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Infants Understand How Testimony Works

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Abstract

Children learn about the world from the testimony of other people, often coming to accept what they are told about a variety of unobservable and indeed counterintuitive phenomena. However, research on children's learning from testimony has paid limited attention to the foundations of that capacity. We ask whether those foundations can be observed in infancy. We review evidence from two areas of research: infants' sensitivity to the emotional expressions of other people; and their capacity to understand the exchange of information through non-verbal gestures and vocalization. We conclude that a grasp of the bi-directional exchange of information is present early in the second year. We discuss the implications for future research, especially across different cultural settings.

Keywords

Testimony; Infants; Social referencing; Joint attention; Pointing; Head gestures

1 Introduction

For some years, we have been arguing that when young children learn about the world, they are deeply dependent on what other people tell them (Harris 2002, 2007, 2012a, b; Harris and Koenig 2006; Lane and Harris in review). This dependence on the testimony of others is readily seen in the way that young children make sense of phenomena that they cannot observe for themselves but hear other people talk about. For example, they come to the realization that the earth is round, contrary to their first-hand perceptions. They also come to understand that unseen mental processes are intimately connected to the functioning of an unseen organ—the brain. In the absence of any straightforward, observational evidence, they are very confident about the existence of invisible entities such as germs and oxygen. In addition to their grasp of such natural phenomena, children also subscribe to the existence of various religious phenomena that they have not, presumably, encountered first-hand. Thus, in many cultures, they believe in the existence of God; they eventually attribute omniscience and immortality to him; and depending on the beliefs of the surrounding community, they claim that animal species were created by him (Evans 2001; Harris and Corriveau in press; Harris 2012b).

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An ability to acquire beliefs from the testimony of others can be observed even among 2-year-olds. When they are told that an object that they can no longer see has undergone a change—for example, it was dry when last seen but they are told that it is now wet, or it was last seen in a box but they are told that it is now in a cupboard—they are able to use this testimony to update their representation of the object (Ganea and Harris 2010; Ganea et al. 2007). Asked to retrieve the object, they appropriately retrieve a wet version of the object and not a dry one. Similarly, they search for the object in the cupboard and not in the box. At first, this process of updating via testimony is prone to error. For example, when younger toddlers are told that the object has been moved, they often search in the location where they originally witnessed the object—something they do not do if they *see* the object moved (Ganea and Harris 2013). Nevertheless, by approximately 30 months, children are quite systematic in acting appropriately in light of what they have been told.

From a developmental perspective, it is plausible that in the early stages of language acquisition—during say the first 18 months of life—children learn very little from the testimony of others and rely primarily on their own powers of observation. Certainly, a large body of research conducted over the past 40 years has shown that infants have a remarkable capacity to observe and make sense of the world in a relatively autonomous fashion (Carey 2011; Spelke and Kinzler 2007). More generally, it is plausible that children’s learning from the testimony of other people will typically occur when two conditions are fulfilled: (i) the entity or phenomenon is difficult for children to observe autonomously or is ambiguous so that, in the absence of definitive perceptual input, they are receptive to the testimony of other people; (ii) children can nonetheless imagine—mentally represent—the state of affairs that is described via the testimony. So, returning to the examples set out above, we may suppose that toddlers will be receptive to information about the current location of an object when: (i) they have no perceptual access to its current location and (ii) they can mentally represent its new location, having decoded the testimony of an informant.

At first glance, it seems unlikely that these two conditions can be fulfilled in the earliest stages of language acquisition because most conversation is tied to the here and now (Morford and Goldin-Meadow 1997). Moreover, it might be difficult for infants to imagine a state, an object, or a situation that does not correspond to what they can currently observe—or have recently observed—whereas with the onset of pretend play, in the course of the second year, we know that such flexible mental representations of potential states of affairs are possible. On this view, therefore, we might expect learning from testimony to become increasingly obvious from approximately 18 months onward and to be especially important for learning about aspects of the world that are inaccessible or difficult to observe first-hand. This is essentially the position taken by Harris (2012b) in an overview of young children’s learning from testimony.

Despite the plausibility of this conclusion, it is worth stepping back to examine the infancy period more carefully in order to distinguish between two possibilities. On the one hand, it is possible that learning from the testimony of others is intimately connected to language, so that we will see few signs of this type of learning during infancy. On the other hand, it is possible that infants are sensitive to other, non-verbal media of communication. Testimony is often conveyed in words, but other people’s non-verbal expressions or gestures might

‘speak’ as loudly. On this second view, the type of learning from testimony that we clearly see in the preschool years and beyond is likely to be found in infancy and may even be an important propaedeutic for subsequent learning from verbal testimony. In the next sections, we examine two sources of evidence concerning social learning in infancy to adjudicate between these two views. We first review infants’ receptivity to the emotional expressions of other people. We then examine their sensitivity to non-verbal gestures and vocalizations.

To anticipate, we will argue that social learning in infancy, especially when it involves gestural rather than affective signals, displays key features of learning via testimony. In particular, we will argue that infants understand how communication can involve the transfer of information from an informant to a recipient. In making this claim, we approach early communication with a distinctive emphasis. The study of non-verbal communication, especially pointing, has typically examined the extent to which infants are able to align themselves with a partner by, for example, attending to the same object or focusing on the same goal-directed activity. This approach emphasizes the establishment of convergence between infant and partner—their joint focus on a common object or project.

We argue that recent evidence reveals another major but less studied type of convergence during infancy. Communication involving testimony typically starts from discrepancy between two interlocutors with respect to their knowledge. One person knows something whereas another does not. For successful communication to take place, the one who knows should adopt the role of informant and convey what he or she knows to a less informed recipient. Thus, on this testimony-oriented view, communication is often characterized by: (i) an initial asymmetry between interlocutors in their knowledge; and (ii) a transfer of information that reduces or eliminates that epistemic asymmetry. What ends up being shared, therefore, is knowledge rather than a focus on common object or a project, as traditionally investigated in studies of early adult-infant communication.

2 Social Referencing

We have known since the mid-1980s that infants can regulate their activities in light of the emotional expressions of their adult caregivers. In a landmark study, conducted by Sorce et al. (1985), when 14-month-olds approached an apparently deep cliff (actually, a transparent but solid surface) and looked up at their mothers, they saw her silently produce either a negative or a positive facial expression of emotion. Infants were more likely to cross the cliff toward their mother following the positive expression.

More recent studies have analyzed three important questions about this type of social referencing. First, in attending to the emotions of other people, do infants treat that affective input as a guide for their ongoing actions or alternatively do they take it to be a commentary on some aspect of the external world? The emotional expressions of adults might be roughly comparable to traffic lights in the sense that infants respond as if they had received the message *Stop* or the message *Go*. An alternative, richer interpretation is that infants realize that emotions are typically provoked by some object or situation, regard emotions as comments on that aspect of the world, alter their own appraisal and act upon their new appraisal.

We can also ask about the conditions under which infants are receptive to the emotional expressions of other people. Are they receptive to such input when it contradicts firm judgments and conclusions that they arrive at for themselves? Alternatively, are they most receptive when the available evidence leaves them uncertain? The findings of Sorce et al. (1985) point to the latter possibility. When faced with an obviously *shallow* cliff that did not provoke uncertainty, few infants looked up at their mother and so they did not register their mothers' silent expression of affect. Nevertheless, had they done so, they might have heeded her reaction.

Finally, we can ask if infants are selective when they monitor the emotional signals of other people. They might only turn to attachment figures, or they might sometimes look to a comparative stranger, particularly if she is better informed.

2.1 Stop/Go Signal or Comment on the World?

Moses et al. (2001) studied infants' reactions when an adult's emotion could plausibly be interpreted as either relevant or irrelevant to a salient, novel object. In the *relevant* condition, when the infant looked at an ambiguous, bumble-ball toy,¹ an adult seated nearby voiced either positive or negative emotion and looked at the ambiguous toy. Thus, in principle, infants could use the adult's gaze direction to figure out what had provoked her emotional reaction. In the *irrelevant* condition, by contrast, another adult, whose view of the toy was occluded by a barrier, also expressed either positive or negative emotion but her inability to see the toy implied that it had not provoked her emotion. In gauging whether to approach the toy, both 12- and 18-month-olds were influenced by the reactions of the relevant adult—they were more likely to approach the toy if she had reacted positively rather than negatively—but they were unaffected by the reactions of the irrelevant adult. By implication, infants did not respond to vocal expressions of affect as if they were simply stop-go signals for their behavior. They adjusted their behavior toward an object only if the expressions were visibly directed at that object—and they used their capacity for joint attention to identify that object.

Comparable results emerged in a follow-up study in which two toys were presented simultaneously. In the *jointfocus* condition, the adult looked at and voiced positive or negative emotion toward the toy that the infant was also looking at. In the *discrepant-focus* condition, the adult looked at the other, adjacent toy and voiced emotion toward it. Both 12- and 18-month-olds were more likely to look over to the adjacent toy in the *discrepant-focus* condition—effectively giving themselves an opportunity to figure out what had provoked the adult's emotion. In addition, both age groups responded with more positive emotion to the toy targeted by the adult when the adult had voiced positive rather than negative emotion and they did so in both conditions, implying that they had read the adult's gaze direction appropriately. This result held even when allowances were made for infants' emotional reaction to the toy ignored by the adult. A similar pattern emerged when infants' toy exploration (as indexed by looking and touching) was examined. Infants spent more time exploring the targeted toy when the adult had voiced positive rather than negative emotion toward it.

¹Moses et al. (2001) actually tested infants with two different toys but only the bumble ball toy proved ambiguous. The other toy appeared to make most children apprehensive.

Suppose that infants observe other people's emotional reactions to a stimulus and are later tested in the absence of any further social input. If they indeed construe the earlier emotional reactions as having told them something about the stimulus and not just about their ongoing behavior, we might expect their later behavior toward that stimulus to reflect what they learned. De Rosnay et al. (2006) had infants ranging from 12 to 14 months watch their mother interact with two different strangers. She responded to one stranger in a normal, friendly fashion but she responded to the other in an anxious fashion. In an immediate follow-up test, infants' reactions were recorded as each stranger approached them. During this follow-up, the mother was engrossed in reading a magazine and provided no cues to her infant as to how he or she should respond. Infants displayed greater fear toward the stranger who had earlier provoked anxiety in their mother, and a subgroup of infants who were temperamentally fearful were especially avoidant of this stranger. In short, infants appeared to have encoded their mother's prior response to the two strangers and subsequently behaved in a similar fashion even when she was providing no further emotional signals. By implication, infants had taken their mothers' earlier signals to be appraisals of the strangers.

Summing up, these three studies show that infants appreciate the targeted or intentional nature of emotional reactions—the fact that they are directed at a particular object or person in the environment. In the presence of an expressive adult, infants monitor her gaze in order to identify the referent and then respond to the referent appropriately, as indexed by their subsequent behavior. If infants hear an adult's emotional reaction but its target cannot be identified, it is not used as a behavioral guide, presumably because the expression is not deemed to pertain to any object in the infant's immediate environment. But in cases where an emotional message is clearly linked to an object—such as a particular toy or person—infants remember that link and adjust their behavior on subsequent encounters.

2.2 When are Infants Receptive to Emotional Expressions?

The findings discussed so far show that infants are receptive to an adult's emotional messages. However, other evidence shows that this only happens when they are uncertain about the object or situation in question. A study by Tamis-LeMonda et al. (2008) illustrates this restriction. In an initial test, 18-month-old infants were given various slopes to walk down in order to identify what angle of slope they found safe, risky, or borderline. Left to their own devices, infants were invariably prepared to walk down what they regarded as safe slopes and did so successfully. They were unwilling and unable to walk down what for them were risky slopes. Finally, they showed a mixed reaction when confronted by borderline slopes—managing them successfully on two-thirds of trials but falling—or baulking—on the remaining trials. In the next stage of the procedure, mothers were invited to either encourage their infants to walk down a given type of slope or to discourage them. In doing so, mothers used a range of emotional signals, vocal as well as facial. Note that because the signals were vocal as well as facial, they could not go unattended. Nevertheless, when faced with either safe or risky slopes, the majority of infants ignored their mother's affective signals. Whether she offered encouragement or discouragement, they were prepared to walk down safe slopes but not down risky slopes. By contrast, when faced with borderline slopes, they were more receptive to their mother's signals. Indeed, they were nearly three times more

likely to attempt to walk down a borderline slope if they received maternal encouragement as opposed to discouragement.

Kim and Kwak (2011) obtained similar findings with infants of 12 and 16 months. Infants were presented with a variety of toys that prior testing had shown to elicit positive, negative, or ambiguous reactions from them, as judged by two observers. As in the study by Tamis-LeMonda et al. (2008), adults' emotional signals were more effective in changing infants' behavior if they faced uncertainty. More specifically, both age groups looked more rapidly and more often at nearby adults when presented with an ambiguous as opposed to an unambiguous toy. In addition, they were more likely to regulate their response to the ambiguous toy depending on the input they received. No matter whether the adults expressed happiness or fear, infants responded with positive affect to unambiguously positive toys and with negative affect to unambiguously negative toys (just as they had done in prior testing). But faced with the ambiguous toys, infants' emotional reactions shifted to reflect the emotional input they received—positive in the context of happy input but negative in the context of fearful input. A similar pattern emerged for infants' behavioral reactions. They approached positive toys but withdrew from negative toys irrespective of emotional input. On the other hand, they approached or withdrew from ambiguous toys depending on the emotional input they received from adults, with this differentiation being especially clear in the 16-month-olds.

Thus, in each of these studies—using quite different stimuli (i.e., slopes versus toys)—infants were receptive to emotional input when they were uncertain. They were likely to look at a nearby adult, to alter their emotional reactions and to adjust their behavior. They were much less prone to either seek out social input or to act upon it if, in their judgment, the situation was unambiguous.

2.3 Choosing an Informant

Granted that infants seek out and act upon emotional input when facing uncertainty, do they turn to any available adult or do they turn preferentially to some potential informants more than others? Attachment theorists have long emphasized that infants will seek reassurance by looking toward a caregiver to check on her (or his) proximity (Ainsworth 1992). But that interpretation cannot account for the results of Kim and Kwak (2011), described above, for two reasons. If infants were seeking to reassure themselves of caregiver proximity, we might reasonably expect such looking to be especially frequent when the toy was negative rather than ambiguous. But infants looked more often at an adult when faced with an ambiguous toy. Second, infants did not look preferentially at their mothers. They looked more often at the experimenter who had presented them with the toy—even though their mother was nearby. Similar results were reported by Walden and Kim (2005) with older infants: when an unfamiliar experimenter and the infant's mother were both present, infants aged 18 and 24 months tended to direct more looks at the experimenter than at their mother, and this bias increased over the interval following the presentation of a novel toy. Turning toward a stranger would appear to make good sense if infants were looking for information about the toy but not if they were seeking reassurance from their mother.

Stenberg (2009) looked more carefully at the reason why infants preferred to turn to the experimenter rather than their mother. One possibility is that infants had seen the experimenter handle the toy and come to associate it with her for that simple reason. A second possibility is that, within the relatively unfamiliar environment of the laboratory, infants take the experimenter to be the local ‘expert’ rather than their mother. To test these two possibilities, Stenberg (2009) had either an experimenter or the mother remove an ambiguous toy—a mechanical dinosaur that buzzed softly as it moved—from a bag and place it on the table, whereupon it started to slowly approach the 12-month-old infant. Whether it was the experimenter or the mother who presented the toy, she also smiled and offered verbal encouragement to the infant (“What a funny thing!”) whereas the other adult (i.e., the mother or the experimenter, depending on the condition) held a magazine in front of her, as if she was reading. Although infants mostly responded with neutral emotional expressions rather than joy or fear, they produced many puzzled looks (attentive looks with a furrowed brow or wide eyes). These puzzled looks were directed much more often toward the experimenter than the mother. Not surprisingly, this difference was especially marked when the experimenter offered encouragement and the mother was reading but it was even apparent when these roles were reversed. Thus, even if the experimenter was inattentive and reading, infants often looked toward her in a quizzical fashion.

Input from the experimenter was also more effective in ‘telling’ infants what to do. When the experimenter presented the toy and provided input, infants spent more time playing with the toy than when their mother presented it. By implication, infants were prone to treat the experimenter as the go-to person in the relatively unfamiliar laboratory environment. Presented with a puzzling toy, they were more likely to look at her rather than their mother and more likely to act on her encouragement than their mother’s. These findings reinforce the conclusion that social referencing is not just an attachment behavior directed at familiar caregivers. It is also aimed at gathering information about the immediate environment from someone who can be regarded as familiar with it.

In several follow-up studies, Stenberg (2013) examined the conditions in which 12-month-olds preferentially seek information from and follow the guidance of ‘experts’. Infants watched two experimenters interact with three sets of toys. One experimenter (the *expert*) correctly placed bricks in holes, put together blocks to form a clown, and put clothes on a toy ape, all while correctly labeling the pieces she was interacting with (e.g., “Now I am taking the blue brick...”). The other experimenter (the *non-expert*) failed to place the bricks correctly, to build the clown, or clothe the ape, and did not provide any labels for the pieces. Then, half of the infants watched the expert present the mechanical dinosaur toy (used in the study of Stenberg 2009 described earlier), in a positive way—she smiled while saying, “What a fun thing!” and alternately looked between the toy and the infant (while the non-expert read a magazine). The remaining infants saw the non-expert present the toy and provide the same positive information (while the expert read a magazine). Infants tended to look more often at the expert, no matter who had presented the toy. Moreover, infants interacted with the toy more if they received information from the expert rather than the non-expert. Similar results were obtained when informants presented the toy in a negative way—they appeared anxious and said, “What a nasty thing!” Infants looked longer at the

expert informant than the non-expert and played with the toy less when she had provided the negative information.

Infants also take the past reliability of an adult's affective signals into account. Chow et al. (2008) introduced 14-month-olds to a reliable or unreliable looker. The affective signals of the reliable looker were predictive—when she looked into a container and expressed a positive reaction, infants found an attractive object inside when they looked for themselves. The affective signals of the unreliable looker, by contrast, were misleading—when she looked into a container and expressed a positive reaction, infants found nothing inside when they looked for themselves. By implication, the positive emotion of the unreliable looker lacked an appropriate object or target. In subsequent testing, infants treated the unreliable looker as a poor guide. They were less likely to follow her gaze when she looked toward occluded objects. This was not because of any global fatigue or extinction of gaze following in the wake of their interaction with her because infants readily followed the gaze of another, newly arrived looker with no prior history of reliability or unreliability. Thus, infants exert control over the extent to which they establish joint attention with an adult.

Infants' sensitivity to the reliability of an informant's affective signals is further reflected in their imitation. Poulin-Dubois et al. (2011) began with a set-up similar to that used by Chow et al. (2008). Infants ranging from 13 to 16 months watched as a person looked inside a box and produced a positive affective response, "Wow!" In the *reliable-looker* condition the box contained a small toy but in the *unreliable-looker* condition the box was empty. Infants then saw that person perform a novel action: when seated at a table with a lamp, the person leaned over, pressed the lamp with her forehead, and turned it on. Meanwhile, her hands rested on the table, so it was clear that she was deliberately not using her hands. The lamp was then placed in front of the infant, and the experimenter said, "Now, it's your turn." Infants in the reliable-looker condition more often turned the lamp on with their foreheads—whereas infants in the unreliable-looker condition more often turned on the lamp with their hands, as they would normally.²

Summing up these three lines of investigation, we can draw the following conclusions about social referencing in the second year. First, when an adult expresses emotion, infants are likely to look at the adult—if the adult is visible—and to re-direct their gaze toward the object or situation that the adult is attending to. Such monitoring gives infants a chance to work out what has provoked the adult's emotion. Infants subsequently adjust their behavior toward the relevant object or situation in light of the emotional message—they approach and explore the object or situation if the adult's emotion was positive but stop or retreat if the emotion was negative. Indeed, they continue to show this adjustment even when they are no longer receiving emotional signals. Nevertheless, such adjustment occurs within certain

²Infants' sensitivity to informants' trustworthiness goes beyond a preference for accurate emotional signalers. Zmyj et al. (2010) had 14-month-olds watch videos of people whose reliability was demonstrated by how they used common objects. Across three familiarization videos, infants watched either a reliable person who confidently performed typical actions (e.g., in one video, he placed a shoe on his foot and said "Ah!") or an unreliable person who expressed uncertainty while performing unusual actions (e.g., in one video, he placed a shoe on his hand, and said "Hm."). Infants then saw the person perform novel actions—turning on a lamp with his forehead (as in Poulin-Dubois et al. 2011), and turning on a box filled with lights by sitting on it. Following each of these actions, the experimenter placed the objects (the lamp and box, respectively) in front of the infant and said, "Now you can play with it!" Infants who had watched the reliable person were more than twice as likely to imitate his novel actions compared to infants who watched the unreliable person.

constraints. If infants have their own prior convictions, an adult's emotional signals have little impact. Thus, emotional input is especially influential when infants are uncertain how to respond toward a given situation. Finally, infants are selective about their informants. If there are indications that a stranger is better informed than a caregiver, infants look more toward the stranger. But if a stranger's affective signals prove unreliable, they are unlikely to follow her gaze or imitate her later actions. Taken together, the evidence shows that 1-year-olds are receptive to the emotional messages of other people and treat them as comments about aspects of the world that they are uncertain about. Infants are not simply looking for emotional reassurance. Rather, they are seeking guidance because they look to a stranger if she might have relevant and reliable information.

The studies of social referencing offer persuasive evidence that infants seek and act on information from other people. Nevertheless, it is important to underline the restrictions on that capacity. The message repertoire is quite modest: essentially, infants receive and retain information about whether or not to approach a given object or person that is situated within the visual field. In addition, messages do not overturn prior convictions. Rather, they serve only to reduce uncertainty.

Before turning to a discussion of gestural communication, one final issue needs to be considered. Emotional expressions are not necessarily produced with the deliberate goal of communicating to an observer or interlocutor about a target object—they can be more or less involuntary and indeed idiosyncratic reactions. Egyed et al. (2013) asked if 18-month-old infants differentiate between emotions that are evident acts of communication and those that are not obviously intended to communicate. Eighteen-month-olds watched an adult express positive emotion toward one object and negative emotion toward another. In the communicative context, she first looked and smiled at the infant and greeted him or her by name; only then did she express her emotions about the two objects. By contrast, in the non-communicative context, the adult never looked at or greeted the infant before expressing what she felt. When a second adult arrived and asked for one of the objects (without specifying which she wanted), infants were more likely to hand her the positive object following the communicative as opposed to the non-communicative context. Thus, in the communicative context, infants were more likely to regard the adult's reactions as generalizable—as conveying information about the objects and not just about the adult.

Infants in the various social referencing experiments just reviewed likely regarded the adult's signals as deliberate, communicative acts that provided information about a specific target. For example, depending on the particular study, an adult silently expressed facial emotion about the visual cliff, or about nearby toys, but only when infants looked up toward her face (Sorce et al. 1985; Kim and Kwak 2011); or an adult voiced a positive attitude (e.g., "Nice!" or "What a fun thing") or negative attitude ("Yecch!" or "Iuu!") toward nearby toys (Moses et al. 2001; Stenberg 2009, 2013); or mothers gave either brief replies or full and friendly replies to a stranger's questions (de Rosnay et al. 2006); or mothers encouraged their infants both verbally (e.g., "Come on") or with appropriate beckoning gestures or they discouraged their infants, again both verbally (e.g., "No!") or with appropriate prohibitive gestures (Tamis-Lemonda et al. 2008). Thus, in these various cases, it is plausible that infants viewed the adult as deliberately conveying information about a particular entity, be

it a toy, a stranger or a slope, even if the adult was not always directing her signals toward them. As a result, infants aligned their response with the adult's.

3 Communication with Gestures

In the next section, we review evidence on how non-verbal gestures, such as pointing or head movements, can serve as testimony to infants. Such gestures are typically produced deliberately, with the intention to communicate. Indeed, they are akin to ordinary verbal communication because they can assume a dialogic structure: a deliberate gesture by a communicator can elicit a 'reply' from the recipient.

At first, gestural communication might serve purely phatic or social functions, such as greeting or leave-taking. On the other hand, it might also convey novel information. More specifically, as soon as they can communicate via gestures, toddlers might accept information from an interlocutor whom they take to be better informed. Moreover, they might themselves provide information to an interlocutor whom they take to be less well informed. On this view, as argued by Tomasello et al. (2007), the later exchange of information via language could build on an earlier pragmatic and gestural competence. Below, we review recent evidence suggesting that the capacity for exchanging information, and indeed the capacity to make sense of such an exchange from a third-party perspective, is in place early in the second year.

3.1 Pointing and the Exchange of Information

Pointing appears to be a universal, early feature of children's communication. Liszkowski et al. (2012) invited caregivers and their infants (ranging from 7 to 17 months) to visit a space where they could look at various potentially interesting items—a balloon, a blinking light, pictures of animals, vehicles, and so forth. Caregivers were left to their own devices in terms of how they communicated with the infants carried on their hips. There was no mention of pointing. This basic procedure was employed in seven different cultures that varied in language, average family size, urban versus rural setting, and livelihood; for example, infants from Papua New Guinea, Kyoto Japan, rural Nova Scotia and the Yucatan were included. The emergence and morphology of pointing were quite similar across the seven cultures. Whole-handed pointing started at around 8 months; index finger pointing started at around 11 months and eventually became more frequent. Regardless of age, there was a two-way reciprocity between caregiver and infant—a point by the caregiver often elicited (within 10 s) a point from the infant, and vice versa. Indeed, infant and caregiver were equally responsive to one another's points. This overall pattern was evident in each culture although there was cross-cultural variation in the frequency of reciprocal responding.

A follow-up study examined this cross-cultural variation in frequency more thoroughly. Salomo and Liszkowski (2013) observed infants ranging from 8 to 15 months in three different cultures: Yucatec-Mayan (Mexico), Dutch (Netherlands) and Shanghai-Chinese (China). Infants and their caregivers were observed as they went about their regular, daily activities. This naturalistic strategy meant that, in contrast to the more structured setting used in the earlier study, potential differences in the frequency and organization of social interaction were given ample opportunity to emerge—and they did so. The overall frequency

of triadic joint action involving the engagement of infant and caregiver with the same object or event—for example, playing with toys together or looking at a book together—was more frequent in China than in Holland and more frequent in Holland than in Mexico. A similar pattern emerged for gestures. Hand gestures (including pointing, showing an object, placing an object in front of an interlocutor, and offering it to an interlocutor) were more frequent for both caregivers and infants in China as compared to Holland and more frequent in Holland as compared to Mexico. Pointing was the most frequent gesture among the infants, especially in China and Holland. Salomo and Liskowski (2013) plausibly conclude that engagement in triadic social interaction provides a setting in which such gestures are promoted, not necessarily via simple mimicry but by the provision of a context in which joint engagement is possible and can be augmented via gesture.

These observations suggest that there is a dyadic structure to early gestural communication, including pointing—a structure that subsequent language-based communication is likely to build on. Indeed, in a meta-analysis of 18 longitudinal studies, Colnnesi et al. (2010) found strong evidence that infants' pointing, specifically 'declarative' pointing aimed at establishing joint attention rather than 'imperative' pointing aimed at obtaining an object or an action, predicts their later language. This link was found for both the production and comprehension of pointing and for receptive as well as expressive language.

With the importance of pointing for the development of early communication established, we can proceed to ask how far infants treat other people's pointing as providing information about the world. Infants are undoubtedly sensitive to another person's pointing in that they turn to look in the direction of the point and do so with increasing accuracy and flexibility as they develop (Franco and Butterworth 1996). But this evidence shows only that pointing tells infants where to look and what to look at. It does not establish that pointing tells them anything further about the object pointed at. Behne et al. (2012) tested 12-month-olds with this issue in mind. Infants were invited to search for an object in one of two cloth-covered boxes. In warm-up trials, they saw the experimenter holding an object in one hand and then placing it in one of the boxes. These warm-up trials were straightforward hiding trials and as expected, given that there was little delay between the hiding and the opportunity to search, infants usually searched in the correct box. Next, in test trials, the experimenter concealed the to-be-hidden object in one hand and then slid each hand under a different box—preventing infants from knowing which box the object was left in. The experimenter then pointed to one of the boxes and looked toward it. Infants searched in the targeted box on almost three quarters of the 8 trials they received—well above chance. The majority was correct on the very first trial, and almost half were correct on all 8 trials or made only a single mistake.

These results imply that infants realized that the experimenter was not making an empty gesture or even just calling their attention to one of the two boxes. Rather, in the context of the hiding game, they understood that she was informing them where to look for the object hidden in the box. Still, one might argue for a leaner interpretation: perhaps the experimenter's pointing and looking to the correct box drew infants' attention. Then, as a result of this attention bias, infants were more likely to search correctly in that box. However, support for the richer interpretation emerged when the roles of pointer and

searcher were switched. As infants watched, one experimenter hid an object while another experimenter covered her eyes and turned away. On turning back to face the boxes, this latter experimenter both named the object and asked where it was. At issue was whether infants would point to the correct box. Some infants did point—almost always to the correct box, using their index finger. This gesture was produced in an apparent effort to help the experimenter—not to gain the object for themselves because they never whined or produced request-like, hand-grasping movements. Moreover, infants' appropriate pointing in this task was correlated with their correct search in the previous pointing comprehension task. Such a link between production and comprehension would seem unlikely if correct search in the comprehension task had been brought about only by an attention bias as opposed to an appreciation of the gesture's informative intent.

Pointing combined with naming can also prompt 12-month-old infants to anticipate the presence of a particular object at a specific location. In a study by Gliga and Csibra (2009), a speaker pointed toward one of two screens, naming an object behind the screen that infants could not see, for example: "Wow, a duck!" Next, in the test period, the two screens were removed to reveal either the named object in the indicated location and a different object in the other location—as expected given the speaker's communication—or the reverse arrangement. Infants looked longer at the reverse arrangement than the expected one, implying that they did not think of the speaker's message as simply encouraging them to look in a given direction, or even to look at a visible object such as one of the screens. Instead, they appreciated that pointing plus naming signaled the location of a specific hidden object. Moreover, a control study showed that infants did not adopt this reading of the pointer's message when the person pointing and the voice that was heard did not match (i.e., one was male and the other female). Thus, 12-month-olds are responsive to other peoples' expressive signals by virtue of their referential nature and not just because they happen to coincide with the presence of a potentially relevant target. Infants take such gestural and vocal signals to provide relevant information about a particular object even when it is behind a screen, provided the person producing those signals is in evidence.

In summary, although 12-month-olds do not have many words at their disposal, they can learn from the messages of others. In particular, when informed about the location of a hidden object, they respond appropriately—they search for the hidden object and gaze longer if it is not where they were led to expect it. Moreover, when an adult is searching for a hidden object, some infants point toward it in an informative fashion. These findings imply that infants understand two key features of learning via testimony. First, they realize that an informant can provide them with information about a non-visible target. Second, they have a bi-directional understanding of such an exchange—they can assume the role of informant and as well as that of recipient.

3.2 Pointing, Vocalization and the Exchange of Information

Persuasive evidence that infants have such a bi-directional understanding was reported by Krehm et al. (in press). They asked whether infants could infer that learning via pointing had taken place when viewing an information exchange from a third-party perspective, rather than playing the role of either informant or recipient themselves. Infants of 9 and 11

months first saw an informant express her preference for one of two objects by reaching for the object and manipulating it. Next, a recipient appeared and handled both objects, implying that she had no preference for one or the other. In the final test phase, infants saw the informant again but now she could no longer reach either object. She pointed to her preferred object, as the recipient watched. Infants expressed more surprise (i.e., looked longer) when the recipient handed her the non-preferred object rather than the one she had pointed at. In control conditions, infants did not show this selective looking pattern if the informant gestured with a closed fist rather than pointed, and they did not show it if the recipient had covered her eyes during the informant's point. Thus, infants only expected the recipient to realize which object the informant wanted: (i) if the informant produced a communicative gesture like open-fist pointing; and (ii) if the recipient could see that gesture. This basic pattern emerged irrespective of age (9 vs. 11 months) and irrespective of whether or not infants had started to point themselves.

Evidence that 12-month-olds not only have such a bidirectional understanding, but deploy it in the context of a novel lexical item was reported by Martin et al. (2012). As in the study of pointing just described, they asked whether infants could infer that learning via testimony had taken place when viewing an information exchange from a third-party perspective. Infants saw an informant express her preference for one of two objects by reaching for the object and manipulating it. Later, when the two objects were beyond her reach, she spoke to a recipient, using a word ("koba") that infants would not understand but might infer to be a request for the preferred object. Indeed, when the recipient handed the communicator the non-preferred as opposed to the preferred object, infants were surprised—they looked longer than when the recipient handed over the preferred object. Importantly, this pattern of differential looking was not found in the wake of just any vocalization. For example, it was not found when infants heard the informant cough rather than speak, or when they heard the informant produce a positive vocalization ("Oooh!") rather than a lexical item. Nor was it found when infants heard the recipient—as opposed to the informant—say "koba".

Vouloumanos et al. (2012) asked if 12-month-olds can also infer that speech is able to communicate an informant's intended—but as yet unfulfilled—goal. Infants watched as an adult reached out to stack a ring on a funnel but failed to do so because the funnel was too far away. Next, in the absence of the first adult, a second adult appeared and handled all the visible objects. Then, in the test phase, when the two adults appeared together for the first time, the first adult either produced a novel word ("koba") or coughed. The second adult responded by either: (i) stacking the ring on the funnel; (ii) mimicking what the first adult had done earlier, namely attempting to stack the ring but failing; or (iii) carrying out a different action, namely removing a ring from the funnel. The experimental question was whether infants would infer that when the first adult had spoken (rather than coughed) she had informed the recipient of her intended goal. Infants' looking times suggested that they did make that inference: they looked only briefly at the expected outcome—when the recipient stacked the ring, as intended—but they looked for longer when the recipient also failed to stack the ring or did something different. This variation in looking time did not emerge if the informant had merely coughed.

Taken together, these two studies suggest that 12-month-olds make relevant and appropriate inferences about a simple vocal utterance. Even when they have no way to decode the surface meaning of the utterance—the word “koba” is unknown to them—they draw the inference that the informant is telling the recipient what she wants or intends, and they expect the recipient to fulfill this request. Such an inferential capacity implies that infants can make sense of a simple information exchange before they have mastered the language being used. On reflection, this might not be so surprising. When, as adults, we are in a foreign country and do not speak the language, we can make overall sense of an utterance embedded in a predictable exchange—such as a customer speaking to a waiter. We infer that the customer is telling the waiter what she wants and we expect the waiter to act accordingly. Still, infants’ early grasp of how information is exchanged via communication is impressive.

Do infants realize that language can be used to make not just goal-based requests for an object or action but also assertions, including assertions that update a recipient’s beliefs? To examine this issue, Song et al. (2008) presented 18-month-olds with a video of an interchange in which, during familiarization trials, an adult repeatedly placed a ball in a box—rather than in a nearby cup with a lid—as a second adult looked on. Next, the first adult left and in her absence the second adult took the ball out of the box, put it in the cup and replaced the lid. The first adult then returned. At this point, in line with several recent studies (e.g., Onishi and Baillargeon 2005; Southgate et al. 2010) infants should realize that the first adult wrongly thinks that the ball is still in the box. Next, in the *informative* condition, infants witnessed the second adult correct the first adult’s mistaken belief: “The ball is in the cup!” Alternatively, in the *uninformative* condition, they witnessed the second adult say something that would not serve as a corrective: “I like the cup”.

Could infants work out what the first adult would now do? As in previous studies, their looking times were measured to assess what they expected. In the informative condition, infants looked longer when the first adult reached for the ball in the empty box rather than the cup where it was now located, implying that they expected her to have updated her mistaken belief about the ball’s location thanks to the second adult’s corrective assertion. By contrast, in the uninformative condition infants looked longer when the first adult reached for the ball in the cup rather than the box, implying that they expected her not to have updated her mistaken belief about the ball’s location given the second adult’s uninformative remark.³

To understand the implications of such an interchange, infants do not necessarily have to witness an explicit verbal correction, such as, “The ball is in the cup!” In a follow-up study, 18-month-old infants watched a similar set of familiarization trials (Song et al. 2008, Experiment 2). They then saw the first adult leave and the second adult move the ball from the box to a new container, a covered can. When the first adult returned, half the

³There is an ambiguity in this study. The statement that, “The ball is in the cup” provides information to the child, reinforcing his or her prior observation of the transfer, as well as to the returning experimenter. Therefore, when children are surprised in the informative conditions, they may show surprise because they saw the toy moved to the cup, were then told that the toy was in the cup (making it a very strong representation), and yet, the experimenter searched somewhere else. A control condition is needed in which the statement is heard by the child but not by the returning experimenter. I am grateful to Patricia Ganea for calling my attention to this issue of interpretation.

infants saw the second adult point to the can, whereas the remaining infants saw no such gesture. Infants' looking patterns were similar to those observed in the first study. Infants who had seen the second adult point to the new location—the covered can—were surprised, as indexed by their longer looking, when the first adult searched in the box, apparently oblivious to the informative gesture she had just received. Infants who had seen no such gesture were surprised when the first adult reached to the can rather than the box. Moreover, in a control condition in which the second adult pointed to the can after the two adults had jointly observed the ball removed from the box but also returned there, infants were now puzzled when the first adult reached to the can rather than to the box. By implication, infants did not expect the first adult to simply reach wherever the second adult pointed. They expected her to follow the second adult's cues only when those cues served to update her knowledge in the absence of relevant perceptual access.

Further evidence of the early understanding of an information exchange comes from infants' responses to head gestures—notably head nodding and head shaking. Fusaro and Harris (2013) had 18-month-olds witness a short exchange about an object hidden in one of two boxes. An adult asked, "Where is that toy?" and then pointing to each box in succession asked, "Is it in here?" A second adult nodded her head in response to one option and shook her head in response to the other. When infants were then invited to find the toy, they typically chose the appropriate box. Note that they could do this only by processing the connection between the question and the gestural reply. A focus on either the question or the gestural reply in isolation from each other would have left them none the wiser. For example, a focus on the head gesture of the second adult would not have told them which box it applied to, if they did not take account of which box the first adult was querying.

To summarize, 18-month-olds grasp that testimony changes what the recipient knows. They realize that a verbal assertion, a point, or a head gesture from a knowledgeable informant can provide information about an object's current location. They expect a less well-informed recipient—whose beliefs are based on outdated first-hand experience—to understand testimony from an informant. Finally, by tracking the connection between a question and a reply, they can update their own beliefs.

3.3 Seeking and Providing Information

In the experiments described so far, infants have not spontaneously adopted an active role. They have received testimony; they have been prompted to provide it; or, in the role of third-party, they have watched it being offered. How far do infants spontaneously seek and provide testimony in the course of their second year? And as an active participant in an information exchange, do they monitor the knowledge of their interlocutor? As information seekers, infants will learn more if they gather information from knowledgeable rather than ignorant informants. Conversely, as informants, they will be more effective if they inform those who are ignorant rather than knowledgeable.

Begus and Southgate (2012) report that infants are more likely to use pointing as an interrogative, information-eliciting gesture if the available informant appears to be knowledgeable. Sixteen-month-olds watched as a series of novel objects was presented. A female experimenter sat facing the infant and the objects were presented behind her but in

view of the infant. Infants often pointed the objects out to her—signaling that they wanted her to provide information about them—but they did this less often if the experimenter appeared to be poorly informed. They were less likely to point to the novel objects if she had previously named familiar objects incorrectly and now appeared unsure of the names of the novel objects. A follow-up study suggested that it was the experimenter’s prior naming errors that suppressed infants’ interrogative points. If the experimenter had made no explicit naming errors but simply called attention to the objects (e.g., ‘Wow, look at this!’), and then appeared unsure how to name the novel objects, infants still pointed them out.

These findings are nicely consistent with a large body of research on preschoolers. They too are reluctant to seek or accept information from an informant who has proven inaccurate (Harris 2012b; Harris and Corriveau 2011). More generally, these findings suggest that infants point not just to call attention to an interesting object but also to elicit information about it—especially from someone who has proven knowledgeable. Studies of infant pointing have typically emphasized the frequency with which infants point either to request an object or to call attention to it—effectively ‘showing’ it to an addressee (Olson and Masur 2011). As noted earlier, this latter type of pointing has traditionally been described as ‘declarative’ rather than ‘imperative’. But within the broad class of declarative points, it is likely that the gesture often serves an interrogative as much as a declarative function. The infant is seeking information—effectively saying: “What is this?” rather than: “Take a look at this.”

Certainly, caregivers readily interpret infants as posing this type of ‘question’. Chouinard (2007) asked parents to keep a diary record of their young children’s questions. The youngest group ranged from 12 to 17 months and the next from 18 to 23 months. Most of the youngest group and some of the older group posed their questions without the use of words. For example, a parent recorded how, when she was unpacking groceries, her daughter picked up a kiwi fruit—which was unfamiliar to her—held it toward her mother with a puzzled expression on her face, and said “Uh?” The parent interpreted this, plausibly enough, as a question meaning roughly: “What is this?” Adult coders reading through the diary records almost invariably arrived at the same interpretation as the parent. Of course, this agreement may have arisen because coders were influenced by the parent’s report and so it does not guarantee that either the coders or the parent were correct but it encourages us to take the diary data seriously.

Of the hundreds of such non-verbal ‘questions’ that parents recorded, the vast majority—approximately 80 % during the second year of life—appeared to be aimed at obtaining information rather than seeking attention or making a request. Moreover, most of these information-seeking questions appeared to be a request for a name or label between 12 and 17 months—as in the example given above. Such questions about names or labels also predominated between 18 and 23 months but there were also scattered questions about location, activity and identity. Not surprisingly, infants received answers to their questions. Indeed, at the younger age, parents often supplied information beyond whatever the infant had asked.

When infants receive a response to such an interrogative point, how well do they process the information they receive in response, and do they process it more effectively than unsolicited information? To explore this issue, Begus et al. (2012) presented 16-month-olds infants with two objects at once. The experimenter waited until infants pointed to one of them and then demonstrated an action either with the indicated object or with the other one. After a short delay, the demonstration object was re-introduced. Infants reproduced the demonstrated action better for the object that they had pointed at than for the other object. By implication, their pointing had indeed been aimed at eliciting information and that information was better encoded than information they had not sought.

Putting these studies together, we may reasonably conclude that infants adopt an interrogative stance even before they can put their questions into words. They do not have to master language and the question format that it offers to realize that: (i) to varying degrees, other people are able to supply information; and (ii) they will supply information when invited to do so via an interrogative gesture such as pointing or showing plus vocalizing.

If infants have a basic understanding of the way that communication can serve to exchange information, such an interrogative stance makes sense. Effectively, infants use interrogative points to set an information exchange in motion—one in which they will be the beneficiaries. Next, we ask if infants also approach an exchange from the supply side. Do they spontaneously proffer information to those who need it? This is what we would expect if they have a bidirectional understanding of information exchange.

3.4 Providing Information

Infants' ability to help an adult locate a hidden object via pointing was described earlier (Behne et al. 2012). In that study, however, infants were explicitly prompted to help—an adult named the object and asked where it was. Do infants spontaneously provide information even before being asked to do so? Liskowski et al. (2006, Experiment 2) arranged for 12- and 18-month-olds to see an adult mislay an object that she was working with. She looked for it, expressing puzzlement and eventually asked where it was and named it. Both age groups quite often responded to the adult's puzzlement with a point and they typically did so before the adult explicitly asked where the object was.

Are infants selective in their informative pointing? Do they provide information to those who need it? Liskowski et al. (2007) found that 12-month-olds were more likely to point to an interesting object—a moving puppet—not when a nearby adult looked at it but rather when she had failed to notice it. Liskowski et al. (2008) had 12-month-olds watch as an adult sorted through various objects positioned on a folder. While she was so engaged, an object sometimes slid off the folder onto the floor. On half the trials, the adult missed this disappearance—she was temporarily looking in the opposite direction. On the remaining trials, she was looking in the same direction and saw the object slide to the floor. In either case, she expressed puzzlement (“Hm...huh...that’s strange...well”). By implication, she was wondering *where* the object had gone when she had not see it drop but she was wondering *how* it had fallen when she had. Infants were more likely to point to the object on the floor in the former case—apparently realizing that she did not know where the object was.

Knudsen and Liszkowski (2012) report further evidence of spontaneous and selective informative pointing. Eighteen-month-olds watched as an adult searched for an object in several containers, eventually finding it in the last container. The adult then left briefly and did not see the object being moved to a different container by a second adult. On the return of the first adult, even before she has any clear indication of where she was going to look for the object, infants helpfully pointed to its new location. On the other hand, if the first adult had only inadvertently come across the object in the first stage of the study or if she had seen it moved prior to her departure, infants did not engage in such helpful pointing. By implication, they realized that the returning adult was not about to retrieve the object or would do so without help.

Taken together, these studies show that infants point spontaneously and they point to inform interlocutors in a selective fashion. They realize that pointing is especially informative for someone is unaware of an object's current location.

4 Conclusions

Human culture and the traditions that sustain it depend on the deliberate exchange of information. In this respect, human societies appear to depart markedly from those observed among non-human primates (Harris 2012b). Although it is tempting to think that it is the human capacity for language that makes such cultural learning possible, the findings reviewed in this paper suggest a different developmental account. By early in the second year, infants are able to communicate with adults on the basis of non-verbal signals sometimes augmented by vocalization. Such early communication has often been framed in terms of the sharing of affect or attention. From this perspective, infants are equipped to join with a caregiver in such a way that they are engaged by the same object, situation or project. This perspective on early communication can be found, for example, in Trevarthen's pioneering analysis of secondary intersubjectivity (Trevarthen and Hubley 1978). It is echoed in the notion of "joint engagement" (Bakeman and Adamson 1984) or "triadic joint action" (Salomo and Liszkowski 2013).

Without questioning the importance of this type of convergent *attention*, the present review has emphasized the parallel importance of convergent *knowledge*. More specifically, it has highlighted how—even at the beginning of the second year—an initial divergence in knowledge between adult and infant can be turned into a convergence if information is appropriately exchanged. The evidence repeatedly underlines how infants grasp this particular type of communicative act. When faced with uncertainty, they take in information from a knowledgeable adult and act upon it. In addition, they also provide information, particularly to an adult whose ignorance is indexed by his or her uncertainty or absence. Third, as a witness or eavesdropper to an information exchange, they are able to make sense of what transpires between informant and recipient. They realize that the recipient will think and act in light of what the informant communicates. Finally, whether as information-seeker or as information-provider, infants can act spontaneously—they sometimes take the initiative.

This analysis also highlights important differences between social referencing and the exchange of information via gesture or vocalization. When infants receive affective comments about the world via social referencing, those comments typically convey only a positive or negative attitude—they signal whether an object, a person, or a slope is safe to approach or risky. By contrast, information exchanged via gesture and vocalization is considerably richer: even at the beginning of the second year, it can convey information about location, identity and goals. Moreover, there is preliminary evidence that infants realize how an exchange can provide information not just to an uncertain or uninformed recipient, but also to someone who already has their own (mistaken) convictions. Infants realize that gestural and vocal information can override or update the recipient's beliefs.

How does our focus on infants' grasp of the exchange of information compare to other theories of early communication? In their theory of natural pedagogy, Csibra and Gergely (2009, 2011) have proposed that human infants are naturally sensitive to ostensive signals from adults: they readily treat such signals as indicating a referent and they expect to learn something that is generic rather than tied to that specific referent. The present findings are clearly consistent with the emphasis of natural pedagogy on infants' early receptivity to information. Nevertheless, two points of divergence are worth noting. Csibra and Gergely focus on communication from adult to child in the context of face-to-face interaction, a context that facilitates mutual gaze and the use of motherese. More generally, they focus on an asymmetric, one-way transfer of information from the pedagogic adult to the infant pupil.

Our review points to a more powerful, and symmetric, early competence. First, as noted, infants readily make sense of an information exchange even when they observe it from a third-party perspective. In such cases, they are unlikely to have engaged in mutual gaze with the informant or to have benefited from motherese. Nevertheless, they are able to infer what information has been communicated and to anticipate how the recipient will behave as a result. Second, the evidence shows that infants are not just the recipients of information that is offered by adults. Infants also offer information to adults, particularly in situations where they are better informed. Third, the natural pedagogy model portrays the infant as an *attentive* pupil who is receptive to adult input. We have reported evidence for a more *self-directed* pupil—one who is aware of his or her ignorance and actively seeks to remedy it by consulting nearby adults for relevant information. Summing up, we find the natural pedagogy metaphor to be revealing and congenial but it understates the capacity of infants to engage in intelligent eavesdropping, to instruct other people, and to set their own 'educational' agenda by seeking information.

Tomasello and his colleagues (Tomasello 2008; Tomasello et al. 2007) argue that children's early production of gestures, especially pointing, serves three primary communicative intentions: requesting objects or actions from others; sharing emotions and attitudes; and providing information that other people need in pursuing their goals. In this paper, we have focused on the second and third motives: sharing and especially informing. Indeed, our emphasis on the way in which so-called declarative pointing can serve not only to establish shared attitudes to an object of joint attention but can also serve to convey information builds on the earlier analyses of Tomasello and his colleagues. At the same time, our review goes beyond their proposals in three important ways. First, we have emphasized

that with respect to the motive of informing, infants appear to be capable of occupying and conceptualizing the role of both informant and recipient. Thus, not only do 12-month-old infants offer information to a misinformed or ignorant adult—as described by Tomasello and colleagues—but in addition, they take in information and form expectations based on the gestures of a better-informed adult. Second, even when they themselves do not occupy the role of informant or recipient, infants are able to make sense of an information exchange between two adults from a third-party perspective. Finally, our review indicates that infants use gestures, and especially pointing, not only to request objects or actions but to request information. Accordingly, in line with a proposal made by Southgate and her colleagues (Southgate et al. 2007), we would add a fourth ‘interrogative’ motive to the three motives of requesting, sharing and informing emphasized by Tomasello and colleagues. We assume that third-party observation of adult interchanges as well as active questioning each play an especially important role in early social learning when, much like anthropologists, young children are trying to make sense of the surrounding culture (Harris 2012a, b).

5 Future Directions

Infants’ early ability to understand the bidirectional exchange of information raises fascinating questions for future research. First, the study of preschool children has shown convincingly that they are selective about their informants. In seeking and accepting information, they monitor the individual characteristics of potential informants. They prefer informants who are familiar, who have proven accurate in the past, and who are likely to possess relevant expertise. In addition, preschool children monitor the group-related characteristics of potential informants. They are more receptive to informants who belong to the same cultural group as themselves and to individuals who elicit agreement from other members of the group (Harris 2012b; Harris and Corriveau 2011). We do not yet know if infants display the same range of selectivity. The studies reviewed above suggest that infants display at least some degree of discrimination. They look more toward a local expert than to their mother (Stenberg 2013); they follow the gaze of a reliable looker rather than an unreliable looker (Chow et al. 2008); and they direct more interrogative points toward an adult who has recently provided more accurate utterances (Begus and Southgate 2012). Still, we know little about how infants assess expertise, reliability, or knowledge. For example, do they assess it on a geographical basis—assuming that informants are generally knowledgeable about the objects and space where they act—or do they use some other metric? We know still less about infants’ sensitivity to factors such as informants’ age, ethnicity, or membership within an in-group, or to group-based characteristics such as social consensus.

A second important question concerns potential links between infants’ grasp of information exchange and their theory of mind. A flurry of recent studies has consolidated the claim that infants are able to monitor a person’s beliefs, including their false beliefs. For example, they are surprised (look longer) if an adult searches for a hidden object in its actual location when the adult’s restricted perceptual access ought to have left her with a mistaken belief about the object’s location (Apperly and Butterfill 2009). Prior research using standard false belief tasks (in which children verbally report where an adult will search rather than revealing their expectations via a non-verbal index such as looking time) has repeatedly indicated an

important role for language in theory-of-mind development (Harris et al. 2005; Milligan et al. 2007). The recently established success of infants would appear to suggest that language only consolidates or builds upon some prior pre-verbal understanding. By implication, language may have no hand in the initial creation of that mental-state understanding. However, the conclusions of this paper raise the possibility that early communication via gesture and vocalization may actually play a vital role in nurturing infants' insight into beliefs and perhaps other mental states. More specifically, infants have a sufficiently rich grasp of pre-verbal communication and its role in the exchange of information that involvement in this type of exchange might promote their understanding of mental states including false beliefs⁴ in much the same way that participation in certain types of dialogue promotes the understanding of preschoolers, as measured by standard verbal assessments of false belief.

How might this speculation be tested? The findings of Salomo and Liszkowski (2013) suggest an important naturalistic experiment. Recall that they found that triadic, object-oriented interactions involving infant and caregiver were much more frequent in China than in Holland and more frequent in Holland than in Mayan Mexico. In turn, infants in these three cultures varied in the frequency with which they engaged in hand gestures, especially pointing. These gestures were especially widespread and frequent in China, and much less widespread and frequent in Mayan Mexico. Does such variation in gestural communication impact infants' theory-of-mind development as indexed by looking-time measures of false-belief understanding? If so, we can expect that understanding to be accelerated among Chinese infants but slowed among Mayan infants in Mexico.

Finally, we may ask about the origins of infants' understanding of gesture-based information exchange. Two different possibilities seem equally viable at present. One possibility is that that infants' understanding of such exchanges from a third-party standpoint is a developmental antecedent to their active participation in such types of exchange. On this argument, thanks their many opportunities to observe those around them engage in such exchanges, infants would eventually enter into them already equipped with a sense of how such exchanges operate, and more precisely how information is transferred from informant to recipient. An alternative possibility is that infants gradually arrive at such understanding in the course of their own active engagement in such gesture-based 'dialogue'.

Again, the cross-cultural variation that we now know to exist in infants' production of communicative gestures, especially pointing gestures, has created a natural laboratory. Suppose we were to test infants, including those younger than 1 year, in different cultures using the type of third-party paradigm created by Vouloumanos and her colleagues. If the first hypothesis is correct—namely that infants understand information exchange prior to their own active participation—then variability in children's opportunities to observe others

⁴Two recent studies with deaf infants provide some tantalizing, preliminary evidence on this issue. Meristo et al. (2012) report that hearing infants outperformed deaf infants (ranging from 17 to 26 months) born to hearing parents in their comprehension—as indexed by anticipatory looking—of where a cartoon character would search, given the character's false belief. No group difference was observed when the character held a true belief. By contrast, Hobbs, Resendes, Pyers and Carey (2013) found no difference between deaf and hearing children's performance on simple theory-of-mind tasks despite differences in the size of their vocabulary. Watch this space.

engage in communication, including gesture-based communication, should largely account for cultural differences in children's understanding, no matter how often they themselves are actively included in such exchanges. By contrast, if the second hypothesis is correct, we can expect that infants will be more or less accelerated in their grasp of information exchange, depending on the child-rearing philosophy of the culture. If the culture assumes that infants are best not engaged too early because their primary mode of learning is via observation of others from a third party perspective—a philosophy that does appear to characterize various traditional cultures (Shneidman and Goldin-Meadow 2012; Tamis-LeMonda and Song 2013)—then infants growing up in that culture will show a delayed understanding of how information is exchanged relative to their peers whose caregivers espouse a childrearing philosophy that assumes that infants benefit from early and active engagement.

Regardless of how such future experiments turn out, we can already hold onto one important conclusion. Philosophical analysis of the role of testimony in human mentation has, for understandable reasons, focused on the transmission of propositional knowledge through verbal affirmation. Developmental research has followed suit by emphasizing how much children can learn from what other people tell them. However, the findings reviewed in this paper show that that concept of testimony is too restrictive. Whether as participants in an exchange or as third-party observers, children understand that information can be transmitted via gestures and vocalizations. More generally, the findings suggest that infants are constructing a working concept of knowledge—a naive epistemology. Far from egocentrically assuming that others know what they know, they recognize that knowledge is not equally distributed and that communication can overcome some of those inequalities.

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