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Contextual Events and Their Role in a Two-Choice Joint Simon Task

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Abstract

We examined the effects of individual versus joint action on a Simon task using motion tracking to explore the implicit cognitive dynamics underlying responses. In both individual and joint conditions, participants were slower to respond, and were differentially attracted to the distracter response location, when the spatial component of the stimulus was incompatible with the response location. When two people completed similar two choice tasks together, the results were not statistically different from the individual condition, even though the magnitude of the stimulus-response compatibility effect was slightly larger. Neither was there an increased effect when the partner had no stimulus-response conflict to resolve. We found no evidence for an action conflict when the responses of the two partners were different. These data imply that the literature regarding the Joint Simon task is still in the process of determining the relevant events that interact with and support joint action.

Keywords: Joint action; Simon effect; motion tracking

In the two-choice Simon task, the spatial dimension of the stimulus leads to an automatic activation of the response corresponding to that spatial information (e.g., a stimulus located to, or pointing to, the left, primes a left response). If the correct response is located to the same side as the stimulus, responses will be faster than when the spatial features of stimulus and response do not overlap (Kornblum, Hasbrouq, & Osman, 1990). Sebanz, Knoblich, and Prinz (2003, 2005) had participants engage in a Simon task either as individuals or as dyads. The task required that participants respond to pictures of hands wearing a colored ring pointing to the left or right. Response buttons were located to the left or right of the screen. When participants did the task together, one individual was responsible for responding to one component of the stimulus (e.g., respond right for a green ring) while the other was responsible for responding to another component (e.g., respond left for a red ring). Essentially, each participant engaged in a go/no-go task. That is, they responded when the stimulus matched the condition of their rule (i.e., a go trial) and did not respond when the stimulus did not match the condition of their rule (i.e., a no-go trial). In each trial, the direction of response indicated by the ring color was either *compatible* with the spatial dimension of the stimulus (e.g., left response and hand pointing left) or *incompatible* (e.g., left response and hand pointing right). For dyads, response times (RTs) were significantly longer on incompatible trials than compatible trials. This Simon effect did not occur when participants engaged in the same go/no-go task alone. In other words, the spatial compatibility of the pointing hand only affected RTs when participants completed the task with another person. Sebanz et al. argue that the joint Simon effect (JSE) emerged in the dyad condition because participants automatically represented the action of their partner. Consequently, when their partner's co-represented action conflicted with their own, they had to resolve a response conflict.

An alternative account of the JSE is presented by Dolk, Hommel, Prinz, and Liepelt (2013; Dolk et al., 2014). According to their referential coding hypothesis, the JSE does not emerge via co-representation of another's action, but rather the co-actor is treated as a spatial reference frame for coding one's actions. In the individual go/no-go task, there is only one response, which is not spatially coded. When a co-actor is introduced, a response is coded as "left" or "right" relative to the co-actor. Dolk et al. also suggest that, on this view, the source of the reference frame need not be an intentional agent. To test this claim, they replaced the co-actor with objects such as a waving cat, a clock, and a metronome, and found that the JSE still appeared.

Croker, Jordan, Schloesser, and Cialdella (2015) had participants engage in a Simon task alone or with a confederate. However, whereas most researchers have each participant effectively engage in a go/no-go task, Croker et al. asked participants to respond to one of two choices on every trial. In their task, participants always followed the same response rule (i.e., right for a green ring and left is the ring was not green). In the *individual* condition, participants completed this task alone. In the *joint-color* condition, a confederate worked alongside the participant and responded left for red rings and right if the ring was not red. In the *joint-direction* condition, a confederate worked alongside the participant and responded to the direction of the pointing hand. This *joint-direction* condition created two kinds of trials: trials in which the two stimulus dimensions primed the same response for the participant and confederate (i.e., non-conflict trials) and trials in which the stimulus primed opposite responses for the participant and confederate (i.e., conflict trials). In addition to requiring participants to respond on every trial, Croker et al. diverged from the Sebanz et al. (2005) paradigm by having participants indicate their responses using a computer mouse, while the confederate made responses on a button box. To make a response, participants moved a mouse cursor from the bottom center of the screen to a response location in the left or right upper corner of the display. In addition to providing RTs, the use of mouse trajectory responses—instead of button presses—

allowed the authors to obtain an implicit measure of the cognitive dynamics underlying response choice: maximum deviations toward the distracter response (MDs). In order for movement data to be informative, it is necessary to make both response options available to participants. In go/no-go tasks, in which only one response location is utilized (even if the alternative is displayed), participants move the mouse in a straight line from the start location to the response location, even on spatially incompatible trials. A two-choice task means that participants always have to consider both response locations, and we can observe the extent to which a movement is attracted to the alternate response location prior to its arrival at the correct response. Croker et al. replicated the basic Simon effect in both the RT and MD data across all three conditions; both RTs and deviations toward the distracter responses were greater on incompatible trials than compatible trials. On *compatible* trials, mouse trajectories were attracted toward a single strong attractor for that problem. On *incompatible* trials there was greater competition between the two response options, as different dimensions of the stimuli (i.e., color and direction) primed different responses, and there was greater deviation towards the distracter response. Croker et al. also found that RTs were increased, and MDs were decreased, in the joint conditions. This finding was interpreted as evidence for the role of inhibition; participants took longer to respond, but took more direct routes to the response, suggesting that the increased RTs were due to the presence of a co-actor, and not due to increased response-path lengths.

The purpose of the current study is to extend the work of Croker et al. (2015) in two ways. First, to examine the temporal dynamics of *both* partners' response selection in a two-choice Joint Simon task. In addition to the research described above, many other studies have shown a joint Simon effect (JSE) for dyads sharing a task in a go/no-go fashion (e.g., Malone, Castillo, Kloos, Holden, & Richardson, 2014; Welsh, 2009), but in the present study, we look at two participants who are both engaged in two-choice tasks. Croker et al. (2015) were only able to record movement trajectories for one person in joint-action conditions. In the present study, we use motion tracking to record response trajectories of two participants working alongside one another. Second, Croker et al. failed to replicate some of Sebanz et al.'s (2005) findings, concluding that such effects may have emerged specifically out of the unique constraints of the Sebanz et al. task. By collecting data from two participants both engaged in arm reach responses (as opposed to mouse and button responses) we can determine the extent to which the mouse trajectory data and arm reach trajectory data are consistent, or whether Croker et al.'s findings were are also a function of the specific task context.

If the inhibition account of the Joint Simon data proposed by Croker et al. (2015) generalizes beyond the task constraints of that experiment then, in addition to anticipating a replication of the basic Simon effect (i.e., larger RTs and MDs for incompatible trials than compatible trials), we predict that the presence of a co-actor will cause greater automatic inhibition, and thus we expect both partners to exhibit longer RTs in the joint conditions than the individual condition, but we do not expect to see increased MDs. Alternatively, given Malone et al.'s (2014) assertion that Joint Simon effects emerge out of a "…dynamical (time-evolving) interpersonal coupling that operates to perturb the behavior of socially situated actors…" (p. 1), the social availability of each actor's movement dynamics in the present task may lead to the two participants' dynamics becoming coupled. This would be consistent with Malone et al.'s finding that the trial-to-trial RTs collected in a Joint Go/No task were more correlated over the long-term than RT streams collected from pseudo pairs (i.e., randomly paired data from the Individual condition). Such time-evolving, interpersonal coupling in the present task might lead to the participants' real-time dynamics synergistically influencing each other and, as a possible result, generating response synchrony that serves to negate any Joint Simon effects. Such an outcome would imply that the effects deemed due to inhibition in the Croker et al. study do not generalize to a situation in which both actors respond on every trial via socially-observable movements.

Method

Participants and materials

Forty participants (32 female; mean age = 20.2 years) from Illinois State University volunteered as participants for extra course credit. Stimuli consisted of a set of four images, and one image appeared center screen on each trial. Every image was comprised of two stimulus dimensions: hand direction and ring color. In each trial, a hand was presented pointing either left or right wearing a ring that was either green or red. This yields four possible stimulus combinations: left-pointing hand/green ring, left-pointing hand/red ring, right-pointing hand/green ring, and right-pointing hand/red ring. We used a modified version of the Sebanz et al. (2005) paradigm to accommodate motion tracking technology. Stimuli were presented on a screen using Inquisit software (http://www.millisecond.com/), and pairs of participants responded using a wooden hammer to tap either a left or right wooden target (23" apart and 26" above the start location). A Polhemus Patriot motion sensor was attached to each hammer in order to capture the motor dynamics of each response (see Figure 1). Participants were told to respond as quickly as possible and to return to the starting location after each trial. On trials in which one or both of the participants responded incorrectly, a red X was presented on the corresponding side of the screen.

Procedure

After completing four practice trials, participants completed three blocks (100 trials each) of the Sebanz et al. task. In each block, all four images (left-pointing hand/green ring, left-pointing hand/red ring, right-pointing hand/green ring, and right-pointing hand/red ring) were presented 25 times each in a randomized order.

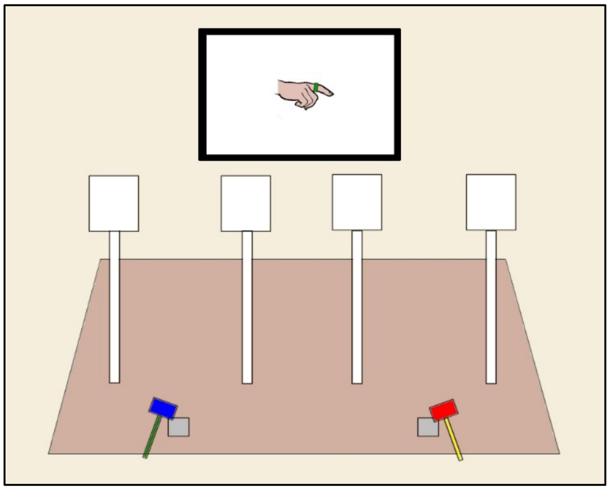

Figure 1: Experimental setup. Each participant responded to a left or right response location using a wooden hammer with a motion sensor attached to it, starting from a point marked on the table (grey square).

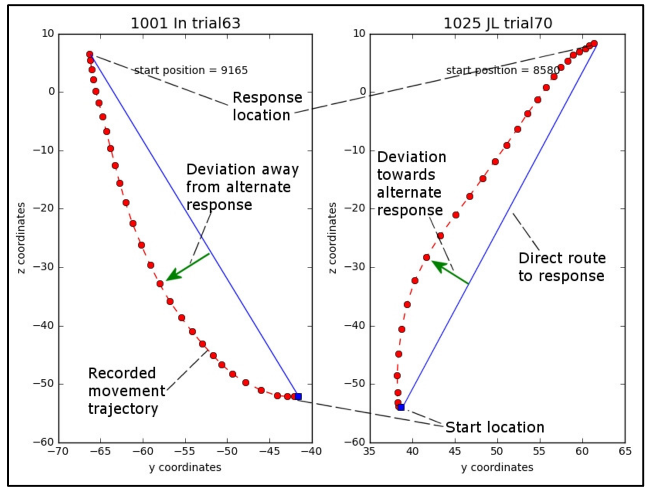

Figure 2: Sample trajectories: (a) a left response with a negative deviation; (b) a right response with a positive deviation.

In the *individual* block, participants completed the task on their own. They were asked to tap the right target whenever the ring was green, and the left target if the ring was not green. In the *joint-color* and *joint-direction* blocks, participants completed the task with a partner. They were instructed that their partner would respond on every trial to the same stimulus at the same time, but that the partner was following a different rule. In the *joint-color* block, participants responded to ring color. Each participant's rule was different, but their actions were the same. Partner A's task was to respond to red rings by tapping the left target and to non-red rings by tapping the right target. Partner B's task was to respond to green rings by tapping the right target and non-green rings by tapping the left target. There were two *joint-direction* conditions: *joint-left* and *joint-right*. In both *joint-direction* conditions, one partner responded to the spatial component of the stimulus (direction) while the other responded to the non-spatial component (color). In the *joint-left* condition, the partner responding to direction (i.e., Partner A) had the task of responding to hands pointing left by tapping the left target and to hands not pointing left by tapping the right target. Partner B's task was to respond to green rings by tapping the right target and to non-green rings by tapping the left target. In the *joint-right* condition, partner A's task was to respond to hands pointing right by tapping the left target and to hands not-pointing right by tapping the right target. Partner B's task was the same as Partner B's task in the *joint-left* condition: to respond to green rings by tapping the right target and to non-green rings by tapping the left target. Partner A completed the individual condition before the joint conditions and partner B completed the individual condition after the joint conditions. Joint conditions were counter-balanced between participants.

Design and Analyses

The dependent variables were *response time* and *maximum deviation* from an idealized trajectory toward the correct response. Streaming *x*, *y*, and *z* coordinates from each pair of participants were recorded at a rate of 60Hz using a Polhemus Patriot magnetic motion tracking system and Liberty 8 Capture software (Richardson, 2007). As the movement of interest is in the *y* (left-right) and *z* (up-down) planes, we did not include *x*-coordinate data (forward-backward) in our analyses. We recorded a continuous data stream for each condition (i.e., 100 trials), and defined trial onset as the point at which the tangential velocity of the movement in the *y* and *z* planes exceeded 5% of the maximum, and trial offset as the point at which tangential velocity dropped below 5% of the maximum, after passing one third of the maximum value. This procedure ensured that we captured just the outward portion of the motion, from the start location to the response location. We computed maximum deviation by comparing the *y*,*z* coordinates of the movement trajectory for each trial with a direct line between the start and end points of each trajectory. The greatest distance between the actual and idealized trajectories is the maximum deviation. A positive MD value indicates deviation towards the distracter response, and a negative deviation indicates deviation away from the distracter (see Figure 2). Only correct responses were included for analysis, but error rates were small (0.6%). Some trials had to be excluded due to noisy data resulting from electromagnetic interference to the magnetic field used by the motion tracking system; in a few cases this meant eliminating all trials for a given participant. After data were excluded, we had 38 participants in the individual condition, and 37 in each of the joint-color and joint-direction conditions.

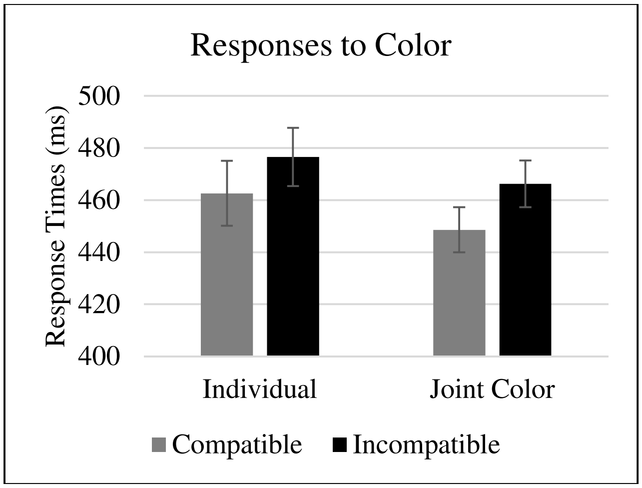

Figure 3: Response times (with standard error bars)

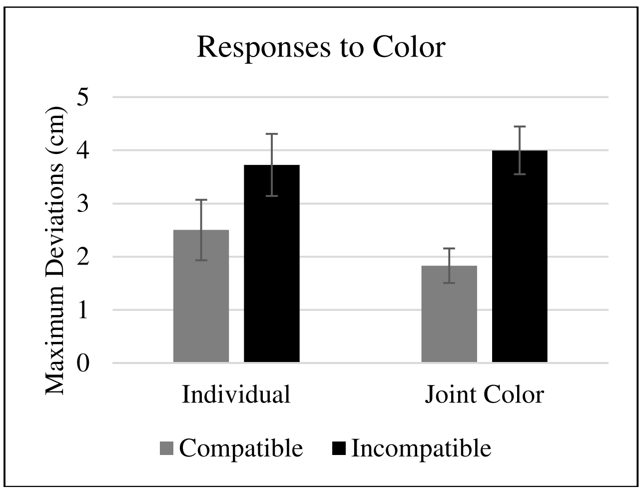

Figure 4: Maximum deviations (with standard error bars)

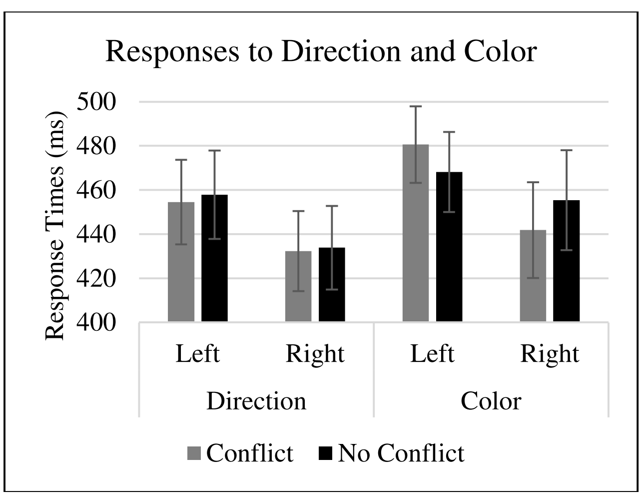

Figure 5: Response times for conflict vs. no-conflict responses for the joint-left and joint-right conditions (with standard error bars).

Results

Individual and Joint-Color Conditions

The individual condition enables us to explore whether we observe the basic Simon effect, and whether motion tracking gives us any additional insight into the effect. The joint-color task, in which partner A responds left to red, and partner B responds right to green, allows us to determine whether the addition of a co-actor with a different task rule, but the same actions, increases the size of the effect. We found an effect of spatial compatibility both for response times (RTs), $F(1,35) = 30.303$, $p < .001$, $\eta_p^2 = .464$, and maximum deviations (MDs), $F(1,35) = 22.825$, $p < .001$, $\eta_p^2 = .395$, for both the individual and joint-color conditions (see Figures 3 and 4). The increase in MDs on spatially incompatible trials shows that participants were differentially attracted to the unselected, incorrect response on these trials, suggesting an early response to the task-irrelevant spatial component of the stimulus, which was later inhibited.

The difference in RTs between compatible and incompatible trials was larger in the joint-color condition than the individual condition (18ms vs. 14ms), as was the difference in MDs. Although the differences were numerically greater in the joint-color condition, we found no statistical difference between the individual and joint-color conditions and, importantly, no interactions between condition and spatial compatibility for either dependent variable.

Joint-Direction Condition

The joint-direction condition allows us to explore the effects of a co-actor who is following a different task rule and sometimes producing different actions. On some trials, both participants respond to the same location (*no-conflict*); on others, they respond to different locations (*conflict*). Participants who completed the *joint-left* task in the joint-direction condition were instructed to respond left to left-pointing hands, which means that all their responses were spatially compatible with the stimulus. Participants who completed the *joint-right* task in the joint-direction condition were instructed to respond left to right-pointing hands, meaning that all trials were incompatible. We conducted mixed ANOVAs on the effects of task (direction vs. color—between subjects), direction-compatibility for the partner responding to the direction of the hand (left vs. right—between subjects), and action conflict between the two participants (conflict vs. no-conflict responses—within subjects) on RTs and MDs.

For RTs, there was an interaction between task, direction-compatibility, and action conflict, $F(1,33) = 9.249$, $p = .005$, $\eta_p^2 = .219$, whereby conflict and no-conflict trials differed for the color-task participants only, and the direction of the effect difference varied according to the direction-compatibility of their partner (see Figure 5). The two stimuli to which the participant given the right-direction task responded to the *same* location as the color-task participant are right/green and left/red. The two stimuli to which the left-direction response was *different* to the color-task response are also right/green and left/red, both of which are spatial conflict trials for the color-task participant. Therefore, the interaction between action conflict and direction-compatibility can be explained as a simple stimulus-response compatibility effect. The participants given the direction task did not respond differentially on conflict or no-conflict trials, suggesting that they did not need to distinguish between own- and other-responses. Note that we do not expect to see stimulus-response compatibility effects for these participants because all responses in the left-direction condition are spatially compatible with the stimuli, and all responses in the right-direction condition are spatially incompatible with the stimuli.

There was an interaction between direction condition and response type for MDs, $F(1,33) = 16.314$, $p < .001$, $\eta_p^2 = .331$, whereby MDs were largest for conflict responses in the left-direction condition and no-conflict responses in the right-direction condition. As with the RT data, these larger MDs correspond to spatially-incompatible trials for the participant given the color-task, yet there was no interaction with participant task (direction vs. color), probably because this pattern also held for participants in the left-direction task. There was also an interaction between direction condition and task, $F(1,33) = 5.75$, $p = .022$, $\eta_p^2 = .148$, such that MDs were larger in the left-direction condition than the right-direction condition for participants given the color task, but there were no differences between these two conditions for participants given the direction task (see Figure 6).

In order to test the prediction that the presence of a co-actor would lead to larger RTs, but not MDs, for the color-task participant, we conducted 2 (task: individual vs. joint-direction) x 2 (spatial compatibility) repeated-measures ANOVAs. We found no main effect of task on RTs, $F(1,17) < 0.01$, $p = .989$, $\eta_p^2 = .000$. As with the joint-color condition, the difference between compatible and incompatible trials was numerically larger in the joint-direction condition than the individual condition (13ms vs. 8ms), but the condition x compatibility interaction was non-significant, $F(1,17) = 1.36$, $p = .260$, $\eta_p^2 = .074$. There was no effect of task on MDs, $F(1,17) = 0.40$, $p = .533$, $\eta_p^2 = .023$.

Finally, given that the role of partner A was just to respond to direction, we conducted mixed ANOVAs on the effects of stimulus direction, stimulus color, and direction-compatibility of the task for partner A only. There was an interaction between stimulus direction and condition for both RTs, $F(1,17) = 6.018$, $p = .025$, $\eta_p^2 = .261$, and MDs, $F(1,17) = 39.657$, $p < .001$, $\eta_p^2 = .700$. RTs and MDs were greater for left stimuli for participants responding to right and vice versa. For the stimuli in which the direction of the hand was congruent with the rule, the MDs are actually negative – participants were repelled from the distracter response (see Figure 7).

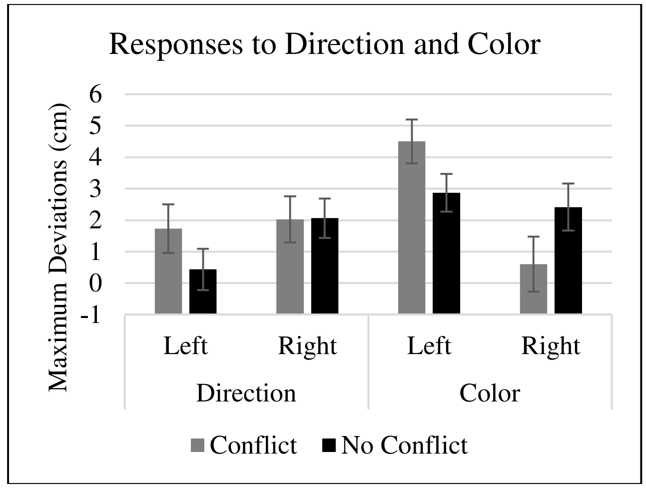

Figure 6: Maximum deviations for conflict vs. no-conflict responses for the joint-left and joint-right conditions (with standard error bars).

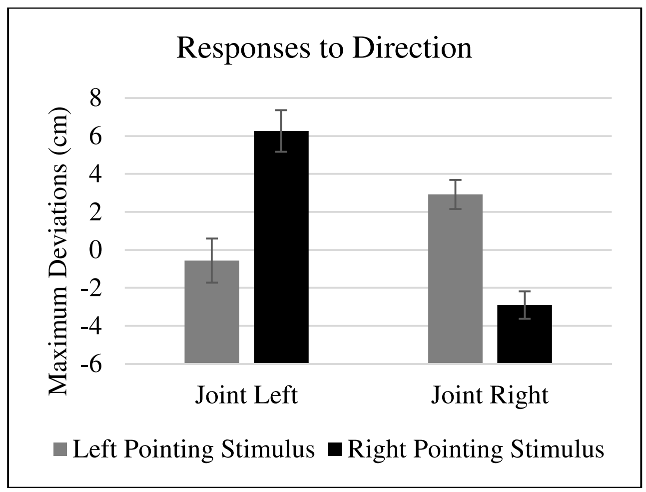

Figure 7: Maximum deviations for left vs. right stimuli for partner A (with standard error bars).

Discussion

As expected, the spatial compatibility of a stimulus had an effect on RTs and MDs in the individual condition. This is the basic Simon effect whereby participants take longer to respond to stimuli with conflicting spatial and non-spatial cues. The MD data give us direct evidence that participants are differentially attracted to the distracter response on spatially incompatible trials; reach trajectories showed early attraction to the response indicated by the direction of the hand, prior to moving toward the correct response location indicated by the color of the stimulus. This effect persisted when participants worked alongside a partner, regardless of whether their partner was responding to the color or spatial dimension of the stimulus. Our prediction that RTs would begreater in the joint conditions was not supported. This is surprising, as we previously found increased RTs for participants responding to color using a mouse tracking paradigm (Croker et al., 2015). However, aside from the difference between moving a mouse cursor through two dimensions and a motion sensor through three dimensions, the major difference between the two studies is the response modality of the co-actor. Croker et al. had a confederate respond with a button press whereas, in the present study, co-actors responded by generating a reach behavior. These behaviors were emitted by both participants simultaneously, in full view of the other. Perhaps the difference in findings between Croker et al. (2015) and the present study is due to an entrainment that may have emerged between the movements of the two participants as they generated responses in the format demanded by the present task.

Contrary to the predictions of both the action co-representation and referential coding accounts, we found no effect of conflict vs. no-conflict trials in the joint-direction condition. If it is the case that participants represent or encode both their action and that of their partner, we would expect faster and more direct responses on trials where both participants respond to the same location than trials where one responds to the left and the other to the right. Participants did not take longer to respond when their action was the opposite of their partner. However, we also found no support for the prediction, based on our inhibitory account, that RTs would be greater in the joint condition than the individual condition.

The MD data present a slightly more complicated picture. We found evidence for a basic Simon effect for the color-task participants, in that MDs were larger for spatially incompatible trials, yet there was no interaction with task (direction vs. color). As shown in Figure 6, the lack of an interaction is probably due to the difference in MDs between conflict and no-conflict trials for participants in the left-direction condition. It could be the case that participants given the left-direction task also encoded the spatial incompatibility for their partners in the conflict trials, and reflected their partner's shifting trajectory as their partners resolved the spatial stimulus-response incompatibility. If this were the case, we would then also expect to see a similar effect for the no-conflict trials for participants given the right-direction task; an effect we did not observe. However, all trials are spatially incompatible in the right-direction task, and the response patterns of these participants may reflect this fact. Rather than a response *cost* for the left-direction participants on conflict trials, there may be a *facilitation* on the no-conflict trials, in which neither participant has to resolve a spatial conflict, either on the basis of partner response or stimulus-response compatibility. This interpretation is consistent with the fact that the MDs for participants given the direction task are smallest on left-direction/no-conflict trials. We also found that participants given the direction task exhibit small, even negative, deviations when the stimulus direction matches the target direction given in the task instructions. Participants given the "respond left to left hands" rule showed a spatial bias towards the left for all stimuli, and participants given the "respond left to right hands" rule showed a bias to the right. This finding suggests that, even though the instructions can be interpreted as stating how to respond to both left- and right-pointing hands, the movement data reflect the fact that only one spatial direction was explicitly mentioned.

In sum, using a novel motion-tracking methodology, we found that movement trajectories offer confirmatory evidence that the response time cost for spatially incompatible trials in the Simon task is due to an initial attraction to the direction indicated by the stimulus. In addition, the present data seem to constitute yet another study that reveals the contextually sensitive nature of Joint Simon effects. That is, while the data of Sebanz et al. (2003, 2005) are consistent with a co-representation account, the data of Dolk et al. (2013, 2014) with a referential coding account, the data of Croker et al. (2015) with an inhibition account, and the data of the present study with an entrainment account, it seems all of these accounts fail to survive generalization to different task constraints. While this lack of replication makes it difficult to assert the "correctness" of any one account, it simultaneously clarifies the immense complexity of interacting factors that contextually and contingently interact and support the phenomenon of joint action.

References

Croker, S., Jordan, J. S., Schloesser, D., & Cialdella, V. (2015). The effects of racial similarity and dissimilarity on the joint Simon task. In D. C. Noelle, R. Dale, A. S. Warlaumont, J. Yoshimi, T. Matlock, C. D. Jennings, & P. P. Maglio, P. P. (Eds.) Proceedings of the 37th Annual Meeting of the Cognitive Science Society (pp. 489-494). Austin, TX: Cognitive Science Society.

Dolk, T., Hommel, B., Prinz, W., & Liepelt, R. (2013). The (not so) Social Simon effect: A referential coding account. *Journal of Experimental Psychology: Human Perception and Performance, 39*, 1248-1260.

Dolk, T., Hommel, B., Colzato, L.S., Schütz-Bosbach, S., Prinz, W., & Liepelt, R. (2014). The joint Simon effect: A review and theoretical integration. *Frontiers in Psychology, 5*:974.

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

Malone, M., Castillo, R. D., Kloos, H., Holden, J. G., & Richardson, M. J. (2014). Dynamic structure of joint-action stimulus-response activity. *PloS One*, *9*, e89032.

Richardson, M. J. (2007). Liberty 8 Capture [Computer Software]. http://www.xkiwilabs.com/downloads_polhemus.html

Sebanz, N., Knoblich, G., & Prinz, W. (2003). Representing others' actions: just like one's own? *Cognition*, *88*, 11-21.

Sebanz, N., Knoblich, G., & Prinz, W. (2005). How two share a task: Corepresenting stimulus-response mappings. *Journal of Experimental Psychology: Human Perception and Performance, 31*, 1234-1246.

Welsh, T. N. (2009). When 1+ 1= 1: The unification of independent actors revealed through joint Simon effects in crossed and uncrossed effector conditions. *Human Movement Science*, *28*, 726-737.