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12- and 18-month-old infants follow gaze to spaces behind barriers

Henrike Moll and Michael Tomasello

Department of Psychology, Max Planck Institute for Evolutionary Anthropology, Germany

Abstract

Infants follow the gaze direction of others from the middle of the first year of life. In attempting to determine how infants understand the looking behavior of adults, a number of recent studies have blocked the adult's line of sight in some way (e.g. with a blindfold or with a barrier). In contrast, in the current studies an adult looked behind a barrier which blocked the child's line of sight. Using two different control conditions and several different barrier types, 12- and 18-month-old infants locomoted a short distance in order to gain the proper viewing angle to follow an experimenter's gaze to locations behind barriers. These results demonstrate that, contra Butterworth, even 12-month-old infants can follow gaze to locations outside of their current field of view. They also add to growing evidence that 12-month-olds have some understanding of the looking behaviors of others as an act of seeing.

Introduction

Among the most fundamental social-cognitive skills is the ability to follow the gaze direction of others to external targets. Many nonhuman primates follow the gaze direction of conspecifics to targets (Tomasello, Call & Hare, 1998), and human infants look in the direction others are looking from as young as 6 months of age (D'Entremont, Hains & Muir, 1997).

When one individual looks where another is looking, the common-sense interpretation is that she wants to see what the other is seeing. But this mentalistic interpretation is not necessary in many cases. For example, 6-month-old infants only follow gaze to a target when it is inside their visual field and the first object on their scan path, suggesting the possibility that infants are simply orienting in the same direction in which the other's head is oriented (Butterworth's ecological mechanism; for mechanisms of joint visual attention, see Butterworth, 1983; Butterworth & Cochran, 1980; Butterworth & Grover, 1988; Butterworth & Jarrett, 1991). Moreover, even when 12-month-olds look to the same external target as the looker (bypassing distractors to do so; Butterworth & Cochran, 1980; Butterworth & Jarrett, 1991), it is still possible that the looking behavior of the other simply attracts the child's attention to the target's location, without inducing her to wonder precisely what the other is seeing (Butterworth's geometric mechanism).

In an attempt to determine more specifically how young infants understand the looking behavior of others – specifically, whether and to what extent they understand it as a mental act of seeing – researchers have created variations on the basic gaze following experiment. There are two basic paradigms: the Eye Status paradigm and the Barriers paradigm. First, in the Eye Status paradigm, Corkum and Moore (1995) and Moore and Corkum (1998) had an experimenter gaze to a specific location either by (1) moving both head and eyes, (2) moving head only (eyes looking straight ahead), or (3) moving eyes only. They found that only the 18-month-old infants seemed to care about eye movements, and even at this age gaze following to eye movements only was fairly rare. Moore and Corkum (1998) thus argued that it is not before 18 months of age that infants understand the referentiality of seeing, that is, that their gaze following can be interpreted as mentalistic.

However, Caron, Butler and Brooks (2002) used the Corkum and Moore (1995) paradigm in a slightly modified way and found different results. With only some small methodological changes, they compared infants' gaze following when the cues given by the experimenter were either congruent (head and eye movements in the same direction) or incongruent (head movement only, eyes straight ahead). Contrary to Corkum and Moore (1995), they found that infants at 14 months of age (but not 12 months of age) were influenced by the eyes in the sense that they looked more in the congruent condition.

Address for correspondence: Henrike Moll or Michael Tomasello, Department of Psychology, Max Planck Institute for Evolutionary Anthropology, Deutscher Platz 6, D-04103 Leipzig, Germany; e-mail: moll@eva.mpg.de or tomas@eva.mpg.de

Other researchers have pointed out, however, that these experimental manipulations create very unnatural situations in which different cues to gaze direction are in direct conflict in the sense that they indicate different directions. Accordingly, Brooks and Meltzoff (2002) assessed infants' sensitivity to eye status by comparing infants' gaze following when an experimenter turned her head in a direction but with eyes either open or closed (thus indicating only one direction, either more or less strongly). They found that open eyes induced more gaze following in infants as young as 12 months of age. In a follow-up study, they compared the eyes open condition to one in which the experimenter's eyes were covered by a blindfold and found that 14- and 18-month-olds (but not 12-month-olds) followed gaze more in the eyes open condition. Although it is not totally clear that knowing the function of the eyes is necessary for a mentalistic interpretation of gaze (Tomasello, 1996), these studies suggest at the very least that when the distraction of conflicting cues is eliminated infants as young as 12 to 14 months of age have some understanding of the function of the eyes in the looking behavior of others.

In the second experimental paradigm, the Barriers paradigm, Butler, Caron and Brooks (2000) had an experimenter sit opposite the infant and either look to the left or right towards a target on the wall. In one condition her line of sight to the target was unimpeded, whereas in another condition an opaque screen (barrier) blocked her line of sight to the target. Infants of both 14 and 18 months looked to the target more when the experimenter's line of sight was clear than when it was blocked. In a follow-up study, to control for the presence of the screen, three conditions were used: the two from the previous study (clear line of sight and barrier) and one in which the experimenter gazed at the target with a screen in the way, but in this case the screen had a large window in it through which the target on the wall could be clearly seen. The 18-month-olds showed an understanding of the requirement of a clear line of sight by following gaze direction in the window condition as much as in the condition without the screen (both more than with the solid screen). Fourteen-month-olds behaved similarly in the window and screen conditions, however, thus indicating a lack of understanding that the window enabled a clear line of sight. Caron, Kiel, Dayton and Butler (2002) found that 15-month-olds knew that the window enabled a clear line of sight but that 12-month-olds did not.

Analogous to the situation in the Eye Status paradigm, however, one could argue that children in this version of the Barrier paradigm are getting conflicting – or at least highly unusual – cues. In the experimental set up, the intervening screen is less than 1 m away from the experimenter's face. As the experimenter turns to look, all bodily cues indicate that the child should turn and look in that direction also. In the normal case in the real world the target of the adult's gaze would be some distance away in that direction, and so looking in that direction some meters away is not completely irrational. This response has to be inhibited when the barrier is noticed. In general, a barrier to vision so close to the looker's face is a highly unusual, perhaps even unnatural, situation.

In the current studies we looked for a more natural situation in which infants could demonstrate their understanding that barriers impede visual access. One such situation occurs when an adult at some distance from the child looks to a target that, *from the child's point of view*, is behind a barrier. This presumably occurs quite often in the child's experience when the adult, for example, looks through a door into an adjoining room or looks into a kitchen cabinet or looks down into an open box. We conducted two studies of this type with children at 12 and 18 months of age, using a variety of different types of barriers and using two different control conditions. In Study 1 we also elicited from the same children straight gaze following responses to see whether following gaze behind barriers was in some sense more difficult for children than straight gaze following.

In addition to its naturalness, this variation on the Barrier paradigm has two other important advantages over the Barrier paradigm used by Caron and colleagues. First, it enables us to test a widely accepted hypothesis in the study of infant gaze following in a new way. Whereas in the Caron *et al.* paradigm the child sees the adult's head turn in a certain direction, and also at some distance in that direction can see an object that the adult could potentially be looking at, in the current paradigm when the child turns to look in the direction in which the adult is looking she sees no object but only some kind of boring barrier. This means that the child who successfully follows adult gaze behind a barrier in our paradigm does so to a space originally out of her field of view – something infants are not supposed to be able to do until 18 months of age (Butterworth's representational mechanism). Second, the response elicited from the child is not simply a turning of the head to follow gaze direction, but rather a much more active response than simple visual orientation. Thus, for example, if the adult looks down into an open box, to follow that gaze to its target the child would have to actively locomote to a new location next to the box so as to obtain a good viewing angle – arguably, this is a more demanding response requirement. Even so, because the current paradigm is more natural for infants, it might be that even younger infants show some skills and knowledge in this new version of the Barrier paradigm.

Study 1

In this study, we investigated whether infants of 12 and 18 months follow the gaze direction of an adult to a location behind various kinds of barriers.

Method

Participants

Participants were 39 children from a medium-sized German city. There were two ages: 20 children (11 boys, 9 girls) were 12 months old (mean = 12;16, range = 12;02 to 13;08) and 19 children (7 boys, 12 girls) were 18 months old (mean = 18;01, range = 17;18 to 18;24). The participants were taken from a database of parents who had volunteered to participate in studies of child development. Nine additional children dropped out of the study because of fussiness or inattentiveness (three 12-month-olds, three 18-month-olds) or because video-recordings were incomplete due to equipment failure or experimenter error (two 18-month-olds, one 12-month-old).

Materials and design

Each participant was tested individually for her tendency to follow an experimenter's gaze behind a barrier. All children were exposed to four different tasks, represented by four different barriers. There was one experimental and one control trial per barrier for each child. The following materials were used as barriers:

1. *Dividing wall*: This was a solid barrier made of wood and cardboard held by four sustainers (1.10 m high, 1.04 m wide, 4 cm thick).
2. *Box*: A cardboard box placed on its side was used as a barrier (54 cm high, 53 cm wide, 30 cm deep). The side opposite to the opening faced the child.
3. *Panel*: A wooden, movable panel functioned as a barrier (1.65 m high, 1.38 m wide, 3 cm thick).
4. *Drawer*: The bottom drawer of a filing cabinet was used as a barrier (height from floor to top = 37 cm; 79 cm wide). The drawer was open throughout.

All barriers had fixed positions in the testing room and were not moved during testing. Four familiar small toys made of plastic or plush were used as the targets to be found behind the barrier in experimental trials. Another four slightly larger toys made of plastic or plush were used as targets in control trials.

Each child received a total of eight trials – one experimental and one control trial for each of the four tasks. Both trials for a task were run before moving on to the next task. For a given subject, order of condition was identical for all four tasks, but order of conditions was counterbalanced across children within age groups. That is, ten 18-month-olds and ten 12-month-olds received the control condition before the experimental condition for each task, and nine 18-month-olds and ten 12-month-olds had the opposite order of conditions for each task. Order of tasks was partially counterbalanced across children within age group as well.

Observational procedure

The study took place in a quiet room (4.5 m × 3.5 m) in a child observation laboratory. Each child was accompanied by a parent and was seen for one session of about 10 to 15 minutes. Before the experiment started, each child had a short warm-up phase in a waiting room where one of two experimenters (E1 or E2) played with the child until she seemed sufficiently acclimatized. E1 was the same female experimenter for all children.

Then E1, the child and the parent went into the testing room. E2 operated a video camera from behind a curtain. The child, either sitting or standing, was positioned on the carpeted floor within an area encircled by chalk (diameter = 25–30 cm) approximately 60 cm in front of the first barrier on the schedule. The parent sat behind the child on the floor. E1 sat next to the barrier facing the child and made eye contact with her by saying her name. Parents were instructed to keep the child from walking/crawling away just before eye contact was established. At this point came the experimental manipulation.

For the experimental condition, E1 leaned over and looked behind the barrier, accompanying her gaze with the sound effect 'Oh!' and a facial expression of excitement. The distance between her and the target toy was approximately 60 cm. The angle of her head turn was about 70° to 80°. She sustained her gaze behind the barrier for approximately 3 s. She then looked back at the child and waited for approximately another 4 s. If children did not locomote behind the barrier, E1 repeated this action up to two times more. The best response was used for analysis. For the control condition, E1 looked to a toy (control target) on the wall in a direction away from the barrier. The distances between the child and the control target, as well as between E1 and the control target, were approximately 1 m to 3 m depending on task. The angles of E1's head turns varied between about 45° and 120° also depending on task. The toy was attached to a curtain at a height of approximately 1.50 m from the floor. The sound effect and the facial expression accompanying the gaze as well as its duration were the same as for the experimental condition. Here also, the cue was repeated up to two times.

After the two trials of the first task, the child, parent and E1 then moved over near to the second barrier and the procedure was repeated in exactly the same manner. The procedure was the same for all four barriers.

Scoring procedure

All trials were scored from the video-recordings by the first author. For all trials, experimental and control, it was judged whether the participant moved around the barrier to gain visual access to what E1 was looking at. For the three barriers in which looking around, rather then looking inside (drawer) was necessary, the criteria were identical: (1) the child had to move the distance until she had visual access to the back of the barrier, and (2) she had to look to the target location where E1 had gazed (e.g. a child crawling past the barrier going somewhere else was not scored a positive response). For the drawer, where looking inside rather than looking around was required, the second criterion was that the child had to lean forward and look inside to the bottom of the drawer. In addition, control trials (but not experimental trials) were also scored for whether the child followed E1's gaze to the control target on the wall.

To assess inter-observer reliability, a random sample of eight out of the 39 subjects (21%) – with equal numbers for both ages and both conditions – was scored by an independent research assistant blind to condition (E1 was blocked out of the videotapes). This observer agreed with the primary coder's judgment in 100% of the trials, leading to a Cohen's Kappa of $\kappa = 1$ for 'looking behind the barrier' in all trials as well as 'gaze following' in control trials.

Results

We conducted a three-way analysis of variance (ANOVA) with age and order as between-subjects factors and condition as a repeated measure. Since no significant effects were found for order, a subsequent two-way ANOVA using only age and condition was conducted. Following significant factor effects or interactions, pairwise comparisons using Fisher's LSD procedure were conducted.

Figure 1 presents the mean scores (out of 4) for looking behind barriers in the two conditions for both age groups. Means (with standard deviations in parentheses) for 12- and 18-month-olds in control trials were .10 (.31) and .26 (.56), respectively. In experimental trials they were .90 (1.29) and 3.26 (1.28), respectively. There was a

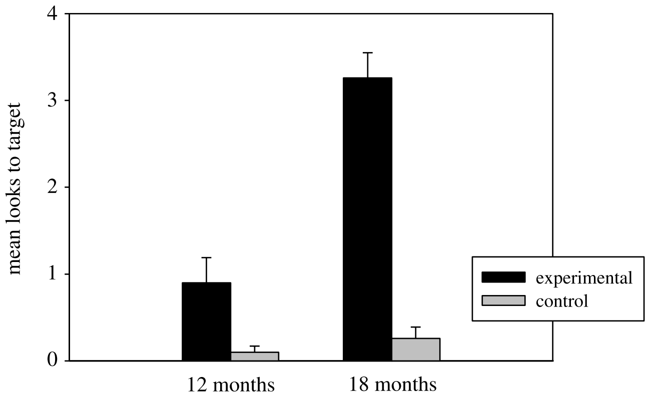

Figure 1 *Study 1. Mean scores (+ SE) of 12- (n = 20) and 18-month-olds (n = 19) for looking behind barriers in experimental and control condition.*

significant main effect for both factors. Eighteen-month-olds looked overall more than 12-month-olds, $F(1, 37) = 28.50$, $p < .001$, and all children looked behind the barrier more in the experimental than in the control condition, $F(1, 37) = 70.35$, $p < .001$. Pairwise comparisons revealed that both 12-month-olds ($p < .01$) and 18-month-olds ($p < .001$) followed gaze behind barriers more often in the experimental than in the control condition. In addition, a significant interaction between age and condition, $F(1, 37) = 30.51$, $p < .001$, revealed that the performance of the 18-month-olds was better than that of the 12-month-olds in that they followed gaze behind barriers more in the experimental trials ($p < .001$) though not in the control trials ($p = .265$).

Also of interest was whether infants followed gaze to the target on the wall in the control condition, and how this related to their following of gaze behind barriers in the experimental condition. Table 1 presents for both ages separately the relation between (a) gaze following to visible control targets on the wall in the control condition and (b) gaze following to targets hidden behind barriers in the experimental condition. The 18-month-olds were good in both tasks. Thirteen of the 19 children followed gaze successfully on all four hidden and all four visible trials. The other six children all obtained a higher score for gaze following to visible targets than to hidden targets ($p < 0.05$, binomial probability). Three 12-month-olds obtained the same score for targets of both types, whereas 17 obtained a higher score for gaze following to visible targets than to hidden targets ($p < 0.001$, binomial probability). This means that for children of both ages it is more difficult (or at least they are less likely) to follow gaze behind barriers than to visible targets (23 to 0; $p < 0.001$, binomial probability).

Table 1 *Gaze following to targets behind barriers and control targets on the wall for both ages*

Age (months)	Gaze following behind barriers	Gaze following to control targets					
		0	1	2	3	4	Total
12	0	1			4	7	12
	1					3	3
	2				1	2	3
	3						0
	4					2	2
	Total	1	0	0	5	14	20
18	0					2	2
	1					1	1
	2					1	1
	3					2	2
	4					13	13
	Total	0	0	0	0	19	19

Discussion

In this study both 12- and 18-month-old infants followed an adult's gaze to a target location behind a barrier. In the previously used Barriers paradigm of Caron and colleagues – in which the adult's, not the child's, view to a target was blocked – the findings with 12-month-olds (and even 14-month-olds) were mostly negative. We believe that our paradigm produced more positive results for young infants because it is a more natural situation with fewer conflicting cues. That is, the adult simply looked to an object that the child was unable to see, a common and salient situation in daily life. And importantly, this behavior produces no inconsistent or mixed cues that the child has to balance. That is to say, whereas in the Caron *et al.* barrier procedure children have to inhibit their natural reaction to follow the adult's gaze to a location some meters away (i.e. by taking into account the adult's blocked view), in our procedure they simply followed their natural curiosity to see what the adult was seeing. It is also important that to do this they had to do more than simply turn their head in the specified direction – the response measure used in the Caron studies as well as all other gaze following studies – but rather they had to actually walk or crawl some steps to gain the appropriate viewing angle. This is arguably a more demanding response measure than turning the head, and so it is very likely not the case that our task is easier for young children for some trivial reason.

When children's gaze following to the targets hidden behind barriers was compared to their gaze following to the visible target in the control condition, it was clear that children found following gaze to visible targets somehow easier. This suggests that it is not the case that from the moment children follow gaze they naturally follow it everywhere, including behind opaque barriers. There is a clear developmental ordering, perhaps suggesting that children need more experience in following gaze to learn how barriers work. (This is assuming that the need to locomote to the barrier, as opposed to simply turning the head, was not a significant impediment to infants' gaze following.)

Nevertheless, even if visible targets are easier, it is still the case that 12-month-olds clearly demonstrated their ability to follow an adult's gaze to locations out of their current field of view. This contradicts the findings of Butterworth (Butterworth & Cochran, 1980; Butterworth & Jarrett, 1991), who looked behind children and required them to turn around and look behind themselves to locate the invisible target. Apparently, when they do not have to turn around and looked behind themselves even 12-month-olds have what Butterworth called a 'representational mechanism' for establishing joint visual attention with another person.

One objection to these conclusions involves the exact nature of the control condition in this study. It could be argued that by looking in a direction away from the barrier in the control condition, the infant's attention was drawn away from the region near the barrier. This is as opposed to the experimental condition in which simple co-orientation would lead the child in the direction of the barrier. This leaves open the possibility that children in this study were not following the adult's gaze to a specific location behind the barrier, but rather they were simply orienting in the direction of the adult and when they saw the barrier they decided, on their own, to look behind it. We therefore designed a second study with a more stringent control condition in which the experimenter gazed to a location on the front side of the barrier, thus drawing attention to the barrier equally in the two conditions.

Study 2

Study 2 was a replication of Study 1 with a more rigorous control condition in which the adult looked to a specific location on the front side of the barrier – thus drawing attention to the barrier equally in the two conditions.

Method

Participants

Participants were a new group of 32 children of the same two ages as Study 1, recruited from the same database. There were 16 (8 boys, 8 girls) 12-month-olds (mean =

12;16, range = 12;05 to 12;27) and 16 (9 boys, 7 girls) 18-month-olds (mean = 18;02, range = 17;29 to 18;16). Five additional children (one 12-month-old, four 18-month-olds) failed to complete the study due to fussiness or inattentiveness.

Materials, design, procedure

The same basic materials were used in the study, except that (a) the box used in Study 1 was replaced by a shallower box (62 cm high, 62 cm wide, 15 cm deep) so that children needed to locomote less along the side of the barrier in order to look behind it (in Study 1 infants looked less behind this than the other barrier types), and (b) the drawer was replaced by a black plastic bucket (40 cm high, diameter = 35 cm) because several children in Study 1 tried to push and pull the drawer. The toys used in experimental trials were similar to the ones used in Study 1. For the control trials small flat stickers (~ 4 cm × 4 cm) were glued onto the lower part of the front of the barrier.

The design of the study was the same as that of Study 1. Eight children of each age group started with the experimental condition in each task, the other 16 children received the opposite order of conditions (randomly assigned). The observational procedure used in this study was identical to that of Study 1 except that in control trials E1 gazed to the sticker on the front side of the corresponding barrier (instead of turning to a different direction in the room away from the barrier, as in Study 1). The distance between the child and the control target was about 60 cm, and between E1 and the control target it was approximately 70 cm. The degree of E1's head turn was about 70° to 80°. A small difference with Study 1 was that in all trials E1 repeated her gaze at most once, and after every trial (not just successful ones) children were shown the toy from behind the barrier (to counteract differences in possible learning effects across trials).

Subjects' responses were scored just as in Study 1. A random sample of nine out of the 32 children (28%, four 12- and five 18-month-olds) were coded by an independent research assistant blind to condition. She agreed with the experimenter's judgment in 100% of the trials, leading to a Cohen's Kappa of $\kappa = 1$.

Results

Descriptive statistics revealed large differences in the variances of gaze following in the experimental condition among the two age groups. Data were therefore subjected to a natural logarithmic transformation and a three-way ANOVA assessing age, order and condition

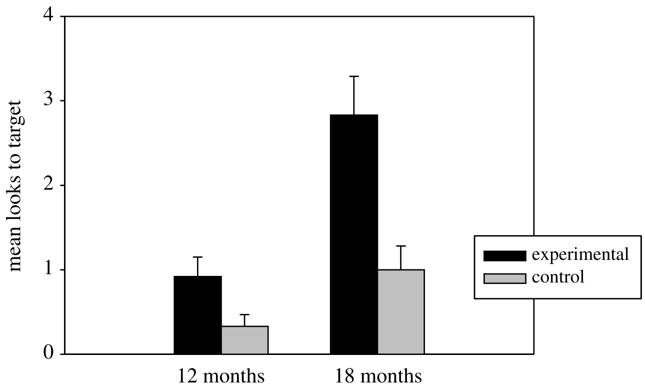

Figure 2 *Study 2. Mean scores (+ SE) of 12- (n = 16) and 18-month-olds (n = 16) for looking behind barriers in experimental and control condition.*

was performed. No significant effects of order were found, and a two-way ANOVA with age as a between-subjects factor and condition as a repeated measure was used for the main analysis.

Figure 2 shows the untransformed mean scores for looking behind the barrier in the two conditions for both age groups. Means (with standard deviations in parantheses) for 12- and 18-month-olds in control trials were .33 (.49) and 1.00 (.95), respectively. In experimental trials they were .92 (.79) and 2.83 (1.59), respectively. There was a significant main effect for both factors. Overall, 18-month-olds looked more than 12-month-olds, $F(1, 30) = 6.10$, $p < .02$, and all children looked behind the barrier more in the experimental than in the control condition, $F(1, 30) = 31.50$, $p < .001$. Pairwise comparisons revealed that both 12-month-olds ($p < .05$) and 18-month-olds ($p < .001$) followed gaze behind barriers more often in the experimental than in the control condition. In addition, a significant interaction between age and condition, $F(1, 30) = 5.55$, $p < .03$, revealed that the performance of the 18-month-olds was better than that of the 12-month-olds in that they followed gaze behind barriers more in the experimental trials ($p < .01$) though not in the control trials ($p = .218$).

Discussion

The results of this study replicate those of Study 1. It is possible that in the control condition of Study 1 children's attention might have been drawn away from the barrier to a different location in the room. In the current study, the target of the experimenter's gaze in the control condition was a sticker on the side of the barrier facing the child, so that in both conditions the child's attention was drawn to the barrier. It is important to note that if there had not been a barrier, in the control condition E's gaze would have targeted almost exactly the same location as in the experimental condition.

Compared to Study 1, the control condition of this study did lead to a higher rate of false positives, as expected. Children sometimes looked behind the barrier in the control condition when the experimenter only looked in front of it. Despite this higher baseline (approximately 3 times higher than in Study 1), both 12- and 18-month-olds still looked behind the barrier significantly more often in the experimental than in the control condition. Again, as in Study 1, this effect was stronger for the 18-month-olds than for the 12-month-olds, indicating that at 12 months this ability has just started to develop and becomes more reliable and robust during the following 6 months.

General discussion

In the current studies 12- and 18-month-old infants crawled or walked a short distance in order to look behind a barrier an adult was looking behind and thereby see what the adult was seeing. They did not do this in two control conditions in which a barrier was present but no one was looking behind it (rather they were looking in front of it or across the room). This is the strongest evidence to date that children in this age range understand that others see things.

These findings are perhaps not so surprising for 18-month-olds, as a number of studies using a variety of different methods all converge on this conclusion (Corkum & Moore, 1995; Moore & Corkum, 1998; Butler *et al.*, 2000; Brooks & Meltzoff, 2002). They are, however, surprising for 12-month-olds since other researchers have not found comparable results with children this young. First, based on the fact that 12-month-olds do not follow gaze to locations directly behind themselves, Butterworth and Jarrett (1991) concluded that 12-month-olds only track gaze direction geometrically to locations within their field of view (only at 18 months do infants understand seeing 'representationally', that is, involving unseen target spaces). The current results clearly contradict this conclusion, as the objects the adult looked at were initially out of the infant's field of view behind one of several different types of barriers. Apparently looking behind a barrier is an easier or more natural situation than turning around to look behind oneself.

Second, in a previously used barrier paradigm, Caron and colleagues placed screens fairly close to an adult's face so that when she turned to look her line of regard was blocked so that she could not see a toy the child could see (Butler *et al.*, 2000; Caron, Kiel *et al.*, 2002). Unambiguously positive results were not found with 12- or 14-month-olds in this paradigm, only with 15-month-olds. This might be because in this paradigm if the child follows the adult's line of regard she will eventually get to the toy some meters away, a fairly common situation in their daily lives, and it is not so obvious why gaze following to the object in this situation is unreasonable, especially when the impression of a visual experience is enhanced by vocal cues (e.g. 'Wow!' in Butler *et al.*, 2000; Caron, Kiel *et al.*, 2002) or pointing (Caron, Kiel *et al.*, 2002). Alternatively, the infant may realize that the adult's line of regard is blocked and stop at the screen. But this requires overcoming a competing response tendency to simply follow gaze direction to a seen object some meters away. In contrast, our barrier study, in which the child's and not the adult's vision is blocked, does not present the child with any competing response tendencies; she is either interested in what the adult is looking at behind the barrier or not. And it is definitely not the case that we had an easier response measure than other studies, as we required infants not just to look in the direction in which an adult was looking (as other studies), but to actively locomote to put themselves in the proper viewing position. Infants had to want to see what the adult was seeing.

The one similar paradigm with positive results for 12-month-olds involved Eye Status. Twelve-month-olds have been found to know something about the role of the eyes in the seeing process in that they follow gaze more often when an adult has open eyes than closed eyes. But they do not make the same difference when the adult's eyes are covered with a blindfold, thus limiting what can be said about their general understanding of the role of the eyes (Brooks & Meltzoff, 2002). But, in any case, following Tomasello (1996) we would argue that knowing the role of the eyes in the seeing process is not the crucial question; it is a mechanical issue. After all, how many adults know whether the iris or pupil or both are crucial to the seeing process? The crucial issue is the epistemological one: do infants know that others see things like they themselves do? In the current study, the most natural interpretation is that infants wanted to see what the adult was seeing no matter how that process was effected mechanically. Supporting this interpretation, Tomasello and Haberl (2003) found that 12-month-olds could determine which one of three objects an adult was attending to based not on her visual line of regard at all, but rather on a knowledge of which of the objects was novel for her. That is, when the infant saw the adult getting excited and asking for an unspecified object from an array of three in front of her, infants knew that she did not want either of the two that they had played together with previously, but rather the one newly arrived on the scene – since people get excited not about old things but about new things. And so we do not believe that the central issue is one of understanding the role of the eyes as mechanisms – though this is of course an interesting question for other reasons – but rather the central issue is how the child understands what the adult is seeing or attending to, however that is accomplished.

Indeed, in one interpretation the current results could be seen as evidence for Level 1 perspective taking, which Flavell (e.g. 1977) defines as knowing what other people can see. This comprises both cases of knowing that another person cannot see something the child can see and knowing that another person can see something the child cannot see (as in the current studies). The child thus knows that the adult sees something she does not, and therefore she moves behind the barrier. However, it is possible that Level 1 perspective taking is more difficult in the other case, where the adult does not see something that the child sees – perhaps due to something like 'the pull of the real'.

No doubt, leaner interpretations of our findings are possible. Indeed, the current study was modeled on a previous study with chimpanzees, who successfully followed human gaze direction behind barriers (although without the control condition of the current Study 2; Tomasello, Hare & Agnetta, 1999), which some people might take as prima facie evidence that following gaze behind barriers does not imply understanding that others see something. But converging evidence from other experimental paradigms, in which chimpanzees compete with one another for food either out in the open or behind barriers, suggests that our closest living relatives do in fact know what other individuals can and cannot see. So the fact that chimpanzees also follow gaze behind barriers does not count as evidence against the hypothesis that in following gaze behind barriers 12-month-olds want to see what the other is seeing.

It is of course possible that 12-month-old infants have some kind of automatic gaze following mechanism that leads them to look where others are looking without any understanding that others are seeing things – a kind of perceptual version of stimulus enhancement (that even includes dealing with barriers). This explanation may be applicable to 6-month-olds, who turn to look in the direction others are looking and fixate the correct target only if it is in their peripheral vision from the beginning (D'Entremont *et al.*, 1997). But it is not likely in the case of 12-month-olds who not only crawl behind barriers to see what others are seeing (as in the current study), but also know what is new for others (Tomasello & Haberl, 2003), point out and show objects to others, engage in joint attentional interactions with others, imitate the intentional actions of others and, in general, seem to show an understanding that others are intentional agents like themselves (Carpenter, Nagell & Tomasello, 1998). It is also possible that all of these different behaviors are learned contingencies (Moore, 1996), but even if that is to some extent true what is being learned depends on an understanding that other persons intend things behaviorally and attend to things perceptually. In general, the fact that something is learned does not mean that sophisticated cognitive processes are not involved.

The current studies thus add to the growing body of evidence that the ontogenetic period around children's first birthdays represents a revolution in the way they understand other persons (Tomasello, 1995, 1999; Carpenter *et al.*, 1998). In addition to understanding what they perceive – as suggested by the current results – infants of this age also seem to know things about what others intend in performing an instrumental action (Behne, Carpenter, Call & Tomasello, 2003). Of course, infants' social-cognitive skills become more flexible and more reliable in the period from 12 to 18 months of age, and, in addition, during this period infants are developing new skills for understanding various types of shared intentionality involving collaborative interaction and symbolic communication. But this all gets its start from 12-month-olds' considerable skills in determining what other persons intend and perceive.

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