

Research Article

One-Year-Old Infants Appreciate the Referential Nature of Deictic Gestures and Words

Teodora Gliga and Gergely Csibra

Centre for Brain and Cognitive Development, School of Psychology, Birkbeck, University of London

ABSTRACT—*One-year-old infants have a small receptive vocabulary and follow deictic gestures, but it is still debated whether they appreciate the referential nature of these signals. Demonstrating understanding of the complementary roles of symbolic (word) and indexical (pointing) reference provides evidence of referential interpretation of communicative signals. We presented 13-month-old infants with video sequences of an actress indicating the position of a hidden object while naming it. The infants looked longer when the named object was revealed not at the location indicated by the actress's gestures, but on the opposite side of the display. This finding suggests that infants expect that concurrently occurring communicative signals co-refer to the same object. Another group of infants, who were shown video sequences in which the naming and the deictic cues were provided concurrently but by two different people, displayed no evidence of expectation of co-reference. These findings suggest that a single communicative source, and not simply co-occurrence, is required for mapping the two signals onto each other. By 13 months of age, infants appreciate the referential nature of words and deictic gestures alike.*

referential in nature, children could rely on general cognitive mechanisms specialized to detect such relations to figure out the referents of communicative signals.

In fact, it has been suggested that infants go through an initial developmental phase during which they detect the relevant relations between signals and referents, but without a real understanding of the signals' referential nature. In the domain of indexical reference, studies have shown that infants follow deictic gestures such as gaze shifts or pointing from a very early age (Farroni, Massaccesi, Pividori, Simion, & Johnson, 2004), but cannot correctly identify what the other person is attending to until after their first birthday (Butterworth & Jarrett, 1991). This led some researchers to propose that gaze or point following is initially an automatic or reinforced response that reflects no referential understanding of the eliciting gestures (Moore, Angelopoulos, & Bennett, 1997; Triesch, Teuscher, Deak, & Carlson, 2006). A similar developmental shift has been suggested to underlie the change from the slow word learning of 1-year-olds, who require plenty of word-object pairings (Werker, Cohen, Lloyd, Casasola, & Stager, 1998), to the fast mapping observed in 2-year-olds (Heibeck & Markman, 1987). It has been proposed that in the 2nd year of life, general-purpose associative mechanisms are replaced by language-specific principles that take into account the speaker's communicative intentions (Nazzi & Bertoncini, 2003).

A potential alternative to these stage theories is the proposal that the notion of reference is not a sudden insight abstracted from experience, but rather an inherent expectation for communicative signals (Csibra & Gergely, 2006; Macnamara, 1982) that precedes and guides infants' discovery and learning of the particular relations that link referential signals to their referents. Several studies have shown that the acquisition of sign-referent mappings is facilitated by communicative cues. For example, infants learn words easily when given rich communicative and deictic signals (Woodward, Markman, & Fitzsimmons, 1994), despite being exposed to fewer word-object

Communication of adults is a crucial source of information for human infants. To benefit from this rich information source, infants have to be able to appreciate the referential nature of communicative signals and to figure out how they are linked to their referents. For example, infants have to learn that deictic gestures, such as pointing or looking, refer to objects by their current spatial locations, whereas words are linked to their referents by arbitrary associations. Because both kinds of reference are established through relations that are not necessarily

Address correspondence to Teodora Gliga, Centre for Brain and Cognitive Development, School of Psychology, Birkbeck, University of London, Malet St., London WC1E 7HX, England, e-mail: t.gliga@bbk.ac.uk.

co-occurrences than in more controlled situations (Werker et al., 1998). Similarly, gaze following is facilitated when communicative cues (e.g., mutual gaze) are present before the onset of the gaze shift (Senju & Csibra, 2008).

It is not easy to develop good tests of referential understanding. Demonstrating that infants make use of the appropriate relation (i.e., spatial alignment or statistical association) between a signal and its referent is not sufficient to show that they also conceive the signal in communicative terms. For example, the fact that 12-month-old infants look at the object associated with a word they hear (Smith & Yu, 2008) does not necessarily entail that they perceive the word as “standing for” that object (Cohen, 1998). Similarly, the fact that infants follow someone’s gaze to a location and expect to find an object there (Csibra & Volein, 2008) could merely indicate that they have learned the relation between looking and object locations, but does not demonstrate that they necessarily interpret looking in referential terms (Caron, Kiel, Dayton, & Butler, 2002). Making use of the relationship between the specific signals and their referents is not sufficient to appreciate that words and deictic gestures, when they originate concurrently from the same source, have to be mapped onto a common referent (*co-reference*). To achieve this appreciation, infants must additionally understand the common and complementary referential nature of the two cues. In fact, theories that emphasize the role of social signals in word learning implicitly rely on the assumption that infants expect co-reference between verbal labels and looking or other deictic gestures (Baldwin et al., 1996; Tomasello, 2001). During word learning in a social context, it is the indexical reference, provided by deictic gestures, that individuates the referent (usually an object) with which the new word, as an unattached symbol, ought to be associated. These two signals individuate object referents two different ways, which are orthogonal to each other. A deictic gesture provides spatial individuation by specifying a location, whereas a word allows identification by specifying an object kind.

Although word learning seems the most appropriate context to demonstrate the understanding of co-reference, word-learning studies have yielded mixed results with younger infants. These studies have shown that 1-year-old infants are sensitive to deictic cues when learning a new word (Hollich, Hirsh-Pasek, & Golinkoff, 2000; Pruden, Hirsh-Pasek, Golinkoff, & Hennon, 2006) and look at the interlocutor for deictic information if none is given (Baldwin & Moses, 2001). However, infants usually fail to acquire novel word-object mappings in these studies. Because word learning not only requires referential understanding but also imposes demands on infants’ memory and attention, we designed a paradigm that requires no learning, but only comprehension of words.

We took two additional steps in order to ensure that infants’ performance in the task would reflect true referential understanding and would not be open to alternative associationist interpretations. First, we used an *absent* referent. When the referent is not visually present at the time when the referential signals are given, infants have to link the properties conveyed by

the cues at an abstract level (Baldwin, 1993). Second, we varied whether the verbal and deictic information came from the same person or two different people. Infants are known to be able to associate various object properties simply by their temporal co-occurrence (Richardson & Kirkham, 2004; Slater, Quinn, Brown, & Hayes, 1999). If a similar mechanism explains infants’ use of co-reference, we would expect infants to succeed in the task even when the words and deictic cues co-occurred but did not originate from the same communicative source.

In our task, two different groups of 13-month-old infants were given two kinds of information about a hidden object: its name and its location. For one group, these signals came from the same person (single-source condition); for the other group, they were provided by two different people (dual-source condition). If infants expect that two concurrent referential signals from a single source co-refer to the same object, their expectation should be violated when they find that the two cues individuate different objects. Crucially, if such a response reflects referential appreciation of the communicative signals rather than their temporal association, the response should be restricted to occasions when the signals are provided by the same person (single-source condition).

METHOD

Participants

The 44 infants who were included in the final sample were equally divided between the single-source condition (10 boys and 12 girls) and the dual-source condition (9 boys and 13 girls). The average age was 391.0 days (range: 366–404 days) in the single-source condition and 392.9 days in the dual-source condition (range: 382–418 days). An additional 20 infants were excluded from analysis (11 in the single-source condition, 9 in the dual-source condition) for the following reasons: failure to complete the study because of fussiness ($n = 2$), behavior that could not be coded from the video recording because of extensive movements ($n = 10$), parental interference ($n = 3$), and experimenter error ($n = 5$).

Stimuli

Infants were presented with short, digitally edited video sequences featuring a female actress (single-source condition) or a male actor (dual-source condition) behind a table. Two white cardboard panels occluded objects located at the bottom left and the bottom right corners of the display. A dark-gray cardboard panel was placed on the table, in front of the actor or actress, to separate the upper and lower parts of the display, thus facilitating the editing of the video sequences (see Fig. 1). The sequences were composed of two phases, the naming phase and the outcome phase. The naming phase in the single-source condition began with the actress smiling and greeting the viewer (“Hey, baby!”). She then named one of the hidden objects three times while

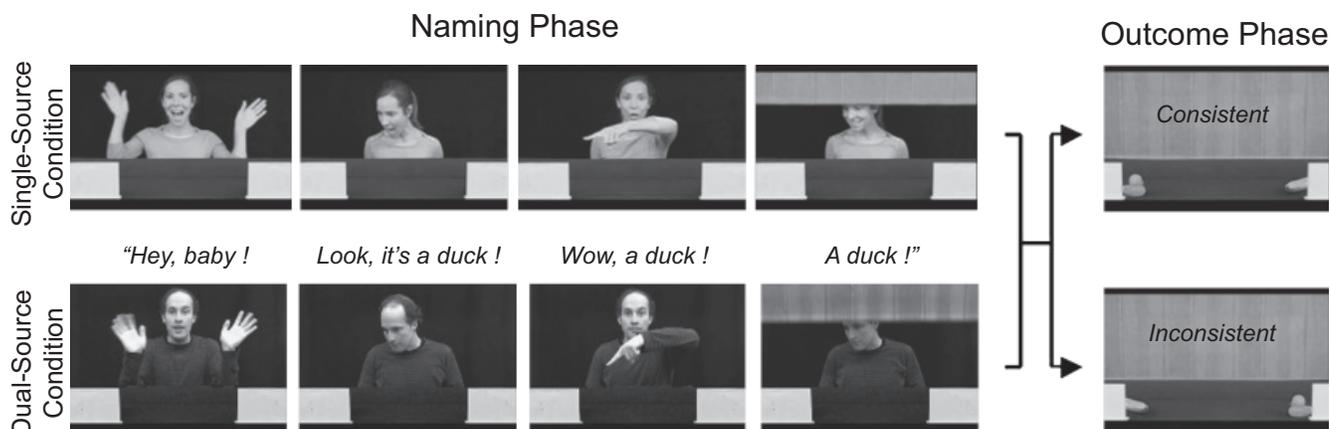


Fig. 1. Selected frames from the video clips used in the single-source and dual-source conditions. In the naming phase of the single-source condition, the actress greeted the viewer and then made gaze shifts and pointed behind one of the ocluders while naming an object. In the naming phase of the dual-source condition, the actor greeted the viewer and then silently made gaze shifts and pointed behind one of the ocluders while the audio track from the single-source condition was played in synchrony with his movements. During the outcome phase, the named object was behind the ocluder previously cued by deictic signals (consistent outcome) or behind the opposite ocluder (inconsistent outcome).

making gaze shifts and pointing behind one of the ocluders. In the naming phase of the dual-source condition, the male actor smiled and greeted the baby, but then proceeded to make gaze shifts and point silently with closed lips while, in coordination with his movements, the audio track from the single-source condition was played. Thus, while the male actor gave deictic location cues silently, an out-of-view female voice named an object three times. Previous studies have suggested that even young infants are capable of mapping male and female voices onto male and female faces, respectively (e.g., Bristow et al., in press), so it is likely that the infants realized that the words were not uttered by the actor they saw on the screen. After the naming phase (12 s), a red curtain came down, and the outcome phase started. The ocluders moved away and revealed two objects, one of which was the object that had been named previously.

Four pairs of objects were used in the clips: duck-banana, ball-shoe, spoon-car, and cup-apple (see Table 1). To ensure that both objects in each pair would be familiar to the infants, we selected objects with labels that are understood by 13-month-old infants (Dale & Fenson, 1996). In addition, parental reports were used to estimate the participants' understanding of the four words infants

heard in the study (*duck*, *ball*, *spoon*, and *cup*). On average, infants in the single-source condition knew 3.5 of the words, and infants in the dual-source condition knew 3.3 of the words, $t(42) = 1.04$, $p = .3$, $p_{rep} = .77$. Because parents tend to underestimate their children's vocabularies (Hamilton, Plunkett, & Schafer, 2000), we did not exclude the few trials that presented words the parents indicated were unknown to their infants.

For both conditions, we created two types of outcomes by digitally reversing the positions of the objects (Fig. 1). In the consistent outcome, the named object was behind the ocluder previously cued by deictic signals, whereas in the inconsistent outcome, it was revealed behind the opposite ocluder. The left/right direction of the deictic gestures was counterbalanced. Thus, we used 16 different video clips, corresponding to four object pairs, two cue directions, and two trial types (Table 1).

Procedure

Each infant sat on his or her parent's lap in a dimmed room approximately 100 cm away from a plasma screen (105-cm diagonal), on which the stimuli were presented. The caregiver

TABLE 1

Summary of the Four Trial Orders Counterbalancing the Named Object, the Direction of the Deictic Cues, and the Order of the Different Outcomes

Order version	Trial 1			Trial 2			Trial 3			Trial 4		
	object	Named Deictic cues	Outcome	object	Named Deictic cues	Outcome	object	Named Deictic cues	Outcome	Object	Named Deictic cues	Outcome
1 ($n = 12$)	Cup	Left	Inconsistent	Duck	Right	Consistent	Ball	Left	Consistent	Spoon	Right	Inconsistent
2 ($n = 10$)	Duck	Right	Inconsistent	Cup	Left	Consistent	Ball	Left	Consistent	Spoon	Right	Consistent
3 ($n = 10$)	Cup	Right	Consistent	Duck	Left	Inconsistent	Spoon	Left	Consistent	Ball	Left	Inconsistent
4 ($n = 12$)	Duck	Left	Consistent	Cup	Right	Inconsistent	Spoon	Left	Consistent	Cup	Right	Consistent

was instructed to look down at the infant and not to interfere with him or her during the study. The experiment began with a single familiarization trial, in which no person was present. Two objects (a book and a milk bottle) were revealed behind the two occluders. This sequence was used to create an expectation for objects to be present behind the occluders. The infant then saw two consistent test trials and two inconsistent test trials. Four orders of presentation were used (Table 1). On each trial, after the objects were revealed, the last frame of the clip froze. The trial was terminated when the infant looked away from the monitor for more than 2 s.

Data Analysis

Video recordings of the infants' faces were coded off-line, frame by frame, with 33-ms accuracy. For each trial, the gaze direction of the infant was coded separately for the naming phase (i.e., before the occluders began to move outward) and for the outcome phase (i.e., after the occluders began to move outward). We measured the looking times to the center and each side of the screen, as well as the total looking time at the screen. We also counted the number of gaze shifts between the two objects after they were revealed. The recordings of 11 participants (25%) were also coded by a secondary coder. Total looking times were correlated between the coders, $r = .957$.

RESULTS

We first investigated whether there was any difference in looking behavior between the two conditions during the naming phase. Infants spent equal amounts of time looking at the screen in the two conditions (13.8 s in the single-source condition and 13.3 s in the dual-source condition), $t(42) = 1.25, p = .2, p_{\text{rep}} = .82$.

We also compared the number of times infants looked toward the side the actors were pointing to and toward the opposite side. An analysis of variance (ANOVA) with side (cued vs. uncued) and condition (single- vs. dual-source) confirmed a main effect of side, $F(1, 42) = 5.85, p = .02, p_{\text{rep}} = .95$, suggesting that infants tended to follow the deictic signals given by the actors. Neither the main effect of condition nor the interaction was significant. Thus, infants' tendency to respond to these signals did not differ between the two conditions. The lack of difference in the time spent looking at the actors and in following their gaze suggests that the infants engaged equally in the two conditions.

We then explored the effect of the outcome by computing within-subjects average total looking times, at any part of the plasma screen, for the consistent and inconsistent trials during the outcome phase. In the single-source condition, infants spent on average 2 s longer looking at the unexpected than at the expected outcome (8.5 s vs. 10.6 s for the consistent and inconsistent trials, respectively; see Fig. 2). In contrast, infants in the dual-source condition spent slightly more time looking at the consistent than at the inconsistent outcomes (11.8 s vs. 10.4 s; see Fig. 2). A 2 (condition: single- vs. dual-source) \times 2 (outcome: consistent vs. inconsistent) \times 4 (order of presentation) ANOVA confirmed that there was a significant interaction between condition and outcome, $F(1, 36) = 5.85, p = .021, p_{\text{rep}} = .95, \eta_p^2 = .14$. No other main effect or interaction was significant. Post hoc t tests confirmed that the consistency between the deictic and verbal signals had a significant effect on looking times in the single-source condition, $t(21) = -2.29, p = .032, p_{\text{rep}} = .94$, but not in the dual-source condition, $t(21) = 0.91, p = .36, p_{\text{rep}} = .74$.

Because the unexpected outcome in the inconsistent trials might have influenced infants' expectancy in subsequent trials, we also analyzed the looking times and number of switches in the

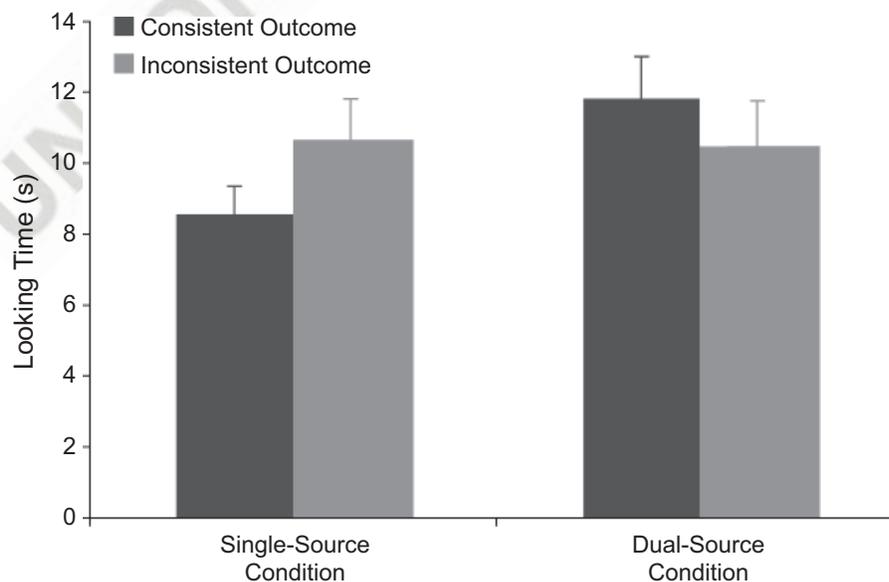


Fig. 2. Looking times at consistent and inconsistent outcomes in the single-source and dual-source conditions. Error bars represent standard error.

first test trial only, which was uncontaminated by previous experimental manipulations. In a two-way ANOVA on the total looking times during the first trial, with condition and outcome as between-subjects factors, we found only a significant interaction, $F(1, 40) = 4.35$, $p = .043$, $p_{\text{rep}} = .92$, $\eta_p^2 = .1$. This interaction was due to infants in the single-source condition looking on average 4.2 s longer at the first trial when it showed an inconsistent outcome than when it showed a consistent outcome (10.4 s vs. 6.2 s), $t(20) = 2.6$, $p = .017$, $p_{\text{rep}} = .95$. This looking-time difference was accompanied by significantly more gaze shifts between the two objects in the inconsistent (5.4) than in the consistent (3.0) trials, $t(20) = 2.9$, $p = .008$, $p_{\text{rep}} = .97$. Infants in the dual-source condition looked longer (10.5 s vs. 9 s) at consistent than at inconsistent first trials, and made more shifts between the two objects (6.9 vs. 4.3) in the consistent trials, but neither of these differences reached statistical significance.

Analysis of the direction of the first looks after the occluders started to move away showed that infants were more likely to look at the previously cued location than at the opposite location in the single-source condition (first look was to the cued location on 61.3 % of the trials, which is significantly higher than chance) $t(21) = 3.17$, $p = .005$, but not in the dual-source condition (53.4 %), $t(21) = 1.00$, $p = .329$. Although these percentages were not significantly different from each other, $t(42) = 1.61$, $p = .121$, this finding indicates that infants' initial looking behavior toward the objects was influenced by the preceding deictic cues differently in the two conditions, and this may have been a confounding factor in our analysis. When infants looked at the indicated side, they found an object different from the named one in the inconsistent condition, but they found the named object in the consistent condition. Thus, infants' first looks landed more frequently on the nonnamed object in the inconsistent trials than in the consistent trials in the single-source condition. It is therefore possible that the looking-time difference between the consistent and the inconsistent trials was due mainly to infants looking longer at the cued side in the inconsistent trials because this location contained an unexpected object.

To test this alternative hypothesis, we reanalyzed the looking times in the single-source condition using a 3×2 ANOVA with location (cued side vs. center vs. noncued side) and outcome as within-subjects factors. We again found a main effect of outcome, $F(1, 21) = 4.88$, $p = .03$, $p_{\text{rep}} = .94$, $\eta_p^2 = .189$, but there was no effect of location and no interaction between outcome and location. This result confirms that infants in the single-source condition looked longer at all parts of the plasma screen during the inconsistent than during the consistent trials.

DISCUSSION

In this study, we aimed to show that 1-year-old infants understand the referential nature of two kinds of communicative signals: words and deictic gestures. Infants' longer looking at the inconsistent than at the consistent outcomes in the single-source

condition supports our hypothesis, because the infants could not have detected the inconsistency by independently using the associations between words or indexical cues and their referents. Had the infants simply expected to find an object at the location indicated by the actor's gestures (as in earlier studies, e.g., Csibra & Volein, 2008), they should have been equally satisfied by the two trial types, because an object was revealed at that location. Similarly, if the infants had simply associated words and objects, and this association made them expect to find the object associated with the familiar verbal label, their expectation would have been met by both outcomes: The labeled object was always present. The outcome in the inconsistent trials would have been unexpected only if the infants thought that the object kind referred to by the verbal label should be mapped onto the location indicated by the deictic gestures of the same communicator, that is, if they expected that these two signals co-referred, albeit in different ways, to the same object.

The infants' failure to determine the location of the named object in the dual-source condition speaks against a simple associationist explanation of performance in the single-source condition. Although the infants were given the same amount of information and in the same temporal synchrony in the two conditions, infants in the dual-source condition did not infer that the visual deictic cues given by the actor referred to the same object named by the disembodied voice. The null result in this group cannot be explained by lower engagement with the stimuli, because looking time and gaze following during the naming phase were comparable in the two conditions. Rather, the fact that the two kinds of referential signals originated from two different sources prevented infants in the dual-source condition from concluding that the signals co-referred to the same object. This effect is analogous to the finding that covariation between infants' own direction of attention and a word uttered by someone else (Baldwin, 1991) or by an out-of-view speaker (Baldwin et al., 1996) is not sufficient for infants to attach the word to the attended object.

In demonstrating that infants understand co-reference between two different kinds of referential signals, this experiment provides powerful evidence that infants appreciate the referential nature of the linkage between signals and their referents. Although it was known that infants make use of referential gestures (Csibra & Volein, 2008; Moll & Tomasello, 2004) or words (Dewar & Xu, 2007) separately to infer the presence of a hidden object, the use of co-reference was previously tested only in word-learning tasks, in which only older infants seemed to be successful (Baldwin & Markman, 1989; Baldwin & Moses, 2001; Bloom & Markson, 1998; Tomasello, 2001). Making use of words infants already knew, we took away the extra attentional and memory load demanded by most word-learning situations, in which unfamiliar words have to be associated with unfamiliar objects.

Thus, our study demonstrates that 13-month-olds (a) conceive both lexical and deictic communicative signals in referential terms and (b) assume that, when these signals occur concur-

rently and originate from the same source, they refer to the same thing. Because we tested 13-month-olds, we are not in the position to make any strong claim about the ontogenetic origin of referential understanding of communicative signals. Nevertheless, we find it unlikely that this achievement around the first birthday is based on a sudden insight into the referential nature of words or gestures, or into the relation between words and gestures. Because the test we employed required a small but existing vocabulary, it could not be used with younger infants, whose abilities for word learning are limited by their developing speech-perception skills (Werker & Yeung, 2005). However, the fact that referential understanding of words can be demonstrated at an age when word learning has hardly begun suggests that the appreciation of reference is not the outcome, but one of the sources, of vocabulary development (Macnamara, 1982).

In our view, referential expectation in infancy does not necessarily require or entail a rich understanding of the speaker's mental states, as suggested by some models of early communication (Bloom & Markson, 1998; Tomasello, 2001). A first level of referential understanding, defined as the ability to perceive certain signals as being content-full and as placeholders for objects in the world, can be used simply for the identification of the referent of a message. However, the recognition of a situation as communication may be a precondition of early referential understanding. From their first months of life, and possibly even from birth, infants are sensitive to ostensive communicative cues (mutual gaze, infant-directed speech, etc.) that signal to the infants that they are being addressed (Csibra & Gergely, 2006). All these cues were deliberately rich in both conditions of our study, because earlier findings indicated that referential understanding of gaze might depend on their presence (Senju & Csibra, 2008).

This demonstration that infants, by the time they start to produce words, have figured out how words and gestures refer to things does not mean that there is no further development in referential understanding. As children grow, they rely more and more on intricate linguistic and pragmatic information in assigning reference. Our finding suggests that what changes with age may be not the understanding of the symbolic nature of words or the deictic nature of certain gestures, but the ability to use multiple and more subtle cues to infer what people refer to during communication.

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