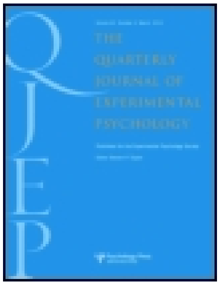

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Why does gaze enhance mimicry? Placing gaze-mimicry effects in relation to other gaze phenomena

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Why does gaze enhance mimicry? Placing gaze-mimicry effects in relation to other gaze phenomena

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Eye gaze is a powerful signal, which exerts a mixture of arousal, attentional, and social effects on the observer. We recently found a behavioural interaction between eye contact and mimicry where direct gaze rapidly enhanced mimicry of hand movements). Here, we report two detailed investigations of this effect. In Experiment 1, we compared the effects of "direct gaze", "averted gaze", and "gaze to the acting hand" on mimicry and manipulated the sequence of gaze events within a trial. Only direct gaze immediately before the hand action enhanced mimicry. In Experiment 2, we examined the enhancement of mimicry when direct gaze is followed by a "blink" or by "shut eyes", or by "occluded eyes". Enhanced mimicry relative to baseline was seen only in the blink condition. Together, these results suggest that ongoing social engagement is necessary for enhanced mimicry. These findings allow us to place the gaze-enhancement effect in the context of other reported gaze phenomena. We suggest that this effect is similar to previously reported audience effects, but is less similar to ostensive cueing effects. This has important implications for our theories of the relationships between social cues and imitation.

Keywords: Eye gaze; Mimicry; Social cognition; Ostensive communication; Audience effect.

Interactive social behaviour requires sensitivity to many different signals and the careful coordination of several different response modalities. These include detecting facial expressions, eye movements, body postures, and hand movements and responding with appropriate actions of the face, eyes, body, and hands. We have recently found evidence for an interaction between the detection of eye contact and the control of hand action responses. People tend to mimic a hand action more when they have eye contact with the actor, which we term the eye-contact-mimicry (ECM) effect. The present paper investigates the precise conditions required to generate this effect and aims to reveal how our results relate to other gaze phenomena reported in social, cognitive, and developmental psychology traditions. We briefly review past work on eye gaze and imitation before outlining the specific conditions that we test.

Eye gaze provides a foundation for communication and social interaction (Senju & Johnson, 2009). It conveys critical information about conspecifics' visibility, attention, interests, and intentions. Gaze shifts to left or right (i.e., averted gaze) seem to trigger a reflexive shift of spatial attention towards the gaze direction (Friesen, Moore, & Kingstone, 2005) and elicit joint attention to the objects of other's interest (Emery, 2000; Kleinke, 1986). Direct gaze or eye contact has different social effects. It facilitates face processing (Conty,

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Tijus, Hugueville, Coelho, & George, 2006; Hood, Macrae, Cole-Davies, & Dias, 2003), person perception/evaluation (Kampe, Frith, Dolan, & Frith, 2000; Macrae, Hood, Milne, Rowe, & Mason, 2002; Mason, Tatkow, & Macrae. 2005), and action understanding/monitoring (Becchio, Bertone, & Castiello, 2008; Kilner, Marchant, & Frith, 2006; Castiello, 2003; Conty, Gimmig, Belletier, George, & Huguet, 2010; Schilbach et al., 2011). As an ostensive cue, direct gaze conveys communicative intention and interpersonal interest, which strongly shape the observer's social motives and desires (Hietanen, Leppänen, Peltola, Linna-Aho, & Ruuhiala, 2008; Kampe, Frith, & Frith, 2003; Senju & Csibra, 2008). Direct gaze (among other cues) can also induce the feeling of being watched (the "audience effect"), which leads to more cooperative/prosocial behaviours (Bateson, Nettle, & Roberts, 2006; Burnham & Hare, 2007; Haley & Fessler, 2005; Jones, Collins, & Hong, 1991; Powell, Roberts, & Nettle, 2012; Rigdon, Ishii, Watabe, & Kitayama, 2009). This audience effect is more than mere social facilitation (Zajonc, 1965) or enhanced arousal (Senju & Johnson, 2009) and is believed to engage processes of reputation management (Frith & Frith, 2012; Haley & Fessler, 2005; Oda, Niwa, Honma, & Hiraishi, 2011) to drive behaviours that enhance social standing.

Mimicry is another important feature of human nonverbal communication. People have a tendency to unconsciously copy the posture, gestures, and speech features of an interaction partner (Chartrand & Bargh, 1999). Such mimicry occurs spontaneously and seems to facilitate social interaction and interpersonal relationship. It is suggested that mimicry acts as a behavioural strategy to increase one's social likeability and functions as a prosocial response to bind and bond people together (Lakin, Jefferis, Cheng, & Chartrand, 2003). Although mimicry is not normally consciously controlled, extensive research suggests that mimicry is flexible and context dependent (Brass, Ruby, & Spengler, 2009; Heyes, 2011). It is sensitive to attention (Chong, Cunnington, Williams, & Mattingley, 2009) and can also be modulated by high-level social factors such as social motivation and social monitoring processes (Chartrand & van Baaren, 2009). For example, mimicry is increased when participants have a need to affiliate (Lakin & Chartrand, 2003; Lakin, Chartrand, & Arkin, 2008), when they have been primed with prosocial attitudes (Leighton, Bird, Orsini, & Heyes, 2010), or when participants are high in self-monitoring (Cheng & Chartrand, 2003; Estow, Jamieson, & Yates, 2007).

We recently found behavioural evidence that mimicry can be rapidly modulated by eye contact in a hand movement task (Wang, Newport, & Hamilton, 2011). We term this the eye-contact-mimicry (ECM) effect. Participants observed a direct or averted gaze followed by a hand opening or closing action. They responded by opening (in some blocks) or closing (in other blocks) their own hand as fast as possible. We found that direct gaze led to faster reaction times for congruent actions only, demonstrating that eye contact causes a rapid and specific enhancement of mimicry responses. The aim of the present paper is to explore in more detail the conditions that lead to the ECM effect and thus to understand how the ECM might related to other reported gaze phenomena.

Past research has identified a number of different effects in which gaze impacts on subsequent behaviour. These include findings commonly attributed to *spatial attention*, findings linked to *ostensive cueing*, and *audience effects*. The underlying mechanisms of these are not yet clear and may well overlap. Here we do not distinguish specific mechanisms, but rather ask how the ECM effect should be categorized in relation to these previous findings. Answering this question will help future study of the underlying cognitive processes involved. We review here these three categories of effect, considering how they might relate to our mimicry findings.

It is well known that gaze shifts lead to reflexive shifts of *spatial attention* (Friesen et al., 2005), and ECM effects might be another example of this. In our previous study, we used a control condition in which a box flashed at the centre or side of the screen to test for the effects of spatial attention and found none (Wang, Newport, et al., 2011, Study 2). However, as our hand stimuli were centred on the face, our study could not distinguish spatial attention to the face from attention to the hand; hence, there is still scope to explore attentional factors further. In particular, if the ECM effect is similar to spatial attention effects, then mimicry should be enhanced whenever stimuli induce reflexive gaze shifts towards the hand action cue (e.g., if hand action is located at the right side of the screen, then enhanced mimicry would be observed by those stimuli that can induce gaze shifts towards the right side of the screen).

Second, it is possible that the ECM effect is similar to *ostensive cueing effects*. Gaze direction is a communicative signal that conveys the sender's communicative intention and may enhance learning (Csibra & Gergely, 2009). Direct gaze indicates that one is being currently addressed or expected to speak and is often a nonverbal invitation to further social contact and reciprocity (Kleinke, 1986). Several studies suggest that ostensive gaze increases the observer's social engagement and expectation (Senju & Johnson, 2009) and increases their motivation to approach, reciprocate, and synchronize (Hietanen et al., 2008; Oberman & Ramachandran, 2007). Joint attention is a subset of ostensive cueing and typically occurs when two individuals ostensively look at each other and then look towards an object (Farroni, Mansfield, Lai, & Johnson, 2003; Frischen, Bayliss, & Tipper, 2007). This social sharing of attention is believed to be important for the development of language and for social learning. There is substantial evidence suggesting that ostensive communication enhances infants' social interactive responses (Jones et al., 1991; Jones & Raag, 1989; Senju & Csibra, 2008) and imitation learning (Brugger, Lariviere, Mumme, & Bushnell, 2007; Carpenter, Tomasello, & Savage-Rumbaugh, 1995; Gergely & Csibra, 2006; Southgate, Chevallier, & Csibra, 2009). Thus, it is possible that the ECM effect is similar to other ostensive or joint attention effects. If this is true, mimicry should be enhanced whenever ostensive cues or joint-attention cues precede the hand action cue.

Third, eye contact can induce an *audience effect*, whereby participants feel they are being watched and for this reason produce more prosocial behaviour. The audience effect is more than just social facilitation (Zajonc, 1965) or enhanced arousal (Senju & Johnson, 2009), because social facilitation occurs in the presence of a conspecific regardless of whether the participant is being watched. Rather, the audience effect is induced by eye contact or other cues that create the feeling of being monitored (Bengtsson, Lau, & Passingham, 2009; Izuma, 2012; Tennie, Frith, & Frith, 2010). These cues lead participants to engage in a process of reputation management and to consider what the observer thinks about the participant (Bateson et al., 2006; Frith & Frith, 2012; Haley & Fessler, 2005; Oda et al., 2011). Previous studies found that people behave more empathically, affiliatively, and prosocially when they were watched by other people (Bateson et al., 2006; Bavelas, Black, Lemery, & Mullett, 1986; Burnham & Hare, 2007; Haley & Fessler, 2005; Milinski, Semmann, & Krambeck, 2002; Piazza, Bering, & Ingram, 2011; Powell et al., 2012; Rigdon et al., 2009; Tennie et al., 2010), and these effects are linked with implicit cognitive processes for managing and monitoring reputation in complex societies (Frith & Frith, 2012; Tennie et al., 2010). Mimicry is an affiliative and prosocial response, which is controlled by a self-monitoring process (Cheng & Chartrand, 2003; Estow et al., 2007; Lakin et al., 2008; Wang & Hamilton, 2012). Thus, it is possible that the ECM effect is similar to other audience effects. If this is the case, then mimicry should be enhanced only if direct gaze is present during the participant's response.

The difference between an ostensive cueing effect and an audience effect is subtle but important. In typical ostensive cueing studies, a participant first sees the social cue (e.g., eye contact or speech) and then sees the action stimulus (Csibra & Gergely, 2009). Thus, the ostensive cue is no longer present at the point when the participant responds. In contrast, an audience effect is defined by the monitoring of a participant's response. In such studies, the precise sequence of events before an action stimulus is not critical as long as the audience is present during the response period (Izuma, 2012). By carefully controlling stimulus timing, it is possible to distinguish between these two categories of effect. In the present paper, we report two studies that use different gaze cueing videos to precisely define the conditions leading to the ECM effect. Thus we can determine where the ECM fits in relation to reflexive attention, ostensive cueing, and the audience effect.

EXPERIMENT 1

Experiment 1 aimed to test whether the order in which gaze cues are presented matters to the enhancement of mimicry. In our previous study (Wang, Newport, et al., 2011), direct/averted gaze always immediately preceded the hand action, and the hand movements were superimposed on the gazing face of the actress, which does not allow us to distinguish attention to the hand and to the face. Here we presented hand movements adjacent to the actress's face and used a novel two-gaze-sequence priming video to dissociate the social and nonsocial effects of eye gaze on mimicry (Figure 1). Participants watched videos involving two gaze events followed by a hand movement. The gaze events could be (a) the actress looking directly at the camera (direct gaze, DG); (b) the actress looking over her own left or right shoulder, with her head at 90° from her straight ahead (averted gaze, AG); (c) the actress looking at her own hand, with her head at 45° from her straight ahead (hand gaze, HG). These three possible gaze events were performed in sequences of two gazes, arranged in a 3×3 factorial design. For example, if the actress begins with a hand gaze and then looks directly at the participant, this sequence is designated HG1–DG2 (Figure 1B). The full set of nine gaze cueing sequences is shown in Figure 1A.

These nine videos provide different types of gaze cue and lead to different patterns of predicted results. First, if the enhancement of mimicry is similar to reflexive spatial attention, then the effect should be strongest in the conditions where the actress's head is turned towards the same side of space as the moving hand at the end of the movie (i.e., AG2 and HG2 conditions rather than DG2 conditions). Second, if enhancement of mimicry is similar to ostensive cueing with eye contact at any point, it should be seen following DG1 or DG2 movies but not the movies that lack any direct gaze. However, if enhancement of mimicry is similar to joint attention, it should be seen only in the condition where direct gaze is followed by gaze to the hand (DG1–HG2). Finally, if the enhancement of mimicry is similar to an audience effect, it should be seen only in the videos where eye contact is present during the hand action (DG2 conditions).

Method

Participants

Twenty undergraduates from the University of Nottingham gave their informed consent to participate in this study (15 females, 5 males; mean age = 21.4 years; $SD = 2.23$ years) and were paid for their participation. All were right-handed, had normal or corrected-to-normal vision, and were naïve as to the purpose of the study.

Stimuli and apparatus

In each trial, participants watched a five-second video where an actress performed a sequence of two gazes and then a hand movement (Figure 1). At the onset of each video clip, the actress kept her eyes closed and held her left hand still on the right side of the screen. Her head was facing towards three possible directions: left sideways, forward, or rightward to her left hand. After 500 ms the actress opened her eyes and provided the first gaze in the same direction as her face orientation for 1500 ms. This could be an averted gaze to the left sideways (AG1), or a direct gaze to the camera (DG1), or a hand-oriented gaze (HG1). Subsequently, the actress naturally turned her head to other directions and provided the second gaze for 1000 ms, which could be a new averted gaze towards the right sideways (AG2), a new direct gaze to the camera (DG2), or a new hand gaze (HG2). The actress also gave a tiny smile

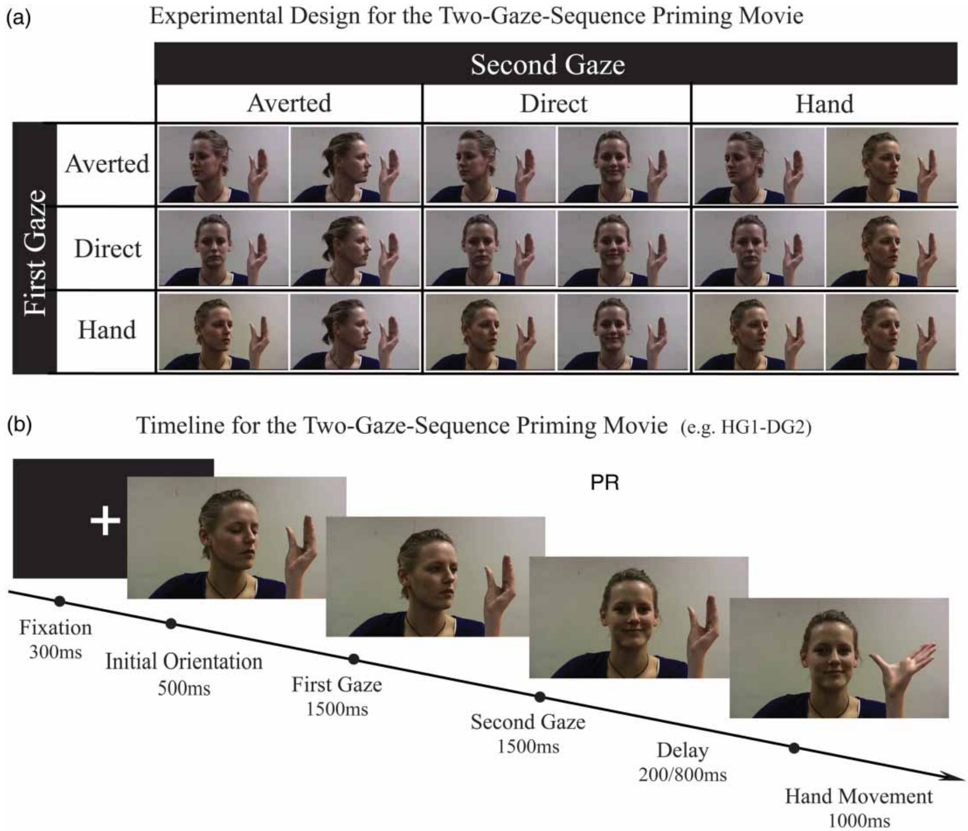

Figure 1. *Experimental design (A) and timeline (B) for the two-gaze-sequence priming movies in Experiment 1. Participants were shown a series of 5-s videos clips where an actress provided two eye gazes and a hand movement. We adopted a 3 × 3 factorial design to present the two gazes, where the actress could look at the camera ("direct gaze") or sideways ("averted gaze") or her acting hand ("hand gaze") in the first (left) and second (right) gaze. [DG1–DG2 videos were filmed as follows: At the beginning, the actress's eyes were closed, and her face was oriented towards the camera. Then the actress naturally opened her eyes, which resulted in a direct gaze (i.e., first gaze). After this direct gaze with neutral facial expression for 1500 ms, the actress began to look at the camera with a greeting smile, which provided an ostensive direct gaze (i.e., second gaze).] After the two gazes, the actress performed a hand-opening or hand-closing movement. To view a colour version of this figure, please see the online issue of the Journal.*

along with the second direct gaze (DG2), which was designed to strengthen the "ostensive" nature of direct gaze. After the two gaze shifts, the actress's hand began to move. She either opened her hand or closed her hand (stimulus trials), or remained hand static (catch trials). Hand movements were created by superimposing images of a hand in the rest posture or one of four frames of the moving hand as it opened/closed on top of the video of the head action. This allows precise control of the hand movement timing. Delay between the completion of second gaze phase and the start of hand action was 200 or 800 ms, and the hand movement stimulus had a duration of 1000 ms.

Procedure

The experiment used a stimulus–response compatibility paradigm to measure mimicry as before (Heyes, Bird, Johnson, & Haggard, 2005; Leighton et al., 2010; Press, Bird, Walsh, & Heyes, 2008; Wang, Newport, et al., 2011). For each block, participants were required to make the same prespecified response in every trial. They had to always open or close their right hand as quickly as possible after the actress's hand in the two-gaze-sequence videos began to move. On some trials, the actress's hand opened, and on others it closed. Therefore, within a block, the hand movement in the movie was either the same as the prespecified response (congruent trials, e.g., open stimulus and open response) or the opposite of the prespecified response (incongruent trials, e.g., close stimulus and open response). Participants were not instructed to mimic or to avoid mimicry but were only instructed to respond as quickly as possible in all trials. Thus, any differences in response time between congruent and incongruent trials (defined as "congruency effect", CE) reflect implicit and unintentional mimicry (Heyes, 2011). Response movement direction was orthogonal to stimulus movement direction to avoid spatial compatibility confounds (Press et al., 2008).

There were six blocks and 270 trials in total; three blocks required hand-close responses, and three blocks required hand-open responses. Block order alternated and was randomized across participants. Each block presented 36 stimulus trials (where the actress's hand opened/closed) and 9 catch trials (where the actress's hand kept still) in pseudorandom order. Participants were instructed to refrain from moving their hand in catch trials. Within a block, we adopted a $3 \times 3 \times 3$ factorial design in which factors were "direction of first gaze" (AG1, DG1, or HG1), "direction of second gaze" (AG2, DG2 or HG2), and "action congruency" (congruent, incongruent, or catch; Figure 1A). Variable delays between second gaze and hand movement (200/800 ms) were used to prevent anticipatory responses.

Reaction time (RT) was measured by an electromagnetic device (Polhemus LIBERTY® system, Colchester, USA). Two sensors were taped on the thumb and middle fingernails of participants' right hands, and the sensor's spatial position was recorded at 240 Hz. Finger and thumb location data were recorded in Matlab, which also controlled presentation of the video and still image stimuli via the Cogent toolbox. Hand aperture was calculated as the distance between thumb and finger markers. Aperture velocity was calculated and then smoothed with a 40-ms-square window. Peak velocity was defined as the first peak in the velocity profile that reached at least 60% of the largest peak. This allowed us to exclude rare "wobbles" in the data and pick the initial fast hand opening or closing movement. RTs were calculated as the time from the presentation of the second frame of the hand movement video to the time when the participant's hand aperture reached its first peak open/close velocity.

Results

To remove trials in which participants did not attend to the hand stimuli, incorrect responses (0.33%) were excluded from the analysis, as were all RTs smaller than 100 ms or greater than 800 ms (0.25%). To minimize the effect of outliers, we also excluded RTs that were greater than two standard deviations from the conditional means of each participant (0.48%). The CE for each participant was calculated by subtracting RT in congruent trials from RT in incongruent trials.

First, in order to examine which features of the gaze sequence movies influence mimicry, we performed a four-way analysis of variance (ANOVA) on participants' mean RT with "congruency" (congruent, incongruent), "first gaze" (AG1, DG1, and HG1), "second gaze" (AG2, DG2, and HG2), and "delay time" (200/800 ms) as variables. The four-way ANOVA analysis revealed a significant main effect of congruency on RT, $F(1, 19) = 73.07$, $p < .001$. On average, responses were faster for congruent trials ($M = 309$ ms, $SE = 14.26$ ms) than for incongruent trials ($M = 353$ ms, $SE = 15.83$ ms). The ANOVA analysis also showed two significant two-way interactions on RT: Congruency × Second gaze, $F(2, 38) = 13.22$, $p < .001$, and First gaze × Second gaze, $F(4, 76) = 12.54$, $p < .001$. There was also a significant three-way interaction, Delay time × First gaze × Second gaze, $F(4, 76) = 5.06$, $p = .001$. As neither first gaze nor delay time interacted with congruency, these results suggested that only the second gaze influenced one's tendency to mimic.

To further explore the interaction between congruency and second gaze, we examined the magnitude of CE in each gaze sequence. Post hoc t tests show that participants had a larger CE when the second gaze was direct gaze (Figure 2). Specifically, when the first gaze was averted gaze (AG1), CE in AG1–DG2 was larger than the one in AG1–AG2, $t(19) = 2.58$, $p = .019$, and AG1–HG2, $t(19) = 3.11$, $p = .006$; when the first gaze was direct gaze (DG1), CE in DG1–DG2 was larger than the one in DG1–AG2, $t(19) = 2.57$, $p = .019$, and DG1–HG2, $t(19) = 2.25$, $p = .037$; when the first gaze was hand gaze (HG1), CE in HG1–DG2 was larger than the one in HG1–AG2, $t(19) = 3.17$, $p = .005$, and HG1–HG2, $t(19) = 3.61$, $p = .002$.

Finally, in order to compare how differently first gaze and second gaze modulate mimicry, we recategorized the RT data by first gaze or second gaze and separately analysed them with a two-way ANOVA on the factors of "congruency" (congruent, incongruent) and "gaze direction" (AG, DG, and HG; Figure 3). The analysis on first gaze data only revealed a significant main effect of congruency, $F(1, 59) = 136.69$, $p < .001$. No other factors reached the significant level (Figure 3A), which suggested that first gaze did not have impacts on mimicry. In contrast, the analysis on "second gaze" data revealed a significant main effect of congruency, $F(1, 59) = 124.48$, $p < .001$, and gaze direction, $F(2, 118) = 4.55$, $p = .013$ (Figure 3B). More importantly, there was an interaction between congruency and gaze direction, $F(2, 118) = 14.90$, $p < .001$. Post hoc t test showed that this interaction resulted from a faster congruent movements in DG-2 than in AG-2, $t(59) = 3.27$, $p < .002$, and HG-2, $t(59) = 4.41$, $p < .001$. These results replicated our previous findings that a single direct gaze enhances mimicry by facilitating responses to congruent trials (Wang, Newport, et al., 2011).

Discussion

Like our previous study showing that mimicry can be modulated by a single direct gaze (Wang, Newport, et al., 2011), Experiment 1 demonstrated

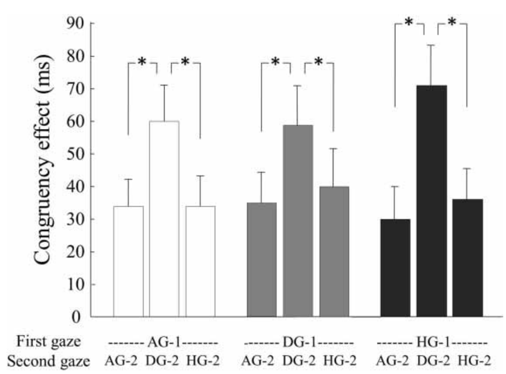

Figure 2. *Mean congruency effect (CE) for each type of the two-gaze-sequence videos in Experiment 1. AG = averted gaze; DG = direct gaze; HG = hand-oriented gaze. 1 denotes first gaze; 2 denotes second gaze. Here, CE was enhanced only when the gaze sequence included DG2. An asterisk represents the statistically significant difference between two bars. Vertical bars indicate standard errors.*

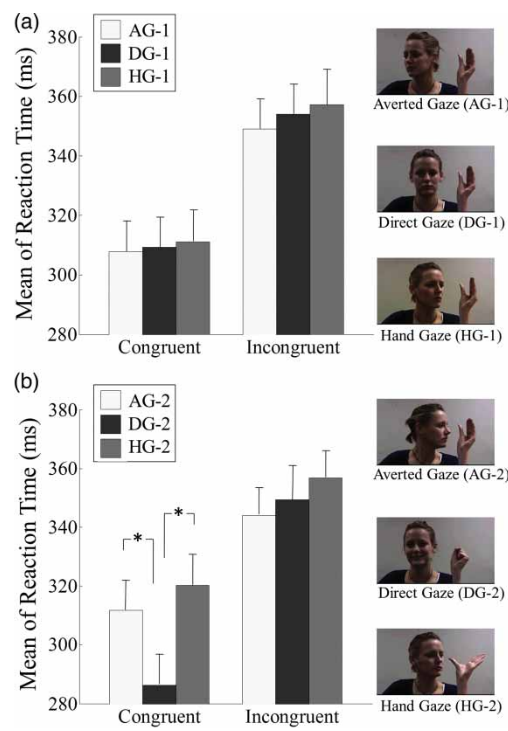

Figure 3. *Mean reaction time (RT) on congruent and incongruent trials for (A) first-gaze groups and (B) second-gaze groups in Experiment 1. AG = averted gaze; DG = direct gaze; HG = hand-oriented gaze. 1 denotes first gaze; 2 denotes second gaze. An asterisk represents the statistically significant difference between two bars. Vertical bars indicate standard error. To view a colour version of this figure, please see the online issue of the Journal.*

that mimicry is also sensitive to a sequence of two gaze shifts. Specifically, the results revealed that mimicry was modulated by the second gaze of the sequence (Figure 3B), but was not susceptible to the first gaze (Figure 3A). Further analysis on the second gaze suggested that the mimicry was enhanced only when the second gaze was a direct gaze (DG-2; (Figure 2 and Figure 3B). Experiment 1 provided a clear result—mimicry is enhanced only when direct gaze was presented immediately before and during the hand action (DG2), not in any other conditions (AG/HG/DG1).

We now evaluate how this ECM relates to other research on gaze effects. First, there was no evidence that the ECM effect is similar to low-level effects of spatial attention or to reflexive gaze following, because there was no enhancement of mimicry in the AG2 or HG2 conditions. Second, the ECM does not seem to be similar to ostensive cueing effects or joint attention effects. Joint attention was specifically induced by the condition DG1–HG2, but there was no evidence of mimicry enhancement in this case. Ostensive cueing could be induced by either the first or the second gaze, but there was no hint that mimicry was stronger following an initial direct gaze (DG1) than following an averted or hand gaze (AG1 or HG1). However, the data are similar to those from previous studies of audience effect. Mimicry was substantially stronger when direct gaze was present immediately before and during the response (DG2) than in all other conditions, and this effect was not modulated by previous gaze conditions (i.e., the first gaze).

One caveat must be applied to these results. When the videos were recorded, the actress gave a small smile during DG2 but did not smile during DG1. In piloting, we have found that actresses who maintain an entirely neutral expression throughout the gaze sequences are judged as “grim”, “scary”, and not socially engaging. It is plausible that gaze + smile (DG2) is a more socially engaging and ostensive signal than gaze alone (DG1; Jones, DeBruine, Little, Conway, & Feinberg, 2006). Thus, the results we report could be driven by the presence of an engaging smile in DG2, rather than by the specific gaze sequence we used. To rule out this possibility and to explore the relationship between the ECM and audience effects further, we conducted a second experiment.

EXPERIMENT 2

The results in Experiment 1 show that the ECM was present only when direct gaze was present immediately before and during mimicry, but not when direct gaze was present at the start of a trial and then removed. This implies that the ECM is similar to an audience effect, rather than an ostensive cueing effect. However, the difference in the actress smile between the conditions is a limiting factor. In this second study, we use a new set of gaze-cueing videos to define more precisely the conditions that lead to the ECM effect.

A key question concerns the timing of the gaze cues. In ostensive cueing situations, the cue is present before the response but is not needed during the response itself. In contrast, an audience effect implies that the audience must be present while the participant makes a response. This means we can distinguish these experimentally by creating video clips with different gaze timing. Here we contrasted five different conditions (Figure 4). In the control condition, the actress never made eye contact (Figure 4A, “averted” condition). In the four remaining conditions, the actress always made eye contact with a small “social greeting” smile, which provides a strong cue to social engagement. Following the eye contact, the actress could turn her face towards the hand to provide a hand gaze (Figure 4B, “hand” condition), intentionally close her eyes (Figure 4C, “close” condition), have her eyes blocked by a black shape (Figure 4D, “block” condition), or naturally blink her eyes once and then continue to look at the camera (Figure 4E, “blink” condition). Conditions C, D, and E were all generated from the same clip by means of video editing, ensuring that the introductory gaze/smile was identical in these conditions.

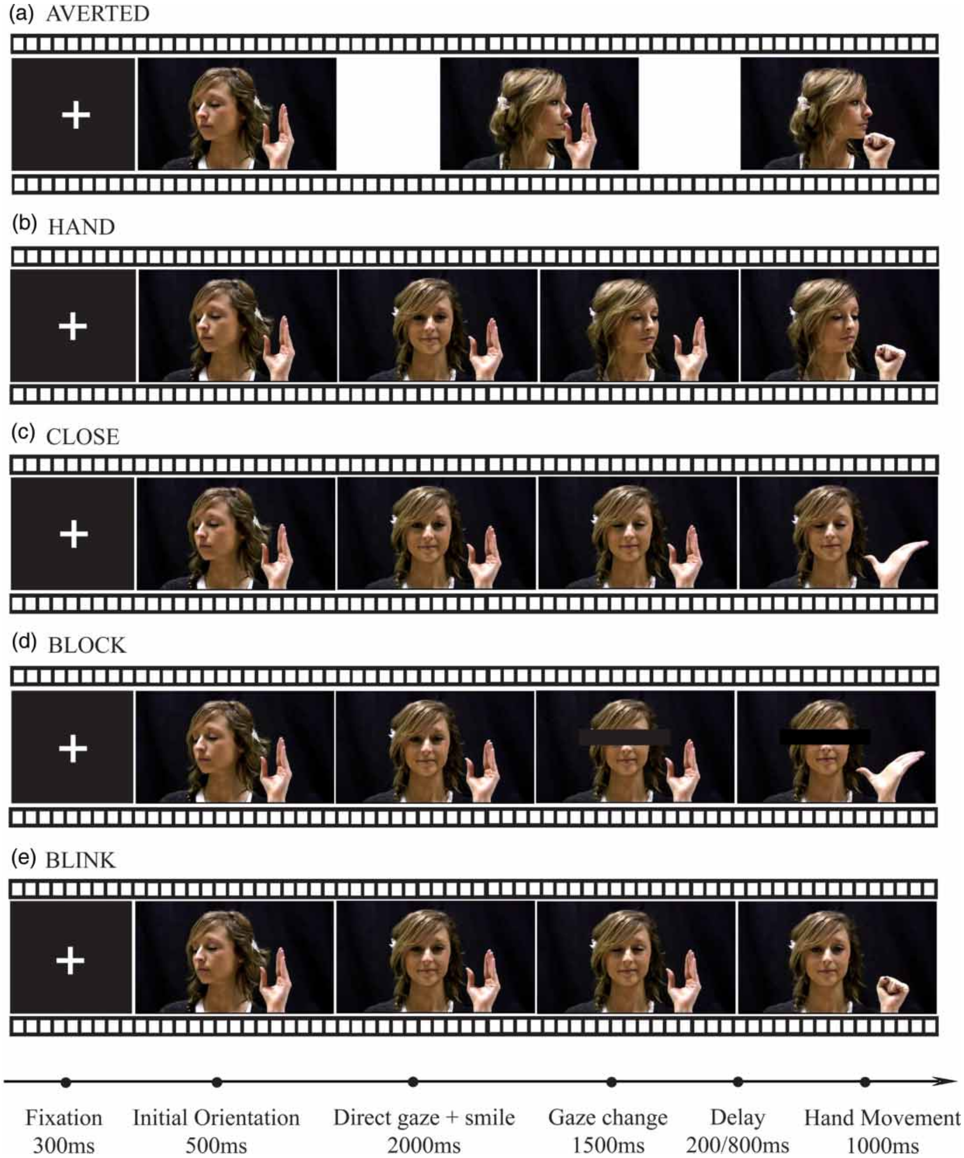

Figure 4. *Experimental design and timeline for five types of gaze sequences priming movie in Experiment 2. All movies started with an actress closing her eyes and facing left sideways (i.e., the first frame after the fixation) and ended with the actress performing a hand opening/closing/warning action (i.e., the last frame). (A) In "averted" movies, the actress turned her head towards the right sideways, which provided an averted gaze. (B)(C)(D)(E) In the other four movies, the actress first turned head towards the camera to provide an ostensive direct gaze for 2000 ms; after that the actress made a gaze change, in which she could (B) turn her head towards her left hand to provide a hand gaze in hand movies; (C) close her eyes intentionally in close movies; (D) be passively blocked by a black rectangle appearing in front of her eye regions in block movies; or (E) naturally blink her eyes once and then continue to look at the camera in blink movies. To view a colour version of this figure, please see the online issue of the Journal.*

If the enhancement of mimicry is similar to ostensive cueing or joint attention, then all four experimental conditions (i.e., hand, close, block, blink) should increase mimicry relative to the control condition (averted). This is because these conditions all provide matched direct gaze at the start of the clip. In contrast, if the eye contact effect is similar to an audience effect, then only the blink condition should lead to enhanced mimicry because this is the only situation where participants are being watched as they perform the hand movement.

Method

Participants

Nineteen undergraduates from the University of Nottingham gave their informed consent to participate in this study (13 males, 6 females; mean age = 23.8 years; $SD = 1.64$ years) and were paid for their participation. All were right-handed, had normal or corrected-to-normal vision, and had not participated in Experiment 1.

Stimuli and procedure

To generate the stimuli, a female actress was filmed performing different head/eye movements. In every video, the actress began with her head turned to the left and her eyes closed. For the averted condition (Figure 4A), the actress opened her eyes and turned her head directly towards the right sideways, which provided a simple averted gaze similar to that in Wang, Newport, et al. (2011). For the hand condition (Figure 4B), she first opened her eyes and turned her head towards the camera to provide a direct gaze together with a small engaging smile; 2000 ms later, she turned towards her hand and gazed at her hand until the end of the clip. For the blink condition (Figure 4E), she also opened her eyes and turned her head towards the camera to provide a direct gaze together with a small engaging smile; 2000 ms later, she blinked and continued to gaze at the camera until the end of the clip. The close condition was generated by taking the blink video clip and freezing the movie at the point where the actress had her eyes closed to blink (Figure 4C). The block condition was generated by taking the blink video clip and imposing a black box on top of the actress's eyes just before she began to blink (Figure 4D). These manipulations mean that these three clips are precisely matched for the action timing and the social engagement cues provided by the eye contact phase. All five of the cue videos were then edited to add the moving hand with appropriate timing as previously. After the gaze sequences, the actress's hand began to move. She either opened her hand or closed her hand (stimulus trials), or remained hand static (catch trials). Delay between the last frame of the gaze sequence and the start of hand action was 200 or 800 ms, and the hand movement stimulus had a duration of 1000 ms.

We used the same stimulus–response compatibility paradigm as that in Experiment 1 to measure mimicry. There were six blocks and 150 trials in total; three blocks required hand-close response and three blocks required hand-open response. Block order alternated and was randomized across participants. Each block presented 20 stimulus trials (where actress's hand opened/closed) and five catch trials (where actress's hand kept still) in pseudorandom order.

Results and discussion

The same procedure as that in Experiment 1 was implemented on raw RT data, to remove incorrect responses (0.28%) and RT outliers (0.84%). First, in order to examine whether different gaze sequences had different influences on mimicry, a two-way repeated measures ANOVA was conducted on participants' mean RT, with congruency (congruent and incongruent) and gaze sequence (averted, hand, close, block, blink) as variables. The analysis revealed a significant main effect of congruency, $F(1, 18) = 26.23$, $p < .001$, a significant main effect of gaze sequence, $F(4, 72) = 14.35$, $p < .001$, and a significant interaction between congruency and gaze sequence, $F(4, 72) = 2.97$, $p = .025$. These results suggest that different gaze sequences induced different magnitude of mimicry.

Second, in order to further examine the specific effect of each gaze sequence on mimicry, post hoc t tests were conducted on the CE (see Figure 5). When comparing the averted condition with other four conditions, we found that only the blink condition displayed significantly larger CE than the averted condition, $t(18) = 2.66$, $p = .016$; other conditions did not reach the

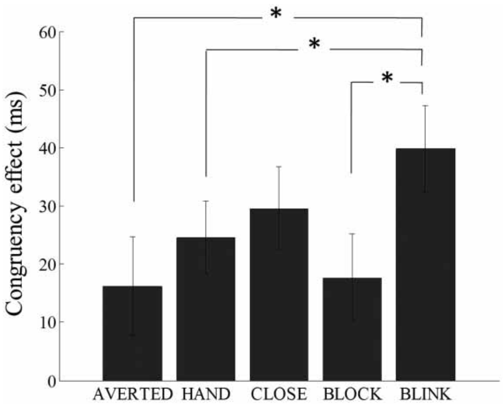

Figure 5. *Mean congruency effect (CE) of five types of gaze sequences in Experiment 2. An asterisk represents the statistically significant difference between two bars. Vertical bars indicate standard error.*

significant level: hand versus averted, $t(18) = 0.800$, $p = .434$, close versus averted, $t(18) = 1.42$, $p = .174$, block versus averted, $t(18) = 0.17$, $p = .870$. When comparing the blink condition with other three ostensive gaze conditions, we found that the CE in the blink condition was significantly larger than the one in the hand condition, $t(18) = 2.14$, $p = .047$, and block condition, $t(18) = 2.77$, $p = .013$, but was not significantly larger than that in the close condition, $t(18) = 1.61$, $p = .126$. This pattern means that, when compared with the baseline (i.e., averted condition), mimicry was enhanced in the blink condition but not in the block or close conditions, which were precisely matched for ostensive cues.

Interpreting this result is complicated by the fact that there was no difference between the CE in the close condition and that in the blink condition. Thus, it is not clear whether closing the eyes really removes the ECM entirely. One possible reason for this null finding is the timing of the stimuli. In both close and blink conditions, the first 2.5 s of the video were identical. The actress then either blinked or closed her eyes, and this status was maintained for either 200 or 800 ms before the hand action cue. The 200-ms delay is very short and might be too short for participants to accurately discriminate between a sustained eyes-closed event and a slightly longer blink. To test this, we examined the data in these two conditions only, split by delay time. We predict that long-delay videos would be more likely perceived as a real close condition but not blink condition, because the actress closed her eyes for as long as 800 ms before the hand movement, which is too long to be understood as a blink; therefore, the CE in long-delay videos should be different from the CE in blink. In contrast, we predict that there would be a null effect in the short-delay videos.

Just as we predicted, we found that CE in long-delay close ($M = 23.87$ ms) was significantly smaller than CE in the blink condition ($M = 39.77$ ms), $t(18) = 2.35$, $p = .030$, whereas CE in short-delay close ($M = 38.15$ ms) was not different from CE in blink ($M = 39.77$ ms), $t(18) = 0.570$, $p = .576$. These results suggest that the ECM effect is larger following a blink than a close, but only in conditions where these two events can be clearly discriminated. Overall, the data demonstrate that the ECM is present only when the participant is being observed and not when the actress's gaze is occluded by either a blank box or the eyelids.

GENERAL DISCUSSION

The present study used a gaze-sequence paradigm to explore the precise conditions that lead to the enhancement of mimicry by eye contact (the ECM effect). In two experiments, we investigated the impact of different gaze cueing sequences on mimicry and examined how the ECM effect might relate to three different gaze effects reported in previous literature—reflexive spatial attention, ostensive cueing, or an audience effect. Both Experiment 1 and Experiment 2 showed that mimicry is enhanced if an actress gazes at the participant during the response period but not under other circumstances.

We now consider how this pattern of behaviour relates to previous reports of reflexive attention, audience effects, and ostensive cueing, before exploring the implications of these results. First, our findings cannot easily be categorized as a reflexive attention effect, because a head turn towards the moving hand (HG gaze in Experiment 1 and hand condition in Experiment 2) did not lead to any enhancement of mimicry. Discriminating between ostensive cueing and audience effects is a little more complex, but a key difference concerns the timing of the stimuli. An ostensive cue present *before* a stimulus can enhance later processing of the action even after the cue itself has been removed (Brugger at al., 2007; Csibra & Gergely, 2009; Southgate et al., 2009). In contrast, audience effects are commonly described in terms of how the feeling of being watched during the response period of a task induces reputation-management strategies in the participant who wishes to maintain a particular reputation in the eyes of the audience (Tennie et al., 2010).

Our novel task with precise control of stimulus timing provides a way to test how the ECM relates to these two effects. Overall, we found that mimicry was enhanced in conditions where the actress was socially engaged with the participant (made eye contact with a small smile) and maintained that engagement during the response period. Closely matched conditions where the actress smiled but then turned her head away or had her eyes blocked (Experiment 2) did not lead to enhancement of mimicry. Furthermore, conditions designed to engage joint attention to the moving hand (DG1–HG2 in Experiment 1, hand condition in Experiment 2) did not lead to enhancement of mimicry. These results suggest that social engagement and ongoing monitoring are critical conditions for enhanced mimicry.

It is important to note that there are several ways in which our study differs from previous investigations of both ostensive cueing and the audience effect. We only used eye contact accompanied by a small smile of social greeting as an ostensive cue. Other studies have used vocal ostensive cues such as the infant-directed speech (e.g., "motherese", Csibra & Gergely, 2009) and the calling of one's own name (Kampe et al., 2003). It would be interesting to see whether these cues also enhance mimicry, because vocal cues do not imply ongoing monitoring in the same way as a direct gaze cue does.

Second, most previous studies of the audience effect have examined the impact of a noninteractive, nonemotional audience (Bateson et al., 2006; Burnham & Hare, 2007; Haley & Fessler, 2005; Powell et al., 2012; Rigdon et al., 2009). For example, participants give more to charity when a photo of a pair of eyes is present (Powell et al., 2012). This effect occurs even when the eyes are only a photo, and participants presumably do not believe anyone is really watching them. In contrast, the actress in our videos made eye contact with a small smile of social greeting and then maintained eye contact during the response period. This style of stimulus has reliably induced enhancement of mimicry in several studies (Wang, Newport, et al., 2011, Experiments 1 and 2; and Experiments 1 and 2 here). Piloting in our lab suggests that a still image of an actress making eye contact (no video) or an actress who makes eye contact with no smile is judged as grim or harsh and does not elicit an ECM effect. Thus, it is possible that the ECM effect requires a continued and engaging social interaction, which is more than a basic audience effect. It is important to note that a smiling actress alone does not drive the enhancement of mimicry, because no enhancement was seen when the eyes of the smiling actress were blocked in Experiment 2. Further study of the relationship between the ECM effect found here and other types of audience effect will be very valuable.

Our conclusion that the ECM effect is similar to other audience effects is consistent with recent studies suggesting that mimicry is more nuanced than previously thought (Bourgeois & Hess, 2008; Hofman, Bos, Schutter, & van Honk, 2012; Lakin et al., 2008; Schrammel, Pannasch, Graupner, Mojzisch, & Velichkovsky, 2009). Although mimicry is believed to be based on a direct perception–action link (e.g., mirror neuron system), it is not a reflex-like response that simply and directly mirrors the observed actions. Rather, mimicry is a subtly controlled social behaviour, which may serve to enhance and maintain social relationships (Lakin et al., 2003; Wang & Hamilton, 2012). The present study suggests that mimicry responses may be controlled to maintain a reputation as a prosocial, imitative agent, rather than being an obligatory response to a social cue.

Our results also have important implications for our current theories of social cueing and imitation. The social top-down response modulation (STORM) model (Wang & Hamilton, 2012) proposes that mimicry responses can be modulated by a variety of social signals including eye contact (Wang, Newport, et al., 2011) and social priming (Wang & Hamilton, 2013). We can now be more specific in describing the types of cue that lead to social modulation of mimicry. The present data demonstrate that ongoing social engagement is important in the ECM effect. This adds weight to our previous claim that evaluation and monitoring of an ongoing social interaction are important drivers behind STORM.

Finally, the present findings parallel our recent neuroimaging study where we found the medial prefrontal cortex (mPFC) as the neural substrate for the eye-mimicry interaction (Wang, Ramsey, & Hamilton, 2011). Using the original single gaze paradigm in functional magnetic resonance imaging (fMRI; Wang, Newport, et al., 2011), we found strong engagement of mPFC when direct gaze enhances mimicry; later dynamic causal modelling analysis confirms that mPFC is the originator of this eye contact effect. As a traditional brain region for social cognition, mPFC has been closely associated with social mechanisms but not nonsocial mechanisms (Amodio & Frith, 2006). Recent studies further revealed that mPFC also plays an important role in social monitoring and reputation management (Izuma, 2012; Tennie et al., 2010). Izuma, Saito, and Sadato (2010) scanned participants while they made self-disclosures. Activity in mPFC during self-disclosure was greatly enhanced by the presence of an audience. Bengtsson et al., (2009) found that mPFC is sensitive to cues implying that participants' performance would be watched by others. They manipulated the instruction of a working memory task by telling one group that the task was to assess their memory capacity and intelligence, and another group that the task was a piloting task so as to optimize certain task parameters and that they did not need to care too much about their own performance. Comparing with the second group, they found better behavioural task performance and significantly increased activity in mPFC when participants in the first group were making errors and reflecting their performance; most interestingly, this mPFC activity correlated with their self-image rating. We suggest that, similar to Bengtsson et al., (2009), it is very likely that the watching eyes in our stimuli activate a reputation management mechanism in mPFC, which strategically monitors one's social responses such as mimicry and enhances affiliative behaviours.

CONCLUSIONS

Over two studies, we found evidence that eye contact enhances mimicry (the ECM effect) only if the eye contact is maintained during the response period. This suggests that the ECM is similar to an audience effect and implies that the social goal of maintaining a prosocial reputation may be important in driving the enhancement of mimicry. This has implications for understanding the cognitive and brain systems supporting the control of mimicry.

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