PAPER

Best friends: children use mutual gaze to identify friendships in others

Erika Nurmsoo[1], Shiri Einav[2] and Bruce M. Hood[1]

1. Department of Experimental Psychology, University of Bristol, UK
2. Department of Psychology, Oxford Brookes University, UK

Abstract

This study examined children's ability to use mutual eye gaze as a cue to friendships in others. In Experiment 1, following a discussion about friendship, 4-, 5-, and 6-year-olds were shown animations in which three cartoon children looked at one another, and were told that one target character had a best friend. Although all age groups accurately detected the mutual gaze between the target and another character, only 5- and 6-year-olds used this cue to infer friendship. Experiment 2 replicated the effect with 5- and 6-year-olds when the target character was not explicitly identified. Finally, in Experiment 3, where the attribution of friendship could only be based on synchronized mutual gaze, 6-year-olds made this attribution, while 4- and 5-year-olds did not. Children occasionally referred to mutual eye gaze when asked to justify their responses in Experiments 2 and 3, but it was only by the age of 6 that reference to these cues correlated with the use of mutual gaze in judgements of affiliation. Although younger children detected mutual gaze, it was not until 6 years of age that children reliably detected and justified mutual gaze as a cue to friendship.

Introduction

Gaze is of paramount importance in social relationships. The levels of eye contact that individuals display towards one another can reveal a friendly, indifferent, or hostile relationship (Kleinke, 1986). To successfully negotiate the social world, children must learn to use eye contact and gaze as both a channel used to communicate and read socially relevant intentions and an overt behaviour that signals reciprocal affiliations among others.

Children are sensitive to the eyes from a very young age, preferring to look at faces with direct gaze over faces with averted gaze from birth, and demonstrating shifts in attention in response to adult gaze shifts soon after (Farroni, Csibra, Simion & Johnson, 2002; Hood, Willen & Driver, 1998). This attention to the eyes plays a formative role in children's sociocognitive and linguistic development, as gaze can serve as an ostensive signal that indicates to children when they are being intentionally addressed by an adult (Csibra & Gergely, 2009), and as a referential signal that establishes the intentions and attitudes that others may have towards objects. For example, infants use gaze to disambiguate the referent of an adult's words (Baldwin, 1991) and emotional displays (Repacholi, 1998), with infants as young as 12 months of age interpreting looking as intentional and goal-directed (Woodward, 2003). By age 4, children can make explicit attributions of attentional focus and desire based on object-directed gaze cues (Einav & Hood, 2006; Lee, Eskritt, Symons & Muir, 1998). Sensitivity to the eyes can provide a powerful means for learning about both the external environment and the internal states of others, and as a consequence, it is considered to be an important developmental precursor to theory of mind (Baron-Cohen, 1995).

In addition to reflecting a looker's intentions or attitudes towards objects, eye gaze cues in social contexts can reveal friendships and affiliations. As in object-directed gaze, lookers may gaze more at people they like than those they dislike (Exline & Winters, 1965; Pellegrini, Hicks & Gordon, 1970). However, using eye contact cues for many social inferences requires more than the understanding of object-directed gaze. In the absence of any hostile or negative cues, mutual eye contact is one of the main markers of friendship or liking (Argyle & Dean, 1965). In these situations, attending to only one individual's looking behaviour is insufficient to infer affiliation. Instead, it is the bi-directional nature of the signal, whereby both parties concurrently focus their attention on each other, that signals the reciprocal nature of the affiliation. By engaging in eye contact, the two individuals indicate their interest in one another and their readiness for social interaction. In contrast, purposefully failing to initiate or reciprocate gaze may reflect disinterest or even the wish to avoid interaction, both states that are not conducive to affiliation (see Adams & Kleck, 2003; Mason, Tatkow & Macrae, 2005). When judging

Address for correspondence: Erika Nurmsoo, School of Psychology, University of Kent, Canterbury, Kent CT2 7NP, UK; e-mail: e.nurmsoo@kent.ac.uk

the social interactions between others, adults interpret higher levels of mutual gaze as a sign of liking or intimacy (Kleck & Nuessle, 1968; Scherer & Schiff, 1973; Thayer & Schiff, 1974). Children's efficient identification of social relationships would be supported by the ability to track gaze behaviours among others, to identify instances of mutual gaze, and to correctly interpret them in terms of social intentions or friendships.

Recent work has revealed that by the age of 10 months, infants distinguish between dyads engaged in mutual versus averted gaze (Beier & Spelke, in press), although how they interpret these gaze exchanges is not yet clear. Between the ages of 3 and 6, children begin to use congruent head and eye gaze cues as an initial clue to mutual liking. Post and Hetherington (1974) showed 4- and 6-year-olds photographs of dyads which varied in whether the individuals faced one another, and how physically close they were to one another. Children were asked to choose which pair of people liked each other, and 6-year-olds, but not 4-year-olds, were more likely to judge that dyads facing one another liked each other more than dyads that did not. Similarly, Abramovitch and Daly (1978) showed 3- and 4-year-olds video clips in which two characters had a conversation while either looking at one another or directly at the camera. Children of both ages judged that characters who spoke while looking at one another liked each other, while those who spoke while looking at the camera did not. When given gaze cues coupled with head direction cues, young children can relate individuals' visual attention towards one another and their mutual liking.

There are several limitations in these two previous studies. First, it is unclear to what extent children used the character's gaze in their judgements. Although head orientation is a salient cue, it is not always a reliable indicator of where a person is actually looking. The neurophysiology of face processing, and the behavioural measures of attentional cueing from faces, both indicate that the eyes are the primary focus for adult face 'reading' (for a review, see Perrett, 2010). Infants are sensitive to mutual gaze and show increased attention and social smiling when adults look directly at them as opposed to away (Hains & Muir, 1996). However, older children may rely more heavily on head direction, at least when identifying where a character is looking (Butterworth & Itakura, 2000; see also Doherty, Anderson & Howieson, 2009). It is not known whether sensitivity to mutual eye gaze evidenced in the infant dyadic scenario can also be used by older children to infer social affiliation between others. To explore this issue, head direction and gaze cues must be uncoupled.

A second concern is that in both these early studies children did not need to establish mutual gaze in order to identify mutual liking. Children expect that characters look longer or more frequently at targets they prefer (e.g., Einav & Hood, 2006). When judging the level of liking within dyads, children could simply evaluate the level of eye gaze one target exhibited towards the other,

concluding affiliation when one character liked the other. However, social affiliation goes beyond one party's inclination towards the other, relying instead on levels of *mutual* liking. Children's abilities must therefore be examined under conditions where one character's eye contact is not returned.

Finally, in the previous studies, the tasks were relatively well defined in that the protagonists were the only individuals under consideration. In many instances, relationships are embedded in more complex scenarios where there are more than two individuals displaying behaviour that could be interpreted in terms of affiliation. Specifically, we are interested in whether children can establish which dyad out of a triad have mutual liking. This is a much more demanding analysis as it involves simultaneously tracking more than one potential relationship.

With these considerations in mind, we developed a more subtle gaze manipulation than previously tested. Rather than presenting children with two individuals who both looked toward or away from each other, our displays included three characters varying in whether they displayed reciprocated or unreciprocated mutual gaze. In three studies, 4- through 6-year-old children watched brief animation sequences in which three smiling cartoon characters looked at one another without head turns. To explore whether children interpreted the videos in terms of mutual eye contact rather than on one character's preference for another, one character's gaze was not reciprocated. Finally, to confirm that participants could identify the cue even if they did not use it to judge affiliation, in two of the studies children's ability to simply monitor the relevant gaze cue was measured.
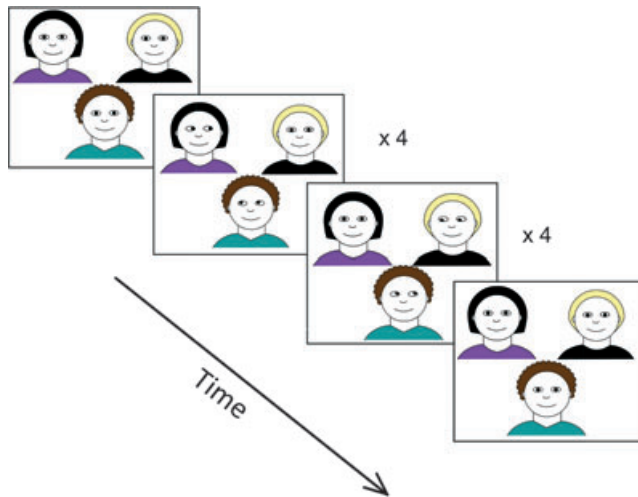
Experiment 1

Method

Participants

Thirty-two 4-year-olds (mean age = 55 months, range 51–59 months; 16 girls, 16 boys), 32 5-year-olds (mean age = 65 months, range 60–71 months; 16 girls, 16 boys) and 32 6-year-olds (mean age = 76 months, range 72–82 months; 16 girls, 16 boys) participated. Information on participant ethnicity and SES was not systematically collected, but participants in this and subsequent experiments were recruited from schools serving predominantly middle-class families of Caucasian descent. Participants were tested either in a quiet space in their schools or in a child-friendly university lab, in sessions lasting approximately 15 minutes.

Materials

Six animated vignettes were used in which three different smiling cartoon children looked at one another. Each
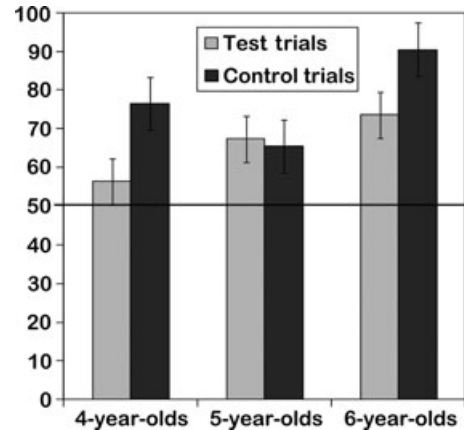
Figure 1 *Illustration of the sequence of events on a single trial in Experiment 1. Here, the Target, located bottom centre, looks at the Reciprocator, top left, who returns the gaze (repeated four times) and then at the Avoidant, top right, who looks at the other character in response (repeated four times).*

Figure 2 *Percent correct performance in Experiment 1, showing standard errors, and with chance level marked at 50%.*

cartoon character appeared only once in any test session. The cartoon faces were simple line drawings presented on a white background, with only T-shirt colour, hair colour, and hairstyle to distinguish them (see Figure 1 for an example). Gender and race of the characters were not specifically manipulated, although some characters had hair that could be interpreted as indicative of a particular gender or ethnic background. The characters were randomly assigned to triads.

In each animation, the Target character appeared alone in the centre of the screen for approximately 2 seconds before moving to the bottom centre. The Reciprocator and the Avoider characters then appeared, one in the top right and one in the top left of the screen (counterbalanced). The Target character looked four times at each of the other two, beginning with the character in the top left. The Reciprocator consistently returned the Target's look with mutual gaze, while the Avoider consistently looked at the Reciprocator in response to the Target's gaze (see Figure 1). In each gaze exchange, the Target shifted gaze 20 ms before the other character's gaze shift, with a total looking time of 1 second. Each vignette, which lasted approximately 27 seconds, ended with a still image of the characters looking straight ahead.

Procedure

Friendship warm-up. To set up a context of affiliation, the experiment began with a brief discussion about friendship, in which participants were encouraged to identify their own 'best friend'. All participants named at least one person. Children were told they would watch animations of three children, and that they were to

identify which one was 'best friends' with the Target character.

Affiliation trials. Across four test trials, at the end of each vignette the Target character was directly pointed out and children were simply asked, 'Who is best friends with [Target]?'

Gaze monitoring trials. Two control trials followed, using the same vignette structure. Participants were asked to identify 'Who looked at [Target] the most number of times?'

Results and discussion

The results for the affiliation and gaze monitoring trials are summarized in Figure 2. Across the four trials, when asked to identify 'Who is best friends with [Target]?', 5-year-olds chose the Reciprocator on an average of 2.69 trials ($SD = 1.06$), or 67% of the time, a rate above chance (50%): $t(31) = 3.67$, $p < .001$, $d = 0.65$. Six-year-olds chose the Reciprocator on an average of 2.94 trials ($SD = 1.34$), or 73% of the time, also above chance: $t(31) = 3.95$, $p < .001$, $d = 0.70$. Both 5- and 6-year-olds successfully identified the Reciprocator as the 'best friend' of the Target character.

In contrast, 4-year-olds chose the Reciprocator on an average of only 2.25 trials ($SD = 0.84$), or 56% of the time, a rate no different from chance, $t(31) = 1.68$, $p = .10$. A between-subjects analysis of variance including age and gender as factors confirmed a significant main effect of age, $F(2, 95) = 3.16$, $p < .05$, partial $\eta^2 = 0.066$, with no effect of gender, nor any interactions. Post-hoc testing revealed that 6-year-olds performed significantly better than 4-year-olds (Bonferroni, $p < .05$).

Importantly, the developmental difference was only observed on Affiliation trials. On the two Gaze Monitoring trials, when children were asked to identify 'Who looked at [Target] the most number of times?', all three

groups of children performed well above chance, with 4-year-olds correctly identifying the Reciprocator on 1.53 trials ($SD = 0.62$) or 77% of the time, $t(31) = 4.84$, $p < .001$, $d = 0.85$, 5-year-olds on 1.31 trials (SD = 0.78), or 66% of the time, $t(31) = 2.27$, $p < .05$, $d = 0.40$, and 6-year-olds on 1.81 trials ($SD = 0.40$) or 91% of the time, $t(31) = 11.6$, $p < .001$, $d = 2.0$ (see Figure 2).

In Experiment 1, 4-, 5-, and 6-year-olds successfully identified relevant gaze cues in a cartoon vignette when explicitly asked to monitor the cartoons for gaze. Despite this success, however, the youngest age group did not seem to use those same cues to identify which characters were friends. By age 5, children used gaze cues, in the absence of head turns, to identify mutual friendships correctly.

Experiment 2

Experiment 1 showed that while 4-year-olds perceived the relevant gaze information, only the older children used it to infer mutual friendship. In that study, children were asked to judge the affiliations of a given target character. However, determining affiliation on the basis of gaze in everyday life requires monitoring multiple social interactions independently, without the benefit of a clearly identified 'target' individual. Accordingly, in a second study we examined children's ability to use mutual gaze without an explicitly identified target character. To succeed, children had to track and reason about the gaze behaviour among all the parties, not just with respect to a specified target character. In order to more directly explore the strategies children might be using to make their judgements, after each trial we also asked children to justify their responses. Because the younger children in Experiment 1 did not use gaze cues to identify friendship, only 5- and 6-year-olds were tested.

Method

Participants

Twenty-eight 5-year-olds (mean age = 63 months, range 60–71 months; 15 girls, 13 boys) and 28 6-year-olds (mean age = 77 months, range 72–84 months; 14 boys, 14 girls) participated.

Procedure

Friendship warm-up.. The warm-up was the same as Experiment 1.

Affiliation trials. Children watched six animations showing three cartoon children looking at one another. The vignettes followed the same format as in Experiment 1, with a Target, Reciprocator, and Avoider, except that (a) the Target character did not appear alone at the beginning, and (b) the Target was positioned equally

often in the three different locations (i.e., bottom centre, top left, or top right), and was not specifically pointed out to participants. Again, the Target character shifted gaze 20 ms before the other characters, each gaze exchange took approximately 1 second, and each vignette lasted approximately 25 seconds. After each vignette, participants were asked, 'Which two children are best friends with each other?', followed by the open-ended justification question, 'How do you know?'

Results and discussion

An initial ANOVA with age and gender as factors revealed no significant effects, nor any interactions.

Any pair of the three characters could be chosen as best friends, setting chance at 33%. Across the six trials, 5-year-olds correctly chose the Target and Reciprocator dyad on 3.43 trials ($SD = 1.14$), or 57% of the time, and 6-year-olds on 3.93 trials ($SD = 1.63$) or 66%. Planned comparisons showed both age groups were well above chance: 5-year-olds, $t(27) = 6.65$, $p < .001$, $d = 1.3$; 6-year-olds, $t(27) = 6.26$, $p < .001$, $d = 1.2$.

The Target character shifted gaze before either of the other two characters, and made twice as many eye movements as any other character. As a result, it is possible that children were more likely to pick the Target as one of the two 'best friends', which might suggest that it would be appropriate to set chance at 50% rather than at 33%. An analysis of the errors, however, shows that this is not the case: of the 130 errors made across the two age groups, 49 (or 38%) incorrectly identified the Reciprocator and Avoidant characters as 'best friends'. That is, participants did not limit themselves to the Target, but considered all three characters as possible best friends.

Nevertheless, as a stricter criterion, we reasoned that if children used mutual gaze to identify the best friends, on those trials in which children selected the Target as one member of the dyad they should be more likely to select the Reciprocator than the Avoider as the second member. On those trials, 5-year-olds chose the Target-Reciprocator dyad significantly more often than the Target-Avoider dyad (96 vs. 49 times, binomial $p < .005$). Similarly, 6-year-olds chose the Target-Reciprocator dyad significantly more often than the Target-Avoider dyad (110 vs. 32 trials, binomial $p < .001$). Both when examining children's individual performance against chance, and when exploring the rate of selecting the Reciprocator over the Avoider, 5- and 6-year-olds succeeded in identifying the Target-Reciprocator dyad as the 'best friends'.

For the justification question, all responses were categorized into two groups. Explanations that referred to the mutual eye contact between two characters (e.g., 'they looked at each other the most', 215 justifications in total) or avoidance of mutual eye contact (e.g., 'the boy looked at that person who didn't look back', nine justifications), regardless of whether they correctly identified which characters shared or avoided this gaze, were coded

as Mutual Gaze explanations. All others, including those that provided no clear response, were not. These included gaze explanations that did not refer to mutual gaze (e.g. 'he looked at her' or 'they moved their eyes first'), and other irrelevant explanations (e.g. 'they both have short hair', 'they want to marry'). Mutual Gaze explanations accounted for 114 of the 168 justification responses (68%) among 6-year-olds, with 23 of the 28 children providing at least one mutual gaze justification. Among 5-year-olds, mutual gaze accounted for 110 of the 168 justification responses (65%), with 22 of the 28 children in this age group referring to mutual gaze at least once in their explanations.

To explore whether participants' justifications were related to their ability to correctly identify the target dyad, we correlated the number of Mutual Gaze justifications offered by each participant with their score on Affiliation trials. For 6-year-olds, there was a significant relationship between the two measures, $r(26) = .53$, $p < .005$, suggesting that their use of mutual gaze explanations was a good indicator of their ability to use mutual gaze in their judgements of affiliation. In contrast, 5-year-olds showed no such correlation, $r(26) = .11$, *ns*. When we expanded the justification category to include all references to gaze, regardless of whether mutual gaze was explicitly identified, we found the same pattern of results. Five-year-olds referred to gaze in 128 justifications (or 76%), but again the rate of offering gaze justifications was not correlated with their accuracy on Affiliation trials, $r(26) = .11$, *ns*. Six-year-olds referred to gaze in a total of 140 justifications (or 83%), and again, this behaviour was correlated with their scores on Affiliation trials, $r(26) = .72$, $p < .001$.

As in Experiment 1, 5- and 6-year-olds successfully identified mutual affiliation among dyads showing mutual gaze, even when they did not know the target character in advance. What was surprising was the lack of relationship between success on identifying mutual gaze and an explicit justification in the 5-year-olds. We tentatively offer the possibility that between 5 and 6 years of age, the capacity to detect mutual gaze and the ability to provide an explicit statement of the basis for that decision become increasingly coupled.

Experiment 3

Experiments 1 and 2 suggest that by the age of 5, children can use mutual gaze to identify affiliation in third parties. Importantly, they could not have succeeded on this task by simply tracking the preferences exhibited by a previously identified target, as the Target character was not explicitly identified, and looked equally often at the Reciprocator and Avoider. However, in the first two studies the Target character was not looked at equally often by the other two characters; the Avoider looked away from the Target. In Experiment 3, a more careful test was used in which one pair, the Target-Reciprocator
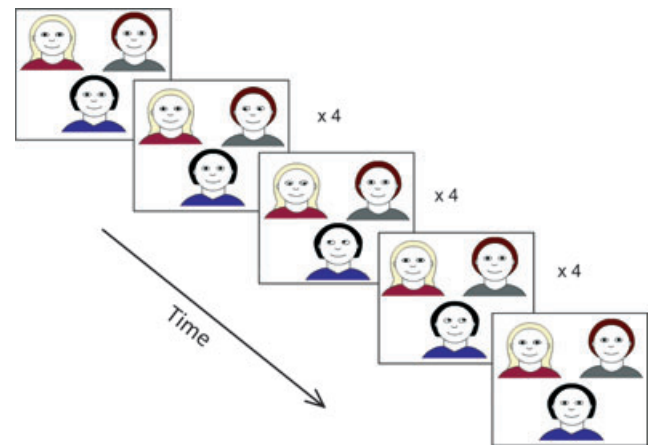
Figure 3 *Illustration of the sequence of events on a single trial in Experiment 3. In this example, the Avoidant (top right) looks at the Target (bottom centre), who does not change gaze direction (repeated four times). The Target then looks at the Reciprocator (top left), who returns the gaze (repeated four times). Finally, the Target looks at the Avoidant, who does not change gaze direction (repeated four times). The order of these three looks was fully counterbalanced.*

dyad, engaged in mutual gaze, while another, the Target-Avoider dyad, looked at one another equally often but not simultaneously. In this way, the Avoider and Reciprocator both looked at the Target an equal number of times, but only one pair shared synchronized mutual gaze (see Figure 3).

In Experiment 1, despite correctly identifying the dyad sharing mutual gaze, 4-year-olds did not use this gaze as a cue to their affiliation. To confirm the results of Experiment 1, and to explore their judgements of affiliation by using the justification question from Experiment 2, we again included 4-year-olds.

Method

Participants

Twenty 4-year-olds (mean age = 55 months, range 49–59 months; 8 boys, 12 girls), 20 5-year-olds (mean age = 64 months, range 60–71 months; 7 boys, 13 girls) and 20 6-year-olds (mean age = 76 months, range 72–82 months; 10 boys, 10 girls) participated.

Procedure

Friendship warm-up. The Friendship warm-up was the same as that for Experiments 1 and 2.

Affiliation trials. Across six test trials, at the end of each animation children were asked, 'Which two children are best friends with each other?', followed by, 'How do you know?' The vignettes followed the same format as in Experiment 2, with a Target, Reciprocator and Avoider, except that (a) while the Target character looked at the

Avoider four times, the Avoider looked straight ahead, and (b) the Avoider looked at the Target character four times, while the Target character looked straight ahead (see Figure 3). The order of these looks was counterbalanced. Again, the Target character shifted gaze 20 ms before the other characters, each gaze exchange took approximately 1 second, and each vignette lasted approximately 34 seconds. The Target was positioned equally often in the three different locations and was not specifically pointed out to participants.

Gaze monitoring trials. Three gaze monitoring trials followed, using the same vignette structure. Participants were asked to identify 'Which two children looked at each other at the same time?'

In both the Affiliation and Gaze monitoring trials, the characters who showed mutual gaze were counterbalanced so that each potential pairing was the 'correct' answer an equal number of times. Within each set of trials, the animations were presented in random order for each child.

Results and discussion

A preliminary ANOVA with age and gender revealed no main effects nor any interactions.

As any pair of the three characters could be chosen as best friends, chance was once again set at two out of six trials, or 33%. As in Experiment 2, although participants could have chosen the Target character more often due to other factors such as the earlier initiation of gaze, participants did seem to consider the Avoidant-Reciprocator dyad as a possible response; of the 169 errors, 41 (24%) incorrectly identified the Avoidant-Reciprocator dyad.

Across the six trials, 4-year-olds correctly chose the Target-Reciprocator dyad on only 2.70 trials ($SD = 1.90$), or 45% of the time, which planned comparisons revealed was no different from chance, $t(19) = 1.65$, $p = .12$. In contrast, 5-year-olds and 6-year-olds both performed better than chance, with 5-year-olds choosing the Target-Reciprocator dyad on 3.10 trials ($SD = 1.71$) or 52%, $t(19) = 2.87$, $p < .05$, $d = 0.64$, and 6-year-olds on 3.75 trials ($SD = 1.97$), or 63%, $t(19) = 3.97$, $p < .001$, $d = 0.89$. By this measure, 5- and 6-year-olds used mutual gaze cues to identify the two affiliated characters, while 4-year-olds did not, consistent with the results of Experiment 1.

Participants could have chosen the Target character more often because she or he initiated gaze earlier, performed twice as many looks as the other characters, and was the recipient of twice as many looks as the other characters. We therefore conducted the same analysis of trials as in Experiment 2. Examining only those trials on which participants selected the Target as one member of the dyad, we explored whether they were more likely to choose the Reciprocator as the second member. Four-year-olds were equally likely to select the Target-Reciprocator and Target-Avoider dyads (53 vs. 41, binomial

ns), and 5-year-olds performed similarly (62 vs. 48, binomial *ns*). Only the 6-year-olds identified the Target-Reciprocator significantly more often than the Target-Avoider dyad (75 vs. 39, binomial $p < .005$). This more conservative measure of performance by trial reveals that 5-year-olds may not be reliably using mutual eye gaze to judge affiliation on this task.

Responses to the justification question were coded as in Experiment 2. Mutual gaze explanations accounted for 41 of the 120 justification responses (34%) among 4-year-olds, 54 (45%) among 5-year-olds, and 74 (62%) among 6-year-olds. It may be surprising that 4-year-olds provided so many mutual gaze explanations in light of their chance performance, as a group, on test trials. However, all mutual gaze justifications were provided by only eight of the 20 4-year-olds (40%). The number of 5-year-olds providing at least one mutual gaze justification was 14 of 20 (70%), and 16 of 20 (80%) of 6-year-olds referred to mutual gaze at least once in their explanations.

Once again, we correlated the number of Mutual Gaze justifications with their score on Affiliation trials. For 4- and 5-year-olds, there was no relationship between their justifications and their score, $r(18) = .30$ and .005, respectively. For 6-year-olds, however, there was a significant correlation between the two measures, $r(18) = .55$, $p < .05$, suggesting that for this older group, reference to mutual gaze cues was a good indicator of their use of these cues in their judgements of affiliation. This finding replicates the pattern observed in Experiment 2.

Again, when we expanded the justification category to include all references to gaze, we found the same pattern of results. Four-year-olds referred to gaze in 50 (or 42%) of their justification responses, and 5-year-olds on 63 (or 53%). In neither age group was performance on Affiliation trials correlated with their use of gaze justifications, $r(18) = .37$ and $r(18) = .22$, respectively, both non-significant. In contrast, the 6-year-olds referred to gaze in 79 (or 66%) of their justifications, and this behaviour was correlated with their success on Affiliation trials, $r(18) = .56$, $p < .05$.

Importantly, when explicitly asked which characters looked at one another at the same time, 4-year-olds correctly identified the Target-Reciprocator dyad on 2.10 trials ($SD = 0.91$) out of three control trials, or 70% of the time, a rate significantly higher than chance, $t(19) = 5.40$, $p < .001$, $d = 1.2$. The older children showed similar success, with 5-year-olds correctly identifying the mutual gaze on 2.45 trials ($SD = 0.61$) or 80% of trials, $t(19) = 9.2$, $p < .001$, $d = 2.3$, and 6-year-olds on 2.80 trials ($SD = 0.52$), or 93% of trials, $t(19) = 15.4$, $p < .001$, $d = 3.5$.

As in Experiment 1, 4- through 6-year-olds were able to explicitly identify the mutual gaze cues in the video vignettes. Despite this success, 4-year-olds were no better than chance at reporting the characters' affiliations. In contrast, 6-year-old children used the mutual gaze shared between characters to identify which two were 'best friends'. The performance of the 5-year-olds is more

ambiguous, as performance was above one measure of chance, but no different from chance when measured more conservatively.

Finally, we explored whether children based their decision of affiliation on the dyad that displayed mutual gaze, or alternatively, on the lack of mutual gaze in the other dyads. Out of all the mutual gaze justifications from Experiments 2 and 3, only 5% (21 out of 402) described a character's failure to initiate or to return gaze (e.g., 'blue didn't look at red that much', 'he [pointed] looked at him [pointed] but he didn't look back'). When referring to mutual gaze in their justifications, children were primarily focusing on the positive affiliation between characters in the reciprocating dyad.

General discussion

Our results reveal that under some circumstances, children as young as 5 years of age can use dynamic mutual gaze to identify which two individuals out of three share an affiliation. Four-year-olds showed no evidence of this attribution, despite being proficient at tracking the relevant gaze information, and despite occasionally justifying their responses in terms of mutual gaze between characters. In contrast, 5-year-olds succeeded when the dyads differed in mutual gaze (Experiment 2), but their performance was less clear when the dyads differed in whether the gaze exchanges were synchronized (Experiment 3), while 6-year-olds succeeded across all tasks. These results support the tentative hypothesis that the ability to use mutual gaze to infer affiliation develops between 5 and 6 years of age.

The performance of the 5-year-olds was mixed. As a group, their performance was clearly above chance in Experiments 1 and 2, when one character responded to the target's gaze with simultaneous mutual looks, while the other character responded by *avoiding* the gaze by looking away from the target. In these cases, success could reflect an understanding of the importance of synchronized mutual gaze, or simply a strategy of selecting characters on the basis of other cues such as who made the most eye movements, or who shifted gaze first. To rule out this second interpretation, the dyads in Experiment 3 looked at one another equally often, but only one showed simultaneous mutual gaze. Five-year-olds appeared to have more difficulty with these vignettes, succeeding against one measure of chance, but failing under a more conservative level. One possibility is that these results reflect difficulty with the increased task demands in Experiment 3, where the length of the vignettes was increased by 35%, requiring participants to hold details in mind for a longer period of time. More likely, however, is that while they understood that mutual gaze behaviour was relevant, the 5-year-olds failed to make use of it when making their judgements. While only 40% of 4-year-olds referred to mutual gaze between characters at least once when asked to justify their

choices (Experiment 3), 70% of 5-year-olds and 80% of 6-year-olds did so. These findings suggest that both 5- and 6-year-olds appreciated that mutual gaze was relevant. Importantly, however, there was no relationship between justifications referring to mutual gaze and children's success in identifying the target dyad among 5-year-olds. In contrast, by the age of 6, children's explicit reference to mutual gaze when justifying their responses was related to their success in identifying the reciprocating dyad. The mixed performance in the 5-year-old group might reflect an intermediate step in children's understanding of eye gaze and affiliation; they show an understanding that gaze cues are relevant to the task, but may not yet appreciate that mutual gaze is most indicative of affiliation when it is simultaneous, or use these cues when judging the friendships of others.

Despite the increased complexity of our task, and the mixed results among the 5-year-olds, the developmental change we found between 4 and 6 years of age is consistent with that found by Post and Hetherington (1974). Our findings extend previous research by demonstrating that 6-year-old children can make such attributions on the basis of eye gaze alone, even when it is dependent on mutual gaze, when the gaze is presented dynamically, and when there are multiple possible dyads.

From these findings we cannot yet pinpoint how children interpreted the gaze of the characters. For example, children might have been basing their judgements solely on the contingencies between the characters, without considering their gaze behaviour in mentalistic terms. Indeed, the act of looking at someone is simultaneously attention-grabbing and a cue to the focus of another's attention (Leslie & Happe, 1989). However, at least the older children's explanations suggest that their judgements hinged on their interpretation of mutual gaze as a sign of relationship. In particular, mutual gaze was seen as a positive relationship marker: children's justifications primarily focused on the positive affiliation, with 95% of gaze-related responses referring to the mutual gaze of the two characters liking each other, rather than on the failure to reciprocate gaze as a negative interpersonal marker. What is crucial for the present purposes is that children viewed the presence or absence of reciprocated mutual gaze as relevant when making social inferences.

It is important to note that the chance performance of the younger children on Affiliation trials is unlikely to be due to a failure to understand what 'best friends' are. In the warm-up phase of each experiment, all participants named others when asked to identify their own best friends. Children's judgements of their own friendships are usually – although not always – in concordance with others' judgements, including parents, teachers, and external observers (Howes, 1988). In addition, the age of acquisition of the word 'friend' appears to be around 3 years of age (Cortese & Khanna, 2008; Hartup & Stevens, 1999). By the age of 4, children seem to understand the concept of friendship, and to be able to identify their own friends.

A more likely explanation for the developmental change is that between 4 and 6, children's opportunities for interactions with others increase, and they monitor these exchanges more closely. In terms of their own affiliations, children form different types of friendships, some temporary and some long term (Howes, 1983, 1988). Although children's friendship patterns develop with age (e.g., Berndt, Hawkins & Hoyle, 1986), stable mutual friendships appear by 3 or 4 years of age (Howes, 1988; see also Barbu, 2003). Children also increase their use of eye contact during peer conversations from ages 4 to 9 (Levine & Sutton-Smith, 1973). Perhaps as their social experience with peers grows, children become increasingly aware of the associated nonverbal behaviour, and come to expect direct eye contact between friends.

The ability to read the social alliances of others by decoding such behavioural cues is likely to be an important tool for children's effective functioning in social groups (Platten, Hernik, Fonagy & Fearon, 2010). Our studies show that the capacity is well established by 6 years of age, though the current findings must be considered in the context of real-world scenarios where there are potentially multiple distracting sources of information competing for children's attention. One important direction for future research is to examine the relationship between children's developing ability to reason about the friendships of others, and their own sociometric standing. Children who have difficulty reading nonverbal signals such as mutual eye gaze may find their own social development or social standing hampered. Indeed, the value of this skill for adaptive social interaction is underscored by the social impairments presented by children with Autism Spectrum Disorder, which is thought to be related to gaze-reading deficits (Baron-Cohen, 1995; Baron-Cohen, Campbell, Karmiloff-Smith, Grant & Walker, 1995; Leekam, Baron-Cohen, Perrett, Milders & Brown, 1997). As Frith (2003) notes, 'If children with autism cannot automatically decode the meaning of eye gaze, then ordinarily silent messages sent by their peers … are likely to be ignored or mistaken' (p.105).

Four-year-olds' failure to use mutual gaze when making explicit social relational judgements does not rule out the possibility that other, indirect behavioural measures might reveal an implicit appreciation of this signal's meaning. For example, 18-month-old children have been shown to be more likely to help another person after seeing photographs in which two dolls faced one another, suggesting affiliation, than after photographs in which those dolls faced away from one another (Over & Carpenter, 2009). Indirect behavioural measures such as these, or measures based on violation-of-expectancy (e.g., Beier & Spelke, in press), might reveal an earlier, implicit appreciation of the social meaning of mutual eye gaze. However, our findings suggest that it is only from the age of 6 that children are able to reliably use this cue to explicitly identify third-party affiliations.

We were interested specifically in whether children would use mutual gaze to identify friendships in others.

The context of friendship was therefore established by engaging children with a warm-up discussion about their own friends prior to the test trials, presenting the characters as smiling, and by asking participants to identify the best friends in each scenario. However, mutual gaze can signal a range of shared relationship statuses. For example, two people looking at one another might be a sign of a competitive stand-off. Importantly, the accompanying facial expressions provide the emotional context that allows us to infer more precisely the nature of the relationship. Mutual gaze accompanied by smiling, as in our experiments, is most likely to signal liking, whereas mutual gaze accompanied by frowning or an aggressive stance is more likely to signal competition or a hostile relationship. Thus, mutual gaze should not necessarily lead to friendship inference. Rather, one should recognize that the meaning of the gaze cue changes whenever the contextual information changes. Further research is needed to clarify whether children are able to interpret mutual gaze in a flexible manner that appropriately takes into account accompanying context cues.

Early sensitivity to gaze allows infants to infer the attention, goals, and preferences of those around them. This sensitivity stands children in good stead; in the present studies, even 4-year-old children were skilled at identifying the relevant eye gaze cues. Although this group did not appear to use it when judging the affiliations of others, this underlying ability may be recruited to help older children understand the relationships between others. As their experience grows, children can use these gaze cues to judge the social relationships of those around them in increasingly complex interactions, even to infer whether a speaker is being truthful (Einav & Hood, 2008) or to evaluate the friendship status of others.

Acknowledgements

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