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Eye contact enhances mimicry of intransitive hand movements

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When two people meet in a bar, a subtle interplay of social behaviours, including eye contact and unconscious mimicry of actions play an important role in how much the individuals like each other by the end of the evening. However, it is not known how these different social signals interact. Here, we adopt a rapid mimicry paradigm, to test if eye contact can modulate mimicry on a second by second time scale. Our results show that direct eye contact rapidly and specifically enhances mimicry of hand actions. These findings have implications for understanding the role of eye contact as a controlling signal in human non-verbal social behaviour.

Keywords: eye contact; mimicry; non-verbal behaviour; social learning

1. INTRODUCTION

Mimicry refers to the unconscious imitation of other people's behaviours (Chartrand & Bargh 1999). Human mimicry is ubiquitous, unconscious and facilitates social interaction. There is a close relationship between mimicry and liking or affiliation. Interactions with more mimicry lead to more liking and affiliation (Chartrand & Bargh 1999), while interactions with an affiliation goal are characterized by more mimcry (Lakin & Chartrand 2003). Motivation and emotion can also foster or inhibit mimicry (Chartrand & van Baaren 2009). However, all these effects take place over minutes or hours; it is not known if faster, more direct modulation of mimicry is possible.

Like mimicry, eye contact is an important signal in non-verbal communication and social interaction (Senju & Johnson 2009). In two-person settings, people spend 31 per cent of the time engaging in mutual gaze, and each mutual gaze lasts around a second (Argyle & Ingham 1972). Increased eye contact is associated with increased liking and affiliation (Mason *et al.* 2005), and with better performance on tasks such as face detection (Conty *et al.* 2006), gender discrimination (Macrae *et al.* 2002) and identity encoding/decoding (Hood *et al.* 2003).

Although mimicry and eye contact both play a pivotal role in social interaction and are both linked to liking and affiliation, the relationship between the two remains unclear. Some theories (Csibra & Gergely 2009) suggest that eye contact is a critical social signal for imitation, with a controlling role, but other approaches focus on the relationship between mimicry and affiliation without emphasizing other social signals (van Baaren *et al.* 2009). Past research on eye contact and action has found that observed gaze can influence the kinematics of motor performance (Castiello 2003) and neural response to observed action (Kilner *et al.* 2006). However, these studies did not directly examine mimicry.

In the present paper, we aimed to link studies of eye contact and mimicry, and to test if eye contact can rapidly and directly modulate action mimicry. We adopted a stimulus-response compatibility paradigm used by Heyes *et al.* (2005), in which participants respond to a hand-opening or hand-closing stimulus by either opening or closing their own hand. Previous research found faster responses to congruent than incongruent actions and took this congruency effect as a measure of mimicry. In the present experiment, an eye contact priming movie was introduced before each trial of the Heyes task, to examine whether direct eye gaze can influence the congruency effect.

2. EXPERIMENT 1: DOES EYE CONTACT MODULATE MIMICRY?

(a) *Material and methods*

Twenty right-handed students participated in this study (19 females, 1 male; mean age = 22.6 years; s.d. = 3.15 years). Participants completed four blocks (240 trials) of a simple stimulus-response compatibility paradigm (Heyes *et al.* 2005). In each trial, participants viewed a movie of a head movement followed by a hand movement, and made a simple hand movement as fast as possible after the stimulus hand moved (figure 1). The participant's hand movement was specified at the start of a block, and was always 'open hand' or 'close hand'. The stimulus hand either opened or closed in a pseudorandom sequence. Thus, the participant's response could be congruent or incongruent with the observed action. Importantly, participants were not instructed to mimic or to avoid mimicry, they were instructed to respond as quickly as possible in all trials. Thus, any differences in reaction time between conditions reflect implicit processes, which are not under conscious deliberate control. Details of stimulus timing and procedures to avoid confounds are given in the electronic supplementary material.

Before each hand action, participants saw a video clip of an actress who turned her head either towards the camera, giving direct eye contact, or away from the camera, providing averted gaze (figure 1). The actress's face remained on screen during the hand movement and the appearance of the moving hand was the actress's hand. We aimed to test if eye contact modulated the mimicry of hand actions, using a 2×2 factorial design with factors gaze direction (direct or averted) and action congruency (congruent or incongruent). Reaction time was recorded with a *Polhemus* motion tracker on the participant's right hand.

(b) *Results and discussion*

Trials in which participants made an error were eliminated from the main analysis (error rate was 0.05% and did not vary with conditions). Reaction time

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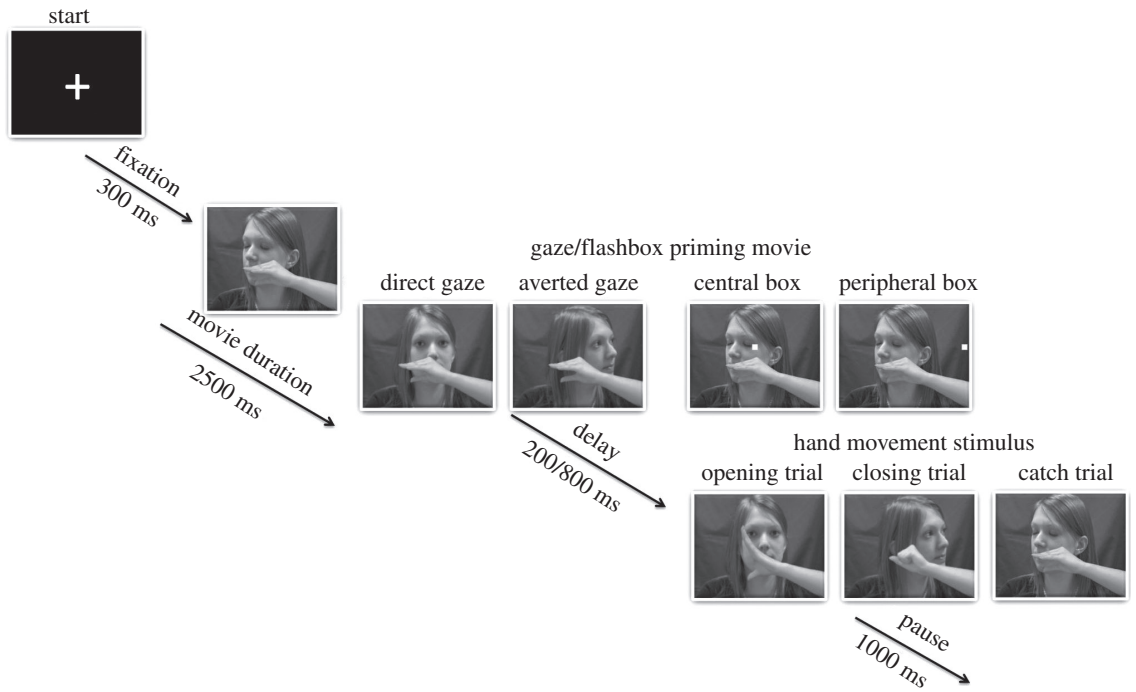

Figure 1. Examples of the stimuli and sequence of events in a typical trial. In experiment 1, the priming movie only included two gaze priming conditions (direct/averted). In experiment 2, two flashbox priming conditions (central/peripheral box) were added.

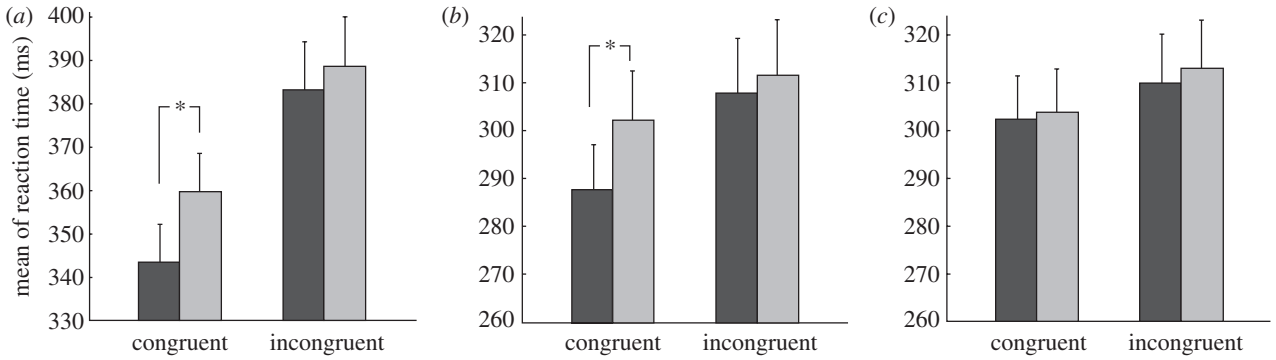

Figure 2. Mean RT on congruent and incongruent trials, for experiment 1 ((*a*) gaze 1) and experiment 2 ((*b*) gaze 2 and (*c*) flashbox). (*a*,*b*) Black bars: direct gaze, grey bars: averted gaze; (*c*) Black bars: central flashbox, grey bars: peripheral flashbox. Asterisk represents the statistically significant difference between two bars and vertical bars indicate s.e.

data were analysed with a two-way repeated measures analysis of variance (ANOVA) (figure 2*a*, gaze 1). The analysis revealed a significant main effect of congruency ($F_{1,19} = 41.0$, $p < 0.001$) and direction ($F_{1,19} = 24.2$, $p < 0.001$); importantly, there was an interaction between congruency and direction ($F_{1,19} = 10.3$, $p < 0.005$). Furthermore, a post hoc *t*-test showed that congruent responses were faster when preceded by direct gaze than by averted gaze ($t_{20} = 6.18$, $p < 0.001$), but incongruent responses were statistically unaltered whenever preceded by direct or averted gaze.

The results from this experiment indicated a facilitatory effect of eye contact on mimicry and more importantly revealed a significant interaction between eye contact and mimicry. That is, direct gaze enhanced the reaction times for congruent trials compared with incongruent trials, while averted gaze did not. This rapid modulation of mimicry by gaze is novel and provides a potent mechanism for social interaction. However, this first experiment did not control for the possibility that, in the averted gaze conditions, the participant's visual attention was distracted away from the centre of the display and this change in visual attention could contribute to the observed effects. We addressed this question in experiment 2, in which an eye-catching white box suddenly flashed on the screen before the hand movement to draw attention in a new control condition.

3. EXPERIMENT 2: IS THIS MODULATION DUE TO SPATIAL ATTENTION?

(a) *Methods*

Twenty-three right-handed students participated in this study (12 females, 11 males; mean age = 23.7 years; s.d. = 3.01 years). Half the trials in experiment 2 used exactly the same stimuli as experiment 1. The other half used a new flashbox priming condition, in which the actress' head remained still and averted

with eye-closed throughout, while a small white square briefly flashed in the centre of the screen or the periphery to draw participant's attention. Thus, the study has a $2 \times 2 \times 2$ factorial design with factors—priming (gaze/flashbox), congruency (congruent/incongruent) and direction (direct (central)/averted (peripheral)). If the effects observed in experiment 1 were only due to differences in spatial attention between the conditions, the same effects should be seen in this flashbox condition.

(b) *Results and discussion*

Error rate was 0.07 per cent and error trials were removed. Reaction time data were analysed with a three-way repeated measures analysis of variance (ANOVA). The analysis revealed a significant main effect of priming ($F_{1,22} = 4.34$, $p < 0.043$), congruency ($F_{1,22} = 29.5$, $p < 0.001$) and direction ($F_{1,22} = 21.2$, $p < 0.001$) and three significant interactions, congruency × priming ($F_{1,22} = 5.20$, $p < 0.027$), direction × priming ($F_{1,22} = 7.58$, $p < 0.008$) and congruency × direction × priming ($F_{1,22} = 4.16$, $p < 0.047$).

To explore these interactions fully, gaze priming data and box priming data were separately analysed with a two-way repeated measured analysis of variance (ANOVA). The analysis of gaze priming data revealed a significant main effect of congruency ($F_{1,22} = 18.4$, $p < 0.001$) and direction ($F_{1,22} = 21.8$, $p < 0.001$) (figure 2*b*, gaze 2) and the critical interaction between congruency and direction ($F_{1,22} = 10.8$, $p < 0.003$). As before, congruent movements were faster when primed by direct gaze than by averted gaze ($t_{23} = 5.37$, $p < 0.001$).

In contrast, the analysis of flashbox priming data only revealed a significant main effect of Congruency ($F_{1,22} = 8.09$, $p < 0.009$); no other factors reached the significant level (figure 2*c*, flashbox), including the non-significant interaction between congruency and flashbox direction ($F_{1,22} = 0.174$, $p = 0.681$).

The results from experiment 2 replicated experiment 1 with a new group of participants and show that drawing attention to the side of the display with a non-social cue does not impact on mimicry. This suggests that the enhancement of mimicry that we observe is specific to eye contact and is not driven by spatial attention.

4. GENERAL DISCUSSION

These two experiments provide strong evidence that eye contact rapidly and specifically enhances mimicry of hand actions. In both experiments, responses to congruent actions were faster when preceded by direct gaze.

To understand the origins of the eye contact effect, we first exclude possible non-social mechanisms. The effect of eye contact on mimicry was not a general arousal effect, because incongruent response times were unaltered (see figure 2*b*). We also controlled for spatial attention. Previous studies reported that observing another person's averted gaze automatically shifts spatial attention (Friesen *et al.* 2005). If the averted gaze draws attention away from the centre of the screen, this might impact on mimicry. However, our flashbox control condition in experiment 2 shows that distracting stimuli at the side of the display do not impact on mimicry. Changes in attention would not predict an enhancement that is specific to congruent actions, as we found in gaze condition. Similarly, our results reflect more than just a general increase in arousal due to eye contact, because we found a specific enhancement for congruent actions compared with incongruent ones. Thus, we conclude that our results reveal a novel and powerful social mechanism whereby eye contact rapidly enhances action mimicry.

Our finding has important implications for emerging ideas about non-verbal behaviour in human social interaction. Our data are congruent with models that emphasize flexible control of imitation (Brass *et al.* 2009) and an influence of eye gaze on action understanding (Castiello *et al.* 2003; Kilner *et al.* 2006). We go beyond these studies in showing that a specific ostensive social cue—eye contact—enhances mimicry actions rather than incongruent actions. More detailed discussion for this topic can be found in the electronic supplementary material.

It is also important to consider how our rapid stimulus-response compatibility task relates to other more naturalistic mimicry paradigms used to study the 'chameleon effect' (Chartrand & van Baaren 2009). Our rapid paradigm puts participants in a very different context (van Baaren *et al.* 2009). However, in both naturalistic and rapid mimicry paradigms, participants are unaware that the experimenter is recording mimicry behaviours or that mimicry is the subject of the investigation. Studies of mimicry in naturalistic situations look at mimicry effects which occur over seconds (Oullier *et al.* 2008) and modulation of mimicry over minutes (Lakin & Chartrand 2003), but this makes it hard to determine causal factors. Our approach allows us to measure response times with millisecond precision and obtain an estimate of the speed of the eye contact effect. The speed of the eye contact effect we report, with just 500 ms between the eye contact event and the mimicry response, suggests that it is not mediated by general changes in affiliation. Rather, we suggest that eye contact directly impacts on the mimicry process, and this could be a causal factor in the 'chameleon effect' (Chartrand & Bargh 1999).

Our results are also congruent with developmental studies that point to eye contact as a critical ostensive signal which modulates social learning. Infants are sensitive to eye contact from birth (Farroni *et al.* 2002) and learn more from situations with eye contact (Csibra & Gergely 2009). As mimicry is a form of imitation and contributes to learning new skills, it is plausible that some of the enhancement of social learning by eye contact in infants and possibly even in adults is mediated by mimicry. Our results provide clear support for the claim that eye contact is an important ostensive signal (Csibra & Gergely 2009), and suggest that eye contact modulates behaviour, not just in infancy, but throughout the lifespan.

In conclusion, the current research has demonstrated that direct gaze is a powerful social signal which can rapidly and specifically enhance

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unconscious mimicry. Our finding suggests that eye contact is more than just an arousal and attentional signal, and that understanding the specific role of the eye contact signal will help researchers learn more about human non-verbal social behaviour.

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