Gaze Following: A Key to Understanding Self, Other, and Language Development

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From the first smile to the first word, infants’ social acts are greeted with joy and awe by parents. Regardless for the reason for the smile, parents are hooked—and so are the researchers who study these acts. Parents connect emotionally to their infants in moments of eye contact and face-to-face interactions; researchers see in the behaviors budding acts of intersubjectivity and the roots of reciprocity and communication. These joyful one-on-one, dyadic interactions are destined not to last, because third parties come onto the scene. Notably the parent’s eyes stray to objects in the surround, and the infant begins to notice. This is the birth of what scientists term “triadic exchanges”—an external object becomes a joint focus of parent and infant play.

For adults, shifts of eye gaze to external objects convey crucial information. When a person suddenly turns to look out a window, onlookers will follow his or her gaze. The observers are prompted look out the window to see what the other gazer sees. Understanding eye shifting as more than a bodily movement, but instead as a perceptual/referential act, informs the observer of the gazer’s perceptions, desires, emotions, and intentions. Thus, understanding the meaning of eye gaze is integrated into our adult social understanding of other people. We do not “follow” the direction of the boughs blowing on a tree, nor follow the doorknob swinging open; we follow the gaze of people. How do we know what movements to “follow”? What makes gaze special? When does it become so to infants?
Following the gaze of others is an entry point into the understanding the minds of others. For adults, it is not simply that the other person turns a direction such as to the left or to the right; rather it is the other’s eye gaze that is understood as seeing or referring to something in the external world—prototypically something that lies in distal space across the room. For example, a mother might look at a distal object with a disgusted facial expression at an object while saying, “Yuck, I don’t like that!” or “That’s so annoying!” Adults viewing this act can follow her gaze and discover what caught her attention and disgusted/irritated her. They can follow gaze to help decode the meaning of her emotion, and in so doing learn assign valences to objects in the objects and events in the world (e.g., Repacholi & Meltzoff, 2007).

Infants enter the interpersonal world of gaze following before their first birthdays. This much is uncontroversial. The way that infants come to understand gaze as a psychological act is more controversial. We hypothesize that an important mechanism for this development is infants’ own first-person experiences with their own vision. We suggest that infants use their own visual experiences to help them interpret the visual experiences of others. We call this the “Like me” developmental framework, a view that has been applied to other aspects of social-cognitive development such as imitation, intention, and emotion understanding (Meltzoff, 2007; in press). The relevant work supporting this developmental view is reviewed in this chapter.

**Looking for Connections: Putting Gaze Following into a Larger Context**

In the chapter we also will examine aspects of “joint visual attention” more broadly. There are several different behaviors and terms that are used in the literature to indicate the sharing attention on distal object (pointing, joint engagement, joint visual attention), and the next section provides an analysis of these terms. Each of these terms has been the focus of a slightly different literature and has been linked to language development (e.g., Baldwin, 1993; Brooks &
Meltzoff, 2008; Carpenter, Nagell, & Tomasello, 1998; Csibra, 2003; Meltzoff, Kuhl, Movellan, & Sejnowski, 2009; Mundy, Sullivan, & Mastergeorge, 2009). We will, therefore, examine each in turn and clarify the relationship to the ontogenesis of gaze following, which is our chief focus.

**Joint engagement.** Joint engagement occurs when two individuals jointly attend to the same object. For infants this usually happens when they are playing with an object and their parent. Infants may look up during play to check what the parent is doing. An argument has been that infants are attempting to share visual attention when they initiate eye contact with an adult and shift their own gaze to a toy. When infants alternate their gaze, they are said to show their awareness of the adult’s eye gaze and visual focus. This type of gaze alternation is called “coordinated joint engagement” (Adamson, Bakeman, & Deckner, 2004; Bakeman & Adamson, 1984). Key to its definition is that infants initiate eye contact with an adult rather than looking up in response to the adult’s verbal comment (Carpenter et al., 1998).

Infants’ alternation of gaze varies by the context of assessment. In clinical assessments, when infants are already facing an adult tester and an object, infants from 9 to 18 months consistently are able to make eye contact with an adult tester and alternate gaze to an object (Mundy et al., 2007). In contrast, in studies of unstructured play with their mothers, infants have only fleeting moments of coordinated joint engagement at 6 to 9 months old, but become more consistent after 12 months old (Carpenter et al., 1998; Striano & Bertin, 2005). However, even at 18 months infants spend less than 30% of their play in coordinated engagement (Adamson et al., 2004; Bakeman & Adamson, 1984). Instances are interspersed into play more often when infants interact with their parents than their peers (Bakeman & Adamson, 1984).

The support or “scaffolding” provided by one’s social partner may induce joint engagement. Infants may look at their mother for a variety of reasons, such as checking what she
is doing (Moore & Corkum, 1994), but without seeking to share visual attention. When a mother observes her child look back and forth from a toy to her face, the mother may verbally label that toy (i.e., “follow-in labeling”). This parental support may enable infants to alternate gaze without recognizing that visual attention connects viewers to objects.

**Links to language.** Infants’ contribution to coordinated joint engagement seems to relate to the development of language. However, parental support may also play an important role in this relationship. The pattern of results shows that the tendency for 14- to 18-month-old infants to initiate and maintain coordinated joint engagement predicts subsequent vocabulary development, especially infants’ productive language (Markus, Mundy, Morales, Delgado, & Yale, 2000; Mundy et al., 2007; Smith, Adamson, & Bakeman, 1988). After infants become more consistent in alternating their gaze (usually after 12 months), infants’ gaze coordination significantly predicts their larger vocabulary, even after accounting for effect of parental labeling (Carpenter et al. 1998). In contrast, at 9 to 12 months of age (when the behavior is very brief and sporadic), infants’ gaze alternation usually does not predict vocabulary size, but maternal follow-in labeling does (Carpenter et al., 1998; Masur, Flynn, & Eichorst, 2005; Rollins, 2003). These findings show that at least at older ages gaze alternation is related to language development.

**Pointing.** Infants can direct attention of others by pointing to objects or events. For pointing to be successful in a communicative context, the recipient should see the pointing gesture and appreciate the “message” of the point. The prototypical demonstration of this gesture is to extend one’s arm and index finger toward an object (Butterworth, 2003), though other hand gestures (e.g., whole hand) are seen in social interactions (Franco & Butterworth, 1996). Infants usually begin pointing to things or events in their surroundings between 9 and 12 months (Butterworth, 2003; Camaioni, Perucchini, Bellagamba, Colonnese, 2004; Carpenter et al., 1998).
Bates and colleagues (Bates, Camaioni, & Volterra, 1975) make a distinction between the types of messages conveyed by pointing—dividing points in proto-imperative (“I want that”) and proto-declarative meanings (“Look at that”). Some theorists argue that proto-imperative points do not require infants to appreciate others’ visual attention. Rather, it has been argued that infants are simply trying to obtain something by directing the adult’s behavior rather than the adult’s attention (Camaioni, 1997; Colonnesi, Stams, Koster, & Noom, 2010). For proto-declarative points, many theorists suggest that infants point to direct and share attention to objects (Franco & Butterworth, 1996; Camaioni et al., 2004; Liszkowski, Carpenter, Henning, Striano, & Tomasello, 2004; Csibra, 2003; Tomasello, Carpenter, Liszkowski, 2007). However, this view of infant pointing (i.e., sharing attention) is not universally accepted (D’Entremont & Seamens, 2007; Moore & Corkum, 1994; O’Neill, 1996).

As noted previously, someone has to see the pointing gesture for it to lead to successful transfer of information and interpersonal communication. Do infants recognize that their gesture should be visible to others? Although not a direct test, researchers have coded whether or not infants look at others as they point. When pointing 10- to 14-month-old infants are likely to first point at the event and then look at the adult (Bates et al. 1979; Franco & Butterworth, 1996; Liszkowski et al., 2004). After 15 months, they become more likely to look the adult before pointing out the event (Franco & Butterworth, 1996). This change may be relevant to the issue of when the infant is initiating the point in order to convey information to the other.

A more direct way of examining infants’ use and understanding of pointing as an act of communication and visual sharing is assess whether infants change their pointing in relation to what others can see. The test of this has often been in contexts in which one event is out of adult’s view, such as behind the adult. By 12 to 15 months old, infants point to a nearby event
(e.g., a moving puppet) when the adult does not turn to face it (Camaioni et al., 2004; see Tomasello et al., 2007, for a review). In situations where an adult is actively searching for an object (e.g., a pen) after accidentally dropping it on the floor, 12-month-olds point to the object’s location (Liszkowski, Carpenter, Striano, & Tomasello, 2006).

Some have argued, however, that even these findings do not clearly show that infants point to direct others’ visual attention (D’Entremont & Seamens, 2007; Moore & Corkum, 1994). Infants might point to the missing pen because it is interesting that it dropped to the floor. A conservative interpretation is that infant pointers indicate objects that are of interest to them without inferring what the adult sees or knows. In contrast, from a rich interpretation, infants point to indicate the object and to inform the adult of the object’s current location (Camaioni, 1997; Tomasello et al., 2007). According to this rich view, infants are informing the adult of the location of the object or the event because the adult has not seen it (and is thus unknowledgeable). A clearer test might involve two identical events of equal interest to the self, but only one of which is unseen/unknown to the adults. Liszkowski, Carpenter, and Tomasello (2008) designed such a test in which two objects happened to fall off a table, but only one was seen by the adult. With this stricter test, 12-month-olds showed some awareness of others and pointed to the object that the adult had not seen.

Links to language and further implications. Pointing could support language development for many reasons. Research shows that, as early as 10 to 12 months old, infants’ pointing predicts subsequently larger vocabulary size (Bates et al., 1979; Brooks & Meltzoff, 2008; Carpenter et al., 1998). In a meta-analysis, Colonnese and colleagues (Colonnese et al., 2010) found that declarative pointing predicted subsequent language, but imperative pointing did not. This specific pattern supports the argument that pointing relates to language because of its
referential function of indicating objects. Pointing also was significantly related to concurrent language (Colonnesi et al. 2010). An infant’s point invites parents to a name an object, and thus, infants’ pointing promotes increased word learning opportunities (Brooks & Meltzoff, 2008).

**Conceptual Issues in Following the Gaze of Others**

It is evident that infants engage in preverbal communication with adults: They can both decipher adult’s references to external objects, as well as direct adult’s attention to them. We now turn to gaze following per se, which is one particular component of this larger network of social-communicative activities. We feel that gaze following is of special importance because it allows infants to eavesdrop on the adult. Adults look at important objects, people, and events in the world, and if an infant can gaze follow, it accelerates their learning because their own attention is brought to these significant places.

Gaze following refers to the act of looking where another person just looked. Adult observers seek to catch a glimpse of what the gazer is seeing. But this seemingly simple act involves understanding a number of components. To start, one must emphasize the word “gaze” in gaze following; similarly, the word “following,” requires that the observer respond to the gazer’s look and not something else. For example, it is not gaze following if a loud plane prompts both the child and mother to look at the object at the same time, because that would be synchronized looking due to a common third cause (the noise). Nor is it gaze following if an infant tracks the adult’s head movement or bodily orientation and does not process the adult’s gaze. In its most sophisticated forms, as in adults, the act of gaze following also includes an inference about perception: The observer follows in order to see what the gazer is perceiving.

Though adults readily make these attributions and follow the eye gaze of others, it is important to examine when an understanding of gaze develops. Across different lines of work,
researchers have examined whether infants recognize and follow the gaze of others to external objects, including distal ones that lie outside of the infant’s current field of view. In analyzing gaze following per se, it useful to distinguish it from other closely aligned phenomena.

**The salience of eyes and gaze shifts.** Gaze detection is one of the closely aligned phenomena that is not gaze following per se, but is sometimes confused with it. In studies with presentations of faces, even newborn infants distinguish whether eyespots are directed forward toward them or averted to the side (Farroni, Massaccesi, Pividori, & Johnson, 2004; Johnson, Grossman, & Farroni, 2008). However, it should be noted that infants could differentiate these displays based on physical properties of the displays, such as whether high-contrast stimuli are centered or lateral.

In another line of research, shifts of eye gaze have been used to cue the location of targets, such as a rectangle or an asterisk (Hood, Willen, & Driver, 1998; Johnson et al., 2008). The classic stimulus in this cueing procedure is a digitized face with eyes that shift to one side before a target appears slightly to the left or the right of the face. The 2D face usually vanishes from the screen before the close-in peripheral targets appear. Adults and infants typically make saccades with shorter latencies to the target that has been cued: If the cue shifts to the right side, they will look to a probe that appears on the right faster than on the left (Frischen, Bayliss, & Tipper, 2007). Under specialized conditions, this cueing effect is even seen with newborns (Farroni et al., 2004).

Though interesting, the findings do not provide evidence about following gaze in actual social interactions—an interaction that typically involves looking at objects in distal space outside of one’s peripheral view. Also, in the real world, when a mother looks at an object, her face does not disappear to allow the infant to disengage from it and make a saccade to the
peripheral target—yet that is the procedure used in the gaze cueing studies. Indeed if the gaze cueing procedure is slightly changed so that the face remains on the screen, the cueing effect disappears (Hood et al., 1998). Moreover in the cueing studies, it is not necessarily the eyes, but apparent motion that provides the directional signal to infants: When the face is artificially displaced laterally (e.g., to the left) and the eyes remain fixed on the screen, this apparent motion cues infants to the left (Farroni, Johnson, Brockbank, & Simion, 2000, Experiment 2). This raises the possibility of motion following and not gaze following. Furthermore, in this cueing paradigm the peripheral targets pop into view (after the face vanishes), and this sudden appearance of a target is in marked contrast to real world social interactions. In social interactions the world stays stable and the parent’s gaze spotlights an existing object. In short, infants’ sensitivity to directional shifts in the cueing paradigm does not ensure that infants would follow the gaze of actual people, and the underlying mechanisms supporting these two behaviors may be different.

Tests of Infant Gaze Following

In the typical gaze-following paradigm, an adult makes eye contact with the infant and then turns to a distal object that is often outside of peripheral view. This situation gives infants an opportunity to follow the adult’s line of regard to the distant object. However, when tracking where the person turns, how do we know that infants are following the looker’s eye gaze?

**Heading toward targets.** Early reports suggested that infants seem to follow an adult’s line of regard by 3 to 6 months of age under certain conditions (Butterworth & Jarrett, 1991; Scaife & Bruner, 1975). A difficulty interpreting these findings is that the adult turns her eyes and head toward a target. The adult’s salient head motion may draw infants in the correct direction without them processing the adult’s gaze at all (Moore, 1999; Moore & Corkum, 1994). Empirical evidence and computational models support the claim that salient head movements
often drive where infants look (Corkum & Moore, 1995; Deák, Flom, & Pick, 2000; Triesch, Teuscher, Deák, & Carson, 2006)—which of course is not gaze following at all.

For our discussion, this is an important claim because with this conservative interpretation infants are pulled in the correct direction by the adult’s head turn, and then they coincidentally notice the same object as the adult. This is not gaze following per se. First, infants are not required to notice the gaze of the adult because infants follow the directional signal of the adult’s head motion. Second, though infants are responding the adult’s action, they are not searching the target of the adult’s gaze; infants come across an interesting object by coincidence. Third, infants need not make any effort to infer what the other sees because the motion is sufficient to attract the infants’ attention. Following body or head motion shifts infants’ own attention without any regard for the adult’s eyes or inference of what the adult has perceived.

A test of gaze following. We developed a test of whether or not infants truly follow gaze (Brooks & Meltzoff, 2002). In the paradigm, an adult turned toward one of two identical targets (situated off to the left and the right side of the infant). Importantly, the adult’s head motion was controlled. Infants were randomly assigned to one of two groups: for one, the adult silently turned toward a target with open eyes and for the other group she turned with closed eyes.

The reason such a manipulation is crucial for theory is that our eyes are our means of visual perception. We see with our eyes and not our head. An important step toward gaining the adult psychological interpretation of “seeing” is to recognize that the eyes are critical. If infants understand that the eyes are relevant for connecting the adult and the object, they should differentiate the two conditions and look at the target object when the adult turns with open eyes. If, however, infants respond to head movements, they should turn in response to both actions.

Brooks and Meltzoff (2002) invited 12-, 14-, and 18-month-old infants into the laboratory
for the Eyes Open/Closed test. Infants’ reactions were scored for when they looked at the correct target (same target as the adult vs. opposite target); turning in the correct direction without looking at the target did not earn them credit for gaze following. Infants at all ages looked significantly more often at the target when the adult turned toward it with open than closed eyes.

We were also interested in the broader network of social acts (pointing, vocalizing) that this gaze following was embedded within. Thus we also made several other measurements beyond where infants turned to look. First, we measured infants’ average duration of correct looking to examine how long the infants stared at a correct target (i.e., the adult’s target) once they gaze followed. This analysis showed that infants inspected the target longer when the adult turned with open versus closed eyes. We also found that infants vocalized toward the correct target more in the open-eyes than closed-eyes condition. Finally, significantly more infants pointed to the correct target in the open-eyes condition than in the closed-eyes condition. The results showed that infants notice others’ eye status and selectively look, vocalize, and point at the target when the adult could see.

These findings have important implications because they help us interpret gaze following. The leanest interpretation of infant behavior has been that the adult’s movement attracts infants’ attention to a hemi-field of space where they (by chance) see an interesting object. This could not explain the results from our study, because head motion was controlled. Moreover, infants marshal other target-directed acts in a selective manner, such as pointing at the target and vocalizing toward it when the adult can see the target. The infants are not imitating the adult because they are generating communicative acts that the adult herself did not produce. Infants cannot be pointing solely because they are interested in the colorful targets, because the objects are equally available in both conditions. Infants point when the social partner can see the objects,
but refrain when the partner cannot, suggesting proto-declarative pointing (e.g., Bates et al., 1975; Franco & Butterworth, 1996).

Finally, the duration measure also helps make sense of infants’ behavior. If the conservative proposal were correct that the adult’s head movement brings the infant’s attention to the object, it would not explain why infants inspect the object longer when the adult’s eyes are open than closed. The object itself is the same whether the adult turns toward it with open or closed eyes. However, the infants treat the adult’s object as if it has a special value once she has looked at it. It is as though the adult has shone a psychological spotlight on an inanimate object, leading infants to look longer at the object. Infants’ selective looking, as well as pointing and vocalizing, when the adult had her eyes open, suggests that infants understand that others make visual contact with objects and, thus, follow the gaze of others.

**Developmental roots of infant gaze following.** This work shows that 12-month-old infants follow the eye gaze of others. The next question is when does this emerge. The Eyes Open/Closed test provides a way to examine the ontogenesis of gaze following.

Because social interactions change near 9 months of age (Bates et al., 1979; Trevarthen & Hubley, 1978), that age was selected for study. To identify whether there is a developmental shift before 12 months of age, Brooks & Meltzoff (2005) recruited infants for a visit within one week of becoming 9, 10, or 11 months of age. With the method described for the older ages, infants were randomly assigned to either the open- or the closed-eyes condition.

The results showed that 9-month-olds did not discriminate between the open- versus closed-eyes conditions. They turned equally often in both cases. It is important to note that 9-month-olds did not fail to follow the adult. In fact, they turned frequently even when the adult turned with closed eyes. However, there was a developmental transition. By 10 months, infants
usually refrained from following turns with closed eyes. For the 10- and 11-month-olds, the
gaze-following scores in the open-eyes group were significantly greater than the closed-eyes
group. By 10 months, but not by 9 months, infants are genuinely following the gaze of others.

These results are important for theory because of claims that gaze following starts as early as 3 or 4 months old (e.g., Scaife & Bruner, 1975). At first, these reports seem to contradict our assertion that the development of gaze following occurs at 10-11 months of age. But there is no contradiction. We believe that infants turn to follow the direction of head movements and postural changes at 9 months and younger. Instead of rarely turning, infants turn even if the adult cannot possibly be looking at the target, and so they are not truly gaze following. We think that 9-month-olds understand others as “body orienters” and are sensitive to the postural changes of adults in relation to objects. We argue that the first evidence for following others’ visual line of regard is at 10 to 11 months.

Converging results showing development. Our interpretation of a developmental shift for gaze following would help explain findings from other researchers who use visual habituation techniques. Changes reported in gaze-following comprehension (i.e., visual habituation techniques) also highlight 9 to 12 months as a watershed time (Johnson, Ok, & Luo, 2007; Woodward, 2003). For example, Woodward found that infants habituated to a person looking to a ball on the left, will dishabituate more to that person looking at a bear on the left (new object, same location) than to the person looking to the ball on the right (same object, new location). The infants encode that a person is looking at a specific object rather than the direction she turns her head. Results show that infants encode this relationship between the looker and the object at 12 months, but younger infants fail to do so (Woodward, 2003). Younger infants appear to need additional cues of head motion to recognize any link between the looker and the object.
For instance, when shown a person who looks at an object from different angles, such as from the side and from above the object, 9-month-old infants notice the target of the look (Johnson, et al., 2007). These findings suggest when different head movements align with a target, those motions draw young infants’ attention to the object.

In sum, by 10 to 12 months, following head motion does not explain why infants look at the adult’s target. The 10- to 11-month-old infants selectively follow the turns of an adult with open eyes and rarely follow the turns of an adult with closed eyes even though the head motion was the same for both types of head turns (Brooks & Meltzoff, 2005). Older infants begin to understand others as visually connected to the external world and turn to follow the other’s gaze. This is an important step in understanding another person as an intentional perceiver (a looker, a gazer). Recent work with ‘social robots’ has extended this work to investigate in detail what constitutes an entity whose gaze the child will follow (Meltzoff, Brooks, Shon, & Rao, 2010).

**Links between gaze following and language.** From a theoretical perspective, following gaze could provide important social-cognitive support for language acquisition (e.g., Baldwin, 1993; Hollich, Hirsh-Pasek, & Golinkoff, 2000; Kuhl, 2004; Slaughter & McConnell, 2003; Tomasello, 1995). It is an avenue by which the child can learn language. For example, when a parent says, “There’s the ball,” the parent is very likely staring at a ball. An infant who can gaze follow can learn what visual object goes with the verbal label.

To empirically test this expectation, Brooks and Meltzoff (2008) conducted a longitudinal follow-up study of the children who had come into the lab at 10 to 11 months of age (youngest ages with clear evidence of following eye gaze). Parents completed language questionnaires to report their infants’ productive vocabulary at their first visit (10 or 11 months) and when their infants were 14, 18, and 24 months old. We expected infants’ vocabulary to grow with age and
tested whether infants’ gaze-following behavior predicted accelerated growth. In addition, we examined how being able to point contributed to vocabulary growth.

Infants with better gaze-following ability had faster vocabulary growth. In particular, the duration measure of gaze following was a significant predictor of the number of words infants produced through 24 months of age. Infants varied in how long they inspected the target after they followed the adult’s gaze; the individual variations of 10- to 11-month-old infants’ gaze following led to significant differences in their productive vocabulary. Infants who had extended looks at the target were the infants who had larger vocabularies, whereas infants with short (or no) glances at the adult’s target had smaller vocabularies by 24 months of age. Infants’ gaze-following ability was still a significant predictor of language outcome even after accounting for significant effects of infants’ pointing and maternal education.

To delve into the findings a bit more deeply, infants’ gaze following and pointing production scores each separately and significantly predicted vocabulary development. As seen in some previous work (Mundy et al., 2007; Slaughter & McConnell, 2003; Striano & Bertin, 2005), gaze following and pointing did not correlate with one another. It is interesting to reflect on the interpretation of these separate predictors. First, only a minority of the 10-11 month olds (34%) spontaneously pointed to the objects in our laboratory test (Brooks & Meltzoff, 2008). In a review of the recordings, we found that infants usually looked at the adult before pointing at the distal targets. This is a context that others use as markers for proto-declarative pointing (Bates et al., 1979; Franco & Butterworth, 1996). Second, with our measure of gaze following, infants had individual differences in how long they inspected at the adult’s target (one of two identical targets in the room). Their longer looks seem to indicate that the target acquired a special valence when another person looked at it and that infants themselves were curious to
visually inspect it. Infants who tend to react in this way may have a great opportunity to learn the name of the object. Not only they have identified it based on the adult’s gaze, but they linger on the object long enough to hear a verbal label uttered by the adult, suggesting an interesting attentional mechanism by which gaze following could be connected to language learning.

**Mechanism of Change: Infants Own Experiences with Seeing**

The difference between open eyes and closed eyes is not the only distinction that infants need to make. People can look through a window but cannot see through a wall. Do infants realize that barriers, such as walls and other inanimate objects, block one’s line of sight? Once infants notice that eye closure affects vision, do they notice the same effect of inanimate objects?

In other work we used a procedure similar to the open/closed eyes paradigm to test what infants understood about inanimate occluders (Brooks & Meltzoff, 2002). The adult turned with a cloth (blindfold) blocking her view for one group of infants. For the other group, the adult had a clear view because the cloth was worn on her forehead as a headband. This at first seemed like a minor variation, but the results were surprisingly different from the eyes open/closed study.

The 12-month-olds mistakenly followed the adult when she wore the blindfold. They turned equally as much when the adult could see (headband) as they did when the adult could not see through the blindfold (Brooks & Meltzoff, 2002, Experiment 2). In contrast, the infants at 14 and 18 months differentiated the headband and blindfold conditions. The older infants rarely followed the turns of the blindfolded adult, whereas they did follow the turns when the cloth was on her forehead (headband). It seems that 1-year-olds know that eye closure blocks the adult’s vision but not that an inanimate occluder does so.

Why is there this décalage between eye closure and blindfolds? It is fascinating for theory that 12-month-olds refrain from following an adult with closed eyes, yet they still follow a
blindfolded adult’s turn. A theory based on salience of head motion cannot explain why there would be this difference because both actions used the same head motion. Further, infants do not seem to use a general rule, such as “I can (or cannot) see your eyes,” to solve this problem, at least not at 12 months. The adult’s eyes were not visible for the blindfold and the eyes-closed conditions, yet those conditions prompted a different response from the infants. The 12-month-olds followed the “gaze” of the blindfolded adult but not the closed-eyed adult. Alternately, if infants use cues of social engagement (e.g., D’Entremont & Seamens, 2007), then infants would refrain from gaze following when their partner is socially unavailable. Both eye closure and blindfolds should make the adult unavailable because they both cause a break in eye contact. However, 12-month-olds treat the biological and the non-biological barrier to eye contact differently. In short, salient motion and social engagement explanations cannot justify why eye closure is understood earlier than blindfolds.

**First-person experience prompts understanding others.** We propose that the difference between eye closure and blindfolds is infants’ self-experience with them. From birth infants are amassing visual experience from opening and closing their own eyes. When they close their own eyes, they can no longer see. We believe that infants are using their own phenomenological experience gained by closing their eyes to give meaning to the corresponding acts of others. If true, then providing infants self-experience with blindfolds should make a difference.

Meltzoff and Brooks (2008) conducted the relevant experiment with 12-month-olds. Infants sat at a table and played with an object. After moving the object on the table, the adult gently raised a blindfold to block infants’ vision. The cloth was a short distance from their eyes so it obstructed their view of the object and its surroundings. Then, the adult lowered the cloth
and play resumed. This process was repeated with other objects for about 7 minutes. The training was restricted to infants rather than anyone else wearing the blindfold, which exclusively provided infants with many instances of being unable to see. Then, for the first time, the adult wore the blindfold and the standard gaze-following test was administered.

The experience completely changed infants’ interpretation of the adult. Now they did not follow the blindfolded adult’s “gaze” to the object, whereas the 12-month-olds without this blindfold experience still followed (Meltzoff & Brooks, 2008). They generalized from their own experience to that of another person. Since they could not see when a blindfold was in front of their eyes, they inferred that the other could not see when in a similar situation.

In the typical course of development, infants change their understanding of visual perception. By 14 to 18 months of age, infants do not act as though adults can see through opaque barriers and refrain from following if an opaque barrier blocks the adult’s view (e.g., Brooks & Meltzoff, 2002; Butler, Caron, & Brooks, 2000; Dunphy-Lelii & Wellman, 2004).

Meltzoff and Brooks (2008, Experiment 2) provided 18-month-olds with novel self-experience that countered this expectation about opaque occluders. We designed a trick blindfold that looked opaque from the outside but was made of special material that could be seen through when held close to the eyes. Infants were randomly assigned to one of three groups: experience with this trick blindfold, experience with the opaque blindfold, and baseline control (familiarity with the blindfold laying flat on the table). After training, infants saw the adult wear the blindfold in the standard test. The finding was that infants who had first-person experience with the trick see-through blindfold followed the adult’s head turns significantly more than did infants in the two other groups.

The effects of training demonstrate that infants’ self-experiences have a powerful effect
on their interactions with others. The information infants learned through self-experience is immediately applied to others. As infants gain firsthand experience they transform their understanding of others who are “like me.” With experience, infants learn that the blindfold affects their own vision, and they, in turn, expect that another person’s vision will likewise be affected. This “like me” mechanism allows infants to leverage their own experiences to understand the acts of others (Meltzoff, 2007).

Conclusions

Gaze following is fundamental to typical social-cognitive understanding. For adults, it is not simply that the other person turns his or her head to the side; rather it is the other’s eye gaze that is understood as an act of perception. In that sense, developmental scientists have considered gaze following a front-end ability that helps promote the development of understanding other minds. Individual differences in following gaze (and pointing) also have importance, because they predict language development (Bates et al., 1979; Brooks & Meltzoff, 2008; Carpenter et al., 1998; Markus et al., 2000; Mundy et al., 2007). Without an ability to follow gaze, a person would miss this point of access into language and mental states of others.

Gaze following deficits are of particular concern for children with autism spectrum disorders (ASD). It has been argued that these deficits in decoding the meaning of people’s looking at distal objects may contribute to downstream deficits in language and social understanding (Baron-Cohen, 1995; Mundy et al., 2009; Toth, Munson, Meltzoff, & Dawson, 2006), including deficits in more sophisticated aspects of perspective taking (e.g., Moll & Meltzoff, 2001), which can be thought of as developmental sequellae of infant gaze following.

Gaze following is itself a developmental accomplishment and helps illuminate changes in infants’ social-cognition. Infants begin to follow the gaze of others before their first birthdays
(Brooks & Meltzoff, 2005). At 9 months of age and younger, though infants appear to gaze follow, they seem to be monitoring the postural and head motion of others and are “body following.” At 10 to 12 months infants differentiate open versus closed eyes, as shown by selectively following turns of an adult with open eyes. They begin to treat the other person as making a perceptual act—and treat gaze as a psychological connection between the gazer and the distal object. They turn because they want to see what the social agent is looking at.

Gaze following has also shown us the importance of infants’ own self-experiences. We argued that first-person experiences influence infants’ own development and their understanding of others. When infants explore their surroundings, they have opportunities to play with their visual experiences, such as closing their eyes to avoid something. These experiences help infants develop personal resources for interpreting the acts of others who are “like me” (Meltzoff, 2007). As infants open and close their eyes—seeing versus shutting out the world—they learn about the consequences of eye closure and rapidly generalize this experience to others. As a test of this idea of interpersonal projection, we systematically manipulated infants’ experiences with a blindfold, a novel object for infants. These studies provided empirical evidence to support the claim that infants’ use their self-experience with occlusion and vision to interpret the looking behavior of others (Meltzoff & Brooks, 2008).

Taken as a whole, the pattern of findings fits well with what has been called the “Like-me” framework for infant social-cognitive development (Meltzoff, 2007). This view holds that infants use their own bodily experiences to give meaning to others’ acts, and reciprocally rely on their observations of others’ acts to change the self. Emerging work in developmental neuroscience is discovering brain correlates of such mirroring phenomena, using infant EEG and other tools to explore the infant’s social world (Marshall & Meltzoff, 2011). The study of gaze
following significantly adds to an interdisciplinary look at infant social-cognitive development.
The eyes and joint actions of young infants is a pathway to understanding their souls.

Notes
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