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Training social cognition: From imitation to Theory of Mind

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ABSTRACT

Evidence for successful socio-cognitive training in typical adults is rare. This study attempted to improve Theory of Mind (ToM) and visual perspective taking in healthy adults by training participants to either imitate or to inhibit imitation. Twenty-four hours after training, all participants completed tests of ToM and visual perspective taking. The group trained to inhibit their tendency to imitate showed improved performance on the visual perspective-taking test, but not the ToM test. Neither imitation training, nor general inhibition training, had this effect. These results support a novel theory of social cognition suggesting that the same self-other discrimination process underlies imitation inhibition and perspective taking. Imitation, perspective taking and ToM are all pro-social processes – ways in which we reach out to others. Therefore, it is striking that perspective taking can be *enhanced* by *suppressing* imitation; to understand another, sometimes we need, not to get closer, but to pull away.

1. Introduction

Sometimes we meet a stranger and the interaction is remarkably smooth; rapport builds, we quickly begin to feel close, to believe that this person can put themselves in our shoes and understand the way we think and feel. Conversely, social interactions can be awkward, and mutual understanding is never achieved. Many factors contribute to complex interactions of this kind, but one that has received much recent attention from social psychologists is imitation (also known as 'mimicry', e.g. Chartrand & Bargh, 1999). Imitation has been shown to contribute significantly to the development of positive social attitudes such as rapport (Lakin & Chartrand, 2003) and liking (Kühn et al., 2010) between strangers. Thus, when an individual imitates our actions we feel closer to them. We may think that they can easily see the world from our perspective. But is this correct – does the act of imitating make the imitator better at taking the perspective of others? Conversely, if an individual inhibits imitation, does he become poorer at understanding the mental states of others?

1.1. From imitation to ToM – two contrasting theoretical approaches

Two current theoretical frameworks suggest contrasting answers to these questions. The first, advanced by various researchers (e.g., Gallese & Goldman, 1998; Rizzolatti & Craighero, 2004), proposes that imitation, and its neural substrate the mirror neuron system (MNS; Catmur, Walsh, & Heyes, 2007; Heiser, Iacoboni, Maeda, Marcus, & Mazziotta, 2003), is at the core of higher-order socio-cognitive functions such as Theory of Mind (ToM) – representing the *mental states* of another – and empathy – representing the *emotions* of another. Under this hypothesis, action observation triggers motor representations that enable the reproduction of the observed action (imitation). This in turn

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results in the ascription to the other of mental states associated with performance of that action (ToM). On this account, one would expect an intervention that promotes the triggering of corresponding motor representations by action observation (imitation training) to enhance the ability to represent the mental states of others.

An alternative theoretical approach suggests that it is processes mediating the *distinction and control* of representations pertaining to the self and the other, rather than the MNS, that plays a crucial role in supporting higher-order socio-cognitive abilities like ToM (Brass, Ruby, & Spengler, 2009). Crucially, this theory suggests that ToM is related not to imitation, but to the *inhibition* of imitation. When inhibiting the tendency to imitate another person's behaviour, the observer must distinguish between their own action intentions and those of the observed person (Brass & Heyes, 2005), and carry out their own motor intention rather than that of the other. The same process of distinguishing the content of one's own mental states from the representation of another's mental state is argued to be necessary for ToM, even though usually the 'control problem' in ToM is usually the converse of that encountered in imitation inhibition; one must inhibit one's own mental state and represent that of the other. Thus, this theory suggests that both ToM and imitation inhibition share the same component self-other processes. Importantly, in contrast to the MNS theory of social cognition, this theory predicts that training in imitation inhibition (rather than imitation) will result in an improvement in ToM.

The present study aimed to test these two contrasting theoretical approaches by training participants either to imitate or to inhibit imitation, and measuring transfer effects on ToM and perspective-taking tasks in healthy adults. In addition to the imitation and imitation–inhibition training groups, a third group received training in general inhibitory control using a Stroop-like paradigm. The third group was introduced in order to ensure that any effects of the imitation–inhibition training were specific to this socially relevant type of training, and not the result of a generalised improvement in inhibitory control. Twenty-four hours after training all participants performed three different tasks: an imitation–inhibition task, an advanced ToM task (Strange Stories, based on Happé, 1994) and a perspective-taking task (Director task – Keysar, Barr, Balin, & Brauner, 2000). The imitation–inhibition task requires participants to perform pre-specified responses while observing either the same or a different action. This test provides an index of the ability to inhibit the tendency to imitate; and therefore affords a method of checking whether the training manipulation was successful. Both the Strange Stories and Director tasks require the attribution of mental states to another. The Strange Stories task requires the attribution of mental states to a protagonist in a story, while the Director task requires participants to adopt the point of view of a character in order to follow his instructions to move objects. Crucially, although both require mental state attribution, successful performance in the Director task requires a high degree of self vs. other distinction, while this distinction is less necessary in the Strange Stories task. The Director task requires participants to continuously separate what they can see from what the Director can see. However, although the Strange Stories task requires participants to represent the mental state of another, there is less demand to isolate the participant's own mental state from that of the protagonist.

This study aims to test whether imitation or imitation–inhibition training results in improved ToM and/or perspective taking. If the MNS hypothesis is correct and there is a direct link between imitation and ToM, then the imitation training group is expected to perform better in the ToM and perspective-taking tasks than the other groups. Conversely, if the imitation–inhibition training group outperforms the other groups, then this study would provide evidence in favour of the hypothesis, put forward by Brass et al. (2009), that the control of shared representations, through self-other distinction, is the 'missing link' between the MNS and ToM abilities. Finally, a lack of an effect on tests of perspective taking and ToM by either type of imitative training would suggest that imitation, perspective taking and ToM are distinct socio-cognitive processes.

2. Method

2.1. Participants

Fifty-three adults (29 females, age range 19–50 years, $M = 26.7$, $SD = 6.6$) participated in this study for a small monetary reward. Participants were randomly assigned to the imitation ($N = 19$), imitation–inhibition ($N = 17$), or inhibitory control ($N = 17$) groups. Groups did not differ in terms of age ($F(2,52) = .221$, ns), gender ($\chi^2 = .257$, ns), or handedness ($F(2,52) = .228$, ns).

2.2. Procedure

All participants attended two sessions on consecutive days. On the first day they received training, and on the second day completed the imitation–inhibition, Strange Stories, and Director tasks in that order.

2.2.1. Imitation and imitation–inhibition training

Participants in these two groups performed a task based on that developed by Brass, Bekkering, Wohlschlager, and Prinz (2000). Stimuli consisted of short videos showing either an index or middle finger performing a lifting movement (Fig. 1). The imitation group were asked to perform the action they observed on the screen. When the index finger of the stimulus hand lifted, participants were required to lift their own index finger. Similarly, when the middle finger lifted, participants were required to lift their middle finger. The imitation–inhibition group were instructed that when they saw an index finger lift they should lift their middle finger, and when they saw a middle finger lift they should lift their index finger. The stimulus hand was rotated around the sagittal and transverse planes with respect to the participant's hand (see Fig. 1), which rested on the computer keyboard. As response movements were spatially orthogonal to stimulus movements, imitation could be isolated from spatial compatibility.

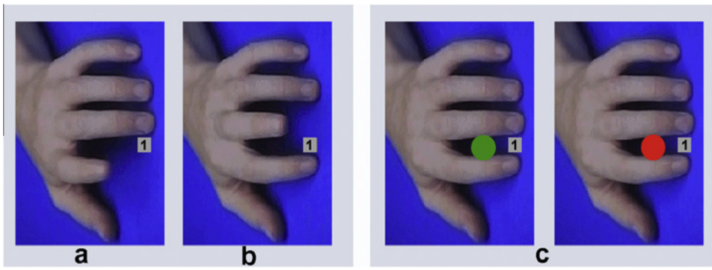

Fig. 1. Panels a and b are examples of the stimuli used for imitation and imitation–inhibition training, and for the imitation–inhibition task. Both images on Panel c are examples of the stimuli used for inhibitory control training.

2.2.2. Inhibitory control training

A third group received training in a Stroop-like task, the temporal and spatial features of which were matched with those of the imitation and imitation–inhibition training procedures (Fig. 1c). A red and a green sticker were placed on the knuckle (where the finger joins the hand) of the participant's right index and middle fingers. Placement of the red and green stickers on the participant's fingers was counterbalanced on each block on a within-subjects basis. On each trial, the stimulus fingers remained static and either a red or green circle appeared between the fingers. Participants were instructed to lift their 'red finger' (the finger with a red sticker) when a green circle appeared, and to lift their 'green finger' when a red circle appeared. Training consisted of six blocks of 72 trials and lasted approximately 40 min.

2.3. Tests of social cognition

2.3.1. Imitation–inhibition task

All participants were presented with the same finger movement videos used for imitation and imitation–inhibition training, but were required to respond with an index or middle finger lifting action to a number cue that appeared between the fingers of the stimulus hand. Participants were asked to lift their index finger upon appearance of a 1, and their middle finger upon appearance of a 2. At the same time as the appearance of the number cue, there was a lifting movement of the index or middle finger of the stimulus hand. Although the observed movements were formally task-irrelevant, the relationship between the observed movement and the movement required by the number defined two trial types. On congruent trials, the required finger movement was the same as the observed movement (Fig. 1b); whereas on incongruent trials, the required finger movement was different from the observed movement (Fig. 1a). Thus, on incongruent trials participants were required to inhibit an imitative response and perform the pre-instructed movement. Twenty trials in each of the four combinations of observed and executed finger movements were presented in a random order.

2.3.2. Strange Stories task

Participants were presented with a total of 32 stories of four different types (mental, physical, animal and natural, based on those developed by Happé, 1994). There were eight stories of each type, matched for the number of words across story type. After reading each story, participants were presented with a comprehension question, followed by three possible answers. Participants selected their answer by pressing one of three keys. Reaction time (from presentation of the question to the keypress response) and accuracy were recorded. Only the mental stories required the correct attribution of mental states for successful performance on this task.

2.3.3. Director task

This perspective-taking task required participants to take into account the point of view of a character, introduced as 'the director'. The visual stimuli consisted of a 4×4 grid ('shelves') containing eight different objects. Five slots were occluded from the view of the director, who stood on the other side of the shelves (Fig. 2). Participants listened to auditory instructions from the director who asked them to move specified objects in a particular direction. On experimental trials, there was a conflict between the participant's and the director's perspective. For example, if the participant was presented with the array shown in Fig. 2a, and was asked to "move the small apple left", they should ignore the smallest apple they can see, the 'competitor object', (because the director cannot see this apple), and instead move the next smallest apple, which is visible to the director. There were two control conditions: C1 and C2. In C1, the director instructed participants to move an object placed in one of the clear slots (Fig. 2a), and therefore there was no conflict between the perspectives of the participant and the director. In C2, an irrelevant object replaced the 'competitor' item from the experimental condition but the instruction remained the same (see Fig. 2b). Accuracy of the selection and movement of the target object and reaction times were recorded. Eye movement data were also recorded using an Eyegaze Edge™ System eye tracker (sampling rate 60 Hz). The eye tracking measure consisted of the number of 100 ms fixations on the 'competitor' object in the experimental condition, relative to the irrelevant object placed on the same slot in the C2 condition. This measurement is an index of the extent to which participants considered (incorrectly) the 'competitor' as the appropriate object to move (Wu & Keysar, 2007).

3. Results

Where sphericity assumptions were not met, Greenhouse–Geisser corrected values are reported. Bonferroni corrections were used for post hoc multiple comparisons.

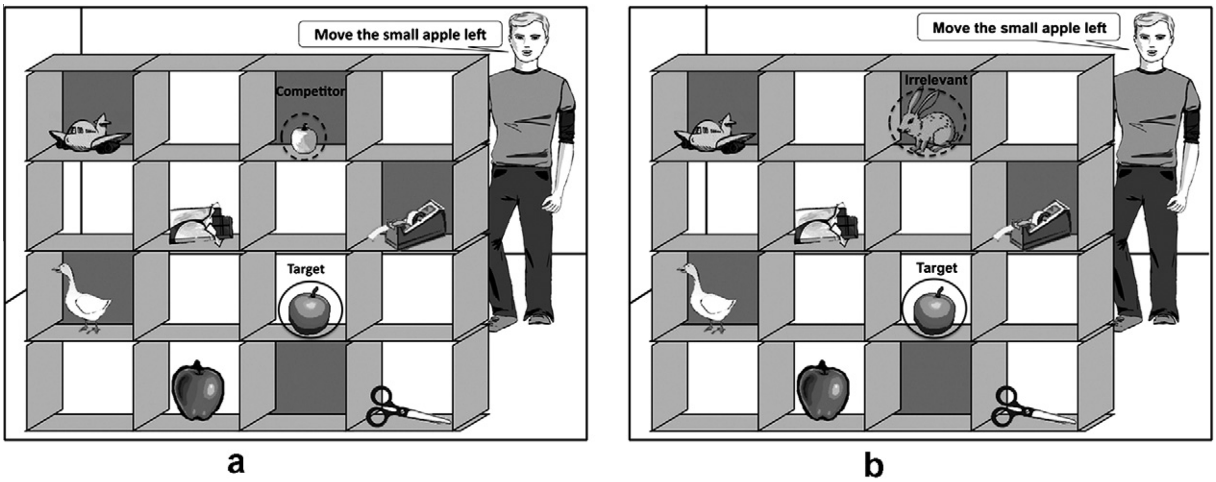

Fig. 2. Perspective-taking task. Panel a shows an example of an experimental trial and Panel b shows an example of one of the control conditions (C2).

3.1. Training

The RT and accuracy data were analysed using a one-way ANOVA with group as the between-subjects factor (imitation vs. imitation–inhibition vs. inhibitory control).

3.1.1. RT

There was a significant effect of group, $F(2,50) = 8.39$; $p = .001$; $\eta_p^2 = .25$. Post-hoc multiple comparisons showed that the imitation training group ($M = 461.65$, $S.E.M. = 13.73$) was faster than the imitation–inhibition ($M = 640.75$, $S.E.M. = 46.96$) and the inhibitory control ($M = 637.39$, $S.E.M. = 41.93$) groups ($ps = .003$); replicating the finding that participants are faster to execute imitative than non-imitative movements in this task (e.g. Brass et al., 2000).

3.1.2. Accuracy

In terms of accuracy, a significant effect of group was also found, $F(2,50) = 3.51$; $p = .03$; $\eta_p^2 = .12$. Post-hoc multiple comparisons revealed that this effect was driven by a significant difference in the number of errors between the imitation ($M = 15.73$, $S.E.M. = 2.57$) and the inhibitory control ($M = 39.35$, $S.E.M. = 9.80$) groups ($p = .03$).

3.2. Imitation–inhibition task

The RT and accuracy data were analysed using ANOVA with group as the between-subjects factor (imitation vs. imitation–inhibition vs. inhibitory control) and trial type as the within-subject factor (congruent vs. incongruent).

3.2.1. RT

Fig. 3a shows RTs from the imitation–inhibition task. Prior to the statistical analysis, extreme RT scores identified by the 1.5× inter-quartile range rule (Tukey, 1977) were removed from each participant's dataset. The analysis revealed a significant main effect of trial type, $F(1,50) = 114.59$; $p < .001$; $\eta_p^2 = .70$, indicating that responses on congruent trials were executed faster than those on

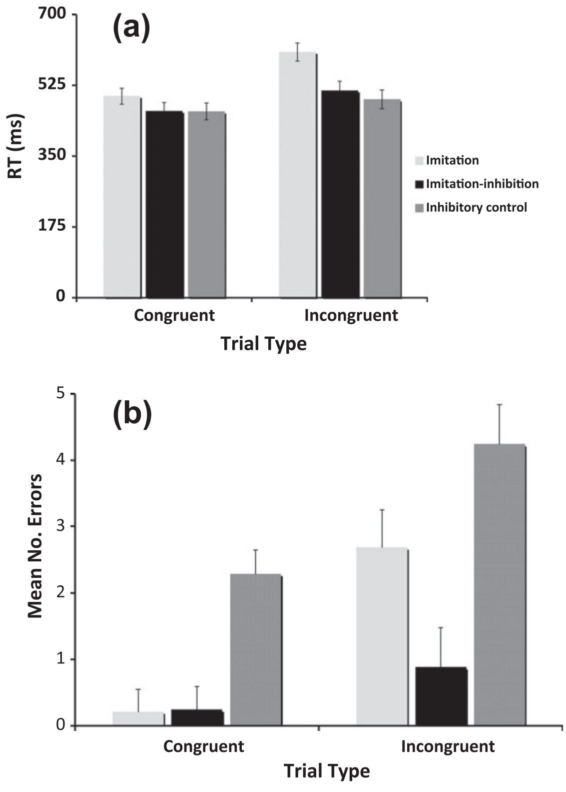

Fig. 3. Mean RT (a) and number of errors (b) on the imitation–inhibition task for each group. The error bars represent standard error of the mean.

incongruent trials. The main effect of group was also significant, $F(2,50) = 4.04$; $p = .024$; $\eta_p^2 = .14$. Pairwise comparisons showed that this effect was driven by the overall difference in performance between the imitation and the inhibitory control group ($p = .035$). Finally, the group × trial type interaction was also significant, $F(2,50) = 16.62$; $p < .001$; $\eta_p^2 = .40$, indicating a smaller RT difference between congruent and incongruent trials in the imitation–inhibition and inhibitory control groups than in the imitation group. The interaction effect could be due to (a) stronger imitation inhibition, or (b) a weaker tendency to imitate in the two inhibition groups than in the imitation training group. To distinguish these possibilities, RTs on incongruent trials were analysed including congruent trials as a covariate (and thereby accounting for the variance due to the tendency to imitate). This analysis revealed a significant effect of group $F(2,49) = 15.43$; $p < .001$; $\eta_p^2 = .39$. Pairwise comparisons showed that the imitation group took longer to inhibit an imitative response than both the imitation–inhibition ($p = .001$) and the inhibitory control groups ($p < .001$), suggesting that RT differences in congruent and incongruent trials were caused by an increased ability to inhibit the tendency to imitate in the imitation–inhibition and the inhibitory control groups. Supporting this interpretation, when congruent and incongruent trials were analysed separately, a significant main effect of group was only observed on incongruent trials ($F(2,50) = 7.54$; $p = .001$; $\eta_p^2 = .23$).

3.2.2. Accuracy

Error data are displayed in Fig. 3b. The mean number of errors was very low (*M* = 3.49, *S.E.M.* = .52). The main effect of trial type was significant, $F(1,50) = 21.16$; $p < .001$; $\eta_p^2 = .29$, overall, participants made more errors in the incongruent (*M* = 2.60, *S.E.M.* = .38) than in the congruent (*M* = .89, *S.E.M.* = .24) trials. The main effect of group was also significant, $F(2,50) = 13.24$; $p < .001$; $\eta_p^2 = .34$. Post-hoc tests revealed that the inhibitory control group made significantly more errors than the imitation ($p < .001$) and the imitation–inhibition ($p = .001$) groups. The group × trial type interaction was not significant ($p = .12$), indicating that training type did not affect accuracy on this task.

3.3. Strange Stories

A preliminary analysis of the three types of control stories revealed no significant differences; therefore the data were combined and compared to the mental stories. Accuracy and RT data were analysed using ANOVA with group as the between subject factor and story type (mental vs. control) as the within-subject factor.

3.3.1. RT

There was a significant main effect of story type, $F(1,50) = 6.43$; $p = .014$; $\eta_p^2 = .11$. Across groups, RTs were faster in the mental stories (*M* = 7.54 s, *S.E.M.* = .04) than in the control stories (*M* = 8.39 s, *S.E.M.* = .04). The main effect of group and the group × story type interaction were not significant (*p*s > .30).

3.3.2. Accuracy

A significant effect of story type was found, $F(1,50) = 47.20$; $p < .001$; $\eta_p^2 = .49$. Overall, proportion of correct responses on the mental stories (*M* = .84; *S.E.M.* = .02) was higher than on the control stories (*M* = .71; *S.E.M.* = .02). Neither the main effect of group nor the group × story type interaction were significant (*p*s > .20). The lack of significant interaction in both the RT and accuracy analyses shows that there was no differential effect of training group on this ToM task.

3.4. Director task

The accuracy and RT data were analysed using ANOVA with group as a between-subject factor and trial type (Exp vs. C1 vs. C2) as the within-subjects factor.

3.4.1. RT

Fig. 4b shows RT data from the Director task. A significant main effect of trial type was found, $F(1.72,86.36) = 35.70$; $p < .001$; $\eta_p^2 = .42$. Overall, participants responded faster to the C1 trials than to the experimental ($p < .001$) or the C2 trials ($p < .001$) – Fig. 4b. Neither the main effect of group nor the group × trial type interaction were significant, (all *p*s > .10).

3.4.2. Accuracy

Fig. 4a shows accuracy data from the Director task. The main effect of trial type was significant, $F(1.02,51.43) = 66.61$; $p = .014$; $\eta_p^2 = .11$. Overall, performance (proportion of correct responses) was worse on experimental trials (*M* = .56, *S.E.M.* = .04) than on control trials: C1 (*M* = .92, *S.E.M.* = .01), C2 (*M* = .90, *S.E.M.* = .01); confirming the previously reported difficulty in taking the director's perspective observed using this task (e.g. Dumontheil, Apperly, & Blakemore, 2010). The group × trial type interaction was significant, $F(2.05,51.43) = 3.45$; $p = .03$; $\eta_p^2 = .12$, indicating that the pattern of performance across experimental and control trials differed between the groups. Post-hoc analysis showed that while all groups performed similarly on control trials, on experimental trials the imitation–inhibition group performed significantly better than the imitation ($p = .01$) and the inhibitory control ($p = .03$) groups. Thus, the imitation–inhibition group were better able to separate their perspective from the director's perspective.

3.4.3. Eye-tracking data

Eye-tracking data from the Director task are presented in Fig. 4c. These data were analysed using ANOVA with group as the between-subject factor and trial type: (Exp vs. C2) as a within-subject factor. The analysis revealed a significant main effect of trial type, $F(1,50) = 93.95$; $p < .001$; i. Overall, participants fixated more on the competitor object in the experimental trials (*M* = 18.5, *S.E.M.* = 1.49) than on the irrelevant object (*M* = 5.7, *S.E.M.* = .53) placed in the same slot in Control trials; again suggesting a difficulty in adopting the director's perspective. The main effect of group was also significant, $F(2,50) = 10.23$; $p < .001$; $\eta_p^2 = .29$). Post-hoc pairwise comparisons revealed that this effect was driven by the fact that the imitation–inhibition group (*M* = 8.02, *S.E.M.* = 1.3) had fewer fixations than the inhibitory control group (*M* = 16.32, *S.E.M.* = 1.3); $p < .001$.

The group × trial type interaction was also significant, $F(2,50) = 7.02$; $p = .02$; $\eta_p^2 = .22$. Inspection of the mean number of fixations on the competitor object in experimental and control trials for each group suggests that the imitation–inhibition group (*M* = 10.88, *S.E.M.* = 2.30) were better able to separate their perspective from the director's perspective than either the Imitation (*M* = 20.16, *S.E.M.* = 2.18; $p = .016$) or the Inhibitory Control (*M* = 24.41, *S.E.M.* = 2.30; $p < .001$) groups.

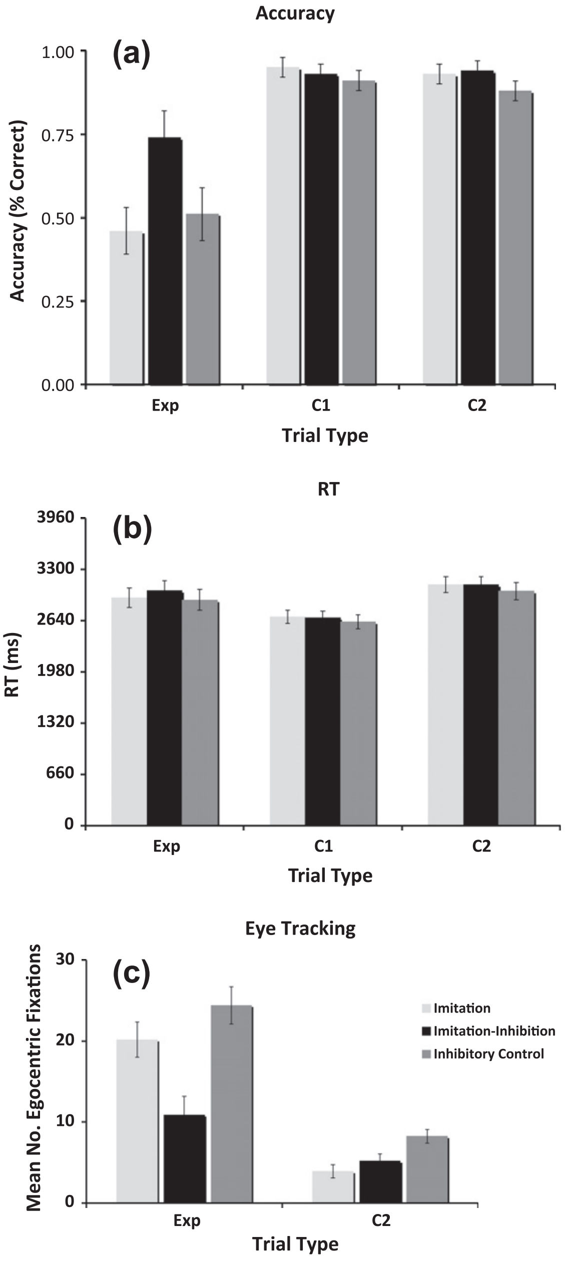

Fig. 4. Performance of each training group on the perspective-taking task. The error bars represent standard error of the mean.

4. Discussion

These results indicate that training in one socio-cognitive domain, inhibition of the tendency to imitate the actions of others, enhances performance in a different socio-cognitive domain, the ability to adopt the perspective of others. This improvement in perspective-taking ability was specific to imitation–inhibition training; it was not seen after either imitation training or training in general inhibitory control. The contrasting performance of participants trained to inhibit imitation and those trained in general inhibitory control is particularly noteworthy. RTs during these two training tasks were within 3 ms of each other, with similar error rates, suggesting that the tasks were well-matched in terms of difficulty. Furthermore, the two types of training were similarly effective in enhancing the capacity to inhibit imitation. Despite these similarities, only imitation–inhibition training – and not inhibitory control training – resulted in an improved ability to adopt the perspective of another. This suggests that enhancement of general inhibitory control is insufficient to account for the differential training effect found on the perspective-taking task. Thus, our results support neurological findings suggesting a distinction between imitation inhibition and classical inhibition tasks such as the Stroop Task (e.g. Brass, Derrfuss, Matthes-von Cramon, & von Cramon, 2003).

4.1. Imitation, ToM and perspective taking

This study contrasted two hypotheses concerning the relationship between imitation and ToM. The first suggests that imitation – and MNS activity – promotes ToM, whereas the second suggests that imitation *inhibition* promotes ToM performance via processes that distinguish and control representations pertaining to the self and the other. The first hypothesis predicts a positive effect of imitation training on ToM performance. This study found no evidence in support of this prediction. Participants who had been trained to imitate were no better than the imitation–inhibition or inhibitory control training groups on either the Strange Stories or Director tasks.

In contrast, this study provides some support for the second hypothesis, which proposes that both imitation inhibition and ToM depend upon the control of processes that distinguish self from other (Brass et al., 2009). Although imitation–inhibition training did not result in improved performance in the Strange Stories task, which measures ToM abilities, an improvement was observed in the Director task, which requires participants to take into account the perspective of a character whose viewpoint is different from their own. The role of self-other distinction in the control of imitative responses (e.g. Brass, Derrfuss, & von Cramon, 2005) and the association of imitation–inhibition with socio-cognitive abilities such as perspective taking (Brass et al., 2009; Spengler, von Cramon, & Brass, 2009, 2010) has been suggested by previous studies on the basis of correlational evidence. However, this is the first study to provide experimental evidence by showing that imitation–inhibition training improves perspective-taking ability. Therefore these data make plausible the suggestion that imitation–inhibition training enhances self-other processes, which in turn facilitates improved performance on both the imitation–inhibition and the perspective-taking tasks. However, they do not allow the locus of the effect to be distinguished; imitation–inhibition training may lead to the enhancement of the *distinction* or *control* of self-other representations, or both.

The lack of a transfer effect from imitation–inhibition training to the mental stories condition of the Strange Stories task appears, at first, to contradict Brass's theory. However, the term 'ToM' is used to describe a range of socio-cognitive abilities, from visual perspective taking to higher order cognitive processes such as second-order false belief reasoning (e.g. Perner & Wimmer, 1985). When attempting to distinguish between perspective-taking and ToM, Aichhorn, Perner, Kronbichler, Staffen, and Ladurner (2006) suggested that visual perspective taking tasks make demands on just one component of ToM – the apprehension that minds can take different perspectives on the world – and therefore continuously requires the ability to distinguish between representations held by the self and by the other. The ToM task used in this study requires a range of mental states to be attributed to the protagonist. To understand the story, participants must separate the facts presented to them from the relevant mental states they attribute to the character. This self vs. other distinction process takes place '*on-line*'. However, when subsequently presented with a question about the protagonist's mental state (i.e. '*off-line*'), participants can answer correctly by 'stepping into the mental shoes' of the character; they do not need to represent simultaneously, or in rapid succession, their own mental states and those of the other agent. This difference between the '*on-line*' processing required in the perspective-taking task and the '*off-line*' measure used in the ToM task could explain why participants in the imitation–inhibition training group outperformed the other groups in the Director task, but not in the Strange Stories task. Concerning the differences between perspective taking and ToM, Spengler et al. (2010) provided neurological evidence for the distinction between these two abilities in relation to imitation–inhibition. They found a correlation between imitation–inhibition and ToM (but not perspective-taking) in patients with frontal lesions, and a correlation between imitation–inhibition and perspective taking (but not ToM) in patients with TPJ lesions.

In principle, there is at least one other candidate explanation why differential effects of training were seen on the Director task but not on the Strange Stories task. Accuracy on mentalising trials in the Strange Stories task was very high; on average participants made approximately only one error. It is possible that a ceiling effect precluded a differential effect of training being seen on this task, and that therefore the task was not sufficiently sensitive to detect improved ToM performance in the imitation–inhibition group. Further investigation with alternative ToM tasks is therefore necessary to determine the selectivity of the effect of imitation–inhibition training on ToM performance.

Research on ToM has found consistently that healthy adults, although able to take another's perspective, often fail to do so (e.g., Apperly et al., 2010). This is known as the egocentric bias (e.g., Birch & Bloom, 2004). Our results suggest that training in the control of imitative responses enhances self-other distinction, which in turn helps to overcome the egocentric bias in perspective taking. Consistent with this finding, a recent study (Todd, Hanko, Galinsky, & Mussweiler, 2011) found that priming self-other differences can facilitate perceptual and conceptual forms of perspective taking.

It should be noted that neither the imitation nor imitation inhibition theories are likely to be sufficient to account for ToM in its entirety. Indeed, the theory of Brass et al. (2009) explicitly states that imitation inhibition is related only to a sub-process within a wider ToM ability, the ability to control shared representations relating to self and the other. In contrast, it is often implied that the imitation/MNS theory provides a sufficient account of ToM competence. For example, it has been claimed that the MNS provides a mechanism by which we may "directly understand the meaning of the actions and emotions of others by internally replicating ('simulating') them without any explicit reflective mediation" (Gallese, Keysers, & Rizzolatti, 2004, p. 396), and may explain how "we assign goals, intentions, or beliefs to the inhabitants of our social world" (Gallese & Goldman, 1998, p. 493). However, many authors have provided theoretical and empirical objections to this view based both on empirical work with typical individuals (e.g., Saxe, 2005; van Overwalle & Baetens, 2009), and with individuals with Autism Spectrum Conditions (Bird, Leighton, Press, & Heyes, 2007; Southgate, Gergely, & Csibra, 2010; Spengler et al., 2010).

In addition to their implications regarding the interrelatedness of socio-cognitive processes, our findings provide positive evidence for the efficacy of socio-cognitive 'brain-training'. There is very little evidence that the beneficial effects of standard brain-training programmes extend beyond the particular tasks in which participants are trained (Owen et al., 2010; c.f. Klingberg, 2010). Here we show that training in one socio-cognitive task (the control of imitation), has a transferable effect on a very different socio-cognitive task (perspective taking). It is particularly striking that imitation–inhibition training had a positive effect, not only on manual responding in the perspective-taking task, but also on participants' eye-movements. After imitation–inhibition training, participants looked less at the self-referenced object than those who received imitation or inhibitory control training. This suggests that the training had a deep effect – influencing, not only final choice behaviour, but also the way in which attentional resources were allocated when differing perspectives were to be resolved.

5. Conclusions

This is the first empirical study to test the relationship between imitation and Theory of Mind. The improved performance in the ability to adopt the perspective of others observed after imitation–inhibition training (but not after imitation or inhibitory control training) provide support for a novel theory of social cognition suggesting that the same self-other distinction process underlies imitation inhibition and perspective taking. The current results therefore raise the possibility that training interventions could be used to enhance self-other distinction in clinical populations known to show socio-cognitive impairments, such as those with autism spectrum conditions and schizophrenia.

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