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Knowledge of response location alone is not sufficient to generate social inhibition of return

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ABSTRACT

Previous research has revealed that the inhibition of return (IOR) effect emerges when individuals respond to a target at the same location as their own previous response or the previous response of a co-actor. The latter social IOR effect is thought to occur because the observation of co-actor's response evokes a representation of that action in the observer and that the observation-evoked response code subsequently activates the inhibitory mechanisms underlying IOR. The present study was conducted to determine if knowledge of the co-actor's response alone is sufficient to evoke social IOR. Pairs of participants completed responses to targets that appeared at different button locations. Button contact generated location-contingent auditory stimuli (high and low tones in Experiment 1 and colour words in Experiment 2). In the Full condition, the observer saw the response and heard the auditory stimuli. In the Auditory Only condition, the observer did not see the co-actor's response, but heard the auditory stimuli generated via button contact to indicate response endpoint. It was found that, although significant individual and social IOR effects emerged in the Full conditions, there were no social IOR effects in the Auditory Only conditions. These findings suggest that knowledge of the co-actor's response alone via auditory information is not sufficient to activate the inhibitory processes leading to IOR. The activation of the mechanisms that lead to social IOR seems to be dependent on processing channels that code the spatial characteristics of action.

1. Introduction

When an individual completes a series of responses to targets that appear randomly at several locations, reaction times (RTs) tend to be longer for responses to targets presented at the same location as a previous target than for responses to targets presented at a different location (e.g., Maylor & Hockey, 1985). This increase in RT for repeated relative to different targets is consistent with the inhibition of return (IOR) effect observed in cue–target paradigms (Posner & Cohen, 1984). The IOR effect is thought to reflect the activation of an inhibitory mechanism that facilitates efficient search patterns by hindering the return of attention to the previously responded-to location and/or the reactivation of a recently executed response used to search a given location in space (see Klein, 2000 for a review).

Although IOR has most commonly been studied in individuals acting alone (i.e., individual or iIOR), a series of studies has revealed that IOR is also present in social action contexts (e.g., Cole, Skarratt, & Billing, 2012; Skarratt, Cole, & Kingstone, 2010; Welsh, McDougall, & Weeks, 2009; Welsh et al., 2005, 2007). In these studies, pairs of individuals execute responses to a common set of target locations. The participants take turns responding to randomly presented targets. RTs for trials on which co-actor A responds to a target presented at the same location as co-actor B's previous response are compared to RTs for trials on which co-actor A responds to a target presented at a different location from co-actor B's previous response. The results of these comparisons consistently reveal that RTs for repeated target trials are longer than those on different trials — a pattern of RTs consistent with the iIOR effect (e.g., Maylor & Hockey, 1985; Welsh & Pratt, 2006). This social IOR (sIOR) effect is thought to be caused by the same set of mechanisms that lead to iIOR (Welsh et al., 2005). In support of the hypothesis that the same inhibitory mechanisms lead to iIOR and sIOR, Welsh et al. (2009) found that the magnitude of the IOR effect on trials in which the individual followed their own response correlated with the magnitude of the IOR effect when they followed their partner's response.

The currently held view regarding the processes that lead to the activation of the inhibitory mechanisms leading to sIOR is that the

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observation of a co-actor's response generates a representation of that action in the central nervous system of the observer. This observation-evoked response representation is subsequently accessed by other systems to shape future behaviour. This hypothesis is consistent with the wealth of behavioural and neurophysiological evidence for an action observation system that enables an individual to represent the actions and the sensory consequences (effects) of the actions for use in numerous social cognitive processes (for relevant reviews see Rizzolatti & Craighero, 2004, and van der Wel, Sebanz, & Knoblich, 2013). In the case of sIOR, it is hypothesized that the observation-evoked representations generate a simulation of the performance in the observer and that this simulation of performance then activates the inhibitory mechanisms that lead to IOR.

There are three sets of results that suggest that knowledge of the spatial characteristics of the response is critical to the generation of the sIOR effect. First, there are a pair of papers reporting that vision of the onset of the target and/or of the contact with the target location is not necessary for generation of sIOR because sIOR was present even when observers were only permitted to see the initial (~25%) of their partner's response trajectory (Skarratt et al., 2010; Welsh et al., 2007). Second, in a study in which participants sat next to each other (instead of across from one another), RTs were longer for movements in the same direction as the co-actor's previous response even though the response terminated on a different location (Welsh et al., 2009). Finally, there is evidence that the goal of the final action executed at the target location (e.g., write vs. erase with a pencil) does not influence sIOR (Cole et al., 2012). Thus, knowledge of the spatial characteristics of the co-actor's response, not just of the interaction with an object at a specific location in space, seems to be critical for the generation of the sIOR effect.

The purpose of the present study was to determine if knowledge of the response endpoint alone, in the absence of directly witnessing some spatial components of the response, is sufficient to activate the inhibitory mechanisms leading to the sIOR effect. To this end, participants completed a sIOR task under two conditions. The Full condition was consistent with typical sIOR protocols in that participant's vision of the environment was not manipulated and they were permitted to witness the entirety of the response. The Full condition was not critical to addressing the main purpose of the study, but was included to ensure consistency with previous sIOR. The key condition for determining the role of knowledge of endpoint was the new Auditory Only condition. In the new Auditory Only condition, participants were prevented from witnessing the response, but were informed of the endpoint of the response via distinct location-contingent auditory information. In Experiment 1, the auditory information was a high or low pitched tone that was presented only when a specific button was contacted. Presentation of the effect tone alone was hypothesized to be sufficient for activating knowledge of the response, and likely the response codes that generate the tone, because there is behavioural (e.g., Elsner & Hommel, 2001) and neurophysiological (e.g., Kohler et al., 2002; Melcher, Weidema, Eenshuistra, Hommel, & Gruber, 2008, Melcher et al., 2013) evidence indicating that response representations can be activated following the perception of similar response-contingent auditory effect information when individual tones are consistently presented following a specific response. In Experiment 2, green and blue coloured paper was placed around the base of the target locations and the auditory information was the spoken words "green" or "blue" presented when the button surrounded by the green or blue paper was contacted, respectively. Thus, by perceiving the auditory information, participants knew which button was contacted by their co-actor, but did not observe the action that generated the effect tone. Hence, if knowledge of the endpoint of the partner's response alone can activate the inhibitory mechanisms leading to sIOR, then sIOR should emerge in the Auditory Only condition. On the other hand, if witnessing some spatial components of the task is necessary for the generation of sIOR, then sIOR will not be observed in the Auditory Only condition.

2. Experiment 1

2.1. Methods

2.1.1. Participants

Five pairs of individuals (6 male; aged 19–24 years) were recruited to complete the study. All participants had a right-hand preference (self-report), had normal or corrected-to-normal vision, and were naïve to the purpose of the study. The procedures of the present study complied with the codes of the Declaration of Helsinki and were approved by the University of Calgary Research Ethics Board. Each participant provided written informed consent prior to data collection.

2.1.2. Apparatus, task and procedures

Participants sat on opposite sides of a table. A black metal board containing four red buttons (2 cm diameter) was placed on the table in between the participants. The four buttons were arranged in a cross with each button located 14 cm from the centre of the board. One starting location button was directly in front of each participant and oriented along their midlines. The two target buttons were located on either side of an imaginary line connecting the two home buttons. Participants were asked to fixate a 2 cm by 2 cm cross located at the intersection of the imaginary line between the two target locations and the imaginary line between the two home positions throughout the blocks of trials.

There were a total of 24 blocks of trials in the study. The 24 blocks were divided into 2 sets of 12 blocks. Each block of trials consisted of 33 trials. Optional breaks were provided between each block to combat mental and physical fatigue. In the each set of 12 blocks, one participant completed the Auditory Only condition while the other participant completed the Full condition. Participants switched conditions at the end of the first 12 blocks. The same sequence of auditory stimuli was presented on every trial whether the participant was in the Full or Auditory Only condition.

The target for a given trial was indicated by the 80 ms illumination of a light-emitting diode (LED) under one of the potential target locations. Participants were instructed to start each trial with the index finger of their right hand depressing their starting button and then to move as quickly as possible to and touch the button that had illuminated. These movements were executed in a paired-alternating order (e.g., AABBAABB…) such that Participant A completed two responses followed by Participant B completing two responses, and so on. This trial arrangement enabled the examination of the effects of response repetition (IOR) on trials on which each individual participant followed their own response (i.e., A*A* and B*B* trials — iIOR) and when the participant followed the response of their partner (i.e., A*B* and B*A* trials — sIOR). Target location was pseudo-random on each trial with the constraints that 1) each trial combination occurred equally often within a block; and, 2) no location could be the target location on more than 4 trials in a row.

Throughout the entire study, both participants wore a pair of sound attenuating headphones that reduced environmental noise and presented the auditory stimuli. The headphones worn by each participant were linked to a common output such that both participants received the same set of white noise masks and tones on each trial. The white noise was presented during the movement time interval to prevent the participants from obtaining spatial information of target contact for a trial by hearing the contact and release of the target button. The white noise mask started 50 ms after the home button was released and continued until one of the buttons was pressed. Immediately after one of the two target locations was pressed, the associated tone was presented for 200 ms. A high-pitched tone (800 Hz) was presented when one button was pressed and a low-pitched tone (200 Hz) was presented when the other button was pressed. Prior to data collection, the participants were told about and given a demonstration of the button/tone mapping. The absolute button/tone mapping was kept