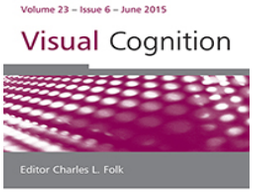

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Do you see what I see? Co-actor posture modulates visual processing in joint tasks

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ABSTRACT
Interacting with other people is a ubiquitous part of daily life. A complex set of processes enable our successful interactions with others. The present research was conducted to investigate how the processing of visual stimuli may be affected by the presence and the hand posture of a co-actor. Experiments conducted with participants acting alone have revealed that the distance from the stimulus to the hand of a participant can alter visual processing. In the main experiment of the present paper, we asked whether this posture-related source of visual bias persists when participants share the task with another person. The effect of personal and co-actor hand-proximity on visual processing was assessed through object-specific benefits to visual recognition in a task performed by two co-actors. Pairs of participants completed a joint visual recognition task and, across different blocks of trials, the position of their own hands and of their partner's hands varied relative to the stimuli. In contrast to control studies conducted with participants acting alone, an object-specific recognition benefit was found across all hand location conditions. These data suggest that visual processing is, in some cases, sensitive to the posture of a co-actor.

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KEYWORDS Feature integration; Hand proximity; Simulation; Joint action; Joint perception; Perspective taking; Mental state attribution

We constantly interact with the people around us. Although our daily interactions with others are often very basic, they nonetheless shape how we perceive and act on the world. For example, a colleague of yours may request "that thing that puts things together" while waving their hand in the general direction of your desk. To satisfy their request, you must first deduce what object, in fact, they are talking about. Your attention shifts towards their other hand which is holding a manuscript, then shifts in the general direction they are pointing and looking. Your eyes rest upon the

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stapler. Should you decide to lend them your stapler, you must pick it up and pass it to them by coordinating your hand and limb movements with their movements. From this example, it is clear how shared attention (or joint attention), representation of others' mental states (perspective taking), and acting together (or joint action) promotes successful daily interactions. The present study was designed to address how the representation of a co-actor's hand posture configuration influences an individual's perceptual space.

Perspective taking during joint action

Although there are many ways of conceptualizing perspective taking within various domains of psychology, here we are concerned with how adopting the physical point of view of a co-actor might shape perceptually-based processes. For example, early research into this topic using gaze cuing paradigms shows that social cognitive factors associated with mental state attributions clearly modulate the way we attend to stimuli in our environment (Bayliss, Schuch, & Tipper, 2010; Frischen & Tipper, 2004; Ricciardelli, Bricolo, Aglioti, & Chelazzi, 2002). For example, Ricciardelli et al. (2002) demonstrated that we have a strong tendency to follow the gaze of others—static and dynamic gaze distractors, but not arrows, resulted in a high number of errors during an instructed eye movement task. This gaze following is one mechanism that allows individuals to create a common attentional and perceptual awareness of objects on interest in the environment. Thus, acting with another individual and sharing "joint" attention to objects may create a common "perceptual ground" over which the individuals can share perspectives and coordinate action.

More recently, the notion of perspective taking has sparked interest in the domain of spatial cognition (see Hamilton, Kessler, & Creem-Regehr, 2014). This more advanced level of perspective taking involves understanding how the world looks from another person's perspective (Flavell, Everett, Croft, & Flavell, 1981). It has been suggested that such visibility-related perspective taking and spatially-related perspective taking require qualitatively different cognitive mechanisms (Michelon & Zacks, 2006). An example of visual-spatial perspective taking is one in which individuals describe a scene that has an agent within it: they are likely to spontaneously adopt the visual perspective of the person within the scene rather than describe it from their own perspective (Tversky & Hard, 2009). Interestingly, it has been reported that people who are less likely to engage in perspective taking, as indexed by a relatively high score on the Autism Quotient (Baron-Cohen, Wheelwright, Skinner, Martin, & Clubley, 2001), have greater difficulty when asked to determine if a target was to the right or the left of an avatar compared to people who are more likely to engage in perspective taking (Brunye et al., 2012). It remains unclear, however, if the influence of perspective taking on perceptual

processes is simply due to the understanding of the other's perspective (direction of view) or if the individual actually *takes on* the perspective as their own. For example, do we describe a scene in terms of the agent in the scene because this is what tends to be beneficial for the person with whom we are interacting, or do we describe the scene in that way because we actually adopt the alternate perspective?

A paradigm grounded in joint action approaches may help further elucidate the influence of perspective taking on perceptual processes. Indeed, many studies point in this direction (e.g., social inhibition of return, Skarratt, Cole, & Kingstone, 2010; Welsh et al., 2005; joint Simon effect, Sebanz, Knoblich, & Prinz, 2003; joint negative priming, Frischen, Loach, & Tipper, 2009). It is thought that when engaging in a (joint) task with another person, the individual represents their partner's task and simulates their actions. The act of perceiving others' actions and cognitive states activates the same cognitive representations that underlie one's own actions and cognitive states (Jeannerod, 2001; Keysers, Kaas, & Gazzola, 2010). The individual is then able to use the self-based representations to simulate the partner's performance to predict and respond appropriately to their partner's behaviour (Bekkering et al., 2009; Sebanz & Knoblich, 2009). Humans have a strong tendency to engage in simulation and co-representation when interacting with one another, though these processes are not entirely automatic (Kilner, Marchant, & Frith, 2006, 2009; Kourtis, Knoblich, & Sebanz, 2013; Kourtis, Sebanz, & Knoblich, 2010). In fact, evidence of simulation and co-representation in joint situations is even found where active simulation and understanding of other people's actions or cognitive states is not necessary, and in some cases detrimental, for completing the required task (e.g., Sebanz et al., 2003) indicating that the tendency to engage in these processes is very strong.

The present paper approaches task co-representation and simulation as a precursor towards the representation of another's mental state. Certainly, motor simulation as a precursor to perspective taking has been discussed briefly from a theoretical stand-point (Creem-Regehr, Gagnon, Geuss, & Stefanucci, 2013). Hence, we begin with the assumption that observers might not only represent their own task and perceptual space, but also the task and perceptual space of their partner. As a result, individuals are likely to process perceptual space differently when they perform a task alone as compared to when they perform it with someone else; thus, certain experimental findings found with individual participants acting alone might or might not persist in shared tasks, with differences between task performance in individual and social contexts are intuited to reflect the influence of the simulation and co-representation process. To test this hypothesis, researchers of the processes of joint action tend to require co-acting participants complete tasks in a common space and assess how behavioural phenomena commonly observed

when individuals act alone (e.g., Simon effect and inhibition of return) may manifest in the shared space (e.g., Sebanz et al, 2003; Welsh et al., 2005). Here, participants in the main experiment (Experiment 1) completed a task in which hand configuration has been shown to alter perceptual processes when individuals act alone (Gozli, Ardon, & Pratt, 2014). Following the typical logic of joint action experiments, it was predicted that if a partner's postural configuration is co-represented and provides valuable information regarding the partner's internal perceptual state, then the hand configuration of the partner may influence the way in which the shared space is represented.

Hand proximity and perceptual biases

It has been repeatedly shown that visual processing is altered when stimuli are presented close to a hand as compared to when stimuli are presented far from a hand (e.g., Abrams, Davoli, Du, Knapp, & Paull, 2008; Kao & Goodale, 2009; Reed, Grubb, & Steele, 2006; Thomas, 2015). For example, stimuli presented close to the hand seem to enjoy enhanced attention towards them compared to stimuli presented far from the hand (Abrams et al., 2008; Reed et al., 2006). Interestingly, this finding has recently been extended to show that the proximity of other people's hands produces similar effects, but only after engaging in joint action with a partner (Sun & Thomas, 2013).

Recently, Gozli et al. (2014) demonstrated that hand proximity has a clear effect on visual processing that does not involve general facilitation. Indeed, they found that hand proximity resulted in a cost. Specifically, participant's tendency to integrate visual features into a perceptual whole was reduced when the participant's hands were near the stimuli. Gozli and colleagues adapted a task first introduced by Kahneman, Triesman, and Gibbs (1992). In the Kahneman et al. study, participants saw two symbols in square placeholders and were asked to remember the symbols. The symbols then disappeared, the placeholders moved and one symbol appeared in one of the placeholders in its new location. Participants then made a recognition judgment: was the symbol new or old? Critically, the symbol could remain in the same placeholder or switch to the opposite placeholder. When the symbol appeared in its original placeholder, a reaction time benefit was observed. Kahneman and colleagues attributed this benefit to the formation of an "object file" or a unified, multi-featured representation including the symbol and the original placeholder. Participants in the Gozli et al. study completed this same basic task twice: once with their hands far from the stimuli and a second time with their hands near the stimuli. Interestingly, Gozli et al. (2014) found an object-specific benefit only when participants' hands were on the keyboard (far from the stimuli). When the participant placed

their hands beside the screen (near the stimuli), no object-specific recognition benefit was observed.

The one prevailing (though not universally held) view regarding the underlying mechanism of such hand proximity effects concerns the magnocellular (M) and parvocellular (P) pathways (see Taylor, Gozli, Chan, Huffman, & Pratt, 2015; and Goodhew, Edwards, Ferber, & Pratt, 2015, for more detailed accounts of the theoretical basis behind hand proximity effects). When processing stimuli near the hands, the M pathway is engaged to a greater extent, which is typically associated with action-oriented visual processes and features relevant for action such as motion (Livingstone & Hubel, 1987) or location (Derrington & Lennie, 1984; Chen et al., 2006). Conversely, when hands are further away from a stimulus, and therefore not oriented for action, then the P visual pathway is more readily engaged. These visual pathways provide input to separate streams of the visual system and are therefore relatively analogous to the functional distinction between the dorsal (action) and ventral (perceptual) streams (Goodale & Milner, 1992). A further component of this theory is that promoting engagement of one pathway will bias activity away from the other (Bocanegra & Zeelenberg, 2009; Yeshurun, 2004; Yeshurun & Levy, 2003). In the context of the current paradigm the P pathway is involved in processing detailed object features (Barense, Gaffan, & Graham, 2007; Barense et al., 2005; Maunsell, Nealy, & DePriest, 1990). Thus, when the contribution of the M pathway is increased (thereby inhibiting the P pathway), a reduced tendency to integrate visual features can be observed (Gozli et al., 2014). This theory holds well with a number of other effects within the literature including, but not limited to, hand proximity's influence on temporal and spatial sensitivity (Gozli, West, & Pratt, 2012), object segmentation (Goodhew, Gozli, Ferber, & Pratt, 2013), perceptual grouping (Huffman, Gozli, Welsh, & Pratt, 2015), semantic processing (Davoli, Du, Montana, Gaverick, & Abrams, 2010), colour and orientation processing (Kelly & Brockmole, 2014), and processing of high and low spatial frequencies (Chan, Peterson, Barense, & Pratt, 2013). For a more general review of hand proximity effects, see Tseng, Bridgeman, and Juan (2012) and Brockmole, Davoli, Abrams, and Witt (2013).

The present studies

To reiterate, our main aim was to investigate if the presence of a co-acting individual influences the processing of visual stimuli in shared space. To this end, we sought to determine if the hand posture of one partner (and presumed alteration of perceptual processes) affects visual processing of the other partner. Pairs of participants completed a joint object recognition task and the relative hand position of each participant was manipulated across blocks of trials (see Gozli et al., 2014). Participants completed the object

recognition task, based on the paradigm by Kahneman et al. (1992), while seated across from each other. In Experiment 1, Participant 1 responded if the target stimulus was a new symbol while Participant 2 responded if it was a repeated symbol. Critically, in the "repeat" condition (requiring a response from Participant 2 only), the symbol could appear in the same placeholder or the opposite one to which it was originally presented in the initial display.

Because hand proximity has been shown to influence the likelihood that object features will be integrated into detailed "object files" (Gozli et al., 2014; Kelly & Brockmole, 2014; see also Ganel & Goodale, 2003), we manipulated postures across blocks such that when one participant had their hands near to the stimuli the other participant had their hands far from the stimuli (see Figure 1). A final "both hands far" condition was also included.

Given the robust evidence for simulation and the representation of co-actor's tasks and mental states in the joint action literature, it was hypothesized that the critical participant (Participant 2) would engage in the active simulation of their partner's postural configuration, which would provide valuable information regarding their perceptual state. Hence, this simulation should result in the representation of their partner's task and perceptual space (including their relative hand posture). If the participant segments space in line with their partner's postural configuration, perceptual biases may emerge across the varied postures. Specifically, when both participants' have their hands far from the display, we should observe a standard object recognition benefit in line with previous literature (Gozli et al., 2014; Kahneman et al., 1992). Thus, the both hands far condition represents our baseline condition from which to assess the influence of the relative positioning of the partner's hand posture.

Figure 1. The experimental setting. A Near/Far block is depicted.

If simulation of the partner's task and hand posture does not occur, then Participant 1's hand position will not affect Participant 2's performance with an object recognition benefit emerging when Participant 1's hands are near the stimuli (and Participant 2's hands are far), but no object recognition benefit when Participant 1's hands are far (and Participant 2's hands are in the near position); a pattern of effects consistent with Gozli et al. (2014). Conversely, the simulation of the other person's hand posture could be expressed in one of two ways. First, if Participant 2 is engaged in simulation processes and presumably codes the position of their partners' hands in addition to their own to segment space, then visual processing should continue in much the same way as if Participant 2's hands were far from the display (though the effect may be attenuated). If this is the case, then a recognition benefit could be observed when Participant 1's hands remain far from the display and Participant 2's hands are near to the display (i.e., in opposition to what Gozli et al. reported in the near hand condition). Second, it is possible that the recognition benefit will be attenuated when Participant 1's hands are close to the display and Participant 2's hands are far from the display.

These hypotheses are, however, by no means exhaustive. An alternative set of outcomes could also be reasonably predicted. Because simulation processes in joint action can be flexibly engaged in certain situations (Kilner et al., 2006, 2009; Kourtis et al., 2010, 2013; Lumsden, Miles, Richardson, Smith, & Macrae, 2012; Miles, Lumsden, Richardson, & Macrae, 2011), it is possible that Participant 2 flexibly employs simulation. Perhaps, because this task is not action-oriented, segmenting space in such a way (hands near) is not required. In an individual task, segmenting space this way may be hard to override, but with another person present, and the subsequent presence of postural cues that promote an alternative processing strategy, this tendency may be easier to ignore. Therefore, due to task demands Participant 2 may preferentially engage in simulation and represent another's perceptual space only when it serves the overall goal (that is, fast reaction times). This line of reasoning would lead to the prediction that when Participant 2 places their hands far from the display (already optimally prepared for the task), a standard recognition benefit will be observed when the symbol remains in the same placeholder frame even if Participant 1 has their hands near the display. When Participant 2 is required to have their hands near the stimuli, however, the person is not in a position to engage visual processing optimally for the task (Gozli et al., 2014). In this circumstance, engaging in simulation of the other person's task and space would prove beneficial. Thus, following this line of reasoning, an object recognition benefit would be observed in all conditions.

To preview the findings from Experiment 1, an object-related benefit was found across all hand posture conditions. To determine if the standard hands far/hands near modulation was absent in Experiment 1 due to an

idiosyncratic aspect of the present experimental set up or simply the "social" nature of the environment given that another person was present (as opposed to the theoretically relevant *co-acting* individuals' posture modulations), we conducted a second experiment. We recruited a new set of participants to perform the same hands near and hands far tasks in individual conditions (i.e., the participant acted alone without a co-actor). Although the participant acted alone in these conditions, they were not acting in complete isolation because an experimenter was present in the room and served as a non-acting observer of the performance of the participant. We also manipulated the experimenter's orientation to the participant. These modulations allowed us to determine if changing the experiment set up (monitor flat on the table) from Gozli et al. (2014) or simply the social environment (direct and indirect observation of participant performance) were determining factors of the results obtained in Experiment 1.

Experiment 1

Method

Participants

Eighteen pairs of volunteers (19 to 35 years of age, three participants were left-hand dominant) participated in this study in exchange for CAD5 each. All participants gave informed consent and had normal or corrected-to-normal vision. All pairs knew each other prior to the experiment except for one pair. There were nine female pairs, four male pairs and five pairs that had both a male and female participant.

Stimuli and apparatus

Stimuli were presented on a DELL 19 inch flat screen monitor (1280 × 1024 resolution, 60 Hz refresh rate) that was lying flat on a table. Participants responded using custom made button boxes that could either be attached to the side of the monitor with Velcro or moved to the participants lap (see Figure 1). Recognition stimuli were from a set of 16 distinct symbols (# $ % + = – ~ ÷ × § : | Ø * ¤ ≠) that were of similar appearance both right way up and upside down. These symbols were presented inside square place holders measuring (2.6 × 2.6 cm) whose centres circled 6.6 cm away from the centre of the screen. Presentation of the stimuli and recording of the timing and identity of the responses was controlled using custom software written in Matlab (Mathworks, Natick, MA) using the Psychophysics toolbox (Brainard, 1997).

Procedure

Participants were seated on either side of a table with the monitor lying flat on the table between them. Each participant were given two button boxes (one

to hold in each hand) and was instructed that they should hold each comfortably with their thumb resting on the button. They were also instructed that they were completing a task together.

Trials began with the presentation of a central fixation cross and horizontally aligned square placeholders for 1000 ms (see Figure 2). Two symbols then appeared in the placeholders for 400 ms which was followed by a 200 ms delay. Participants were instructed to keep the two symbols in memory. The placeholders then moved with constant velocity until they were vertically aligned (clockwise or counter-clockwise, counterbalanced). One symbol then appeared in one of the placeholders. If the symbol was new (i.e., it did not appear just prior in the initial display), then Participant 1 was asked to respond by depressing both buttons with their thumbs as quickly as possible. If the symbol was the same as one of the symbols presented just prior in the initial display, then Participant 2 was asked to depress both buttons with their thumbs as quickly as possible regardless of the placeholder in which it was presented. The stimuli remained on screen until a response was made.

Design

The study consisted of three blocked and counterbalanced conditions (Hands Far, Participant 1 Hands Near, and Participant 2 Hands Near). We did not

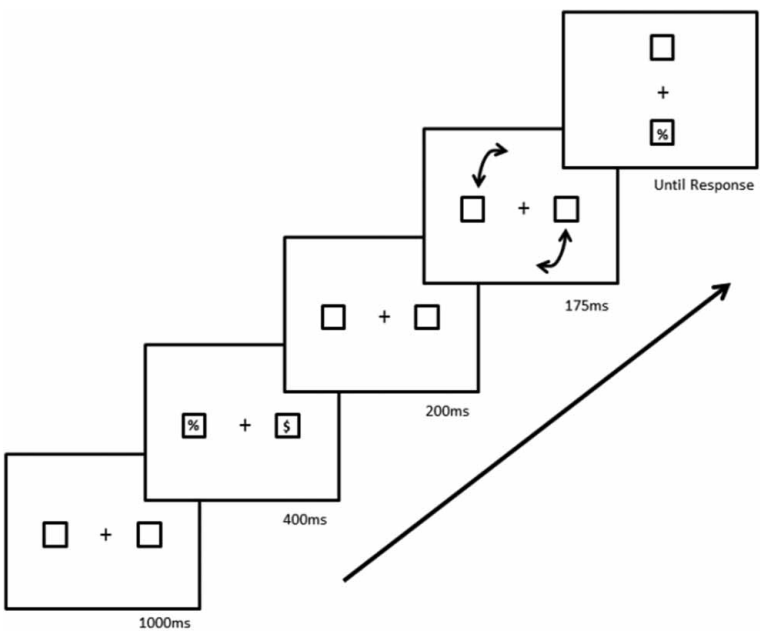

Figure 2. Time course of a trial (stimuli are not to scale). A Repeat | Different Object trial is presented.

include a condition where both participants had their hands close to the stimuli (i.e., a "both hands near" condition) because of practical and potential confounding issues. Namely, this condition would result in the misalignment of one partner's (or both partner's) hands with the stimuli. A misalignment of hands and stimuli would occur in this condition because the stimuli were initially presented across the centre of the screen directly between the two hands in the hands near condition. Hence, in a "both hands near" condition, participants would have to move their hands down on the sides of the screen which would disrupt the spatial alignment of stimuli and hands. Alternatively, participants could maintain alignment with the stimuli by overlapping their hands at the centre of the screen, but at the expense of having the response buttons of one participant be off (i.e., not in contact with) the screen. Further, partners may have considered having their hands in close proximity for long periods of time uncomfortable and such feelings of unease might have modulated visual processing in unexpected ways (see Hommel, Colzato, & van den Wildenberg, 2009, for an example of how relationships might affect the manifestation of joint action effects).

Participant pairs completed 480 experimental trials divided equally between the three blocks. Half of the trials were repeat trials and half were new-item trials. As such, participants were required to respond on an equal number of trials. For the person responding on repeat trials, the location of the recognition stimulus was either in the same-object or different-object. Location of the recognition stimulus and the direction of frame motion were both randomized. In blocks where a participant was required to have their hands up close to the stimuli, the participants attached their response boxes to the side of the screen using Velcro and supported their arms with cushions to promote an adequate level of comfort during the task (see Figure 1).

Results

Trials with reaction times (RTs) that were below 150 ms and above 1000 ms (8.55% of trials) were removed prior to analysis. Such strict criteria was necessary to ensure that the only trials selected for analysis were representative of participants engaging their own perceptual processes to do the task as opposed to waiting to see if their partner was making a response. As the critical comparison of interest is the difference between same-object and different-object trials (i.e., the object recognition effect), only the data from the one participant of each pair who responded to the repeated stimulus was analysed. Once the outlier and error data were eliminated from the set, mean RTs and accuracy percentages were calculated and submitted to a 3 (Hand Position) × 2 (Object) repeated measures ANOVA.

Reaction time

This analysis revealed a main effect of Object, $F(1, 17) = 18.60$, $MSE = 651$, $p < .001$, $\eta_p^2 = .52$. Shorter RTs were observed when the recognition stimulus was presented in its original placeholder (452 ms) as compared to when it switched to the other placeholder (471 ms). Neither the main effect of Hand Position nor the interaction reached significance, $F(2, 34) = .60$, $MSE = 2402$, $p = .56$, $\eta_p^2 = .03$ and $F(2, 34) = .32$, $MSE = 583$, $p = .73$, $\eta_p^2 = .02$, respectively. Given the previously demonstrated clear modulation resultant from hand position, we performed our planned comparisons (paired sample *t*-tests) despite the absence of an interaction to determine if a recognition benefit was indeed present in each task condition. This condition-specific analysis revealed that shorter RTs were observed when the recognition stimulus appeared in the same object, *p*s < .02. Therefore, contrary to typical results observed in an individual task showing an absence of a recognition benefit when hands are proximal to the display (Gozli et al., 2014), the object-based recognition benefit is clearly observed and consistent regardless of hand position (see Figure 3).

We also examined the accuracy data to determine if the differences in reaction times were due to a speed-accuracy trade-off. The errors retained the same pattern of data (higher errors on different object trials than same object trials in all hand configurations) as the reaction times suggesting that a speed-accuracy trade-off is not present in the data (see Table 1).

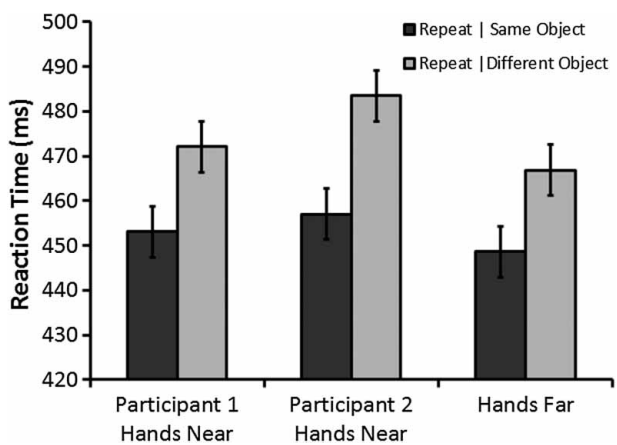

Figure 3. Reaction times towards Repeat (same or different object, Participant 2) targets with hands in a distal position (Hands Far) or with one participant's hands in a proximal position (Participant 1 Hands Near or Participant 2 Hands Near). Error bars denote standard error of the mean for within-subjects effects (Loftus & Masson, 1994).

Table 1. Percentage errors for Repeat (same or different object, Participant 2) targets with hands in a distal position (Hands Far) or with one participant's hands in a proximal position (Participant 1 Hands Near or Participant 2 Hands Near).

Hand Position	Same Object (%)	Different Object (%)
Participant 1 Hands Near	7.78	10.97
Participant 2 Hands Near	7.22	11.25
Hands Far	7.92	11.39

Experiment 2

Given that the results obtained in Experiment 1 were contrary to previous findings (Gozli et al., 2014) in that the proximal hand position never abolished the object specific benefit, we set out to determine if the findings of Experiment 1 were a result of some idiosyncratic aspect of the experimental set-up or simply the "social" nature of the environment. With respect to the idiosyncratic nature of the experimental setup, the standard proximal/distal modulation could have been interrupted by the fact that the monitor lay flat on the table as opposed to upright in previous studies. Alternatively, the mere presence of another person observing the participant closely may have influenced the results (a mere social effect) as opposed to the key factor being a *co-acting* individual. To these ends, 38 new participants were recruited to participate in an individual version of the task. Although participants completed the task without a co-actor, a social environment was created because the experimenter sat in the same room as the participant either directly opposite the participant and directly observed their responses, or off to the side of the participant and only indirectly observed their responses. If the findings from Experiment 1 were driven by the idiosyncratic nature of the task or simply the presence of another individual (and not the theoretically-relevant joint action nature of the task), then we should observe an object-related benefit only in the far hands condition (as in Gozli et al.). If the results obtained in Experiment 1 are dependent on either the orientation of the monitor or the close presence of another person, then an object related benefit should emerge in both hands near and hands far conditions.

Method

Participants

Thirty-eight new volunteers (19 to 35 years of age, five participants were left-handed) participated in this study in exchange for CAD5. All participants gave informed consent and had normal or corrected-to-normal vision. There were 23 females and 15 males.

Stimuli and apparatus

Both the stimuli and the apparatus were identical to Study 1.

Procedure and design

The procedure and design were identical to Study 1 with a few alterations. First, participants completed the study as individuals. Rather than depressing both buttons to make a response, they indicated if the symbol was new or old by depressing either the right or left button (counter-balanced). Further, instead of three blocks, they completed only two blocks (one hands near and one hands far). Last, participants completed the task under either "direct observation" where the experimenter sat directly opposite as the other participant would have in Study 1, or "indirect observation" where the experimenter was present in the room but to the side of the experimental table. These changes resulted in a 2 (Hand Position) × 2 (Object) × 2 (Experimenter Observation) mixed design. Each participant completed a total of 320 trials divided equally between two blocks.

Results

Consistent with the previous study, trials with reaction times (RTs) that were below 150 ms and above 1000 ms (13.45% of trials) were removed prior to analysis. This cut-off procedure yielded a very low cell observation for two participants in some conditions and, as a consequence, we removed the data from these participants from the set prior to analysis. We also removed two participants due to poor accuracy. Once the outlier and error data were eliminated from the set, mean RTs and accuracy percentages were calculated and submitted to a 2 (Hand Position) × 2 (Object) × 2 (Experimenter Observation) mixed ANOVA with Hand Position and Object as repeated measures factors and "Experimenter Observation" as a between-subjects factor.

This analysis revealed a main effect of Object, $F(1, 32) = 11.48$, $MSE = 470$, $p = .002$, $\eta_p^2 = .52$. Shorter RTs were observed when the recognition stimulus was presented in its original placeholder (595 ms) as compared to when it switched to the other placeholder (606 ms). Neither the main effect of Hand Position nor any interactions reached significance, all Fs < 1. Again, given the previously demonstrated clear modulation resultant from hand position (Gozli et al., 2014) and a clear absence of any modulation reported in Experiment 1, we performed planned comparisons for each of the two groups. These group and task condition specific comparisons revealed that, contrary to Experiment 1, shorter RTs for the same object relative to the different object were only observed in the hands far conditions (see Figure 4). That is, there was a significant recognition benefit for both the direct, $t(16) = 2.30$, $p = .035$, and indirect, $t(16) = 2.18$, $p = .045$ experimenter observation groups in the hands far conditions. In the hands near conditions, there were no same object benefits in RT for both the direct, $t(16) = -1.19$, $p = .251$, and indirect, $t(16) = -0.74$, $p = .473$, experimenter observation groups. Therefore, consistent with Gozli et al. when the experiment is conducted in an individual setting

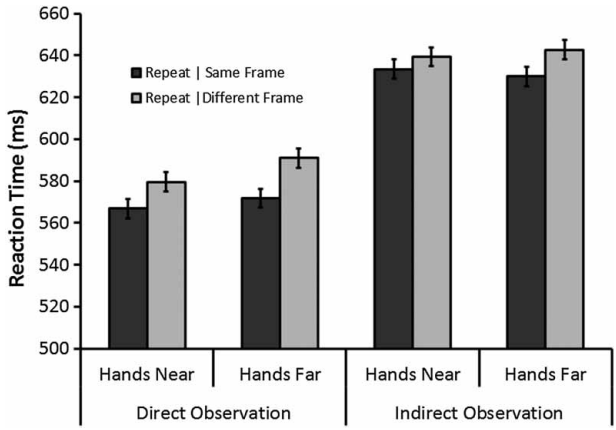

Figure 4. Reaction times towards Repeat (same or different object) targets with hands in a distal (Hands Far) or a proximal position (hands near) for both direct and indirect observation conditions. Error bars denote standard error of the mean for within-subjects effects (Loftus & Masson, 1994).

and participants have their hands in close proximity to the display stimuli, the standard object related benefit is interrupted. Importantly, this pattern of RTs was observed when participant was directly or indirectly observed.

As with Study 1, the accuracy followed the same pattern of results as the reaction time data (see Table 2). Therefore the results cannot be attributed to a speed-accuracy trade-off.

General discussion

Certain postural configurations are highly associated with specific visual biases. Although it seems likely that these associations would be stronger for self-related positions, awareness of another person's postural configuration may allow one to override one's own perceptual biases. Indeed, it has been previously suggested that joint attention supports a "perceptual common ground" which allows two or more individuals to experience the same thing at the same time to facilitate action coordination in a shared

Table 2. Percentage errors for Repeat (same or different object) targets with hands in a distal position (Hands Far) or a proximal position (Hands Near) in both observation conditions (direct/indirect).

Observation condition	Hand Position	Same Object (%)	Different Object (%)
Direct observation	Hands Near	12.31	13.03
	Hands Far	10.19	15.09
Indirect observation	Hands Near	11.08	15.12
	Hands Far	15.76	15.88

environment (Tollefsen, 2005; see also Frischen et al., 2009). The present studies were conducted to investigate this common perceptual ground hypothesis by determining if the presence of a co-actor affects the modulation of an object-specific recognition benefit that is observed when people act alone (Gozli et al., 2014; see also Experiment 2). Consistent with our hypotheses that the simulation of a co-actor's perceptual states could result in perceptual biases similar to those of the co-actor's responses were shorter when the stimulus remained in its original placeholder across *all* conditions in Experiment 1. Importantly, the contrast in the patterns of RTs between Experiments 1 and 2 highlight the important role of an active co-actor in modulating perceptual processes because the mere presence of another individual, either directly across from the participant or beside the participant, did not influence the performance of an individual acting alone.

Given that previous research and Experiment 2 revealed a clear proximal/distal modulation for the same task in an individual setting, what is it about the presence of a co-actor (in contrast to a non-acting observer) that overrides the influence of hand-proximity on visual processing? Answering this question requires considering the accounts of how vision is altered in the near-hand space. As previously mentioned, one proposal is that the near-hand space is purview to a higher contribution of the magnocellular (M) pathway and reduced contribution of the parvocellular (P) pathway (e.g., Abrams & Weidler, 2014; Goodhew, Fogel, & Pratt, 2014; Goodhew et al., 2013; Gozli et al., 2012; Gozli et al., 2014; Thomas, 2015). Consequently, because the object-based processing effect likely relies on the P pathway, the deterioration of the object-based processing in near-hand space can be explained in terms of a weaker contribution of P pathway in near-hand space (Gozli et al., 2014; Kelly & Brockmole, 2014). Assuming this explanation, we suggest that the presence of a co-actor, as well as the co-actor's hands (far from display) may prevent the modulated activity in the visual pathways. Presumably, this modulation occurs because the co-actor's frame of reference and a sharing of common perceptual space when people are co-acting influences how space is segmented into "near" and "far", treating the actor's near-hand space as less "relevant for action" because of how the co-actor represents this space. In other words, what was clearly in "near" and "far" frames of reference when done individually becomes obscured when both participants have hands in both spaces and this change in reference frames subsequently influences perceptual processes.

There is, however, an alternative explanation for the present findings. It may be that simulation and co-representation processes are flexibly engaged depending on the nature of the task. Indeed, simulation processes in joint action are not always evident (Kilner et al., 2006, 2009; Kourtis et al., 2010; Kourtis et al., 2013; Lumsden et al., 2012; Miles et al., 2011). Thus, it is possible that participants simulate and represent others' perceptual states

selectively on the basis of task demands. Specific to our joint study (Experiment 1), we speculate that segmenting space in relation to one's own action-relevant space was not necessary, therefore M pathway activity was not increased nor was P pathway activity subsequently decreased in conditions where the participant was already optimally engaged with the space for perception. Perhaps the flexible simulation of co-actor posture and subsequent representation of their perceptual state actions primes the seemingly flexible selection of the P pathway. This flexible selection may be the critical mechanism that allows Participant 2 to preserve normal levels of object-based processing (i.e., P pathway activity) while their hands are near the stimuli and oriented for action. We should note this is not necessarily against our first interpretation, the P pathway may be the generally dominant or more readily activated system when the nature of the task requires "space for perception".

This proposal has implications for other paradigms in which "space for action" is compared with "space for perception". Ganel and Goodale (2003) reported that, compared to a distal viewing condition that involves attention to both task-relevant and task-irrelevant object features, grasping an object promotes attention to its task-relevant feature at the expense of attending to the task-irrelevant feature (e.g., the object's length while grasping its width). This observation is consistent with the reduced P pathway contribution in the space for manual action. According to our proposal, grasping in the presence of another person may render the target of grasp within a "space of perception", thus causing attentional allocation to both task-relevant and task-irrelevant features.

Although we did not find a Hand Position × Object interaction in the second experiment, the planned comparisons did reveal a proximal/distal modulation of the object related benefit consistent with Gozli et al.'s (2014) findings. The lack of the interaction may be understood in the context of the current theoretical discussions of M and P pathways. Specifically, it is thought that when M pathway contribution is increased the relative contribution of the P pathway is decreased (Bocanegra & Zeelenberg, 2009; Yeshurun, 2004; Yeshurun & Levy, 2003). However, there is no evidence that the P pathway contribution, which is implicated in featural binding, is all together abolished. Therefore, there could simply be a weaker featural binding effect with a proximal hand position that may be far less reliable. Extending this notion to the results of Experiment 1, the joint nature of the task and the hand position of the partner simply provides a means of increasing the P pathway contribution to a level that an object related benefit is readily observable regardless of hand position. Regardless, the key observation should be that the patterns of RTs in this task were different when the other individual in the room was a co-actor (Experiment 1) or passive observer (Experiment 2).

Although not the first indication that mental state attribution can influence information processing (e.g., Sebanz et al., 2003; Welsh et al., 2005), the present study provides the first indication that perceptual biases might be flexibly modulated in association with the simulation of a co-actor's posture and subsequent representation of their perceptual states. These findings may be a first step towards elucidating the mechanisms behind more complex joint tasks where standard simulation processes may actually impair performance. For example, complementary forms of joint action involved in dancing (as opposed to synchronized movement) may suffer if we do not inhibit imitative tendencies grounded in simulation (Sacheli, Tidoni, Pavone, Aglioti, & Candidi, 2013; Sartori, Betti, & Castiello, 2013). Although it has been suggested that we can engage in multiple simulations at once (Vesper, Knoblich, & Sebanz, 2014), Sebanz et al.'s (2003) seminal research on the joint Simon effect shows that co-representation another's task can clearly interfere with our own responses. Indeed, subsequent research may show that overall performance differences can be explained by the ability to selectively inhibit simulation or co-representation on the basis of the task we are engaged in, or alternatively, represent joint action or perceptual space only when it is beneficial. In sum, the present research integrates two important areas to determine the extent to which common representations in pairs influence our own individual perception. Future research should aim to determine if this flexibility is due to the nature of the task by comparing tasks that require space for action or space for perception.

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