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Re-Encountering Individuals Who Previously Engaged in Joint Gaze Modulates Subsequent Gaze Cueing

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We assessed the extent to which previous experience of joint gaze with people (i.e., looking toward the same object) modulates later gaze cueing of attention elicited by those individuals. Participants in Experiments 1 and 2a/b first completed a saccade/antisaccade task while a to-be-ignored face either looked at, or away from, the participants' eye movement target. Two faces always engaged in joint gaze with the participant, whereas 2 other faces never engaged in joint gaze. Then, we assessed standard gaze cueing in response to these faces to ascertain the effect of these prior interactions on subsequent social attention episodes. In Experiment 1, the face's eyes moved before the participant's target appeared, meaning that the participant always gaze-followed 2 faces and never gaze-followed 2 other faces. We found that this prior experience modulated the timecourse of subsequent gaze cueing. In Experiments 2a/b, the participant looked at the target first, then was either followed (i.e., the participant initiated joint gaze), or was not followed. These participants then showed an overall decrement of gaze cueing with individuals who had previously followed participants' eyes (Experiment 2a), an effect that was associated with autism spectrum quotient scores and modulated perceived trustworthiness of the faces (Experiment 2b). Experiment 3 demonstrated that these modulations are unlikely to be because of the association of different levels of task difficulty with particular faces. These findings suggest that establishing joint gaze with others influences subsequent social attention processes that are generally thought to be relatively insensitive to learning from prior episodes.

Keywords: gaze behavior, social learning, social attention, social cognition, eye tracking

As humans, we are social beings and spend a considerable amount of time interacting with each other. During such social interactions, we seem to be especially sensitive to the eye region (e.g., Emery, 2000; Kano & Call, 2014; Shepherd, 2010). This propensity to focus on eyes represents an essential ability because, from other people's eye gaze, we are able to detect their focus of attention, and orient our own attention toward the same object: "Joint attention" (see Emery, 2000). Joint attention helps us to infer goals and predict future actions of the individuals we are interacting with and it is important for social development (e.g., Baron-Cohen, 1995; Charman, 2003; Mundy, 1995; Nummenmaa & Calder, 2009; Tomasello, 1995). Our first experiences of joint attention are likely to be as the *responder*, following the gaze of another toward a source of interest. Indeed, the mechanisms required to respond to joint attention develop early (e.g., Farroni, Csibra, Simion, & Johnson, 2002), and crucially they do so earlier than those required to experience joint attention from the initiator's perspective (Mundy & Newell, 2007). Thus, the experiences related to each side of a joint attention episode, whether initiating or responding, can be seen as distinct but highly related components of social orienting (Bayliss et al., 2013; Caruana, Brock, & Woolgar, 2015; Mundy & Newell, 2007; Pickard & Ingersoll, 2015; Schilbach et al., 2010).

Engaging with others in joint attention is a highly natural, reflexive, and usually advantageous behavior. Indeed, we may hold an expectation that our gaze will be followed (Pfeiffer, Timmermans, Bente, Vogeley, & Schilbach, 2011), and that following others' gaze will lead us to find interesting objects (Bayliss & Tipper, 2006). In this study, we were interested in examining the extent to which social orienting in response to others' looking behavior is affected by the quality of previous social orienting interactions one has had with particular individuals. Specifically, we asked whether the strength of responding to joint attention, assessed in a gaze cueing paradigm, is modulated by whether the participant had successfully engaged in joint attention with the cueing faces in previous encounters, or had failed to, either by previously following their gaze (Experiment 1) or by leading their gaze (Experiments 2a/b). In other words, is the social attention system sensitive to knowledge about which people are reliable joint attention partners?

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The aforementioned "gaze cueing paradigm" is one way to assess gaze following (responding to joint attention) and uses a modified version of the Posner cueing paradigm (Posner, 1980; see Driver et al., 1999; Friesen & Kingstone, 1998; and for a review see Frischen, Bayliss, & Tipper, 2007). In such experiments, a central face is presented with direct gaze, which then moves its eyes toward a specific spatial location. After a certain time period ("stimulus onset asynchrony," SOA), a target requiring some kind of response appears at a peripheral location that can be congruent or incongruent to gaze direction. Generally, this task triggers rapid (e.g., Friesen & Kingstone, 1998) and reflexive (e.g., Driver et al., 1999; Galfano et al., 2012) shifts of attention toward the spatial location indicated by gaze—"gaze cueing." The rapid nature of gaze cueing has been shown through experiments demonstrating that gaze cueing can emerge at cue-target SOAs of just 14 ms (Hietanen & Leppänen, 2003), though SOAs of 100–300 ms are frequently used to demonstrate strong cueing effects (e.g., Friesen & Kingstone, 1998; Friesen, Ristic, & Kingstone, 2004; Marotta, Lupiañez, & Casagrande, 2012; Tipples, 2008). Typically, cueing effects are absent by around 1 s after cue onset (e.g., 1,200 ms, Frischen & Tipper, 2004; 1,005 ms, Friesen & Kingstone, 1998).

One question about the gaze cueing effect concerns the extent to which person information is coded. We know that gaze cueing is strong when using stimuli that are impoverished representations of people (e.g., schematic faces) that do not necessarily possess the usual characteristics of social agents (e.g., Dalmaso, Galfano, Tarqui, Forti, & Castelli, 2013; Kuhn & Kingstone, 2009; Marotta et al., 2012; Ristic, Friesen, & Kingstone, 2002). Nevertheless, when gaze cueing studies do manipulate the social information about the faces they use in the studies, some subtle and intriguing modulations of this apparently robust and automatic social attention mechanism can be uncovered. One way in which social information might influence social orienting has been addressed by examining the influence of invariant visual features of the face (e.g., masculinity/dominance, Jones et al., 2010; Ohlsen, van Zoest, & van Vugt, 2013; ethnicity, Pavan, Dalmaso, Galfano, & Castelli, 2011; or age, Ciardo, Marino, Actis-Grosso, Rossetti, & Ricciardelli, 2014; Slessor, Laird, Phillips, Bull, & Filippou, 2010). Changeable aspects of face information, for example facial expression, have also been examined (e.g., Kuhn & Tipples, 2011; Mathews, Fox, Yiend, & Calder, 2003).

Another way to investigate the influence of face properties on social attention is to instead manipulate social knowledge about the individual stimuli, rather than by manipulating physical characteristics. Indeed, in everyday life we tend to re-encounter people we have previously interacted with or whom we could know aspects relating to their identity. "Person knowledge" about individuals would incorporate representations of their personal traits and biographical information, but would also involve knowledge of previous behavioral interactions that could be used to guide future interactions with these people (see Gobbini & Haxby, 2007; see also Bayliss, Naughtin, Lipp, Kritikos, & Dux, 2012; Todorov, Gobbini, Evans, & Haxby, 2007). Only a few studies have assessed the role of this nonvisual information associated with faces in modulating social orienting. For example, faces of known individuals (Deaner, Shepherd, & Platt, 2007; see also Frischen & Tipper, 2006), or those belonging to one's own political group (Liuzza et al., 2011), have been shown to produce a greater gaze cueing effect. Moreover, in other studies the social knowledge relating to faces was acquired by having participants read short biographies about the faces with which they were going to encounter in a gaze cueing task, with a greater gaze cueing effect being observed for high, compared with low, social status faces (Dalmaso, Galfano, Coricelli, & Castelli, 2014, Dalmaso, Pavan, Castelli, & Galfano, 2012; for social learning effects see also Hudson, Nijboer, & Jellema, 2012).

Of interest to the authors, processing others' gaze direction not only elicits shifts of attention in an observer but it is also a relevant facial cue that leads to profound influences on basic aspects of interpersonal perception. There seems to be a benefit for interpersonal evaluation for those who engage in joint attention with us—we tend to evaluate as more trustworthy faces that consistently look toward an object to which we must orient, than faces that consistently look toward the opposite direction (e.g., Bayliss, Griffiths, & Tipper, 2009; Bayliss & Tipper, 2006). This latter result fits with the notion that a key role of joint attention is to share information, to use others' gaze as a reliable indicator of interesting objects, for example food or predators. Accordingly, we would tend to assign more positive traits to an individual that provides reliable and valid information about the location of interesting objects.

In the aforementioned studies by Bayliss and colleagues showing that we trust faces that provide valid information about the location of objects, there was only evidence that the socioevaluative system learns about the individuals from their pattern of interaction and no evidence that the social attention system itself treats faces with different behavioral histories differently. Indeed, previous exposure to gaze stimuli is linked to later gaze cueing within the gaze processing system (see Bayliss, Bartlett, Naughtin, & Kritikos, 2011). However, whether specific gaze based interactions can modulate the way social attention mechanisms respond to specific identities is a relatively unexplored question—to our knowledge Frischen and Tipper (2006) is the only contribution to this issue, finding that single exposures to a gaze cue by a given (famous) identity modulates how attention orients when re-encountering that individual a second time, based on memory encoding of individual episodes. Here, we were more interested in the influence of exposure to consistent patterns of gaze behavior on subsequent gaze-based interactions.

The Present Study

In the present study we conducted three experiments (Experiments 1 and 2a/b) to directly assess the impact of the gaze behavior of a set of to-be-ignored faces—who could act cooperatively with participants looking, or not, toward the same object (i.e., *joint/disjoint gaze*)—on the subsequent gaze cueing effect. Furthermore, to confirm that our results reflected a genuine social process, we conducted a control experiment (Experiment 3) to investigate the influence of associating a nonsocial factor with faces on subsequent gaze cueing. In more detail, in Experiments 1 and 2a/b, we were interested in examining to what extent engaging in joint gaze episodes (as opposed to not engaging in joint gaze episodes), influences subsequent gaze cueing with individual faces. In other words, does the quality of previous social attention experiences with an individual modulate how social attention operates when that same individual is encountered later?

On this basis, we used a novel paradigm composed of two tasks. First, participants were asked to take part in a social learning phase. This consisted of a gaze-contingent eye-tracking experiment using a saccade/antisaccade task to expose participants to different faces that would consistently either engage in joint gaze, or consistently look at a different location to the participant's eye movement target. A saccade/antisaccade task requires participants to respond to the onset of a stimulus by either (a) looking directly at it (saccade), or on other trials (b) looking at the contralateral location on the display (antisaccade; e.g., Everling & Fischer, 1998; Munoz & Everling, 2004). In Experiment 1, this saccade/antisaccade task was set up such that centrally placed faces would show averted gaze before the onset of the peripheral stimulus that acted as an instruction cue for the participant (see Figure 1, Panel A). Therefore, after the participant performed the required eye movement (i.e., a saccade or an antisaccade), according to the

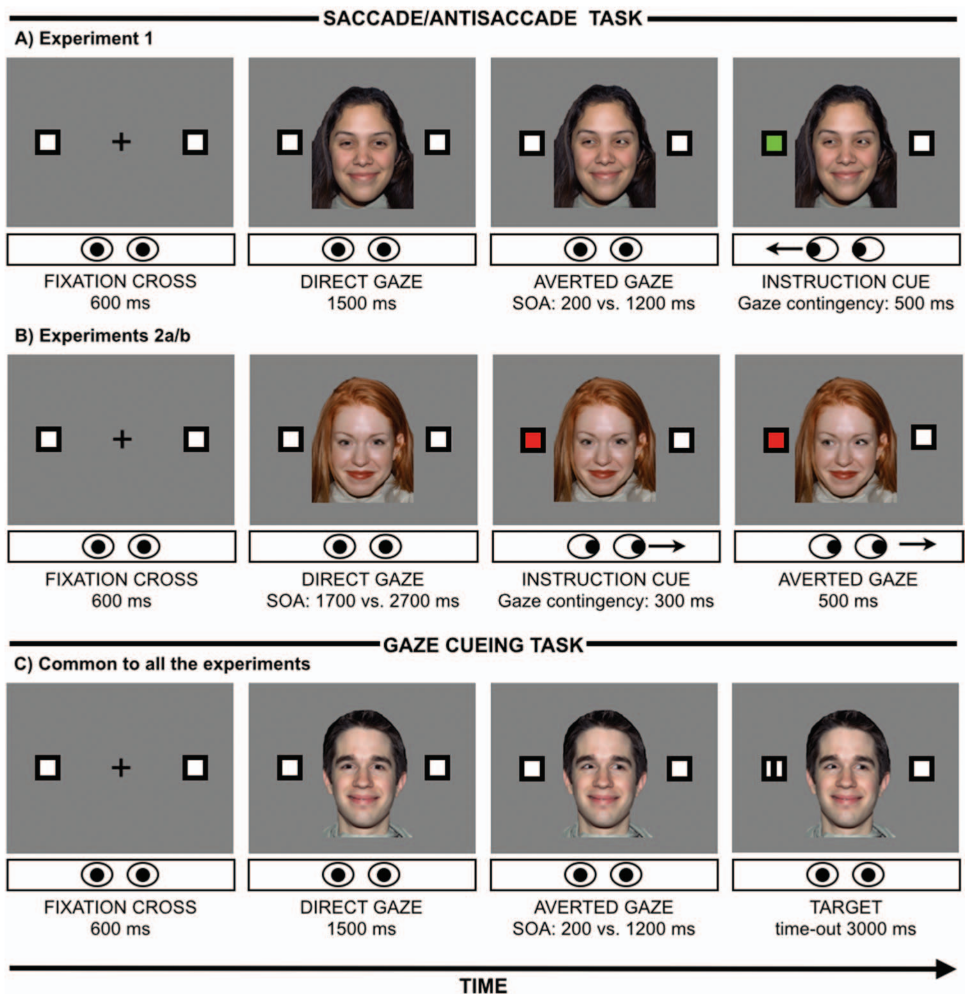

Figure 1. Panel A: Stimuli, trial sequence and timing of the saccade/antisaccade task (Task 1) used in Experiment 1. An example of joint gaze is depicted, in which the central face looks toward the green instruction cue, to which the participant is asked to make a saccade. Panel B: Stimuli, trial sequence and timing of the saccade/antisaccade task (Task 1) used in Experiments 2a/b. An example of disjoint gaze is depicted, in which a participant is asked to make an antisaccade (red instruction cue), and the central face looks toward the opposite placeholder. Panel C: Stimuli, trial sequence and timing of the gaze cueing task (Task 2) common to all the experiments. An example of an incongruent trial is depicted, in which a vertical target line appears in the opposite placeholder with respect to the placeholder gazed at by the central face. Schematic eyes below each picture frame represent the correct eye movement requested of participants during the saccade/antisaccade task (Panel A and B) whereas in the gaze cueing task participants were asked to maintain their eyes at the center of the screen (Panel C). Stimuli are not drawn to scale. Note: Our experimental stimulus set comprised NimStim model numbers 2, 5, 24, and 25. These models are not depicted to comply with conditions of use of the NimStim database. *Source:* Development of the MacBrain Face Stimulus Set was overseen by Nim Tottenham and supported by the John D. and Catherine T. MacArthur Foundation Research Network on Early Experience and Brain Development. Please contact Nim Tottenham at tott0006@tc.umn.edu for more information concerning the stimulus set. See the online article for the color version of this figure.

color of the peripheral stimulus, they would find themselves either in a condition in which they were fixating toward the same position as the face's eyes (i.e., joint gaze) or toward the opposite position (i.e., disjoint gaze). In this experiment, the face always looked at the stimulus, but two faces would look at the stimulus that instructed the participants to execute a saccade and two faces would look at the stimulus that indicated that an antisaccade should be performed. This meant that participant responses were subsequent to the face's behavior, and therefore, would engage in overt gaze following with the faces that were associated with "saccade" trials, but should never overtly follow the eyes of faces that were associated with "antisaccade" trials.

In Experiments 2a/b, the participant was the gaze *leader*, moving their eyes first (see Bayliss et al., 2013), and the faces associated with saccade trials would always follow the participant's eyes, while faces appearing on antisaccade trials would never follow the participant's eyes. That is, the temporal relationship was reversed, with the instruction cue (i.e., the onset of the peripheral stimulus) being presented before the central face moved its eyes. Hence, in both experiments, two faces always led to a state of joint gaze with the participant whereas two others never led to a state of joint gaze with the participant.

Next, the same faces were used in a standard gaze cueing task, identical in Experiments 1 and 2a/b, in which a peripheral to-be-discriminated target could be congruent or incongruent to the gaze direction of the central face. More important, in the gaze cueing task, gaze direction was equally nonpredictive of target location for all faces. This second task allowed us to examine the influence of prior joint gaze episodes (successful or unsuccessful gaze following in Experiment 1 and successful or unsuccessful gaze leading in Experiments 2a/b) on subsequent social orienting with the same individual faces.

In these experiments, we expected to observe a greater gaze cueing effect for faces who had engaged in joint gaze with participants, because of the positive traits they should convey to an observer (see Bayliss & Tipper, 2006). Furthermore, this question was tested using two different SOAs (i.e., 200 ms and 1,200 ms), to explore the time course of attention shifting elicited by the two groups of faces, if any. At the first SOA, we anticipate strong gaze cueing that could be modulated by prior experience. At the longer SOA, it is typical to find a null effect of gaze cues on attention. However, our manipulation may lead to sustained orienting of attention under some conditions hence we included the condition in all Experiments. Finally, as our manipulation during the saccade/antisaccade task also—by definition—involves comparing an easier task (saccade) with a more difficult task (antisaccade), in Experiment 3, we investigated the influence of prior association with faces as a function of nonsocially related task difficulty, in which we predicted a null effect.

Experiment 1: Gaze Following

Participants in Experiment 1 were exposed to four faces, two of whom they would always follow (saccade toward the direction in which the face was looking) and two whom they would never follow (look at the opposite location). They then completed the gaze cueing task. In this and all four experiments, we have reported how we determined our sample size, all data exclusions (if any), all manipulations, and all measures we have collected (see Simmons, Nelson, & Simonsohn, 2012; see also LeBel et al., 2013).

Method

Participants. Nineteen students at the University of East Anglia (*Mean age* = 21 years, *SD* = 4.1 years; 8 men) participated in return for payment (£7) or course credits. All had normal or corrected-to-normal vision, were naïve to the purpose of the experiment and gave written consent. The ethics committee for psychological research at the University of East Anglia approved the study. We had decided a priori to test around 20 participants, which is standard for gaze cueing tasks; we stopped at $n = 19$ for convenience (end of a block of testing sessions). Data from two participants was not recorded for one of the experimental tasks; therefore, $n = 17$ for the saccade/antisaccade task only, and $n = 19$ for the gaze cueing task, which is of primary interest.

Apparatus and stimuli. A PC running E-Prime 2.0 (Psychology Software Tools, Pittsburgh, PA) handled stimulus presentation. A video-based (infrared) eye tracker (Eyelink 1000, SR Research, Ontario, Canada) recorded right eye position (spatial resolution of 0.1°, 500 Hz). Participants placed their head on a chinrest in front of a 19-inch monitor (1,024 × 768 px, 75 Hz). Viewing distance was 65 cm. A standard keyboard collected manual response.

Four smiling faces of White adults (2 males) were taken from the NimStim face set (Tottenham et al., 2009). Smiling faces were chosen because of the positive context they create appears to encourage social learning processes (e.g., Bayliss et al., 2009). Faces of the same gender were matched for age and attractiveness (see Bayliss et al., 2009, 2012). Then, one male face and one female face were randomly allocated to Face Group A, and the others to Face Group B and used in the experimental blocks. An additional smiling face of a White adult male was used in the practice block only.

Design and procedure.

Task 1: Saccade/antisaccade task. Each trial began with a central black fixation cross (0.8° height × 0.8° width) on a dark gray background flanked by two white square placeholders (1° height × 1° width) with black contours (0.2° width) placed 9.8° rightward and leftward from the cross. Participants were asked to fixate on the cross and press the space bar once they had achieved fixation. This procedure ensured that participants fixated the center of the screen and allowed us to perform a drift correction. Six hundred milliseconds after the key press, the fixation cross was replaced by a central face with direct gaze (11° height × 8° width) for 1,500 ms, followed by the same face with averted gaze rightward or leftward. After a 200 ms or 1,200 ms SOA, the white area of the gazed-at placeholder turned green or red (instruction cue). Participants were instructed to move their eyes toward the placeholder if it turned green (i.e., a saccade), or to move their eyes toward the opposite placeholder if it turned red (i.e., an antisaccade). A trial ended after participants had maintained their eyes on the correct placeholder for 500 ms, assessed by a gaze-contingent trigger (see Figure 1, Panel A).

The instruction cue always appeared at the location to which the face looked—in other words it was spatially congruent to the gaze direction of the central face. For half of the participants, faces belonging to Face Group A always appeared on saccade trials.

Therefore, they always looked toward the same placeholder (green) that the participant was required to look at, whereas faces belonging to Face Group B always appeared on antisaccade trials. Furthermore, they always looked toward the opposite placeholder (red) to which the participant was asked to look. In this way, one set of faces always led to a state of joint gaze with the participants, while the other faces never engaged in joint gaze with the participant. For the other half of the participants, the type of trial associated with each face was reversed.

Participants were instructed to move their eyes as quickly and as accurately as possible and to ignore the faces and gaze direction. There were 16 practice trials followed by 240 experimental trials divided into three blocks of 80 trials each. Each block was composed of an equal number of trials presented in a random order and each experimental condition was presented equally. A 5-point calibration was conducted at the beginning of each block. At the end of the task a brief break was granted.

Task 2: Gaze cueing task. Each trial began with a central black fixation cross (0.8° height × 0.8° width) on a dark gray background flanked by two white square placeholders (1° square) with black contours (0.2° width) placed 9.8° rightward and leftward from the cross. After 600 ms, the fixation cross was replaced by a central face with direct gaze for 1,500 ms, followed by the same face with averted gaze rightward or leftward. The faces were the same as those in Task 1. After 200 ms or 1,200 ms, depending on SOA, a black target line (1° height × 0.2° width) appeared centrally placed inside one of the placeholders (see Figure 1, Panel C). The inclination of the target line could be vertical or horizontal. Half of the participants were instructed to press the 'H' key with the middle finger of their dominant hand if the line was vertical, and the space bar with the index finger of their dominant hand if the line was horizontal. The other half of the participants responded using the opposite mapping between key and target letter. Both face and target line remained visible until the participant responded or 3,000 ms elapsed, whichever came first. The centrally placed red words "ERROR" or "NO RESPONSE" replaced the central face for 500 ms in the case of a wrong or a missing response, respectively.

Contrary to Task 1, now the participants were instructed to maintain their eyes at the center of the screen. Moreover, although in Task 1 there was a clear mapping between face identity and trial type, there was no such mapping here. In fact, all faces could produce valid or invalid gaze cues equally often with respect to target position—in other words the target line, independently of its inclination, was spatially congruent or incongruent to gaze direction of the central face with the same probability.

Participants were asked to respond as quickly and as accurately as possible and to ignore the faces and their gaze direction. There were 10 practice trials followed by 256 experimental trials in which all the experimental conditions, each of them consisting of an equal number of trials, were chosen randomly. A 5-point calibration was conducted at the beginning of the practice block. The whole Experiment (Task 1 and Task 2) lasted about 1 hr.

Results

Task 1: Saccade/antisaccade task. The behavior of participants in the gaze cueing task (Task 2) was of primary interest; however, it was important to ensure that we could replicate the standard decrement of performance on antisaccade trials in our paradigm before investigating subsequent effects on later gaze cueing (e.g., Hallett, 1978; Wolohan & Crawford, 2012). Eye tracking data from the first two participants were not recorded because of technical problems, leaving a sample of 17 participants for this analysis (*Mean age* = 21 years, *SD* = 4.3 years; 7 men). Eye movement onset latency was defined as the time that elapsed from the instruction cue (color change of the placeholder) to the initiation of the first saccade/antisaccade. The first saccade/antisaccade was defined as the first eye movement with a velocity exceeding 35°/s and an acceleration exceeding 9,500°/s^2. Only saccades/antisaccades with a minimum amplitude of 1° were analyzed (for a similar procedure, see Kuhn & Tipples, 2011).

Trials containing blinks (0.7% of trials) were removed. Errors, namely trials in which the first saccade/antisaccade was in the opposite direction according to the instruction cue (8.56% of trials), were excluded from calculation of saccadic reaction times (sRT) and analyzed separately. Outliers, defined as trials in which sRT exceeded 3 *SD* above or below participant's mean (1.14% of trials) were also discarded.

The percentages of errors for each participant in each condition were submitted to a 2 × 2 repeated-measures analysis of variance (ANOVA) with Task (2: antisaccade vs. saccade) and SOA (2: 200 ms vs. 1,200 ms) as within-subjects factors. The main effect of Task was significant, $F(1, 16) = 11.060$, $p = .004$, $\eta_p^2 = .409$, owing to less errors for the saccade movements ($M = 5.4\%$, $SD = 4.1\%$) than for the antisaccade movements ($M = 11.6\%$, $SD = 9.5\%$), whereas the main effect of SOA approached statistical significance, $F(1, 16) = 4.130$, $p = .059$, $\eta_p^2 = .205$, reflecting fewer errors at the longer SOA ($M = 7.5\%$, $SD = 6.5\%$) than at the shorter SOA ($M = 9.5\%$, $SD = 6.4\%$). The Task × SOA interaction was significant, $F(1, 16) = 10.333$, $p = .005$, $\eta_p^2 = .329$. Paired comparison between antisaccade and saccade movements for each SOA revealed that the percentage of errors was smaller for the saccade than for the antisaccade movements at the shorter SOA, $t(16) = 3.846$, $p = .001$, $d_z = .92$, but not at the longer SOA, $t(16) = .070$, $p = .945$, $d_z = .02$.

A second ANOVA was conducted on mean sRT with the same factors considered for the analysis of the errors. The main effect of Task was significant, $F(1, 16) = 4.941$, $p = .041$, $\eta_p^2 = .236$, owing to smaller sRT for the saccade movements ($M = 267$ ms, $SD = 36.2$ ms) than for the antisaccade movements ($M = 282$ ms, $SD = 45.8$ ms), whereas the main effect of SOA did not reach statistical significance, $F(1, 16) = 2.475$, $p = .135$, $\eta_p^2 = .134$. The Task × SOA interaction was significant, $F(1, 16) = 6.484$, $p = .022$, $\eta_p^2 = .288$. Paired comparisons between antisaccade and saccade movements for each SOA revealed that sRT were smaller for the saccade than for the antisaccade movements at the shorter SOA, $t(16) = 3.142$, $p = .006$, $d_z = .76$ (25 ms), but not at the longer SOA, $t(16) = .660$, $p = .519$, $d_z = 0.16$ (5 ms).

Overall, these results showed that the oculomotor task required of participants varied in the degree of difficulty. In particular, performing a saccade movement was easier than performing an antisaccade movement, consistent with previous studies (e.g., Wolohan & Crawford, 2012). This was expected, given that a saccade is an eye movement toward the same location occupied by a target, whereas an antisaccade movement requires more cognitive effort to localize the position of the target and to program the consequent eye movement toward the opposite spatial location. Of interest to the authors, each of the saccade and antisaccade tasks were always associated with a specific and distinct set of faces. Therefore, participants may have learned this association, which could be reflected in the subsequent gaze cueing task, in which the same faces were used.

Task 2: Gaze cueing task. Errors (5.24% of trials) and outliers, defined as trials in which RTs were 3 *SD* above or below participant's mean (1.79% of trials), were discarded from manual RT analysis. The mean error percentages for each participant in each condition were submitted to a 2 × 2 × 2 repeated-measures ANOVA with Cue-target spatial congruency (2: congruent vs. incongruent), SOA (2: 200 ms vs. 1,200 ms), and Type of face (2: disjoint gaze face vs. joint gaze face) as within-subjects factors. No main effects or interactions emerged ($Fs < 1.9$, $ps > .185$).

A second ANOVA was conducted on mean RT with the same factors considered for the analysis of the errors. The main effect of Cue-target spatial congruency was significant, $F(1, 18) = 18.498$, $p < .001$, $\eta_p^2 = .507$, owing to smaller RT on congruent trials (M = 651 ms, SD = 101.7 ms) than on incongruent trials (M = 670 ms, SD = 109 ms), as well as the main effect of SOA, $F(1, 18) = 5.884$, $p = .026$, $\eta_p^2 = .246$, owing to smaller RT at the longer SOA (M = 651 ms, SD = 103.6 ms) than at the shorter SOA (M = 670 ms, SD = 109 ms). Neither the main effect of Type of face nor any two-way interactions were significant ($Fs < 1$, $ps > .355$). Critically, the Cue-target congruency × SOA × Type of face three-way interaction was significant, $F(1, 18) = 9.112$, $p = .007$, $\eta_p^2 = .336$. Paired comparison between congruent and incongruent trials for each Type of face and SOA revealed that participants shifted their attention in response to disjoint gaze faces at the longer SOA, $t(18) = 4.031$, $p < .001$, $d_z = .92$, but not at the shorter SOA, $t(18) = .351$, $p = .73$ $d_z = .08$. On trials in which they viewed a face that had—in Task 1—engaged them in joint gaze, the reverse pattern emerged. These faces produced reliable gaze cueing at the shorter SOA, $t(18) = 3.657$, $p = .002$, $d_z = .84$, but not at the longer SOA, $t(18) = .669$, $p = .512$, $d_z = .14$ (see Figure 2).

Discussion

In this experiment, we found that the timecourse of gaze cueing was markedly influenced by the type of previous interaction the participant had earlier experienced with the face producing the gaze cue. Faces that had earlier looked at the participant's eye movement target, later elicited a standard gaze cueing effect that was strong at an early stage of visuospatial orienting, but was absent at the later SOA. This is what has been shown in numerous gaze cueing studies that did not manipulate the faces in any way (e.g., Driver et al., 1999; Friesen et al., 1998). A completely different pattern of data emerged from the faces that had always looked away from the participant's eye movement target (i.e., they looked at the imperative stimulus, but away from the location to which the participant had to look in the antisaccade task). Now, the gaze of these faces did not elicit the usual early gaze cueing effect, but strikingly—and contrary to any other report of gaze cueing—produced a strong gaze cueing effect only at a late SOA (i.e., 1,200 ms). Hence, the two face types diverged in the timecourse of attention orienting that their gaze evoked; faces with whom participants had previously engaged in joint gaze by following their eyes produced a standard gaze following response, while a delayed attentional orienting response was elicited by the averted gaze of faces that had previously always looked away from the participants saccade goal.

Experiment 2a: Gaze Leading

To further explore the influence of prior joint gaze experiences on subsequent gaze cueing, in Experiment 2a, we altered the first task (i.e., saccade/antisaccade task) while keeping the second task

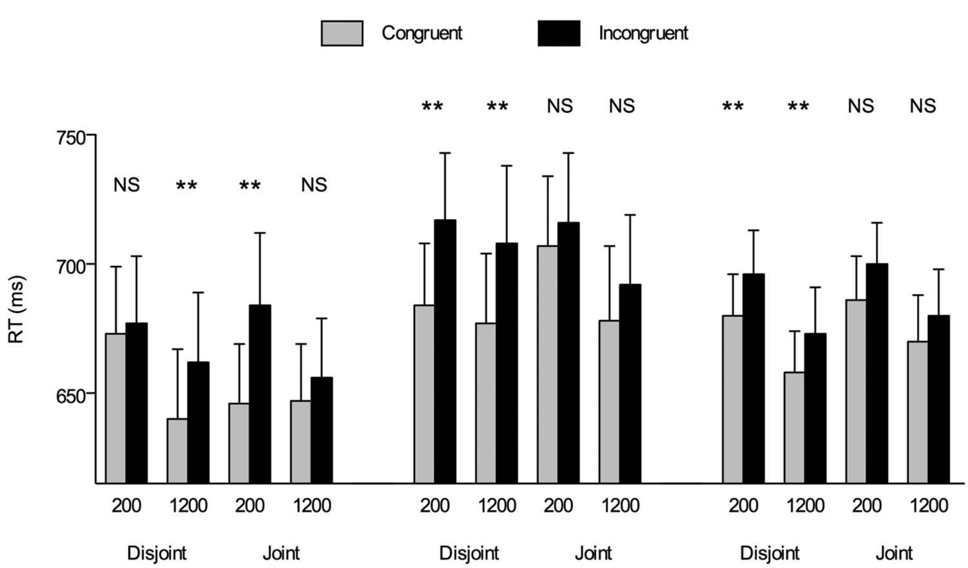

Figure 2. Mean reaction time (RT) for the gaze cueing task (Task 2) divided by type of face and SOA in Experiments 1 and 2a/b. Error bars represent *SEM*. Double asterisk denote $p < .05$. NS = nonsignificant.

(i.e., gaze cueing task) identical to Experiment 1. In this Experiment, the faces in the saccade/antisaccade task looked toward or away from the participant's eye movement target *after* the participant had executed their eye movement and fixated the correct placeholder. This had the effect of having two faces consistently *following the participant* to engage in joint gaze, while two other faces would always look at the opposite location. In other words, now the participant would experience joint gaze by *leading*, rather than *following*, the face's eyes. We were interested in determining how these previous interactions would influence subsequent gaze cueing.

Method

Participants. Twenty-three students at the University of East Anglia (*Mean age* = 24 years, *SD* = 4.3 years; 3 men) participated in return for payment (£7) or credit course. All had correct or corrected-to-normal vision, were naïve to the purpose of the experiment and gave written consent approved by the local ethics committee. We decided to target a sample size of around 20 and stopped at 23 for convenience at the end of a run of booked experimental sessions.

Apparatus and stimuli. Apparatus and stimuli were the same as in Experiment 1.

Design and procedure.

Task 1: Saccade/antisaccade task. The procedure was the same as Experiment 1 (Task 1) with the following exceptions: after the fixation cross, a central face with direct gaze appeared for 1,700 ms or 2,700 ms, depending on SOA. These two SOAs were chosen to present faces for a temporal duration comparable with that in Experiment 1. After that, the instruction cue appeared and participants were asked to move their eyes toward the correct placeholder (i.e., on saccade trials, toward the placeholder that turned green and, on antisaccade trials, toward the opposite placeholder with respect to the one that turned red). After 300 ms of fixating the placeholder the eyes of the central face moved to either look at, or away from the placeholder at which the participant was looking.

Like in Experiment 1, the gaze direction of the central face was always spatially congruent to the instruction cue position. For half of the participants, faces belonging to Face Group A always looked toward the same placeholder (green) that a participant was looking at (joint gaze faces), whereas faces belonging to Face Group B always looked toward the opposite placeholder (red) that a participant was looking at (disjoint gaze faces). For the other half of the participants, this association was reversed. After 500 ms, with the participant still looking at the placeholder and the face's eyes still averted, the trial ended (see Figure 1, Panel B).

Task 2: Gaze cueing task. The procedure was the same as that in Task 2 of Experiment 1 (see Figure 1, Panel C). The whole Experiment (Task 1 and Task 2) lasted about 1 hr.

Results

Task 1: Saccade/antisaccade task. Saccades/antisaccades were extracted using the same procedure as that in Experiment 1 (Task 1). Trials containing blinks (3.1% of trials) were removed. Errors, namely trials in which the first saccade/antisaccade was in the opposite direction according to the instruction cue (4.5% of trials), were excluded from RT analysis and analyzed separately. Outliers, defined as trials in which sRT were 3 *SD*s above or below participant's mean (1.09% of trials), were discarded from analysis.

The percentages of errors for each participant in each condition were submitted to a 2 × 2 repeated-measures ANOVA with Task (2: antisaccade vs. saccade) and SOA (2: 1,700 ms vs. 2,700 ms) as within-subjects factors. The main effect of task was significant, $F(1, 22) = 5.910$, $p = .024$, $\eta_p^2 = .212$, owing to less errors for the saccade movements ($M = 2.7\%$, $SD = 3.4\%$) than for the antisaccade movements ($M = 5.8\%$, $SD = 6.8\%$). Neither the main effect of SOA nor the Task × SOA interaction approached statistical significance (Fs < 1, ps $> .399$).

A second ANOVA was conducted on mean sRT with the same factors considered for the analysis of the errors. The main effect of Task was significant, $F(1, 22) = 11.197$, $p = .003$, $\eta_p^2 = .337$, owing to smaller sRT for the saccade movements ($M = 330$ ms, $SD = 59.7$ ms) than for the antisaccade movements ($M = 354$ ms, $SD = 65.6$ ms), as well as the main effect of SOA, $F(1, 22) = 31.578$, $p < .001$, $\eta_p^2 = .589$, owing to smaller sRT at the longer SOA ($M = 327$ ms, $SD = 63.1$ ms) than at the shorter SOA ($M = 356$ ms, $SD = 59.7$ ms). The Task × SOA interaction was not significant ($F < 1$). Taken together, these results confirmed that saccades were easier to perform than antisaccades, in line with Experiment 1.

Task 2: Gaze cueing task. Errors (3.45% of trials) and outliers, defined as trials in which RT were 3 *SD* above or below participant's mean (1.9% of trials), were discarded from RT analysis. The percentages of errors for each participant in each condition were submitted to a 2 × 2 × 2 repeated-measures ANOVA with Cue-target spatial congruency (2: congruent vs. incongruent), SOA (2: 200 ms vs. 1,200 ms), and Type of face (2: disjoint gaze face vs. joint gaze face) as within-subjects factors. The main effect of Cue-target spatial congruency approached statistical significance, $F(1, 22) = 3.048$, $p = .095$, $\eta_p^2 = .122$, reflecting more errors on incongruent trials ($M = 3.8\%$, $SD = 3.3\%$) than on congruent trials ($M = 3.1\%$, $SD = 2.7\%$). The Cue-target spatial congruency × SOA interaction was significant, $F(1, 22) = 9.469$, $p = .006$, $\eta_p^2 = .301$. Paired comparisons between congruent and incongruent trials for each SOA showed that at the shorter SOA participants committed more errors on incongruent than on congruent trials, $t(22) = 3.087$, $p = .005$, $d_z = .66$, whereas no differences emerged at the longer SOA, $t(22) = .755$, $p = .458$, $d_z = .15$. No other main effects or interactions approached significance (Fs < 1, ps $> .45$).

A second ANOVA was conducted on mean RT with the same factors considered for the analysis of the errors. The main effect of Cue-target spatial congruency was significant, $F(1, 22) = 22.758$, $p < .001$, $\eta_p^2 = .508$, owing to smaller RT on congruent trials ($M = 687$ ms, $SD = 126$ ms) than on incongruent trials ($M = 708$ ms, $SD = 128$ ms), as well as the main effect of SOA, $F(1, 22) = 5.298$, $p = .031$, $\eta_p^2 = .194$, owing to smaller RT at the longer SOA ($M = 689$ ms, $SD = 132.9$ ms) than at the shorter SOA ($M = 706$ ms, $SD = 122.6$ ms). The SOA × Type of face interaction was significant, $F(1, 22) = 7.075$, $p = .014$, $\eta_p^2 = .243$ (see Figure 2). Also the Cue-target spatial congruency × Type of face interaction was significant, $F(1, 22) = 4.972$, $p = .036$, $\eta_p^2 = .184$. Further analysis was performed on the latter interaction; paired comparisons between congruent and incongruent trials for each type of face revealed that participants oriented their attention in response both to disjoint gaze faces, $t(22) = 4.409$, $p < .001$, $d_z = .91$, and to joint gaze faces, $t(22) = 2.182$, $p = .04$, $d_z = .46$. However, the magnitude of the gaze cueing was larger in the former case (31 ms vs. 12 ms). The Cue-target spatial congruency × SOA × Type of face three-way interaction was not significant ($F < 1$). Nevertheless, for completeness paired comparison between congruent and incongruent trials divided by Type of face and SOA revealed that participants shifted their attention in response to disjoint gaze faces at both SOAs ($ps < .01$) but not in response to joint gaze faces at either SOAs ($ps > .135$).

Discussion

This experiment showed that faces with whom participants had previously led to a common gaze target were later less effective as gaze cues than faces who never followed the participants' gaze. This is counter to our initial hypothesis, where the idea was that people with whom we have shared a joint gaze experience in the past would be stronger social attention partners in other contexts. This can be interpreted as further evidence that initiating—in addition to responding to—a state of joint gaze can lead to the emergence of intriguing and unexpected social behaviors over subsequent interactions with individuals (see Bayliss et al., 2013).

Experiment 2b: Gaze Leading–Replication and Extension

To further examine the underlying mechanisms that lead to the intriguing results of Experiment 2a, we performed a direct replication, with a larger sample and some additional posttask measures. Specifically, participants were asked to rate the faces they had encountered for perceived dominance and trustworthiness. It is possible that leading some faces to follow our participants gaze resulted in our participants feeling dominant over these individuals, which would result in reduced perceived dominance ratings of those faces. This notion does have empirical support—we know that lower-dominant individuals tend to strongly follow the gaze direction of superiors, a robust result reported both in humans (e.g., Dalmaso et al., 2012; Jones et al., 2010) and in nonhuman primates (e.g., Shepherd, Deaner, & Platt, 2006).

Trustworthiness was chosen because many studies reported a link between this variable and gaze behavior. In particular, faces who engage in joint gaze with us are generally evaluated as more trustworthy than faces that consistently look elsewhere (e.g., Bayliss et al., 2009; Bayliss & Tipper, 2006), so it is possible that a similar effect could emerge here.

Finally, participants were asked to complete the Autism-Spectrum Quotient questionnaire (AQ; Baron-Cohen, Wheelwright, Skinner, Martin, & Clubley, 2001), because it is well known that autistic-like traits that vary within the nonclinical population can heavily shape social attention in a straightforward (Bayliss, di Pellegrino, & Tipper, 2005) or highly context-sensitive manner (Bayliss & Tipper, 2005).

Here we were also interested in investigating a crucial question concerning the longevity of Task 1's influence on the subsequent Task 2, which could reasonably decay over time.

Method

Participants. Thirty-eight students at the University of East Anglia (*Mean age* = 19 years, *SD* = 1.1 years; 4 men) were recruited in return for payment (£8.5) or course credit. All had correct or corrected-to-normal vision, were naïve to the purpose of the experiment and gave written consent. We decided to target a sample size of around 40 and stopped at 38 for convenience at the end of a run of booked experimental sessions. Two participants did not complete Task 1; one because of technical failure and another did not follow instructions. Additionally, data from one participant was not recorded for Task 1 because of technical failure. Therefore, $n = 35$ for the saccade/antisaccade task, and $n = 36$ for the gaze cueing task.

Materials, design, and procedure. The procedure was identical to Experiment 2a, except that there were additional measures taken after Task 2. Participants first rated how dominant, and then how trustworthy, they thought each face was (7-point Likert-type scale, from 1 = "low" to 7 = "high"). Participants then completed the AQ questionnaire. The whole Experiment (Task 1, Task 2, and questionnaires) lasted about 75 min.

Results

Task 1: Saccade/antisaccade task. Saccades/antisaccades were extracted using the same procedure as in previous experiments (Task 1). Trials containing blinks (3.64% of trials) were removed. Errors, namely trials in which the first saccade/antisaccade was in the opposite direction according to the instruction cue (12.16% of trials), were excluded from RT analysis and analyzed separately. Outliers, defined as trials in which sRT were 3 *SD*s above or below participant's mean (1.38% of trials), were discarded from analysis.

The percentages of errors for each participant in each condition were submitted to a 2 × 2 repeated-measures ANOVA with Task (2: antisaccade vs. saccade) and SOA (2: 1,700 ms vs. 2,700 ms) as within-subjects factors. The main effect of task was significant, $F(1, 34) = 44.786$, $p < .001$, $\eta_p^2 = .568$, owing to less errors for the saccade movements ($M = 4.57\%$, $SD = 3.68\%$) than for the antisaccade movements ($M = 19.79\%$, $SD = 12.9\%$), as well as the main effect of SOA, $F(1, 34) = 4.866$, $p = .034$, $\eta_p^2 = .125$, owing to less errors at the longer SOA ($M = 11.22\%$, $SD = 6.82\%$) than at the shorter SOA ($M = 13.14\%$, $SD = 7.49\%$). The Task × SOA interaction was not significant, $F = 2.710$, $p = .109$.

A second ANOVA was conducted on mean sRT with the same factors considered for the analysis of the errors. The main effect of Task was significant, $F(1, 34) = 41.569$, $p < .001$, $\eta_p^2 = .550$, owing to smaller sRT for the saccade movements ($M = 306$ ms, $SD = 49.9$ ms) than for the antisaccade movements ($M = 348$ ms, $SD = 58.5$ ms), as well as the main effect of SOA, $F(1, 34) = 89.556$, $p < .001$, $\eta_p^2 = .725$, owing to smaller sRT at the longer SOA ($M = 315$ ms, $SD = 52.8$ ms) than at the shorter SOA ($M = 340$ ms, $SD = 49.9$ ms). The Task × SOA interaction was also significant, $F(1, 16) = 9.422$, $p = .004$, $\eta_p^2 = .217$. Paired comparison between antisaccade and saccade movements for each SOA revealed that sRT were smaller for the saccade than for the antisaccade movements both at the shorter SOA, $t(34) = 6.592$, $p < .001$, $d_z = .91$, and at the longer SOA, $t(34) = 5.333$, $p < .001$, $d_z = 0.59$, but this difference was bigger in the former case (50 ms vs. 34 ms). Taken together, these results confirmed that saccades were easier to perform than antisaccades, in line with previous experiments.

Task 2: Gaze cueing task. Errors (4.68% of trials) and outliers, defined as trials in which RT were 3 *SD* above or below participant's mean (2.05% of trials), were discarded from RT analysis. The percentages of errors for each participant in each condition were submitted to a 2 × 2 × 2 repeated-measures ANOVA with Cue-target spatial congruency (2: congruent vs. incongruent), SOA (2: 200 ms vs. 1,200 ms), and Type of face (2: disjoint gaze face vs. joint gaze face) as within-subjects factors. There were no significant interactions or main effects (Fs < 2.52, ps $> .121$).

A second ANOVA was conducted on mean RT with the same factors considered for the analysis of the errors. The main effect of Congruency was significant, $F(1, 35) = 13.890$, $p = .001$, $\eta_p^2 = .284$, owing to faster RT on congruent trials ($M = 673$ ms, $SD = 100$ ms) than on incongruent trials ($M = 687$ ms, $SD = 103$ ms), as well as the main effect of SOA, $F(1, 35) = 6.956$, $p = .012$, $\eta_p^2 = .166$, owing to faster RT at the longer SOA ($M = 671$ ms, $SD = 104.3$ ms) than at the shorter SOA ($M = 690$ ms, $SD = 99.2$ ms). There was also a significant effect of Type of face, $F(1, 35) = 4.936$, $p = .033$, $\eta_p^2 = .124$, showing that RT were faster with disjoint gaze faces ($M = 677$ ms, $SD = 99.4$ ms) than joint gaze faces ($M = 684$ ms, $SD = 104$ ms). No interactions reached significance (Fs < 1). Nevertheless, although—in stark contrast to Experiment 2a—the Cue-target spatial congruency × Type of face interaction did not approach statistical significance in this experiment, $F(1, 35) < 1$, we performed the planned comparisons as in Experiment 2a. These revealed the same pattern of data as in Experiment 2a. Indeed, participants showed reliable cueing of attention only in response to disjoint gaze faces, both at the shorter SOA, $t(35) = 2.33$, $p = .026$, $d_z = .39$ (16 ms), and at the longer SOA, $t(35) = 2.46$, $p = .020$, $d_z = .40$ (15 ms). On the contrary, no gaze cueing emerged in response to joint gaze faces, both at the shorter SOA, $t(35) = 1.61$, $p = .116$, $d_z = .27$ (14 ms), and at the longer SOA, $t(35) = 1.58$, $p = .123$, $d_z = .26$ (12 ms). Clearly, given the null two-way interaction, these contrasts can only be interpreted in a limited fashion, but it is notable that these cues—produced by faces that had previously engaged in joint gaze—did not elicit reliable cueing effects at in a sample of $n = 36$, when the basic gaze cueing effect can routinely be detected in very small samples indeed (e.g., $n = 8$; Driver et al., 1999).

Face ratings. Mean ratings of the faces on *dominance* and *trustworthiness* can been seen in Table 1. There was no difference in ratings of dominance between the two face types, $t(35) = -.699$, $p = .489$, $d_z = .12$. However, faces that had, in Task 1, always followed the gaze of the participant were rated as more trustworthy than those faces that repeatedly looked elsewhere, $t(35) = 2.203$, $p = .034$, $d_z = .37$.

Table 1
Mean Ratings for Dominance and Trustworthiness of Disjoint and Joint Gaze Faces in Experiment 2b

	Dominance		Trustworthiness	
	Disjoint	Joint	Disjoint	Joint
M	3.74	3.60	4.54	5.08
SD	(1.45)	(1.31)	(1.19)	(1.06)

Autism Spectrum Quotient. To explore the possible underlying mechanisms of the observed differences in cueing power of joint gaze and disjoint gaze faces, AQ score was correlated against the cueing effect magnitude (i.e., RT on incongruent trials—RT on congruent trials) of each type of face. AQ did not correlate with the cueing effect elicited by disjoint gaze faces, $r(34) = -.028$, $p = .87$, two-tailed. However, there was a significant positive correlation between AQ and the cueing effect elicited by joint gaze faces, $r(34) = .37$, $p = .03$, two-tailed, indicating that participants with more self-reported autistic-like traits were cued by the joint gaze faces more than those with lower AQ scores (see Figure 3).

Longevity of impact of gaze leading on subsequent gaze cueing. An interesting question concerns the longevity of gaze leading task's influence (Task 1) on subsequent gaze cueing of attention (Task 2). To investigate this aspect with appropriate statistical power, we combined samples from Experiments 2a/b ($n = 59$). Here we expected that the modulation of the type of face might have been stronger at the beginning of the gaze cueing task, and then progressively dissipated. The analysis supported this notion. In the first half of trials, the critical Cue-target spatial congruency × Type of face interaction was significant, $F(1, 58) = 4.139$, $p = .046$, $\eta_p^2 = .067$, because of 20 ms cueing from disjoint gaze faces and only 12 ms cueing from joint gaze faces. In the second half, the Cue-target spatial congruency × Type of face interaction was not significant, $F(1, 58) < 1$, which suggests that that the face's behavior in Task 1 was no longer influencing gaze cueing by the second half of Task 2.

Discussion

Overall this replication and extension is in line with the pattern of the results observed in Experiment 2a. Indeed, at both SOAs participants showed a reliable gaze cueing effect only in response to faces who had not previously followed their gaze. However, this effect was not as stable at the group-level as in Experiment 2a because the critical interaction did not approach significance. Nevertheless, we uncovered further interesting features about the influence of prior gaze interactions on subsequent gaze cueing. As faces that followed participants' gaze were rated as more trustworthy than those that did not, it appears that the two face types have been evaluated differentially in a socially relevant way. Most intriguingly, participants with higher AQ scores were still cued by faces that had previously followed them, which suggests a specific difference in how having our eye-gaze followed is interpreted. In effect, those with high AQ scores were less contextually sensitive to the behavioral history of the different face types (see also Bayliss & Tipper, 2005). Participants with low AQ scores modulated their interactions with faces they had previously encountered in a similar way to that which was fully statistically reliable in Experiment 2a.

In summary, it is notable that in both Experiments 2a/b, the standard gaze cueing effect was not reliable over four comparisons (at each SOA in each experiment) for faces that had previously engaged in joint gaze episodes with the participants. On the other hand, gaze cueing was reliable for faces that had never engaged in joint gaze with the participants. The critical interaction supporting this effect was only significant in Experiment 2a and when considering only the first half of trials in a combined Experiment 2a/b analysis. However, where the effect appears unreliable—in Exper-

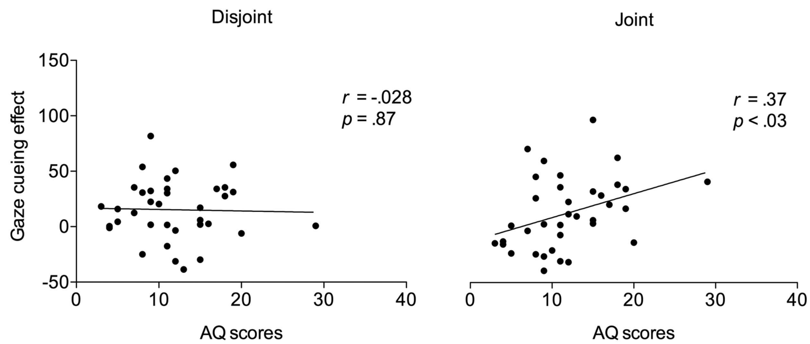

Figure 3. Correlations between Autism-Spectrum Quotient Questionnaires (AQ) scores and the gaze cueing-effect (i.e., reaction time [RT] on incongruent trials—RT on congruent trials) for disjoint gaze faces (left panel) and joint gaze faces (right panel).

iment 2b—individual differences are shown to contribute to the effect, with people with higher AQ scores being relatively uninfluenced by the context in which the faces were previously encountered.

Thus, repeatedly engaging in joint gaze, or not (Task 1), appears to impact future gaze interactions (Task 2), but this effect appears to decline rapidly. It is notable that as Task 2 is a nonpredictive gaze-cueing procedure, all face identities are equally nonpredictive. Therefore, a possible explanation for this effect dissipating through the time course of Task 2 could be that participants are correcting their learning—now the gaze behavior of the two face types is identical, and over time they are less distinguishable.

Experiment 3: Control for Difficulty

In Experiments 1 and 2a/b we manipulated whether the faces to which the participants were exposed engaged in joint gaze with the participants or not. However, this was confounded with whether the participants were performing an easier task (i.e., saccade/joint gaze) or a more difficult task (i.e., antisaccade/disjoint gaze). In this experiment, instead of associating faces with a social contingency, we associated different faces with an easier or a more difficult perceptual task. We predicted that the later-performed gaze cueing task would not be influenced by the task-related difficulty faces had been associated with.

Method

Participants. Nineteen students at the University of East Anglia (*Mean age* = 23 years, *SD* = 4 years; 4 men) participated in return for payment (£7) or course credits. All had correct or corrected-to-normal vision, were naïve to the purpose of the experiment and gave a written consent approved by the local ethics committee. We were aiming for a sample size of around 20 and stopped at 19 for convenience at the end of a block of booked testing sessions.

Apparatus and stimuli. Apparatus and stimuli were the same as in Experiment 1.

Design and procedure.

Task 1: Difficulty manipulation task. The procedure was the same as that in Experiment 1 (Task 1) with the following exceptions: participants were instructed to maintain their eyes always at the center of the screen, placeholders were absent and after the averted gaze face onset, a black target line (1.3° height × 0.4° width) appeared 9.8° rightward or leftward from fixation. The target line could be vertically inclined of ±5° or ±45°. Participants were instructed to press the 'Z' key with their left index finger if the line was inclined leftward (i.e., −5° or −45°), and the 'M' key with their right index finger if the line was inclined rightward (i.e., 5° or 45°). In this manner, a different degree of difficulty was associated to the task required of participants.

The target line was always congruent to gaze direction of the central face. For half of the participants, faces belonging to Face Group A always looked toward a target line inclined ±5°, so they were associated with a more difficult response, whereas faces belonging to Face Group B looked always toward a target line inclined ±45°, so they were associated with an easier response. For the other half of the participants, this association was inverted.

Task 2: Gaze cueing task. The procedure was the same as that in Experiment 1 (Task 2). The whole Experiment (Task 1 and Task 2) lasted about 1 hr.

Results and Discussion

Task 1: Difficulty manipulation task. Errors (3.66% of trials) and outliers, defined as trials in which RT were 3 *SD* above or below participant's mean (1.4% of trials), were discarded from RT analysis.

The percentage of errors for each participant in each condition were submitted to a 2 × 2 repeated-measures ANOVA with Target inclination (2: ±5° vs. ±45°) and SOA (2: 200 ms vs. 1,200 ms) as within-subjects factors. Only the main effect of the inclination of the target was significant, $F(1, 18) = 5.052$, $p = .037$, $\eta_p^2 = .219$, owing to fewer errors in response to targets inclined ±45° (*M* = 2.8%, *SD* = 6.16%) than ±5° (*M* = 4.5%, *SD* = 5.26%). Neither the main effect of SOA nor the Target inclination × SOA interaction approached statistical significance (*F*s < 1, *p*s > .517).

A second ANOVA was conducted on mean RT with the same factors considered for the analysis of the errors. The main effect of Target inclination was significant, $F(1, 18) = 128.482$, $p < .001$, $\eta_p^2 = .877$, owing to smaller RT in response to targets inclined ±45° (*M* = 541 ms, *SD* = 100.5 ms) than ±5° (*M* = 625 ms, *SD* = 120.7 ms) whereas the main effect of SOA did not reach statistical significance, $F(1, 18) < 1$, $p = .726$. The Target inclination × SOA interaction was significant, $F(1, 18) = 7.011$, $p = .016$, $\eta_p^2 = .28$. Paired comparison between targets inclined ±5° and ±45° divided by SOA revealed that RT were smaller in response to the ±45° target inclination both at the shorter, $t(18) = 8.340$, $p < .001$ $d_z = 1.92$, and at the longer, $t(18) = 10.873$, $p < .001$, $d_z = 2.52$, SOA, but the difference between target inclination was greater in the former case (100 ms vs. 68 ms).

Taken together, these results confirmed that a different degree of difficulty was associated with the task required of participants. In particular, identifying the direction of a target line was easier when it was inclined ±45° rather than ±5°, reflecting the performance associated with saccade and antisaccade movements emerged in the oculomotor task of Experiments 1 and 2a/b.

Task 2: Gaze cueing task. Errors (4.15% of trials) and outliers, defined as trials in which RT were 3 *SD* above or below participant's mean (2.08% of trials), were discarded from analysis. The percentages of errors for each participant in each condition were submitted to a 2 × 2 × 2 repeated-measures ANOVA with Cue-target spatial congruency (2: congruent vs. incongruent), SOA (2: 200 ms vs. 1,200 ms) and Difficulty associated to face identity (2: easy vs. difficult) as within-subjects factors. No main effects or interactions emerged ($ps > .12$).

A second ANOVA was conducted on mean RT with the same factors considered for the analysis of the errors. The main effect of Cue-target spatial congruency was significant, $F(1, 18) = 8.340$, $p = .01$, $\eta_p^2 = .317$, owing to smaller RT on congruent ($M = 656$ ms, $SD = 87.37$ ms) than on incongruent ($M = 671$ ms, $SD = 95.66$ ms) trials. No other main effects or interactions approached statistical significance, confirming the presence of a comparable gaze cueing effect across conditions ($Fs < 1$, $ps > .37$; see Table 2). As previous association with an easier or a more difficult perceptual tasks did not modulate the degree to which a given face could elicit gaze cueing, these results suggest that differences in task difficulty are unlikely to explain the pattern of the results observed in the subsequent gaze cueing task in Experiments 1 and 2a/b.

General Discussion

Here we conducted Experiments 1 and 2a/b to assess how the gaze behavior of a set of faces impacted their subsequent power to elicit gaze cueing in observers. We were interested in uncovering whether previous encounters with people in which joint gaze was established—or not—can subsequently modulate gaze cueing of attention with those individuals. In Experiment 1, participants were asked to move their eyes toward one of two possible spatial positions *after* the eye movement of the central face (i.e., gaze following condition). In Experiments 2a/b this sequence was reversed, namely participants moved their eyes *first* and then the central face moved its eyes (i.e., gaze leading condition). In all these experiments, we expected to observe a greater gaze cueing effect in response to faces that elicited a joint gaze state rather than a disjoint gaze state.

Table 2
Mean RT in All Conditions Presented in Experiment 3

	Easy				Difficult			
	200 ms SOA		1,200 ms SOA		200 ms SOA		1,200 ms SOA	
	C	I	C	I	C	I	C	I
RT (millilseconds)	662	674	653	668	657	672	649	668
SD	91	104	90	92	101	99	84	108

Note. RT = reaction time; C = congruent trials; I = incongruent trials.

Results from Experiment 1 somewhat supported our hypothesis. Faces that had earlier looked at the participant's eye movement target (i.e., leading to joint gaze) later elicited a strong gaze cueing effect at the shorter SOA, but no effect at the longer SOA, a result in line with several previous studies in which face identities were not manipulated (e.g., Friesen & Kingstone, 1998; Frischen & Tipper, 2004). On the contrary, faces that had always looked away from the participant's eye movement target (i.e., leading to disjoint gaze) did not produce the usual gaze cueing effect at the shorter SOA, as expected. Curiously, however, a reliable gaze cueing effect did emerge at the longer SOA. This latter result is somewhat surprising as it is unusual to observe gaze cueing at SOAs longer than 1,000 ms.

Thus, the timecourse of attentional orienting in response to these disjoint gaze faces appears to be delayed, probably reflecting a delay in the processing of gaze cues from these faces. This delay could be because of Task 1's request to suppress the natural tendency to generate a saccade, in favor of an antisaccade. Therefore, in Task 2 this learned unnatural oculomotor behavior may have delayed the emergence of the gaze cueing effect, necessitating the activation of more volitional attentional components. Similarly, because disjoint gaze faces had potentially enhanced the participant's ability to process the instruction cue (see Koval, Thomas, & Everling, 2005), the delay in processing of these faces could relate to the dichotomy of helping participants to process the cue while also avoiding engaging in joint gaze with them. However, a higher level explanation may also suggest that this delay in attentional orienting could be because of continuing social evaluation of these faces who are, in effect, deceptive. Indeed, it is known that deceptive faces capture attention in an observer (see Vanneste, Verplaetse, Van Hiel, & Braeckman, 2007). In all these scenarios, our data suggest that noncooperative individuals impact social attention peculiarly.

With regards to Experiments 2a/b, a reliable gaze cueing effect emerged in response to faces that had led to a state of disjoint gaze with participants but not in response to faces that had led to a state of joint gaze. Strikingly, the same pattern of results emerged at both SOAs, suggesting that whether someone has reliably followed our eye-gaze, or not, leads to somewhat robust changes in how our social attention system will interact with him or her later.

As relatively less research has assessed the role of the initiator in a joint gaze scenario, the results of Experiments 2a/b are particularly interesting. It is possible that in Task 1 the gaze direction of the disjoint gaze faces may have been evaluated as particularly informative, probably in terms of "correcting" an unnatural eye movement (i.e., orienting attention away from a stimulus), whereas the gaze direction of the joint gaze faces was completely redundant. Therefore, participants may have learned these differences in the faces' gaze behavior, subsequently impacting gaze cueing.

Considering previous literature, there are also a number of social factors that could have contributed to this pattern of results, and Experiment 2b was conducted to empirically assess some of these factors. First, we reasoned that a reliable gaze cueing effect emerged only in response to disjoint gaze faces because these were perceived by participants as more dominant individuals. Indeed, it is known that dominant individuals tend to ignore the gaze direction of subordinates (Dalmaso et al., 2012; Jones et al., 2010; Shepherd et al., 2006). Conversely, joint gaze faces might be perceived as subordinates, as the participant has affected change of their eye-gaze. However, both disjoint and joint gaze faces were rated equally for dominance, therefore excluding the potential role of this variable in shaping gaze behavior, at least within the present paradigm. Although no explicit rating differentiation was shown for dominance, in Experiment 2b we did find that participants rated joint gaze faces as more trustworthy. This fits well with the literature, where it has been shown that we tend to evaluate as more trustworthy faces who engage in joint gaze bids with us, rather than faces that consistently look elsewhere (e.g., Bayliss et al., 2009; Bayliss & Tipper, 2006). Of interest to the authors, to the best of our knowledge, so far only one study has observed a modulation of trustworthiness on gaze cueing in young adults, reporting greater gaze cueing in response to trustworthy faces (Süßenbach & Schönbrodt, 2014; see also Petrican et al., 2013, for a similar results in older adults). However, it is important to note that Süßenbach and Schönbrodt (2014) manipulated trustworthiness explicitly before the gaze cueing task, while in our study differences in trustworthiness emerged as a direct consequence of the gaze behavior requested of participants in the saccade/antisaccade task, which suggests we respond differently to first hand experiences compared with second hand information.

Individual differences can also be highly informative with regards to social orienting processes. For example, autistic-like traits in the normal population are linked to social attention (e.g., Bayliss et al., 2005; Bayliss & Tipper, 2005). Thus, in Experiment 2b, participants completed the AQ questionnaire (Baron-Cohen et al., 2001). Of interest to the authors, the magnitude of the gaze cueing effect elicited by joint gaze faces positively correlated with AQ scores, meaning that the higher the number of autistic-like traits a participant had, the greater the magnitude of orienting in response to joint gaze faces was, with no such correlation emerging with disjoint gaze faces. In other words, individuals with high AQ scores were not sensitive to the social context in which joint gaze faces were previously presented, which in turn has lead to different social orientating behaviors later. At first glance, the finding that cueing effects were larger in high AQ participants *in any condition* may be surprising, given a negative correlation is typically found (Bayliss et al., 2005). However, Bayliss and Tipper (2005) noted that although cueing effects may generally be modulated by AQ overall, it is the context in which the cues are presented that may drive AQ effects.

The present evidence, and the explanations that they afford, are of course not exhaustive and future work is necessary to test other potential hypotheses. For example, it may be that the stronger cueing by disjoint gaze faces is actually an attempt to reconnect with an individual who has previously ostracized the participant by not engaging with him or her. Ostracism can profoundly impact on gaze behavior (e.g., Böckler, Hömke, & Sebanz, 2014; Wilkowski, Robinson, & Friesen, 2009) and people who are ostracized tend to (re)establish contact with individuals who are the source of such exclusion (e.g., Wirth, Sacco, Hugenberg, & Williams, 2010); thus, the enhanced gaze-cueing provided by these faces may relate to the participant's need to (re)establish control of the social situation (e.g., Warburton, Williams, & Cairns, 2006) or, more generally, satisfy the need to "close the loop" (see Frith, 2007).

Finally, there are also a number of methodological considerations that may have contributed to the present findings. For instance, on antisaccade trials (Task 1), while the face stimulus looked toward the instruction cue, the participant did not, but still had to attend covertly to this cue to make the antisaccade away from it. Conversely, on saccade trials, both the face stimulus and participant looked toward the same target. Thus, every single trial in Task 1 had an initial component of joint attention and therefore saccade and antisaccade trials differed mainly in terms of the overt component of orienting. Furthermore, in Experiments 2a/b (i.e., gaze leading condition) the learning process of face identities was impoverished: as participants moved their eyes first, they could only see the gaze direction of the facial stimuli through their peripheral vision. In turn, this might have influenced the modulation of the subsequent gaze cueing effect, at least to some extent. Future studies are necessary to further address this unexplored research question.

To recap, the present series of experiments show, for the first time, that the social attention system is sensitive to gaze-based person information. Specifically, Experiments 1 and 2a/b show that the quality of previous interactions with an individual impacts that individual's ability to later influence our attention. Furthermore, when we re-encounter someone with whom we have previously interacted, our knowledge of this person (particularly regarding our previous interaction with them) is recalled, and thus influences how we then interact with them. Therefore, we have further evidence suggesting a direct link between gaze perception and subsequent attentional processes (see Bayliss et al., 2011), but we can now also conclude that the social orienting system is sensitive to information from previous gaze based interactions when re-encountering individual people.

In conclusion, the present results are interesting for a number of reasons. First, they present further evidence of the importance of others' gaze behavior in modulating our own behavior, suggesting that the system underlying interpersonal perception plays a key role in shaping social attention mechanisms. In particular, we reported that even social learning of information related with gaze behavior (i.e., joint gaze) can subsequently impact both gaze-mediated orienting of attention with the same people and person perception. Second, they confirm the importance of distinguishing between *initiating* joint gaze and *responding* to joint gaze; both initiating and responding lead to modulations in future gaze behavior, but they did so in different manners. Finally, this work also highlights the potential benefits of using social stimuli in interactive gaze-contingent eye-tracking tasks to create innovative paradigms (see also Pfeiffer, Vogeley, & Schilbach, 2013). A large scale implementation of such paradigms may provide researchers the opportunity to enlarge and expand the investigation of social attention. For these reasons we feel that, because of relative novelty of these interactive paradigms, many different avenues of research are available that will expand our knowledge concerning mechanisms that underlie social cognition with particular emphasis to attentional processes.

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