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Imitation in one's own presence: No specific effect of self-focus on imitation

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ABSTRACT

Previous studies have reported that imitative responses may be modulated by top-down social factors such as self-focus. However, growing evidence suggests that such social factors may actually modulate domain-general processes such as spatially compatible responding, rather than specifically social processes such as imitation. In this study, we aimed to identify the cognitive processes being modulated under conditions of heightened or diminished self-focus. Participants performed a stimulus-response compatibility task which independently measures both spatial and imitative response tendencies, under two conditions: heightened self-focus, where the task was performed in the presence of two mirrors; and diminished self-focus, where the mirrors were covered. While participants were faster to respond to compatible trials than to incompatible trials, both imitatively and spatially, there was no significant modulation of either spatial or imitative compatibility by self-focus; although the magnitude of the modulation of spatial compatibility was numerically similar to the effect of self-focus on imitation found in previous studies. These results provide no evidence for an effect of self-focus on either social-specific, or domain-general, processes.

1. Introduction

Humans tend to spontaneously imitate the movements, facial expressions, postures and speech patterns of others (Bock, 1986; Chartrand & Lakin, 2013; Sheflen, 1964). Multiple accounts suggest that observation of an action elicits a matching motor representation in the observer, and these perception-action links induce strong imitative tendencies (Fadiga, Fogassi, Pavesi, & Rizzolatti, 1995; Greenwald, 1970, 1972; Heyes, 2011). There is considerable evidence that such perception-action links, and their behavioural outcome, imitation, can be modulated by social factors including social group membership (Gleibs, Wilson, Reddy, & Catmur, 2016; Miles, Griffiths, Richardson, & Macrae, 2010; Rauchbauer, Majdandžić, Hummer, Windischberger, & Lamm, 2015; Rauchbauer, Majdandžić, Stieger, & Lamm, 2016; Yabar, Johnston, Miles, & Peace, 2006), direct eye gaze (Wang & Hamilton, 2014; Wang, Newport, & Hamilton, 2011; Wang, Ramsey, & Hamilton, 2011), and pro-social priming (Cook & Bird, 2011, 2012; Leighton, Bird, Orsini, & Heyes, 2010). However, the specificity of such social modulation is unclear: is such modulation specific to imitation (the production of a movement that matches an observed movement in terms of the configural relationships between body parts), or is it the result of a domain-general cognitive process, which would produce effects on any type of perception-action link (such as the tendency to respond on the same side of space as an observed stimulus)?

One reason for expecting such modulation to be imitation-specific stems from evidence suggesting that the control of imitation appears to involve a social-specific neurocognitive mechanism (Brass, Bekkering, Wohlschläger, & Prinz, 2000; Brass, Ruby, & Spengler, 2009), sometimes termed self-other control. Self-other control has been proposed as a cognitive process involved in controlling self- versus other-relevant mental representations and is thought to contribute to higher-order sociocognitive functions such as theory of mind and empathy (de Guzman, Bird, Banissy, & Catmur, 2016; Santiesteban et al., 2012). Evidence from both brain stimulation and neuropsychological studies suggests that the control of imitation is governed by cognitive mechanisms distinct from those involved in general inhibition (Brass, Derrfuss, & von Cramon, 2005; Hogeveen et al., 2015; Sowden & Catmur, 2015), and such mechanisms may be specific to the regulation of self- versus other-related representations (Brass et al., 2009; de Guzman et al., 2016). On the other hand, recent studies have cast doubt on the suggestion that previously reported modulation of imitation is in fact specific to imitation. For example, Marsh, Bird, and Catmur (2016) utilised

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a design in which the ability to control imitative responses could be isolated from the ability to control the tendency to respond in a spatially compatible manner (Catmur & Heyes, 2011). Marsh et al. demonstrated that previously used social modulators of imitation (group membership and eye gaze) in fact modulated spatial compatibility but not imitative compatibility.

The importance of accounting for non-imitative processes such as spatial compatibility is underlined by the fact that the majority of research exploring the social modulation of imitation has utilised stimulus-response compatibility tasks to measure imitative tendencies. In such tasks, the participant performs movements which are either the same as (compatible with) or different from (incompatible with) observed movements, which are usually irrelevant or incidental to the participant's instructed task. Response times on compatible trials are typically faster than those on incompatible trials, demonstrating the influence of the task-irrelevant stimulus movement on the instructed response. It is usually presumed that this response time effect ('imitative compatibility effect') is the result of the topographical similarity, in terms of body part configuration, between the observed and performed movements. However, in many cases, imitative compatibility effects are confounded by spatial compatibility (Aicken, Wilson, Williams, & Mon-Williams, 2007; Bertenthal, Longo, & Kosobud, 2006; Jansson, Wilson, Williams, & Mon-Williams, 2007). For example, I may be faster to perform a right-hand index finger movement than to perform a right-hand middle finger movement in the presence of a task-irrelevant right-hand index finger movement, not just because the stimulus hand is performing the 'same' movement as me, but also because the stimulus movement occurs to the left of a fixation point, and my index finger response occurs on the left side of space relative to the other movement in my task set (a middle finger movement). It is therefore necessary to control for the possible influence of spatial compatibility on response times by manipulating, and measuring, both spatial and imitative compatibility (Catmur & Heyes, 2011).

In most previous studies of the social modulators of imitation, imitative compatibility and spatial compatibility have been confounded. For example, Rauchbauer et al. (2016) demonstrated an effect of group membership and emotional expression on a measure that confounded imitative and spatial compatibility (on imitatively compatible trials, observed finger movements occurred on the same side of space as responses, while the reverse was the case for imitatively incompatible trials). A further study confirmed the effect of emotional expression on the same measure (Butler, Ward, & Ramsey, 2016). As indicated above, however, when imitative compatibility is disentangled from spatial compatibility, some data suggest that social modulators including group membership and eye gaze in fact modulate spatial, rather than imitative, compatibility (Marsh et al., 2016).

Not all social modulators may affect perception-action links in the same way, however: Cook and Bird (2011, 2012) demonstrated an influence of pro-social priming on imitation of finger movements but not on a closely matched 'effector priming' measure. Thus it is possible that some social modulators, including group membership, eye gaze, and emotional expression, modulate perception-action links via domain-general processes, whereas others, including perhaps pro-social priming, may act in a socially-specific way. However, as very few studies have disentangled the effects of social modulators on imitation from their effects on spatial compatibility (to our knowledge, only Cook & Bird, 2011, 2012, and Marsh et al., 2016), the question of whether most social modulators act on imitation or on domain-general processes remains unresolved. Here, therefore, we chose to re-examine a modulating factor, self-focus, that has previously been shown to affect imitation (Spengler, Brass, Kühn, & Schütz-Bosbach, 2010), and to test whether its effects are specific to imitation or may instead arise via the modulation of domain-general perception-action links.

Self-focus is an interesting example of a social modulator because although ostensibly related to the self, the theory of objective self-awareness (Duval & Wicklund, 1972) suggests that increasing self-awareness also increases focus on social norms and morals by making the self the object of one's attention. In terms of perception-action links, it has been argued that under conditions of self-focus, effects of perception on behaviour may be modulated (Dijksterhuis & Bargh, 2001), because at any given time, multiple action tendencies are activated and self-focus may thus facilitate performance of the self-relevant action, rather than the other-relevant action. Such facilitation would result in reduced imitation. Furthermore this effect should be specific to imitation, as the selection of self-versus other-relevant motor representations is thought to require self-other control, as outlined above.

Spengler et al. (2010) investigated whether manipulating self-awareness, via changing participants' level of self-focus, would modulate imitative tendencies. Participants performed an imitative compatibility task under conditions of either heightened or lowered self-focus induced by either the presence or absence of a mirror. During the high self-focus condition (i.e., with mirror), participants showed less imitation of task-irrelevant finger movement stimuli than during the low self-focus condition. However, the finger movement stimuli were not only imitatively compatible or incompatible with the participants' responses, they were also presented on the same or opposing side of space as those responses. Thus, it is possible that the self-focus manipulation in Spengler et al. (2010)'s study could potentially have influenced spatial compatibility rather than imitative compatibility.

In the present study, therefore, we aimed to re-examine a previous method of modulating imitation, self-focus, and test whether such modulation is indeed specific to imitation, by measuring the extent to which self-focus exerts an influence over both imitative and spatially compatible response tendencies. Self-focus was manipulated in the same way as Spengler et al. (2010, Experiment 1), through the presence or absence of mirrors either side of the participant's computer screen. Imitative and spatial compatibility were isolated and measured using the same task as Sowden and Catmur (2015), allowing assessment of the independent effects of the self-focus manipulation on each of these processes. Self-focus was manipulated in a within-subjects design, with each participant experiencing either the self-focus condition or the control condition first. However, given that it seemed likely that participants would become more aware of the relevance of the mirrors once they experienced the second condition in which the mirrors were revealed or covered, respectively, we included the order in which participants experienced the two conditions as a between-subjects factor in preliminary analyses (see Supplementary materials). If interactions are found with this between-subjects factor, subsequent analysis can be carried out on participants' responses on the first condition they performed, when they were less likely to be aware of the nature of the experimental manipulation.

If the modulation of imitation by self-focus is specific to imitation, we should observe an interaction between self-focus condition and imitative, but not spatial, compatibility. If instead it is having its effects on non-imitative processes, we should observe an interaction between self-focus condition and spatial compatibility. This study will therefore help to determine whether self-focus (and, by extension, other social modulators of imitation) affects imitation-specific or domain-general processes.

2. Method

2.1. Participants

A power analysis revealed that at least forty-four participants would be required to be able to detect the key effect ($d = 0.425$) found in the previous study which investigated the effect of self-focus on stimulus-response compatibility (Spengler et al., 2010; Experiment 1). However, to account for potential participant exclusion based on high error rates or drop-outs, sixty-two adult volunteers were recruited for this study through the King's College London research participation system. Two of these participants were provided with a small cash remuneration while the rest took part in partial fulfilment of course requirements. One participant was excluded as they were able to identify the purpose of the mirror manipulation, and two participants were excluded due to their mean reaction time exceeding 2.5 standard deviations from the sample mean.

The final sample therefore comprised 59 participants (6 males; 4 left-handed; $M_{age} = 18.8$ years, $SD_{age} = 0.795$). A power analysis conducted in G*Power 3.1 revealed that a sample of 59 participants allows us to detect a minimum effect size of $d = 0.35$ at 80% power. All participants had normal or corrected-to-normal vision. The experiment was approved by the King's College London research ethics committee and was performed in accordance with the principles of the Helsinki Declaration (World Medical Association, 2013). All participants provided written informed consent and were aware they could withdraw at any time.

2.2. Stimuli and experimental design

2.2.1. Stimulus-response compatibility task

Automatic imitation and spatial compatibility effects were measured using a computerised stimulus-response compatibility task involving the observation and execution of finger lifting movements (Catmur & Heyes, 2011; Sowden & Catmur, 2015). The modulation of automatic imitation and spatial compatibility was assessed in a within-subject design by combining the finger movement task with two different experimental conditions. In the self-focus condition participants were primed with heightened self-focus, while in the control condition self-focus was not manipulated (see Section 2.2.2). The order of the conditions was counterbalanced across participants.

Throughout the experiment participants were required to hold down the "N" and "M" keys on a computer keyboard with their right index and middle fingers. The computer keyboard was positioned horizontally, parallel to the base of the desktop with the "N" and "M" keys in line with the centre of the computer screen to ensure optimum spatial mapping between observer and stimulus hands. Participants had to respond to an imperative cue by releasing a key thus performing a finger lift. Trials started with a grey screen with "GET READY" in the centre displayed for 1000 ms. This was replaced with either a right or left resting hand, with a fixation point equidistant between the index and middle fingers (see Fig. 1), for a variable inter-stimulus interval (randomly selected from values between 800 ms and 1500 ms in steps of 50 ms). The hand image then changed to show either a raised index or middle finger (hand movement trials), or a pixelated version of the hand (baseline trials) for 500 ms. The change in finger position induces apparent motion in the observer so that they perceive a finger lifting movement (Press, Gillmeister, & Heyes, 2007). Simultaneously, an imperative cue (purple or green square) replaced the fixation point. This cue acted as a signal to the participant to respond by lifting their own index or middle finger. Cue colour-response mapping (e.g. purple-index lift, green-middle lift) was counterbalanced between subjects.

On hand movement trials, spatial and imitative compatibility between the observed and the instructed finger movements were manipulated in a 2 × 2 factorial design. In order to manipulate imitative compatibility, the imperative cue instructed the participant to lift either the same finger (imitatively compatible) or a different finger (imitatively incompatible) to that lifted by the hand. Spatial compatibility was manipulated in an orthogonal manner to imitative compatibility due to the inclusion of both left and right hand stimuli, meaning that the participant's movement could be performed on either the same side of space (spatially compatible) or the opposite side of space (spatially incompatible) to the side of space on which the hand movement occurred. For example, if the observed hand was a right hand, then imitatively compatible actions were also spatially compatible, because the observed finger lift was on the same side of space as the finger to be moved; and imitatively incompatible actions were also spatially incompatible. However, if the observed hand was a left hand, imitatively compatible actions were spatially incompatible and imitatively incompatible actions were spatially compatible (see Fig. 2).

On baseline trials, the stimulus hand became pixelated in order to match the visual change occurring on hand movement trials. Baseline trials were included to permit comparison of response times across the two experimental conditions when no finger movements were presented. A difference in response times on baseline trials in the self-focus compared to the control condition could indicate general effects of self-focus on processes such as attention or motivation.

After the presentation of the hand movement or baseline image, another grey screen was presented for 500 ms – 1200 ms depending on the previous interval to ensure that all trials lasted 3500 ms.

Imitative compatibility (compatible, incompatible), spatial compatibility (compatible, incompatible) and experimental condition (self-focus, control) were manipulated within-subject in a 2 × 2 × 2 factorial design for hand movement trials. For baseline trials, stimulus hand (left,

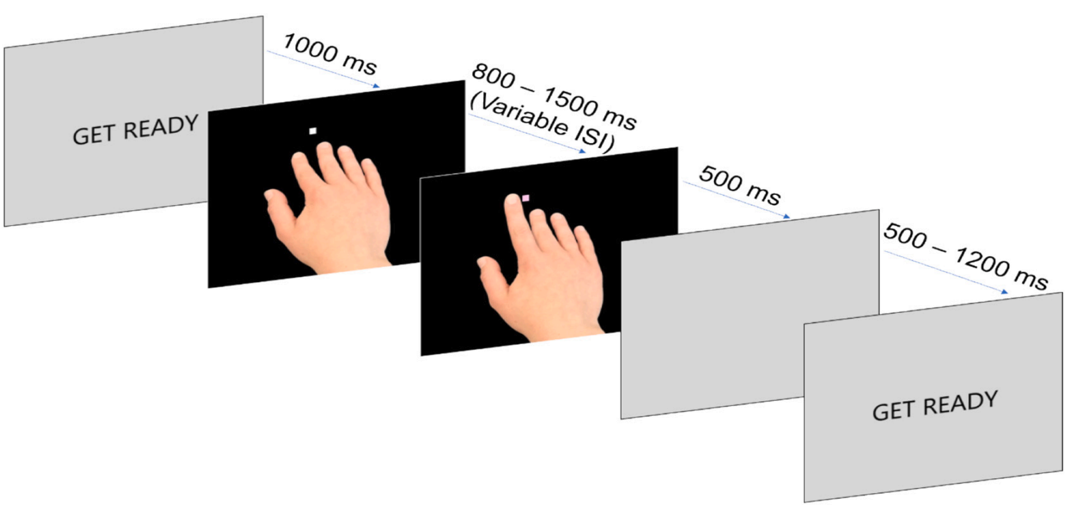

Fig. 1. Timeline of a single hand movement trial. Participants were first instructed to get ready, meaning that they should use their index and middle fingers of their right hand to depress the "N" and "M" keys, respectively. After a brief interval, the static hand was presented, followed by the task-irrelevant finger lift stimulus. Responses (finger lifts) were made according to the colour of the task-relevant cue (green or purple) presented with the task-irrelevant stimulus. For the response mapping in which a purple cue requires a middle finger lift, this trial is imitatively and spatially incompatible, whereas for trials in which a purple cue requires an index finger lift, it is imitatively and spatially compatible.

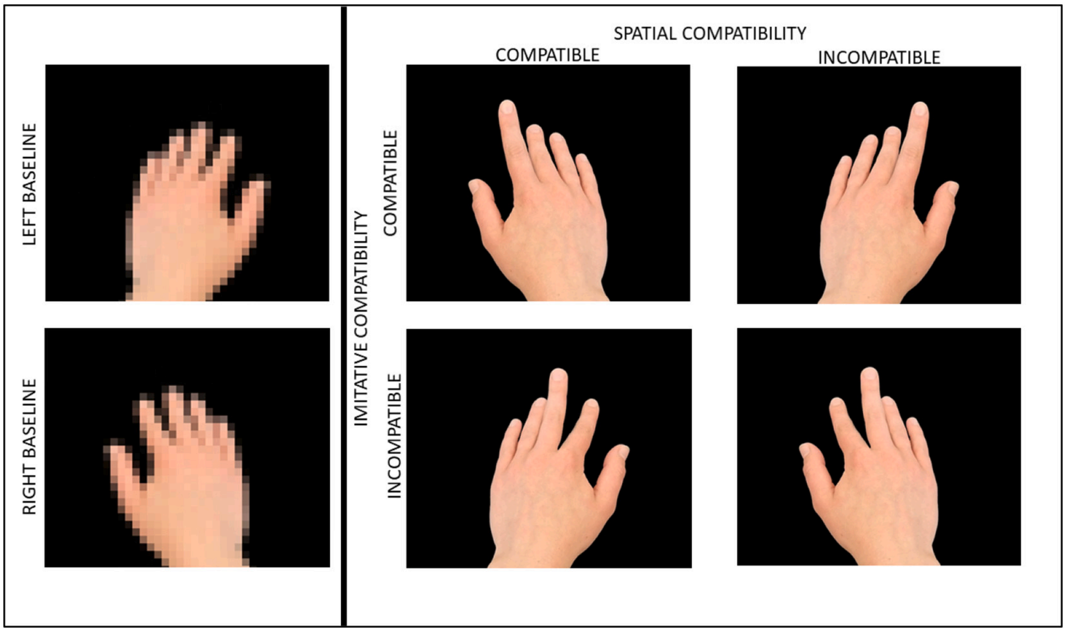

Fig. 2. Left panel: Left and right baseline stimuli. Right panel: The 2 (imitative compatibility) x 2 (spatial compatibility) task design, illustrated for a trial when an index finger lift is the instructed response. When a middle finger is the instructed response, the levels of spatial and imitative compatibility are each reversed.

right) and experimental condition (self-focus, control) were manipulated in a 2 × 2 factorial design. Dependent variables were response time (measured from onset of the imperative cue) and number of errors. Participants completed 120 trials in each experimental condition, with each trial type repeated 20 times per condition and presented in a random order. Trials were separated into three blocks per condition and participants were instructed that they could take a short break between blocks. The task took no longer than 15 min. All stimuli and instructions were coded in Matlab 2012 (The Mathworks, Matick, MA) and presented with Cogent 2000.

2.2.2. *Self-focus manipulation*

In the self-focus condition, mirrors (height: 70 cm; width: 50 cm) were positioned on both sides of the computer screen so the participants saw their head and upper body while they were responding to the presented stimuli. The mirrors were positioned relative to each participant's position on the seat such that each participant could view their head and upper body in both mirrors. The bottom of each mirror was covered with black card to avoid participants being able to see their own finger movements. In the self-focus condition, the rest of each mirror was uncovered while the participants performed the computer task. In the control condition, the mirrors were fully covered with black cloth. Apart from the visibility of the mirrors, the self-focus condition and the control condition did not differ.

2.2.3. *Self-Construal Scale*

Imitation in a naturalistic setting has previously been shown to vary as a function of levels of self-construal (van Baaren, Maddux, Chartrand, De Bouter, & Van Knippenberg, 2003, Study 3). Therefore, in order to assess possible changes in self-construal as a result of the manipulation of self-focus, a questionnaire was filled out by participants after each experimental condition, comprising items from the Self-Construal Scale (Singelis, 1994). The Self-Construal Scale measures two factors: independent and interdependent self-construal. Participants scoring high on the independent factor (example item: "My personal identity, independent of others, is very important to me") describe themselves as individualistic and unique, stressing their independence. High interdependent scorers (example item: "I have respect for the authority figures with whom I interact") endorse their connectedness to relatives and dependency on other people. The scale includes 24 items and all responses are made on a 7-point Likert-type scale with anchors of 1 (strongly disagree) and 7 (strongly agree). The two factors are not related ($r = -0.04$; Singelis, 1994), so it is possible to score high or low on both factors. Exploratory factor analysis conducted in the original paper reports medium-to-high internal consistency for the independent (Cronbach's $\alpha = 0.69$) and the interdependent factors (Cronbach's $\alpha = 0.73$). For the current experiment, the scale was divided in two parallel forms. The items were evenly distributed on the two forms, with twelve questions in total on each form, six of each factor. The forms were presented in a counterbalanced order after each of the two experimental conditions.

2.3. *Procedure*

The experiment took place in a quiet testing lab in King's College London. After reading the information sheet and signing the consent form, participants were provided with the instructions for the stimulus-response compatibility task. They then performed a practice version of this task which included 12 trials, comprising a fully factorial combination of all six stimuli with both responses. Participants who made more than three errors were required to repeat the practice trials until they made no more than three errors on the 12 trials. The experimenter remained in the room during the practice to answer any questions the participant had about the instructions. Once the participant completed the practice trials, the experimenter either revealed the mirrors or left them covered, and left the room. After three blocks had been completed the participant was told to ask the experimenter outside the room for further instructions. The participant then filled out the first half of the Self-Construal Scale. The next condition followed, with the mirrors now covered/revealed, followed by the other half of the Self-Construal Scale.

Following the last questionnaire, participants were asked two questions to ascertain the degree to which they could infer the purpose of the study and of the self-focus manipulation. Each participant was first asked "What is the purpose of this study?" followed by "What effect did the mirrors have while you were doing the task, if any?" Participants' responses were noted down verbatim.[1] Any participant who identified that the presence or absence of the mirror might affect imitation of the on-screen hand was excluded.

3. Results

3.1. Stimulus-response compatibility task

Preliminary analyses of the effect of the self-focus manipulation on spatial compatibility revealed a trend-level interaction with condition order, indicating an effect of the first condition completed on performance during the subsequent condition. Therefore, all analyses were performed on the first condition only. Results of the preliminary analyses are included in Supplementary materials.

For each participant, the mean and SD response times on correct trials were calculated and any response times more than 2.5SD from the overall mean of that participant were excluded (1.9% of trials). The mean response time on the remaining trials was calculated for each cell of the design for each participant. Fig. 3 displays the mean response times across all participants for each cell of the design, including baseline trials.

The total number of errors was also calculated for each cell of the design, including baseline trials, and the means of these values across all participants are displayed in Fig. 4.

3.1.1. Response time (RT) analysis

The response time data were subjected to a repeated measures ANOVA with within-subjects factors of imitative compatibility (compatible, incompatible), and spatial compatibility (compatible, incompatible) and between-subjects factor of experimental condition (self-focus, control). The ANOVA revealed a main effect of imitative compatibility, ($F(1,57) = 28.20$, $p < .001$, $\eta_p^2 = 0.331$), and spatial compatibility, ($F(1,57) = 185.06$, $p < .001$, $\eta_p^2 = 0.765$), such that mean response time on incompatible trials was significantly higher than that on compatible trials, both imitatively and spatially. No main effect of experimental condition was found, ($F(1,57) = 0.024$, $p = .876$, $\eta_p^2 = 0.000$), indicating that response times were not significantly different between the self-focus and control conditions. Crucially, no interaction was found between experimental condition and imitative compatibility, ($F(1,57) = 0.23$, $p = .631$, $\eta_p^2 = 0.004$), or experimental condition and spatial compatibility ($F(1,57) = 1.22$, $p = .274$, $\eta_p^2 = 0.021$), suggesting that the self-focus manipulation did not significantly influence imitative or spatial compatibility.

Response time on the baseline trials was also analysed using a repeated measures ANOVA with within-subjects factor of stimulus hand (right, left) and between-subjects factor of experimental condition (self-focus, control). This revealed no significant main effects or interaction (all $F(1,57) < 1.04$, all $p > .311$, all $\eta_p^2 < 0.018$), indicating that overall response times did not differ across experimental conditions, and that the laterality of the on-screen hand did not affect response times.

3.1.2. Error analysis

The error data were subjected to a repeated measures ANOVA with the same factors as the response time data. This revealed a main effect of imitative compatibility ($F(1,57) = 60.48$, $p < .001$, $\eta_p^2 = 0.515$), and spatial compatibility ($F(1,57) = 48.09$, $p < .001$, $\eta_p^2 = 0.458$), similar to the effects found in the RT data. Additionally, a significant interaction between spatial and imitative compatibility was detected ($F(1,57) = 14.57$, $p < .001$, $\eta_p^2 = 0.204$), such that the imitative compatibility effect was greater during spatially incompatible trials than during spatially compatible trials. No other main effects or interactions were detected (all $F(1,57) < 0.73$, all $p > .396$, all $\eta_p^2 < 0.013$).

Error data on the baseline trials were also analysed using the same ANOVA as for the response time data. This revealed no significant main effects or interaction (all $F(1,57) < 1.26$, all $p > .266$, all $\eta_p^2 < 0.022$).

3.2. Self-Construal Scale

Table 1 presents the descriptive statistics for the Self-Construal Scale data. Two independent samples *t*-tests were performed, one for each self-construal factor, to test the effect of the experimental manipulation on self-reported self-construal. No significant difference was detected for either the interdependent ($t(57) = 0.59$, $p = .557$, $d = 0.14$) or the independent ($t(57) = 0.85$, $p = .400$, $d = 0.20$) factors. This shows that the mirror manipulation did not significantly influence scores on the self-construal scale.

4. Discussion

The present study aimed to identify the mechanisms involved in the social modulation of imitation. We investigated whether a social factor previously shown to modulate imitation, self-focus, specifically modulates imitative processes when spatially compatible responding is controlled for. By utilising a stimulus-response compatibility task which allowed the dissociation of imitative and spatial compatibility, we aimed to determine whether social modulators impact on imitation via domain-specific or domain-general processes.

Analysis of both the response time and error data in the first condition completed by participants revealed no significant interaction between self-focus and spatial or imitative compatibility, showing no evidence that self-focus affects imitation or spatial compatibility. The baseline data for both response time and errors showed no effect of the self-focus manipulation on responses, confirming that the self-focus manipulation did not affect 'raw' response times or accuracy. Interestingly, although there was no significant effect of self-focus on spatial compatibility, the magnitude of the spatial compatibility effect in each of the two experimental conditions (self-focus: 41 ms; control: 49 ms) was similar to the magnitude of the effect of self-focus on imitation reported by Spengler et al. (2010, Experiment 1; self-focus: ~45 ms; control: ~55 ms), suggesting that numerically at least, our manipulation had a similar effect to that of Spengler and colleagues. The preliminary within-subjects analysis revealed a trend-level effect of condition order on spatial compatibility, suggesting that participants' involvement in the first condition may have impacted their performance on the second condition they performed. As a result, we only used data from the first condition in the main analyses. While switching from a within-subjects analysis to a between-subjects analysis will have impacted the statistical power of the study, the within-subjects analysis reported in Supplementary materials also showed no effect of self-focus on imitation, making it unlikely that our current results are due to a reduction in statistical power.

These results indicate that – at least when implemented using a mirror manipulation of the sort used here – self-focus does not have a significant influence on either spatial compatibility or imitation, contrary to the findings of Spengler et al. (2010). It is possible that the lack of a modulatory effect on both spatial and imitative compatibility may be due to potential weakness in the self-focus manipulation. Although we used the same manipulation as Spengler and colleagues, it is possible that the current manipulation created only a limited sense of heightened self-focus. To our knowledge, only Spengler et al. have previously used a mirror manipulation to investigate the effect of self-focus on imitation; but large numbers of previous studies have used mirrors to induce a state of heightened self-focus (e.g. Dijksterhuis & van Knippenberg, 2000; Martin, Perry, & Kaufman, 2020; Ross, Anderson, & Campbell, 2011; Silvia, 2012; Wicklund & Duval, 1971). Thus it seems that a mirror manipulation is a commonly used and generally robust method of

[1] The manipulation check was added to the procedure after approximately one-third of participants had been tested; a separate analysis revealed no difference in results between those who did, and those who did not, receive the manipulation check.

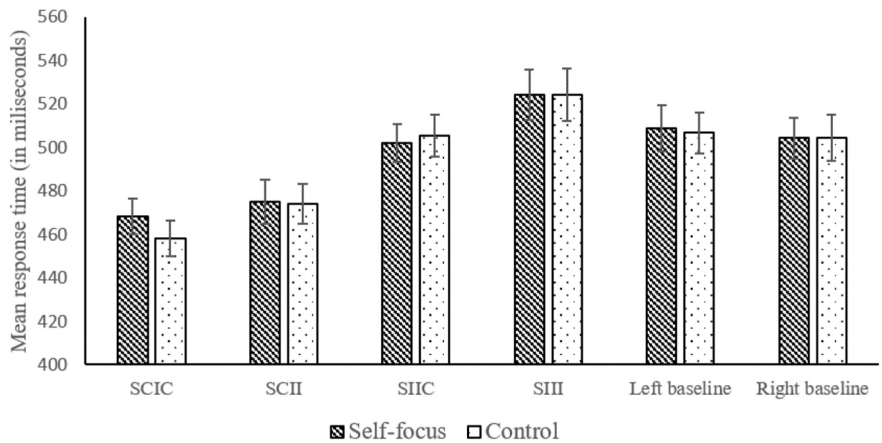

Fig. 3. Mean response time for each level of spatial and imitative compatibility, and for the baseline stimuli, for each experimental condition. SC = Spatially compatible; IC = Imitatively compatible; SI = Spatially incompatible; II = Imitatively incompatible. Error bars indicate standard error of the mean.

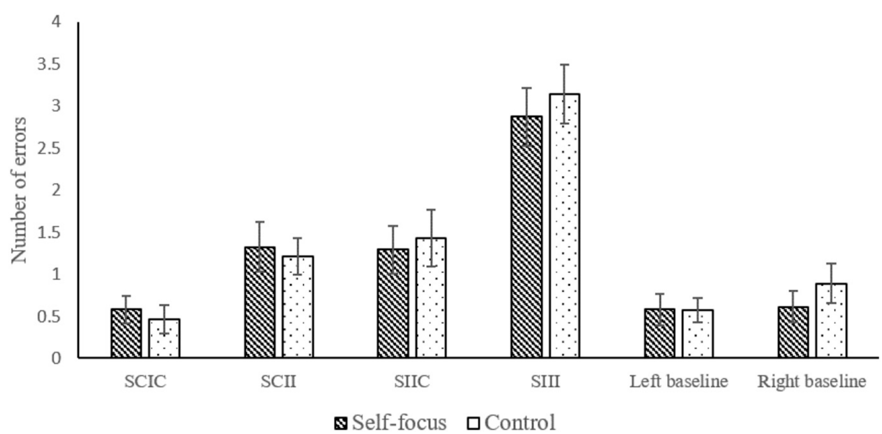

Fig. 4. Mean number of errors for each level of spatial and imitative compatibility, and for the baseline stimuli, for each experimental condition. Twenty trials were presented in each cell of the design in each condition. SC = Spatially compatible; IC = Imitatively compatible; SI = Spatially incompatible; II = Imitatively incompatible. Error bars indicate standard error of the mean.

Table 1
Mean ± standard deviation responses to each self-construal factor across the experimental conditions.

Experimental condition	Interdependent self-construal	Independent self-construal
Self-focus	29.93 ± 4.67	25.24 ± 4.39
Control	28.39 ± 4.47	26.57 ± 5.92

increasing self-focus, although of course it remains a possibility that other papers reporting null effects of such a manipulation have been less commonly published in the past (Rosenthal, 1979).

One previous study has shown that self-focus can reduce behavioural mimicry; but in that study, self-focus was manipulated in a different way. van Baaren et al. (2003, Study 1) asked participants to perform a bogus translation task alongside confederates who were performing task-irrelevant movements. In the self-focus condition, participants were asked to fill in omissions in the translated text by choosing between the words "I", "me", or "mine", thus increasing attention to the self. In a control condition, the words were "he", "him", and "his". During the self-focus condition, participants showed less imitation of the confederate's movements than during the control condition. Therefore, perhaps a more robust self-focus manipulation than the use of mirrors may be able to successfully produce modulation of perception-action links.

Supporting the above point as one potential limitation of the current study is the lack of an effect of the self-focus manipulation on the self-construal measure. We included a measure of self-construal because levels of independent and interdependent self-construal have previously been shown to affect imitation (van Baaren et al., 2003, Study 3). If we had found increased endorsement of statements relating to independent self-construal following the self-focus condition, this would have provided an additional confirmation of the impact of the self-focus manipulation on a relevant personality dimension. On the other hand, however, it may have been unlikely that we would have observed an effect of such a brief manipulation on a relatively stable trait (Singelis et al., 2006). Therefore, future studies should attempt to include a more sensitive measure for the effectiveness of the self-focus manipulation.

The lack of evidence for social modulation of imitation has possible implications for our understanding of the role of self-other control in social cognitive functioning. Previous research has suggested that self-other control may contribute to higher-order sociocognitive functions such as theory of mind, perspective-taking and empathy (Happé, Cook, & Bird, 2017; Sowden & Shah, 2014; Santiesteban et al., 2012; de Guzman et al., 2016). However, the current evidence does not support the converse relationship, that is, that high-level social factors influence self-other control. Thus, it is possible that the relationship between self-other control and higher-order social functioning may be a bottom-up process rather than a bidirectional association between higher-order and low-level processes.

In summary, the current findings do not provide support for the claim that self-focus modulates imitation-specific processes. However, evidence for modulation of spatial compatibility was not found either. Future studies should therefore aim to use more robust manipulations to uncover the precise nature of the cognitive processes that are modulated in social contexts.

CRediT authorship contribution statement

Divyush Khemka: Methodology, Investigation, Formal analysis, Writing – original draft. Narges Ahmadilari: Investigation, Writing – reviewing and editing. Geoffrey Bird: Writing – reviewing and editing. Caroline Catmur: Conceptualisation, Methodology, Formal analysis, Software, Supervision, Writing – reviewing and editing.

Declaration of competing interest

None.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.actpsy.2020.103194.

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