Infants' Contribution to the Achievement of Joint Reference

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BALDWIN, DARE A. *Infants' Contribution to the Achievement of Joint Reference.* CHILD DEVELOPMENT, 1991, **62**, 875–890. This research examines whether infants actively contribute to the achievement of joint reference. One possibility is that infants tend to link a label with whichever object they are focused on when they hear the label. If so, infants would make a mapping error when an adult labels a different object than the one occupying their focus. Alternatively, infants may be able to use a speaker's nonverbal cues (e.g., line of regard) to interpret the reference of novel labels. This ability would allow infants to avoid errors when adult labels conflict with infants' focus. 64 16–19-month-olds were taught new labels for novel toys in 2 situations. In follow-in labeling, the experimenter looked at and labeled a toy at which infants were already looking. In discrepant labeling, the experimenter looked at and labeled a different toy than the one occupying infants' focus. Infants' responses to subsequent comprehension questions revealed that they (*a*) successfully learned the labels introduced during follow-in labeling, and (*b*) displayed no tendency to make mapping errors after discrepant labeling. Thus infants of only 16 to 19 months understand that a speaker's nonverbal cues are relevant to the reference of object labels; they already can contribute to the social coordination involved in achieving joint reference.

Word learning depends critically on the achievement of joint reference. To learn a new word, one must, on at least one occasion, link that word with the very object, scene, or event to which a proficient speaker of the language is referring. Achieving joint reference is a complex undertaking, even in what would seem to be the simplest case—the case of object labels. The world is littered with objects, so when a new label is heard, how does one know *which* object to connect with that label? And how does one know that the object label should be linked with the object per se, as opposed to its color, shape, size, movement patterns, etc.? Originally posed by philosophers such as Quine (1960) and Wittgenstein (1953), the latter question has recently received considerable attention from researchers (see, e.g., Baldwin, 1989; Markman, 1989, in press; Merriman & Bowman, 1989). However, it is the former aspect of the joint reference problem—in particular, the question of how an *infant* word learner identifies the correct object upon hearing a new label—that is the focus of the present research.

Some time ago, Bruner and his colleagues (e.g., Bruner, 1978; Churcher & Scaife, 1981; Scaife & Bruner, 1975) pointed out the important role that joint *attention* undoubtedly plays in facilitating joint reference for infant word learners. Their point was that joint reference occurs quite natu-

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rally if adult and infant happen to be focused on the same thing at the time of the adult's utterance (see also Quine, 1973). Joint attention at the time of labeling is easily achieved if adults do much of the work, that is, if adults are careful to label objects at a time when infants are already focused on them. It turns out that parents, or at least Western, middle-class parents, are reasonably accommodating in this respect. By the time infants are about 9 months old, mothers frequently follow infants' line of regard or pointing gesture and label the object on which infants' attention is focused (e.g., Collis, 1977; Leung & Rheingold, 1981; Masur, 1982; Murphy, 1978). Harris, Jones, and Grant (1983) found that a full 70% of mothers' utterances referred to the object already occupying the focus of 6–10-month-olds' attention.

Such adult vigilance appears to play an important role in infants' label-learning success. Harris, Jones, Brookes, and Grant (1986) demonstrated that mothers of infants learning language at a normal rate made more references to objects that were at the current focus of infants' attention than did mothers of slower language learners. Similarly, Tomasello and his colleagues (e.g., Tomasello, Mannle, & Kruger, 1986; Tomasello & Todd, 1983) found that infants had larger vocabularies the more time they typically spent in joint attentional focus with their mothers. Further, maternal directiveness (i.e., failing to follow in on infants' attentional focus when labeling) was negatively related to the proportion of object labels in infants' productive vocabularies. In a lexical training study (Tomasello & Farrar, 1986), infants were more likely to learn to comprehend a new label if that label was presented at a time when infants were already focused on its referent, as opposed to when the label was presented in an attempt to redirect their attentional focus (i.e., when an adult held up a toy and uttered its label at a time when infants were not focused on any particular object). Thus word learning is most likely to take place when cooperative labeling on parents' part reduces the effort that infants themselves must direct toward joint reference.

However, these same studies also indicate that parents are not always able to follow in on infants' focus of attention at the time of labeling. In some cases, infants are actually focused on an incorrect referent at the time that a label is uttered. Instances of such "discrepant labeling" are far from uncommon: they have been observed across a number of studies (e.g., Harris et al., 1983, 1986; Tomasello & Farrar, 1986; Tomasello & Mannle, 1985). In Collis's (1977) study, mothers' labels failed to correspond with the object infants were looking at about 50% of the time, and this occurred for roughly 30% of mothers' labels in the Harris et al. (1983) study. The phenomenon of discrepant labeling raises interesting questions concerning the social processes governing joint reference. In cases of discrepant labeling, adult and infant are attending to different objects at the time the label is uttered: joint attention is violated. Is joint reference also necessarily violated, and if so, what are the implications for word learning? These questions cannot be answered until we know the extent to which infants themselves actively contribute to the achievement of joint reference.

It is possible that, when discrepant labeling occurs, infants tend to link the label with whichever object is currently occupying their focus, thus leading them to establish an incorrect word-object mapping. This is the scenario we would expect if associative principles are the sole mechanisms that govern word learning. In the case of discrepant labeling, temporal contiguity, for instance, pulls for infants to link the label with the object of their own focus.

On the other hand, infants may possess skills that allow them to avoid mapping errors when faced with discrepant labeling. Adults tend to offer explicit cues concerning the referent of a label that they utter. For example, parents typically look at or point to the object they are labeling (e.g., Messer, 1978), even in cases of discrepant labeling (when infants happen to be focused on a different object). If infants notice these nonverbal cues at some point, and if they also realize that the cues are informative about the reference of the label being uttered, then infants themselves may be capable of actively salvaging joint reference when discrepant labeling occurs. The speaker's nonverbal cues would alert infants to the discrepancy of focus, enabling them to block a mapping error. And perhaps infants can go further than just avoiding an incorrect mapping under conditions of discrepant labeling. By checking and following the speaker's cues to the correct object after hearing the label, infants may even discover the correct referent as well. That is, infants may be able to

use the speaker's cues to correctly interpret the label's reference, despite the violation of joint attention at the time of labeling.

If infants possess such a "cue-sensitive" understanding—an appreciation of the linguistic relevance of speakers' nonverbal cues—then the burden adults carry for infants' word-learning success is to some degree alleviated. Infants need not make mapping errors when adults fail to achieve follow-in labeling, as long as adults provide salient and unambiguous cues as to the correct referent.

All in all, an early understanding that nonverbal cues are relevant to word reference would smooth the course of word learning by preventing mapping errors. Infants of about 18 months and older have been observed to learn new object labels based on only one or two exposures to that label (e.g., Nelson & Bonvillian, 1973). With label learning proceeding at such a rapid pace, the ability to use others' nonverbal cues to clarify word reference would be crucial for avoiding a proliferation of mapping errors. Moreover, the cue-sensitive understanding could help to speed the course of word learning in another way as well; this ability would provide infants with more opportunities for learning the connection between labels and their referents. They could conceivably pick up on word-object mappings under conditions of discrepant labeling (roughly 50% of instances in Collis's data) as well as under follow-in conditions.

Current evidence indicates that associative principles such as temporal contiguity play a role in early word learning. For instance, a word is more likely to be learned the smaller the gap in time between presentation of the word and its referent (e.g., Whitehurst, 1979; Whitehurst, Kedesdy, & White, 1982). Temporal contiguity is generally a good guide to identifying the correct referent of an adult's utterance, given that, on many occasions, adults do follow-in labeling. Temporal contiguity is misleading only when discrepant labeling occurs. What is in question, then, is whether infants favor nonverbal cues over temporal contiguity specifically when faced with discrepant labeling.

At present, there is no empirical evidence to clarify whether infants appreciate the linguistic significance of a speaker's nonverbal cues. While infants as young as 9–12 months can follow nonverbal cues such as pointing and line of regard (e.g., Butterworth & Cochran, 1980; Butterworth & Grover, 1988; Churcher & Scaife, 1981; Grover, 1982; Lempers, 1976; Leung & Rheingold, 1981; Murphy & Messer, 1977; Scaife & Bruner, 1975), it has yet to be determined whether infants understand that nonverbal cues can and should be used to help in determining the reference of a novel label.

As described earlier, recent research points to a learning advantage for follow-in labeling over labeling that occurs during an attempt to redirect infants' attentional focus (e.g., Tomasello & Farrar, 1986). If infants' word-learning difficulties in the absence of follow-in labeling were clearly the result of mapping errors, then these results could already be taken as evidence *against* the cue-sensitive understanding under present discussion. However, these difficulties may have occurred simply because the demands of switching attentional focus reduced infants' ability to learn the labels. Because these studies did not specifically diagnose the incidence of mapping *errors*, they do not speak to the question of present interest.

The following study was designed to yield evidence concerning the likelihood of mapping errors when joint attention is violated at the time of labeling. In a discrepant labeling condition, the experimenter uttered a new label precisely at a time when infants were focused on an incorrect referent. If infants lack an understanding of the linguistic significance of nonverbal cues, temporal contiguity should lead them to make mapping errors in this situation. That is, when subsequently tested for comprehension of a new label, infants should select the object they were themselves focused on at the time they heard the new label. On the other hand, if infants are sensitive to nonverbal cues as relevant to word reference, they could avoid making mapping errors in the discrepant labeling condition. Thus they might fail to link the label with either object, or they might link the label with its correct referent, despite the fact that they were looking at a different object at the time the new label was actually uttered.

Each infant also participated in a follow-in labeling condition, in which the experimenter labeled the object upon which infants were already focused. In the follow-in case, joint reference can be achieved solely through the auspices of temporal contiguity; hence word learning should proceed

without error. Thus the follow-in labeling condition was designed to provide a baseline level of word learning in the laboratory situation.

In the present study, several types of nonverbal cues were available to infants. One cue was line of visual regard: the experimenter looked at the object upon which infants themselves were focused during follow-in labeling, and during discrepant labeling, the experimenter looked at a different object. At least two other cues were also available: voice direction and body posture. The experimenter's body and utterances were oriented toward infants during follow-in labeling, while her body and voice were oriented down and away from infants during discrepant labeling. This study does not clarify the particular cue, or set of cues, that infants might consult for word-learning purposes.

The study also included a control to determine whether infants in the two labeling situations indeed established word-object mappings. It is possible that the adult's nonverbal cues might increase infants' interest in the object of the adult's focus, leading them to prefer that toy on the comprehension tests, without any word mapping having occurred at all. To test this alternative explanation, half of the infants were asked preference-control questions (e.g., "Where is your favorite one?") after follow-in labeling or discrepant labeling, rather than comprehension questions. Infants' selections in response to such questions should simply reflect their toy preferences. If infants were to display a different pattern of selections for the preference-control questions than for the comprehension questions, then comprehension performance could not be merely a function of their preference for one toy over the other.

An additional feature of the present study was an assessment of infants' comprehension of well-known, familiar labels, such as *dog, bottle,* and *ball.* Infants' ability to select the correct object when asked about familiar labels provides another kind of baseline estimate; it is informative about the highest level of comprehension performance that could reasonably be expected with the comprehension measure utilized in the study.

Method

Subjects

Ninety-four infants between 16 and 19 months participated in the study. The data from 30 of the infants were omitted,[1] leaving 64 infants from two equal-sized age groups: 16–17-month-olds (M = 16.4 months) and 18–19-month-olds (M = 18.4 months). All infants were full term at birth, developing normally, and came from monolingual, native English-speaking families. Boys and girls were represented equally in the two age groups.

According to parental report using an adapted version of the Bates (1979) early language questionnaire, infants in both age groups generally possessed productive vocabularies in excess of 50 words. As expected, the older infants possessed somewhat larger vocabularies, both receptive and productive, than the younger infants. The 16–17-month-olds already understood an average of 180 words (range: 67–332; object labels 64% of total), and they were already producing an average of 61 words (range: 5–176; object labels 67% of total). The 18–19-month-olds understood an average of 225 words (range: 82–359; object labels 62% of total), and they produced 92 words on average (range: 2–308; object labels 69% of total). Infants' vocabulary size did not predict their comprehension performance in the experimental situation on any measure, either for novel or familiar labels.

Materials

Stimuli.—Each infant saw five pairs of toys, three familiar and two novel. Parents were interviewed by phone to select the familiar toys for each infant. All infants saw the same two pairs of novel toys. One pair included a green, oblong, extendable peri-

[1] Infants were omitted due to excessive fussiness or fatigue (11 infants), experimenter error (5 infants), parental overinvolvement (1 infant), and/or when the design criteria of the study were not satisfied (13 infants). The last basis for omission included (*a*) when infants happened to look away from the toy they were holding at the time the experimenter uttered the novel label during the training phase (6 infants), (*b*) when infants spontaneously produced a label for a toy that was intended to be novel (2 infants), and (*c*) when infants provided fewer than two interpretable responses for a given item on the comprehension or preference-control questions (5 infants). The omitted infants did not differ from the infants included in the experimental sample on any of the parental report measures of vocabulary development.

scope and a disc encircled by yellow rubber suction cups, and the other pair was comprised of a set of multicolored wooden cubes strung together by elastic and a blue, cylindrical, collapsible telescope. Criteria for selection of the novel toys were that (*a*) toys be novel, attractive, balanced in salience within a pair, and manipulable for infants between 16 and 19 months of age, and (*b*) the two toys in a pair be visually distinct from one another.

Novel labels.—Two novel labels were used in the study: *peri* and *toma*. These word forms were selected according to: (*a*) novelty for infants, (*b*) distinctiveness from one another and from the familiar labels used in the study, and (*c*) ease of pronunciation for infants. Novel labels (which obey the rules of English phonology) were used instead of standard English labels to allow counterbalanced assignment of the labels to the four different novel toys.

Equipment.—A video camera equipped with a stopwatch function and a video cassette recorder equipped with frame-by-frame viewing capability were used to record infants' and the experimenter's behavior during the experimental session. The time-stamped video record provided continuous information about the temporal flow of events.

Phone questionnaire concerning familiar labels.—Prior to the laboratory visit, parents were interviewed about infants' familiarity with 18 object labels: *airplane, rabbit, bird, cat, doll, ball, sock, duck, car, shoe, spoon, flower, bottle, dog, banana, boat, cup,* and *keys*. Only labels that parents were certain infants understood were used in the experimental session.

Design

The study included two conditions: follow-in labeling and discrepant labeling. The two conditions each included two phases: (*a*) a training phase, in which a new label was introduced to infants under controlled conditions, and (*b*) a test phase, in which infants were either asked comprehension questions regarding the newly trained novel label (e.g., "Where is the *peri*?") or preference-control questions regarding the novel toys involved in the preceding training (e.g., "Where is your favorite one?"). The training phases of the follow-in labeling and discrepant labeling conditions differed in certain essential ways. First, the experimenter's nonverbal cues differed in the follow-in labeling versus discrepant labeling conditions. In the follow-in labeling condition, the experimenter uttered the novel label while looking at the toy that the infant was already examining, the "visible" toy. In contrast, the experimenter looked down into a bucket containing a second toy, the "bucket" toy, while labeling in the discrepant labeling condition. An additional difference between the follow-in and discrepant labeling conditions concerns how the experimenter coordinated labeling with the infant's focus on the visible toy. In the follow-in labeling condition, the experimenter glanced at the infant between labeling utterances to check when the infant was focusing on the visible toy. However, in the discrepant labeling condition, the experimenter avoided looking at the infant. Instead, she intermittently glanced at a side-view mirror that displayed the infant's activities to ascertain when the infant was focused on the visible toy. This procedure was chosen to minimize confusion that infants might experience regarding the experimenter's focus of attention. If the experimenter were to look at infants intermittently during discrepant labeling, infants might become confused as to whether discrepant or follow-in labeling was occurring.

Each infant participated in both follow-in labeling and discrepant labeling conditions with one trial of each condition. However, half of the infants answered comprehension questions after follow-in and discrepant labeling, while the other half answered preference-control questions after follow-in and discrepant labeling. The order in which infants experienced follow-in labeling versus discrepant labeling was balanced with respect to age group and question type (i.e., comprehension vs. preference control). Assignment of toy pairs, target toy (i.e., the labelled toy), and labels was also counterbalanced with respect to age group, question type, and the direction of the experimenter's focus (i.e., follow-in labeling vs. discrepant labeling). During the test questions for any given infant, the target toys appeared equally often in the right- versus left-hand position. Assignment of the familiar toys was also roughly counterbalanced with respect to age group, experimenter's focus, and question type (precise counterbalancing could not be achieved because infants differed in terms of which six labels they previously comprehended). Comprehension questions about the familiar labels were intermixed with questions about the novel labels in both comprehension and

preference-control test phases. This intermixing occurred in a fixed order for all subjects.

Procedure

After a short warm-up period with two familiar toys, the infant was placed in an infant seat at a table, with the parent seated nearby and the experimenter seated across the table from the infant. Parents filled out the language questionnaire during the session in order to keep parent-infant interaction to a minimum. The first activity of the experimental procedure was a brief familiarization with the comprehension test format using the familiar toys that were available during warm-up: the infant was asked one or two comprehension questions concerning one of the familar items (e.g., "Where is the *ball?* Can you find the *ball?*") and the experimenter clapped and cheered when the infant touched or picked up the correct toy. The familiarization procedure was the same for all infants, regardless of whether they were asked comprehension questions or preference-control questions.

Discrepant labeling condition: Training.—The experimenter produced a colored plastic bucket (rattling it until the infant looked at it), opened the bucket, removed the two novel toys, and placed them side by side on the table. She then placed one of the novel toys back inside the bucket, making certain that the infant watched her do this. Returning to the still-visible toy, she demonstrated what it could do, and then handed it over for the infant to explore. Then the experimenter grasped the bucket in both hands, while keeping it upright so that the infant was unable to see what was inside. She waited until the infant was looking at the visible toy (using the side-view mirror to make this judgment), looked down into the bucket, uttered a novel label (e.g., "It's a *toma*"), and maintained her gaze toward the bucket for 4 sec. The labeling procedure was then repeated three more times; each time the labeling was initiated when infants were looking at the visible toy. Thus infants were exposed to the label a total of four times during the training, and each and every exposure occurred when they were examining the visible toy. The experimenter continued to hold the bucket throughout the training. After the experimenter uttered the fourth label, she waited 4 sec, then rattled the bucket until the infant looked at it, whereupon she angled the bucket so the infant could see the toy inside. She then removed the toy from the bucket, demonstrated what it could do, and offered it to the infant. Both toys were left available to infants for up to 30 sec. Thereafter, the experimenter removed the toys, and the test phase began.

Follow-in labeling condition: Training.—The training procedure for the follow-in labeling condition was identical to that of the discrepant labeling condition, except that the experimenter gazed in the direction of the visible toy at the time of uttering the novel label, and the mirror, though present, was not used by the experimenter. As in the discrepant labeling condition, the experimenter was careful to produce the novel label only when infants were already focused on the visible toy. The experimenter held the bucket throughout follow-in labeling just as she did throughout discrepant labeling.

Test phase.—The test phase examined the consistency with which infants selected a particular toy in response to questioning by the experimenter. The test phase included either comprehension or preference-control questions concerning the novel toys as well as comprehension questions about a familiar label. A given infant answered the same type of question in both follow-in and discrepant labeling conditions.

When asked questions about novel toys, infants were shown the two novel toys from the immediately preceding training phase. When asked about a familiar label, infants were shown two familiar toys. The same two novel toys appeared for each and every novel label question, and the same two familiar toys appeared for each and every familiar label question. An array of only two toys was decided upon to reduce the information-processing load on infants, and the same two toys were used for each question to help reduce the influence of novelty and familiarity effects on infants' toy selections.

Comprehension questions.—For infants who were asked comprehension questions during the test phase, the experimenter began by placing the two novel toys on a tray. She offered the tray to the infant while encouraging the infant to select one of the toys (e.g., "There's a *peri* here. Can you point to the *peri?* Point to the *peri*"). The experimenter was careful to look only at the infant's face during questioning to avoid biasing the infant's selection via nonverbal cues.

When the infant made a selection, the experimenter said "Did you find it?" in a neutral tone, regardless of which toy was chosen. If infants showed the toy they selected to the parent seated nearby, the parent likewise responded in a neutral manner (e.g., the parent said "oh" or "that's nice" in a neutral tone regardless of which toy infants selected) based on prior instruction from the experimenter. The experimenter then retrieved the toys and began the next question trial. Infants were asked eight comprehension questions in all for each condition, four concerning the newly trained novel label and four concerning a familiar label. If infants failed to respond to a question twice in a row, the experimenter moved to the next question trial. If infants became disturbed or failed to answer six questions in succession, the comprehension testing was discontinued.

Containers of different kinds (e.g., a tray, a basket, and a pouch) were used to present the toys to infants during questioning. This variety helped maintain infants' interest. For the same reason, questions were asked in several different ways (e.g., "Point to the *peri*" vs. "Where is the *peri*?"). The use of these different questions and containers occurred in a prearranged order that was held constant for all test phases.

Preference-control questions.—Preference-control questions involved asking infants to select one of the two toys without any mention of the novel label (e.g., "Point to the one you like" or "Where's your favorite one?"). The experimenter asked infants a total of four preference-control questions and four familiar label comprehension questions for each condition. Containers and questions varied in the same fixed order as in comprehension questioning.

Coding and Reliability

Test phase coding.—Infants' responses to comprehension or preference-control questions were coded in terms of (*a*) which of the two toys infants selected first in response to the question, and, in some cases, (*b*) which of the two toys infants used in responding to the experimenter's request (e.g., "Show Mommy the *peri*"). Coders were blind to the training conditions of the novel labels and hence did not know which toy was the correct referent of a given label. The test phases of eight randomly selected infants were coded independently by two coders. They demonstrated 92% agreement in their judgments of which toy infants selected first and which toy infants used to perform a requested action.

Looks during training coding.—Coders judged (*a*) whether infants were looking at the visible toy at the time of the experimenter's labeling utterance, (*b*) when infants looked to the experimenter and/or the bucket, and (*c*) whether these looks occurred in response to hearing labels. Coders' view of the experimenter was screened; thus coders were blind to condition (i.e., follow-in vs. discrepant labeling). Based on the follow-in and discrepant training phases experienced by seven randomly selected infants, two coders demonstrated 91% agreement.

Differential labeling coding.—To verify that the experimenter maintained equivalent enthusiasm during follow-in as opposed to discrepant labeling, coders judged, on a seven-point scale, the overall level of enthusiasm with which the experimenter produced the label. During this coding the video monitor was screened; thus coders were blind to whether follow-in versus discrepant labeling was occurring. The training phases of all 64 infants were coded.

Feedback coding.—To examine whether feedback from the experimenter might have biased infants' toy selections, one coder judged whether the experimenter seemed pleased or displeased on the basis of hearing the experimenter's "Did you find it?" feedback. The coder was blind as to which toy the infant had actually selected prior to the experimenter's utterance. Feedback judgments were made for eight randomly selected infants who answered comprehension questions (in both the follow-in and discrepant labeling conditions). Comparisons between the coder's enthusiasm judgments and infants' actual selections revealed no relation between feedback and infants' pattern of selections: the experimenter was rated as enthusiastic on only 50.4% of instances in which infants had just made a correct selection (i.e., the visible toy after follow-in labeling or the bucket toy after discrepant labeling). Thus infants were just as likely to receive somewhat unenthusiastic feedback to a correct choice as to receive somewhat enthusiastic feedback. Moreover, the experimenter's feedback was judged to be enthusiastic on 54.7% of cases when infants had made an *incorrect* selection. Clearly, the experimenter's feedback

was not biased in favor of correct performance on infants' part.

Results

Looks during Training

The training phase lasted approximately 30 sec, with no significant differences in length of the training phase for follow-in versus discrepant labeling (follow-in labeling M = 31.62 sec [SD = 7.12] and discrepant labeling M = 34.39 sec [SD = 10.20]). During the training phase, infants were looking at the visible toy at the time the experimenter uttered the novel label, regardless of whether follow-in versus discrepant labeling occurred. However, infants quite often looked away from the toy at other points during the training phase. Of particular interest is the extent to which infants looked toward the experimenter and/or the bucket after hearing a label (or both in immediate sequence in response to labeling, to be called "responsive sequential looking"). Such monitoring behavior may provide information about the degree to which infants were sensitized to the experimenter's nonverbal cues. Table 1 displays a summary of infants' pattern of looks with respect to the three looking measures.

Overall, infants demonstrated a sizable amount of monitoring in both experimental conditions; for example, in both follow-in and discrepant training phases, virtually all infants (62 out of 64) looked at least once toward the experimenter in response to labeling. A 2 (age) × 2 (question type: comprehension vs. preference-control) × 2 (experimenter's focus: follow-in vs. discrepant) mixed-design MANOVA including all three looking measures revealed a main effect of experimenter's focus, $F(3,58) = 13.44$, $p < .00005$, but no effects of age or question type, and no significant interactions. The main effect of experimenter's focus was due to a higher level of monitoring during discrepant labeling than during follow-in labeling, as is apparent from Table 1. Subsequent univariate tests revealed that the main effect of experimenter's focus held up for looks-to-experimenter, $F(1,60) = 5.08$, $p < .05$, and responsive sequential looks, $F(1,60) = 35.03$, $p < .00005$, but not for the looks-to-bucket measure.

The looks-during-training results are noteworthy on two counts. First, the absence of a main effect or interactions involving question type helps to verify the equivalence of the training phases for infants who were asked comprehension questions and those who were asked preference-control questions. More importantly, the greater incidence of monitoring during discrepant labeling suggests that infants were sensitized to the discrepancy between their own and the speaker's focus and sought to identify the target of the speaker's focus. However, the comprehension data presented next are needed to clarify whether infants *used* what they noticed about the speaker's focus to help them in determining the reference of the novel label.

Novel Toy Selections

Selection of the visible toy.—If infants fail to understand the significance of the speaker's focus for the reference of the novel label, when tested for comprehension they should select the visible toy regardless of whether the label was introduced during follow-in or discrepant labeling. In contrast, infants who are sensitive to the linguistic relevance of the speaker's focus should select the visible toy less often when it is introduced during discrepant relative to follow-in labeling. Also in question is whether infants' selections differ when asked comprehension questions versus preference-control questions. Thus, of particular interest in the comprehension results is the possibility of an interaction between the direction of the experimenter's focus (i.e., follow-in vs. discrepant labeling) and the type of question infants were asked (i.e., comprehension vs. preference-control questions). Infants' toy selections were analyzed by means of a 2 (age) × 2 (question type) × 2 (experimenter's focus) mixed-design ANOVA.[2] Because infants varied in the number of questions they answered, their performance was analyzed in terms of the proportion of questions for which they selected the visible toy out of the total number of questions answered.[3] The ANOVA revealed a main effect

[2] Preliminary analyses revealed no effects or interactions involving either sex or order of condition (i.e., follow-in labeling first vs. follow-in labeling second). For simplicity of presentation, all analyses are presented without these variables.

[3] Based on Winer's (1971) recommendation, proportions in all analyses were submitted to the arcsin transformation ($X'_{ijk} = 2 \arcsin \sqrt{X_{ijk}}$), with values close to zero or unity corrected in the following way: $X'_{ijk} = 2 \arcsin \sqrt{X_{ijk} \pm [1/(2n)]}$. However, for ease of comprehension, the mean scores (and standard deviations) reported throughout the article are those for the *untransformed* proportions (expressed as percentages).

TABLE 1

MEAN NUMBER OF LOOKS DURING TRAINING

	Follow-in	Discrepant
Looks to experimenter	4.02 (1.90)	4.86 (2.53)
Looks to bucket	1.97 (2.00)	2.28 (1.96)
Responsive sequential looks	.23 (.53)	.95 (.90)

NOTE.—Standard deviations in parentheses.

of question type, $F(1,60) = 5.94$, $p < .05$. As may be seen in Table 2, this main effect was due to infants who were asked comprehension questions selecting the visible toy more frequently than infants who were asked preference-control questions. The ANOVA also revealed a main effect due to experimenter's focus, $F(1,60) = 5.65$, $p < .05$, reflecting a greater selection of the visible toy after follow-in labeling than after discrepant labeling. Finally, the ANOVA yielded a significant question type × experimenter's focus interaction, $F(1,60) = 5.27$, $p < .05$. No other effects were significant.

An analysis of simple effects (Keppel, 1982) conducted to determine the locus of the interaction revealed that infants who were asked comprehension questions selected the visible toy more frequently in the follow-in labeling condition than in the discrepant labeling condition, $F(1,60) = 10.92$, $p < .005$. This finding is consistent with the prediction that infants appreciate the linguistic relevance of the speaker's nonverbal cues.

The simple-effects analysis further revealed that the experimenter's focus during label training did not significantly affect infants' tendency to select the visible toy in response to the preference-control questions. That is, when asked a question such as "Where is your favorite one?" infants were equally likely to select the visible toy after discrepant labeling and after follow-in labeling. Thus, the impact of the experimenter's focus on infants' response to *comprehension* questions can more clearly be interpreted as reflecting knowledge of word-object mappings.

In addition, the simple-effects analysis provided specific evidence concerning whether word mappings were established. For follow-in labeling, infants selected the visible toy significantly more often when asked comprehension questions than when asked preference-control questions, $F(1,60) = 12.02$, $p < .005$. Thus, in the follow-in labeling condition, infants who were asked comprehension questions chose the visible toy more often than they would have by preference alone, again suggesting that the comprehension questions indeed tapped word learning.

However, performance on comprehension questions and preference-control questions did not differ for the discrepant labeling condition. This was true both when the results were collapsed across age and when each age group was considered individually. This analysis thus fails to clarify whether word mappings per se were established during discrepant labeling.

Tests against chance performance.—Also in question is whether infants selected

TABLE 2

MEAN PERCENT SELECTION OF THE VISIBLE TOY

	Follow-in	Discrepant
Comprehension questions:		
16–17-month-olds	65 (26)	53 (36)
18–19-month-olds	72 (30)	34 (25)
Both age groups	69 (28)	44 (32)
Preference-control questions:		
16–17-month-olds	48 (31)	46 (30)
18–19-month-olds	42 (23)	42 (28)
Both age groups	45 (27)	44 (29)

NOTE.—Standard deviations in parentheses.

the correct toy more often than would be expected if they were merely making random selections. Recall that the correct toy would be the visible toy in the follow-in labeling condition and the bucket toy in the discrepant labeling condition. In the follow-in labeling condition, infants who were asked comprehension questions selected the visible toy more often than would be expected by chance, $t(30) = 3.82$, $p < .001$, while infants who were asked preference-control questions did not differ significantly from chance in their pattern of selection. The same pattern of results emerged when the two age groups were considered separately, with $t(14) = 2.34$, $p < .05$ for younger infants, and $t(14) = 2.99$, $p < .01$ for older infants, respectively, who were asked comprehension questions. Thus infants as young as 16–17 months were able to map the novel labels to the correct objects when labels were introduced during follow-in labeling.

In the discrepant labeling condition, by contrast, infants performed at a level consistent with random responding regardless of whether they were asked comprehension or preference-control questions. However, it is worth noting that when the two age groups were considered separately, older infants selected the bucket toy (the correct toy) more often than would be expected by chance when asked comprehension questions following discrepant labeling, $t(14) = 2.56$, $p < .05$ (they did not differ from chance when asked preference-control questions). Younger infants performed at levels not significantly different from chance for both comprehension and preference-control questions in the discrepant labeling condition.

Up to this point, then, three main findings have emerged. First, infants were able to link a new label with its appropriate referent in the follow-in labeling condition. Second, infants did *not* fall prey to mapping errors when discrepant labeling occurred: they did not link the novel label to the visible toy. In fact, older infants were significantly less likely than would be expected by chance to display mapping errors. However, younger infants did not systematically link labels with *any* object when faced with discrepant labeling. Apparently younger infants were able to inhibit a mapping when discrepant labeling occurred, yet they were unable to actively infer the correct mapping. Finally, older infants' greater-than-chance selection of the bucket toy after discrepant labeling suggests that they may have been able to go beyond inhibiting errors to actively infer the correct referent of the label. However, given the absence of differences between comprehension and preference-control questions, it remains somewhat inconclusive at this point in the analysis whether older infants indeed established word mappings in the case of discrepant labeling.

Criterion-based results.—Infants' selection patterns across both labeling conditions were also examined. If infants actively consult the speaker's nonverbal cues, they should systematically select both (*a*) the visible toy after follow-in labeling *and* (*b*) the bucket toy after discrepant labeling. On the other hand, if infants fail to recognize the significance of such cues, they should systematically select the *visible* toy after both follow-in and discrepant labeling. For these analyses, a criterion of at least three out of four same-toy selections (for a given condition) was used because it was relatively rare for infants to select the same novel object on all four questions. Table 3 displays the criterion-based results in contingency-table format.

Of the 23 infants who answered all four comprehension questions in both labeling conditions, 11 fit the pattern predicted by the cue-sensitive understanding (i.e., visible toy after follow-in labeling and bucket toy after discrepant labeling). This frequency is both well above chance (binomial test $p < .00005$) and significantly greater than that obtained for preference-control questions, $\chi^2(1) = 7.74$, $p < .01$. In contrast, only three of the 23 infants who were asked comprehension questions displayed the pattern to be expected if infants failed to consult nonverbal cues (i.e., selection of the visible toy after both follow-in and discrepant labeling), which does not differ from the 2.25 predicted by chance nor, by Fisher's exact test, from the frequency observed among infants who were asked preference-control questions.

In sum, like the previous findings, the criterion-based results point to an early sensitivity to the linguistic significance of the speaker's nonverbal cues: a significant number of infants linked the label with the correct toy across both follow-in labeling *and* discrepant labeling. These findings indicate that some infants were able to go beyond the avoidance of mapping errors during discrepant labeling; they used the speaker's nonverbal cues in an active way as a guide to the correct interpretation of the novel label.

TABLE 3

NUMBER OF INFANTS WHO MET THE THREE OR FOUR OUT OF FOUR SELECTION CRITERION

FOLLOW-IN LABELING	DISCREPANT LABELING		
	3 or 4	2	0 or 1
Comprehension questions:			
3 or 4	3 (2.25)	2 (2.70)	11 (2.25)
2	3 (2.70)	0 (3.23)	1 (2.70)
0 or 1	1 (2.25)	2 (2.70)	0 (2.25)
Preference-control questions:			
3 or 4	1 (2.05)	2 (2.46)	2 (2.05)
2	2 (2.46)	0 (2.95)	2 (2.46)
0 or 1	3 (2.05)	4 (2.46)	5 (2.05)

NOTE.—Only infants who answered all four test questions included. Chance frequencies in parentheses.

Comprehension of Familiar Labels

Infants' responses to comprehension questions about familiar labels were examined to provide baseline information about the sensitivity of the comprehension measure. Comprehension performance for the novel versus familiar labels can be compared directly if we consider only those infants who were asked comprehension questions about both novel and familiar labels.

As shown in Table 4, infants' overall comprehension performance was better for familiar labels (M = 72%, SD = 24) than novel labels (M = 63%, SD = 30), but the familiar versus novel label difference was significant only in the discrepant labeling condition, paired $t(31) = 2.21$, $p < .05$. As is clear from Table 4, this difference in the discrepant labeling condition was primarily due to differences between novel versus familiar label performance in younger infants. In general, then, infants performed nearly as well on the comprehension questions regarding novel labels that they had heard only four times as they did on questions regarding labels that they had known for some time, with the exception that younger infants tended to respond more accurately to familiar labels when novel labels were introduced under conditions of discrepant labeling.

Ruling Out Alternative Explanations

The results considered thus far suggest that infants of 16–19 months are sensitive to the speaker's nonverbal cues as a source of information about the reference of novel object labels. However, there are several plausible alternative explanations that must be ruled out before this conclusion can be accepted. First, decreased selection of the visible toy following discrepant labeling may have occurred simply because during discrepant labeling infants became (*a*) distracted and/or (*b*) irritated by the experimenter's inattentive and relatively directive behavior. If distracted, infants may have spent less time examining the visible toy during discrepant labeling than during follow-in labeling, and therefore may have been less able to map the novel label to the

TABLE 4

MEAN PERCENT CORRECT FOR INFANTS WHO WERE ASKED COMPREHENSION QUESTIONS ABOUT BOTH NOVEL AND FAMILIAR LABELS

	Follow-in	Discrepant
16–17-month-olds:		
Familiar labels	78 (23)	60 (29)
Novel labels	65 (26)	47 (36)
18–19-month-olds:		
Familiar labels	79 (22)	73 (19)
Novel labels	72 (30)	66 (25)

NOTE.—Standard deviations in parentheses.

visible toy. If irritated, infants may have been less responsive to comprehension questions and hence less likely to display a mapping of the novel label to the visible toy. A direct measure of distraction was available in the data—the time infants spent examining the visible toy during the training phase of follow-in versus discrepant labeling. Infants' irritation could be diagnosed by their performance on familiar label comprehension questions that followed discrepant labeling. If irritated, infants should also have been uncooperative in answering questions about familiar labels and hence have displayed poorer familiar label comprehension performance after discrepant as opposed to follow-in labeling (note in Table 4 that younger infants indeed displayed a decrement in familiar label comprehension performance after discrepant labeling relative to follow-in labeling).

Another possibility is that infants avoided selecting the visible toy after discrepant relative to follow-in labeling as a result of differences in the way the experimenter presented the labels during these training phases. Perhaps the experimenter produced the label less enthusiastically during discrepant training than during follow-in training. As described earlier, such differential labeling on the experimenter's part was measured by having blind observers code the enthusiasm with which the experimenter produced the novel labels in the two types of training phases.

The validity of these alternative explanations was tested by entering the three measures, each tied to a separate alternative, as covariates in a 2 (age) × 2 (question type) × 2 (experimenter's focus) ANCOVA with the dependent variable being the proportion of time infants selected the visible toy. This analysis revealed the same pattern of effects as the original analysis: no significant age differences, a significant main effect of question type, $F(1,57) = 5.41$, $p < .05$, a significant main effect of experimenter's focus, $F(1,57) = 4.21$, $p < .05$, and a significant question type × experimenter's focus interaction, $F(1,57) = 5.61$, $p < .05$. An analysis of simple effects verified that this interaction followed the same pattern as originally observed. In sum, this analysis demonstrates that the measures associated with the proposed alternatives do not, by themselves, account for the effects obtained.

Discussion

The present investigation attempted to clarify infants' contribution to the achievement of joint reference, specifically, whether infants can actively make use of a speaker's nonverbal cues for interpreting novel object labels. If so, infants could identify the referent of a new label, even when the label refers to a different object than the one upon which infants themselves are focused. This cue-sensitive understanding could play a crucial role in helping infants to avoid many mapping errors because (*a*) it is not uncommon for adults to label a different object than the one occupying infants' focus (e.g., Collis, 1977; Harris et al., 1983), and (*b*) word learning proceeds very quickly when infants reach 16–19 months; words can be learned based on only one or two exposures.

The findings provided clear support for an early appreciation of the linguistic significance of the speaker's nonverbal cues. Infants did not tend to make mapping errors when they were introduced to novel labels under discrepant labeling conditions. Rather, they tended to select the visible toy when it was the correct referent (i.e., when introduced during follow-in labeling) but not when it was an incorrect referent (i.e., when presented during discrepant labeling). This is a striking result. During discrepant labeling, not only were infants looking at an incorrect referent at the time they heard the novel label, but the incorrect referent was in fact the only novel object in sight. Infants would seem to have been under considerable pressure to establish an incorrect mapping. Yet they did not.

Although infants used the speaker's focus to guide their interpretation of novel labels, they did not use the speaker's focus to guide their object preferences, based on their responses to preference-control questions. It is clear, therefore, that the comprehension results indeed reflect word learning. Infants' reduced tendency to select the visible toy in response to comprehension questions following discrepant labeling could not have been the result of demand characteristics introduced by the training circumstances, or such a pattern would have emerged for the preference-control questions as well as for the comprehension questions.

All in all, infants' performance indicates that they possess at least one word-learning strategy that goes beyond simple associative processes such as temporal contiguity. Namely, infants spontaneously use the speaker's nonverbal cues to guide the word-object associations that they form. This is not to say that infants can deal with the discrep-

ant labeling situation effortlessly. Rather, it seems to be easier for infants to learn labels under conditions of follow-in labeling than discrepant labeling, just as others have demonstrated (e.g., Harris et al., 1983; Tomasello & Farrar, 1986). What is significant is that infants possess abilities that buffer them from making errors during discrepant labeling.

Avoiding Errors versus Inferring Correct Mappings

There is some question as to whether infants were able to do more than merely inhibit mappings (and hence avoid errors) when discrepant labeling occurred. The criterion-based results indicated that at least some of the infants successfully used the speaker's cues to establish a mapping with the bucket toy during discrepant labeling. Similarly, 18–19-month-olds selected the bucket toy in response to comprehension questions more often than would be expected by chance following discrepant labeling (although not significantly more often than infants who were asked preference-control questions).

Why did many infants experience difficulty in establishing correct mappings during discrepant labeling? One possibility to consider is that these infants were entirely insensitive to the linguistic implications of the discrepancy between their own and the speaker's focus. However, if this were so, the criterion-based results should have displayed some incidence of mapping errors, which they did not. A second possibility is that infants' appreciation of the discrepancy in focus led them to block a mapping, but they were not yet able to use the speaker's cues in an active way to seek out the correct referent. Finally, perhaps most infants *were* capable of using the speaker's cues in an active way to infer the correct mapping, but many were unable to display this ability due to intervening obstacles. Several such obstacles were present in this study. For example, the correct referent was actually hidden from view throughout the period of labeling. Thus, infants could not simply solve the mapping problem by immediately glancing over to the object at which the experimenter was looking. Infants would need to be able to mentally represent the object in the bucket and link the label to this representation during the training phase, or else they would need to inhibit a mapping between the label and the visible toy while retaining the label in memory until the bucket toy was revealed. Perhaps if these additional obstacles to mapping were removed, many more infants would reveal an ability to infer the correct mapping from the adult's nonverbal cues when discrepant labeling occurs.

Infants' Sensitivity to Nonverbal Cues during Training

Infants' pattern of looks during the training phase was also indicative of the cue-sensitive understanding. When the experimenter produced a label, infants looked more frequently toward the experimenter and showed more glances between the experimenter and the bucket during discrepant than follow-in labeling. These findings suggest that infants noted the discrepancy between their own and the experimenter's focus, leading them to check the experimenter's gaze more frequently and to attempt to pinpoint the target of the experimenter's gaze. Infants' tendency to check the experimenter's face during discrepant labeling suggests that line of regard is an important cue for them. Again, however, line of regard was not the only cue available to infants concerning the speaker's focus in this situation, and such redundancy of cues is probably typical of most everyday interactions. Thus, even when infants do not glance up at a speaker's face, they may nevertheless be aware of a discrepancy in focus.

The looks-during-training results also help to rule out a low-level interpretation for the comprehension results. Given that the experimenter seldom looked in infants' direction during discrepant labeling, infants might have lost interest in the experimenter, leading them to ignore the experimenter's utterance, and hence, for this relatively low-level reason, to inhibit a mapping between the label and the visible toy. However, the fact that infants showed an *increased* tendency to look toward the experimenter (and between the experimenter and the bucket) during discrepant labeling suggests that they did not ignore the experimenter but rather were specifically seeking information concerning the experimenter's focus.

Nature and Source of Infants' Cue-Sensitive Understanding

The ability infants displayed in the present study can be interpreted in both a "frugal" and a "profligate" light, to use Premack's (1988) terms. A frugal interpretation is that infants possess only a low-level understanding of both nonverbal cues and the way that nonverbal cues relate to correct mappings. Infants may follow nonverbal cues because they have learned that these cues predict interesting visual experiences; they may use nonverbal cues as a guide to

word reference because they have come to realize that nonverbal cues and labels tend to be directed toward the same object. In particular, infants may appreciate the relation between nonverbal cues and word reference without understanding why this relation exists. Though superficial, this ability would nevertheless be an effective aid to word learning by enabling infants to avoid mapping errors when discrepant labeling occurs. How might such a superficial understanding of nonverbal cues be acquired? Perhaps when infants have learned to comprehend labels, they notice that, when an adult speaker utters those labels, he or she tends to look or gesture toward the labels' referents.

In contrast, the profligate interpretation views infants as possessing a tacit understanding of *why* nonverbal cues should be consulted when establishing word-object mappings. Perhaps infants implicitly understand that both labels and nonverbal cues reflect what a speaker is thinking about. When infants hear a label they do not know, they interpret this label in light of the available nonverbal cues because they understand that nonverbal cues and labels converge on the same thing, the speaker's mental focus. Put another way, infants may understand that when uttering a label, a speaker intends to refer to a particular object, while also understanding that nonverbal cues are a good source of information about the target of that intent. Thus the profligate view attributes to infants some elementary understanding of mental phenomena such as "intent" and "focus of attention," as well as an understanding that both nonverbal cues and labeling utterances bear some relation to these mental phenomena.

The profligate explanation for infants' tendency to use nonverbal cues to guide word mappings is of course both speculative and controversial (see Baldwin, 1988; Shatz, 1983; Smiley, 1987). Nevertheless, a number of researchers have argued recently that infants of about this age are sensitized to others' focus of attention and understand that nonverbal cues signal focus of attention (e.g., Baldwin, 1988; Baron-Cohen, 1989; Bretherton, 1988; Bretherton, McNew, & Beeghly-Smith, 1981; Trevarthen, 1980). There are also some hints that infants are increasingly interested in maintaining joint attentional focus with adults at this time. Bakeman and Adamson (1984) have shown, for instance, that infants begin to spend substantial amounts of their free play time in active coordinated attention with their mothers from the age of about 15–18 months (e.g., joining with the mother in focusing on a set of objects, both by playing with those objects and looking back and forth between the individual and the objects of focus). Thus it seems possible that infants understand something about the "jointness" of coordinated attention at an early age, and are interested in achieving and maintaining it. The findings of the present research, on a rich interpretation, suggest that infants of 16–19 months not only appreciate the "jointness" of coordinated attention but also recognize that language, and, in particular, word reference, trades on this intersubjectivity.

Supposing for a moment that the profligate interpretation is correct, we should question how infants could achieve such insight into language and human behavior as early as 16–19 months of age. Some researchers have argued that such understanding is innately given. For example, Bruner (1983) writes, "the 'intent to refer' is unlearned and . . . so too is the recognition of that intent in others. . . . Logically, there would be no conceivable way for two human beings to achieve shared reference were there no initial disposition for it" (p. 122) (see also Leslie & Happe, 1989). Macnamara (1982, 1990) specifically argues that infants are innately supplied with an ability to recognize the intent to refer in another person's *utterance*. Perhaps, however, infants could acquire an understanding that labels and nonverbal cues converge on a speaker's intent to refer with only the nonverbal cues side of this triangle innately specified. According to this scenario, infants recognize from early on that nonverbal cues reflect some information about other people's intentions and focus of attention, while not yet understanding that language similarly manifests such mental phenomena. Infants might then build up such an understanding about language through observing the way that nonverbal cues are correlated with language use. There would seem to be ample opportunity for such observation given the rich array of cues that adults tend to supply when talking to young children (e.g., Collis, 1977; Messer, 1978, 1983; Murphy & Messer, 1977; Ninio & Bruner, 1978).

Conclusion

The findings presented here reveal that infants of only 16–19 months appreciate that speakers supply nonverbal cues that are relevant to the interpretation of novel object labels. At this early age, then, infants are already capable of carrying some of the burden of social coordination that is necessary

for the achievement of joint reference. This enables them to establish word-world correspondences with only a modicum of error. Thus these findings help to illuminate the rapid trajectory that is characteristic of early semantic development.

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