small aperture to the left), side of target event (left or

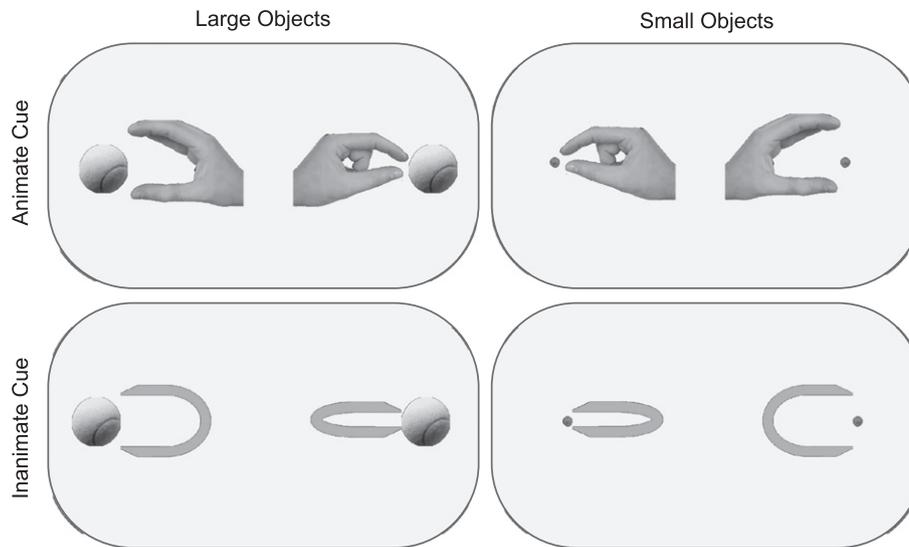


Fig. 1. Illustration of the cueing stimuli in the different Cue Type (animate, inanimate) and object size conditions (small, large). The original stimuli were coloured. In the depicted examples, the aperture-congruent objects and thus the cued locations are always at the left side. The two objects were presented throughout the trial. The to-be detected target event consisted of a colour change of the left or right object (not depicted here).

right object), and Stimulus Onset Asynchrony (200, 300, 650 ms). The study comprised 180 experimental trials plus addition 18 catch trials (10%). All trials were presented in random order. Before the actual experiment, participants performed 15 randomly chosen training trials.

2.4. Analysis

Reaction-time differences between invalid and valid trials were used as an index of attentional modulation. Trials with anticipatory responses (e.g., button presses ahead of the target onset or within the first 100 ms of its onset), missing responses (e.g., button presses exceeding 800 ms after the target onset), or false alarms (e.g., button presses to catch trials) accounted for less than 2% of all trials and were excluded from the analysis. A type-I error rate of $\alpha = .05$ was used in all statistical tests. In order to report standardized effect size measurements we calculated our statistics using the omega squared (ω^2) parameter as suggested by Kirk (1996).

2.5. Results

We applied a three-way mixed-model analysis of variance (ANOVA) with the within-subject factor Cue Validity (valid, invalid), Stimulus Onset Asynchrony between cue and target (SOA: 200, 300, 650 ms) and the between-subject factor Cue Type (animate, inanimate) on the reaction time data. The reaction times in trials with hands and U-shapes did not differ significantly, $F(1, 24) < 1$. The analysis yielded however a main effect for the factor Cue Validity, $F(1, 24) = 4.39$, $p < .05$, $\omega^2 = .06$, showing that target detections were faster for valid cues (340 ms) than after invalid cues (346 ms). Most importantly, the significant interaction between Cue Type and Cue Validity, $F(1, 24) = 11.54$, $p < .01$, $\omega^2 = .16$, confirmed our hypothesis that the cueing effect depended on the stimulus types. As Fig. 2 illustrates, the target detections were affected by the Cue Validity only if the cues consisted of animate hand cues (346 ms versus 356 ms), $t(12) = -3.50$, $p < .01$, but not for inanimate condition in which U-shapes were presented (338 ms versus 337 ms), $t(12) < 1$. The main effect of the factor SOA, $F(1, 24) = 32.24$, $p < .01$, reached significance indicating that the response times were on average short in trials with a 300 ms SOA (328 ms) than

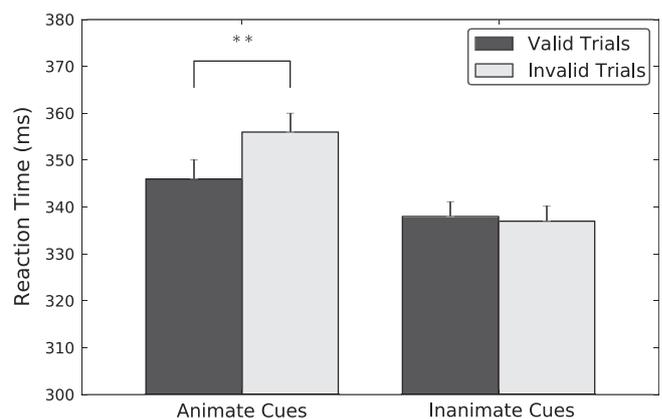


Fig. 2. Mean reaction times in the simple detection task as a function of the factors Cue Type and Cue Validity. Error bars represent 95% within-subjects confidence intervals that are appropriate for comparing the means of valid and invalid trials (cf. Loftus & Masson, 1994).

in trials with a 200 ms (354 ms), $t(25) = 6.36$, $p < .01$, or 650 ms SOA (351 ms), $t(25) = 5.75$, $p < .01$. The SOA effect interacted with the Cue Type, $F(1, 24) = 5.66$, $p < .01$, and the Validity, $F(1, 23) = 7.28$, $p < .01$. There was furthermore a significant three-way interaction between all factors, $F(1, 23) = 4.81$, $p < .05$.

In order to explore the effects of SOA in greater detail and to understand the time course of the cueing effect, we ran separate two-way repeated measures ANOVAs for the hand and U-shape condition with factors Cue Validity and Stimulus Onset Asynchrony between cue and target (SOA: 200, 300, 650 ms). For animate cues, there was a main effect of the factor SOA, $F(2, 24) = 9.21$, $p < .001$, $\omega^2 = .29$, indicating that response were faster for the middle SOA (338 ms) as compared to short (352 ms), $t(12) = -2.34$, $p < .05$, or long SOA (362 ms), $t(12) = -6.15$, $p < .001$. The main effect of Cue Validity was significant, $F(1, 12) = 9.37$, $p < .01$, $\omega^2 = .24$. Interestingly, cueing effect was modulated by the SOA, $F(2, 24) = 9.80$, $p < .001$, $\omega^2 = .18$. That is, cueing effect tended to rise already at the 200 ms SOA, $t(12) = -2.0$, $p < .08$, but reached significance only for the 300 ms SOA, $t(12) = -4.2$, $p < .01$. For long SOAs (650 ms), the cueing effect disappeared again, $t(12) = 1.7$, $p > .05$ (see Fig. 3). The ANOVA for

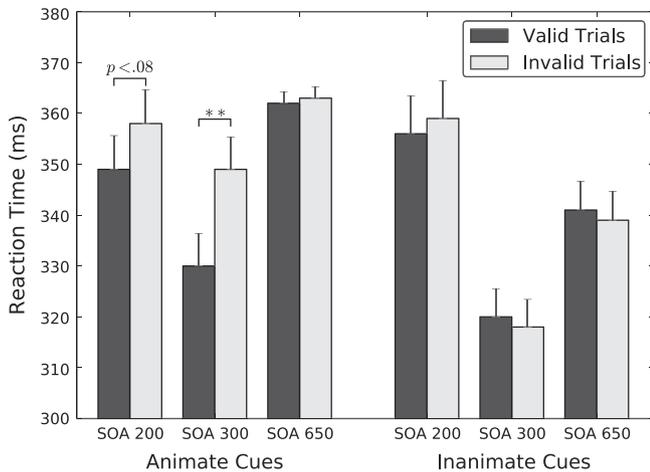


Fig. 3. Mean reaction times for each Cue Types as a function of the factors Stimulus Onset Asynchrony (SOA, in ms) and Cue Validity. Error bars represent 95% within-subjects confidence intervals that are appropriate for comparing the means of valid and invalid trials.

the inanimate condition mirrored the SOA main effect for animate cues, $F(2, 24) = 20.58$, $p < .001$, $\omega^2 = .50$, with faster RTs for middle SOA (316 ms) as compared to short (354 ms), $t(12) = -12.73$, $p < .001$, and long SOA (340 ms), $t(12) = -3.12$, $p < .01$. However, the factor Cue Validity did not reach significance and did not interact with the SOA, both $F_s < 1$. This outcome clearly shows that target detection were unaffected by inanimate cues for all SOA conditions (see Fig. 3).

Taken together, the data showed that responses to colour changes of aperture-congruent object were detected faster than target events at the uncued location. Importantly, this response pattern differed for the hand and U-shape stimuli, showing that aperture cueing effects were limited to animate cues. In line with previous research on visual cueing (e.g., Fischer et al., 2008; Posner, 1980), we interpret that the faster detections to animate cues as evidence for shift of visual attention to the cued object or location.

Since the attentional effect in the present study is defined as the reaction time difference between uncued and cued location, we cannot distinguish with our data whether the reported grasp-cueing effect is driven by a facilitated processing of the cued target or by an impaired processing of the uncued target or both. To distinguish between these two possible processes, a measurement of the average response time to a third neutral target location for each participant is required. It is however important to notice that the average reaction time to inanimate cues does not provide such a within-subject baseline estimation. Moreover, animate and inanimate cues differ strongly in their visual complexity. It can consequently not be ensured that responses to the simple inanimate U-shapes are not systematically faster than to the hands.

3. Discussion

Observing an aperture-congruent configuration of a grasping hand and an object resulted in faster detections of targets appearing together in contrast to targets appearing within an aperture-incongruent configuration. Most importantly, our data showed that aperture cueing is not present for inanimate stimuli. This dissociation of attentional effects after the processing of animate and inanimate visual cues suggests that grasp cueing of joint attention involves spontaneous cognitive simulation of the observed motor behaviour.

In line with previous research (Fischer & Szymkowiak, 2004; Fischer et al., 2008; Tschentscher and Fischer, 2008), our data

provide new evidence for an automatic joint attention mechanism when observing biological agents and show that observers rapidly encode the goal of another persons' actions and direct their attention to the location of that goal. The present study furthermore extends previous research on attentional cueing effects by grasping posture. Our data demonstrate for instance that perceived animacy modulates the presence of action or grasp-cueing effects. The fact that cueing effects in the present study were only present for animate stimuli provides new and direct behavioural support for the notion that joint attention mechanisms are based on a simulation of the observed motor act. The absence of a cueing effect for inanimate cues clearly rejects the possibility that aperture cueing is merely the result of perceptual association between two stimuli matching in size.

Interestingly, the time course of the grasp aperture cueing effect is in accordance with reflective stimulus-based priming effects as found in studies in which the visual primes are presented exogenously (see e.g., Klein and Taylor (1994); for an overview). This research demonstrates that exogenous primes attract the observer's attention reflexively if targets are presented approximately 100 ms after the prime onset. Attention toward the regions of interest is however inhibited if the target is presented 500 ms after the cue onset. Our finding of cueing effects for short and middle but not for long delay intervals suggests that the alignment of the observer's attention to the action goal of the other agent occurs in a reflexive and automatic fashion.

The action-cueing effect observed in the present study reflects a faster detection of a change of the colour of the cued object compared to uncued object and indicates thus a shift of attention to either the left or right object. As shown by several studies in vision research, visual attention not only selects between different locations in space but can also select between objects. For instance, cueing the attention to one part of an object facilitates the detection of a target presented at a different location in the same object, compared with when the target appears an equal distance away from the cue but in a different object (Egly, Driver, & Rafal, 1994; Matsukura & Vecera, 2006). These object-based attentional shifts have been shown to coexist with space-based processes of attention. Since the present paradigm does not allow a comparison of target detections at different locations within the same object, it remains at this point an open question whether the reported grasp-cueing effect is primarily driven by object- or space-based processes. Future studies on joint attention that compare between and within object priming of observed actions are therefore needed to distinguish between these different attentional processes.

Knowledge about object use is learned through daily interactions with the environment. This knowledge is integrated into a semantic network representing the meaning of object-directed actions (e.g., Klatzky et al., 1989; Lindemann, Stenneken, van Schie, & Bekkering, 2006; McCloskey, Klatzky, & Pellegrino, 1992; Rueschmeyer, Lindemann, van Rooij, van Dam, & Bekkering, 2009). In a similar vein, it is possible that the observation of human postures may also activate semantic representations of functional hand-object interactions, which might in turn trigger the attentional shift to the meaningful hand-object configurations. However, due to the rapid development of the priming effect after 150–300 ms it seems unlikely that the attentional shift to the aperture-congruent object is mediated by mnemonic representations of action semantics. We therefore argue that the observed grasp-cueing effect can be best explained by a motor simulation account (e.g., Brass et al., 2000; Wilson & Knoblich, 2005). Motor simulation has typically been measured by motor priming effects that reflect a facilitated execution of motor responses congruent to a simultaneously observed but task-irrelevant movement of another actor. Our data show that action observation not only affects the selection of responses and preparation of motor programs, but also modulates

visual attention. Interestingly, the dissociation of cueing effects shows moreover that biological relevance due to perceived animacy has already an important influence on very early stages of cognitive processing like visual attention.

We know that humans determine a conspecific's region of interest by aligning their attention with the other's gaze (Friesen & Kingstone, 1998; Kingstone, 2009; Nuku & Bekkering, 2008). It has been argued that this alignment of attention due to gaze cues is highly relevant for human interactions and might find its origin in the aim to predict the others' actions (Tomasello, 2000). Our finding of priming effects of animate manual actions on early cognitive processes provides empirical support for the idea that the function of joint attention is to support the prediction of movement goals and thus the understanding of action intentions.

In conclusion, this study showed that grasping actions performed by humans modulate the observer's attention whereas the perception of inanimate stimuli does not result in comparable aperture cueing effect. The attentional modulation resulting from observing human hands is consequently not merely perceptual in nature, but rather relies on the human ability to simulate motor action of biological agents. Moreover, the time course of the grasp aperture cueing effect is in accordance with reflexive stimulus-based priming effects. Taken together, the present study is in line with the notion that the attributing of goals to others' actions is a automatic process that, even in the absence of a motor prerequisite, modulates the observers' attention.

References

- Allison, T., Puce, A., & McCarthy, G. (2000). Social perception from visual cues: Role of the STS region. *Trends in Cognitive Sciences*, 4(7), 267–278. doi:10.1016/S1364-6613(00)01501-1.
- Brass, M., Bekkering, H., Wohlschläger, A., & Prinz, W. (2000). Compatibility between observed and executed finger movements: Comparing symbolic, spatial, and imitative cues. *Brain and Cognition*, 44(2), 124–143.
- Castiello, U., Lusher, D., Mari, M., Edwards, M. G., & Humphreys, G. W. (2002). Observing a human or a robotic hand grasping an object: Differential motor priming effects. In W. Prinz & B. Hommel (Eds.), *Attention and Performance XIX: Common mechanisms in perception and action* (pp. 314–334). Cambridge, MA: MIT Press.
- Craigero, L., Bello, A., Fadiga, L., & Rizzolatti, G. (2002). Hand action preparation influences the responses to hand pictures. *Neuropsychologia*, 40(5), 492–502.
- Egley, R., Driver, J., & Rafal, R. D. (1994). Shifting visual attention between objects and locations: Evidence from normal and parietal lesion subjects. *Journal of Experimental Psychology: General*, 123(2), 161–177.
- Fadiga, L., Fogassi, L., Pavesi, G., & Rizzolatti, G. (1995). Motor facilitation during action observation: A magnetic stimulation study. *Journal of Neurophysiology*, 73(6), 2608–2611.
- Fischer, M., Prinz, J., & Lotz, K. (2008). Grasp cueing shows obligatory attention to action goals. *The Quarterly Journal of Experimental Psychology*, 61(6), 860–868. doi:10.1080/17470210701623738.
- Fischer, M. H., & Szymkowiak, A. (2004). Joint attention for pointing but not grasping postures. *Cortex*, 40(1), 168–170.
- Friesen, C., & Kingstone, A. (1998). The eyes have it! Reflexive orienting is triggered by nonpredictive gaze. *Psychonomic Bulletin and Review*, 5(3), 490–495.
- Gallese, V., Fadiga, L., Fogassi, L., & Rizzolatti, G. (1996). Action recognition in the premotor cortex. *Brain*, 119(2), 593–609. doi:10.1093/brain/119.2.593.
- Gazzola, V., Rizzolatti, G., Wicker, B., & Keysers, C. (2007). The anthropomorphic brain: The mirror neuron system responds to human and robotic actions. *NeuroImage*, 35(4), 1674–1684. doi:10.1016/j.neuroimage.2007.02.003.
- Girardi, G., Lindemann, O., & Bekkering, H. (2010). Context effects on the processing of action-relevant object features. *Journal of Experimental Psychology: Human Perception and Performance*, 36(2), 330–340. doi:10.1037/a0017180.
- Heyes, C., Bird, G., Johnson, H., & Haggard, P. (2005). Experience modulates automatic imitation. *Cognitive Brain Research*, 22(2), 233–240. doi:10.1016/j.cogbrainres.2004.09.009.
- Iacoboni, M., Woods, R. P., Brass, M., Bekkering, H., Mazziotta, J. C., & Rizzolatti, G. (1999). Cortical mechanisms of human imitation. *Science*, 286, 2526–2528.
- Kilner, J. M., Paulignan, Y., & Blakemore, S. J. (2003). An interference effect of observed biological movement on action. *Current Biology*, 13(6), 522–525. S0960982203001659.
- Kingstone, A. (2009). Taking a real look at social attention. *Current Opinion in Neurobiology*, 19(1), 52–56.
- Kirk, R. E. (1996). Practical significance: A concept whose time has come. *Educational and Psychological Measurement*, 56(5), 746–759.
- Klatzky, R., Pellegrino, J. W., McCloskey, B. P., & Doherty, S. (1989). Can you squeeze a tomato? The role of motor representations in semantic sensibility judgments. *Journal of Memory and Language*, 28(1), 56–77.
- Klein, R. M., & Taylor, T. (1994). Categories of cognitive inhibition with reference to attention. In D. Dagenbach & T. H. Carr (Eds.), *Inhibitory processes in attention, memory, and language* (pp. 113–150). San Diego, CA: Academic Press.
- Liepert, R., & Brass, M. (2010). Top-down modulation of motor priming by belief about animacy. *Experimental Psychology*, 57(3), 221–227. doi:10.1027/1618-3169/a000028.
- Lindemann, O., Steneken, P., van Schie, H. T., & Bekkering, H. (2006). Semantic activation in action planning. *Journal of Experimental Psychology: Human Perception and Performance*, 32(3), 633–643.
- Loftus, G. R., & Masson, M. E. J. (1994). Using confidence intervals in within-subject designs. *Psychonomic Bulletin and Review*, 1(4), 476–490.
- Longo, M. R., & Bertenthal, B. I. (2009). Attention modulates the specificity of automatic imitation to human actors. *Experimental Brain Research*, 192(4), 739–744. doi:10.1007/s00221-008-1649-5.
- Matsukura, M., & Vecera, S. P. (2006). The return of object-based attention: Selection of multiple-region objects. *Perception & Psychophysics*, 68(7), 1163–1175.
- McCloskey, B. P., Klatzky, R. L., & Pellegrino, J. W. (1992). Rubbing your stomach while tapping your fingers: Interference between motor planning and semantic judgments. *Journal of Experimental Psychology: Human Perception and Performance*, 18(4), 948–961.
- Nuku, P., & Bekkering, H. (2008). Joint attention: Inferring what others perceive (and don't perceive). *Consciousness and Cognition*, 17(1), 339–349.
- Posner, M. (1980). Orienting of attention. *The Quarterly Journal of Experimental Psychology*, 32(1), 3–25.
- Press, C., Bird, G., Flach, R., & Heyes, C. (2005). Robotic movement elicits automatic imitation. *Cognitive Brain Research*, 25(3), 632–640. doi:10.1016/j.cogbrainres.2005.08.020.
- Rueschemeyer, S., Lindemann, O., van Rooij, D., van Dam, W., & Bekkering, H. (2009). Effects of intentional motor actions on embodied language processing. *Experimental Psychology*, 57(4), 260–266. doi:10.1027/1618-3169/a000031.
- Stürmer, B., Aschersleben, G., & Prinz, W. (2000). Correspondence effects with manual gestures and postures: A study of imitation. *Journal of Experimental Psychology: Human Perception and Performance*, 26(6), 1746–1759.
- Tai, Y. F., Scherfler, C., Brooks, D. J., Sawamoto, N., & Castiello, U. (2004). The human premotor cortex is 'Mirror' only for biological actions. *Current Biology*, 14(2), 117–120. doi:10.1016/j.cub.2004.01.005.
- Tomasello, M. (2000). Culture and cognitive development. *Current Directions in Psychological Science*, 9(2), 37–40. doi:10.1111/1467-8721.00056.
- Tschentscher, N., & Fischer, M. H. (2008). Grasp cueing and joint attention. *Experimental Brain Research*, 190(4), 493–498. doi:10.1007/s00221-008-1538-9.
- Vogt, S., Taylor, P., & Hopkins, B. (2003). Visuomotor priming by pictures of hand postures: Perspective matters. *Neuropsychologia*, 41(8), 941–951.
- Wilson, M., & Knoblich, G. (2005). The case for motor involvement in perceiving conspecifics. *Psychological Bulletin*, 131(3), 460–473.