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14-Month-Old Infants Form Novel Word–Spatial Relation Associations

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Abstract

This study explored 14-month-old infants' ability to form novel word–spatial relation associations. During habituation, infants heard 1 novel word (e.g., *teek*) while viewing dynamic containment events (i.e., Big Bird placed in a box) and, on other habituation trials, a second novel word (e.g., *blick*) while viewing dynamic support events (i.e., Big Bird placed on the box). Each novel word was presented in a sentence (e.g., “She’s putting Big Bird teek the box”). During the test, infants discriminated an event that maintained the habituation word–relation pairing from one that presented a switch in this pairing. The results indicate that 14-month-olds can learn to form word–relation associations quickly, requiring only a few minutes of experience with each word–relation pairing.

Although word learning is the end result of a number of linguistic, cognitive, and social abilities, infants also can learn novel labels under impoverished conditions, relying on a few or even a single source of information to link a novel word to its referent. For example, infants can use the co-occurrence of a novel word and a referent as the sole source of information for associating the word to an object (Schafer & Plunkett, 1998; Werker, Cohen, Lloyd, Casasola, & Stager, 1998) or an action (Casasola & Cohen, 2000). When co-occurrence is insufficient to specify the referent of a novel word, 16-month-old infants use a speaker’s gaze to disambiguate which of two objects is being labeled (Baldwin, 1993). Hence, when it comes to word learning, infants are quite resourceful in finding information to link novel words to their corresponding referents. Thus far, research on early word learning has focused mainly on infants’ acquisition of object labels and the range of cues they to use to map a novel word onto an object (e.g., Baldwin & Moses, 2001; Hollich et al., 2000). The question explored in this study is whether infants as young as 14 months can be resourceful in using limited sources of information, and limited exposure to a novel word and an event, to link a novel word to a spatial relation.

Rather than relying on the spatial words produced by children (e.g., Choi & Bowerman, 1991; Tomasello, 1987), more recent studies on the acquisition of spatial language have examined infants’ and toddlers’ comprehension of spatial morphemes. For example, Meints, Plunkett, Harris, and Dimmock (2002) found that 15-month-old infants comprehend *on* as corresponding to a cat sitting on the center of a table and *under* as corresponding to the cat sitting under the table. Similarly, Choi, McDonough, Bowerman, and Mandler (1999) found that English- and Korean-learning toddlers of 18 to 23 months comprehend spatial terms according to the semantic pattern of their ambient language. They found that English-learning toddlers comprehended *in* as referring to one object being placed in a containment relation to a second object, whereas Korean-learning toddlers correctly comprehended the Korean morpheme *kkita* as referring to one object being placed in a tight-fit relation to a

second object. Thus, within their second year, infants and toddlers display little difficulty in learning to comprehend the spatial terms of their language, despite cross-linguistic differences in how languages organize spatial events into semantic spatial categories (Choi & Bowerman, 1991).

Young children's ease in acquiring spatial language raises the question of how language-specific semantic categories are formed and the sources of information that children recruit to form them. Bowerman and Choi (2001) suggested that linguistic input is an important component in how young children learn to attend to those spatial relations that are linguistically relevant. Hearing the same word across different contexts may highlight which relations are relevant for a child's language. They also argued that children's own linguistic knowledge plays an important role in directing their attention to the referent of a novel word. Indeed, Waxman and Booth (2001; Booth & Waxman, 2003) showed that infants of 14 months can use the syntactic context of a novel word to map a novel count noun onto an object and a novel adjective onto an object property. However, research has yet to explore whether 14-month-old infants can do the same with a novel word that refers to a spatial relation.

There is, however, evidence from older children that the syntactic context of a novel word can direct children's attention to an object versus a spatial relation. Landau and Stecker (1990) presented preschool children with a novel word in either a noun phrase ("This is a corp") or a prepositional phrase ("This is a corp my box") while placing a novel object on top of a box. The children then viewed the same object that they had seen during training plus two novel objects. As the experimenter placed each object in each of five different positions, she asked the children who had heard the noun phrases, "Is this a corp?" but asked those who had heard the prepositional phrase, "Is this a corp the box?" Children in the noun phrase condition only accepted the familiar object as "a corp" regardless of its spatial relation to the box. In contrast, children in the prepositional phrase condition only accepted the familiar spatial relation as the correct referent for "a corp the box" regardless of the object used to depict the relation. Their results demonstrate that young children can use the syntactic frame of a novel word to infer the correct referent of a novel noun versus a novel spatial preposition, providing insight into one linguistic cue that children use to acquire spatial language.

More recently, Casasola, Wilbourn, and Yang (in press) also taught English-learning toddlers a novel spatial word for a spatial relation, one that is lexically marked in Korean but not English. In Korean, actions resulting in a tight-fit containment relation or a tight-fit support relation are described as *kkita*. Thus, the Korean semantic category of *kkita* intersects the English semantic categories of *in* and *on*. Casasola et al. explored whether 20-month-old toddlers, whose ambient language was English, could learn to form a semantic spatial category consistent with the Korean semantic category of *kkita*, one comprised of tight-fit containment events and tight-fit support events. Toddlers viewed an experimenter demonstrate two tight-fit containment relations and two tight-fit support relations, each described with the novel word *keet*. A control group of toddlers viewed the same events but were never provided with a label. After the training session, both groups of toddlers were tested in a preferential-looking paradigm. They viewed a tight-fit support event paired with a loose-fit containment event and, on other trials, a loose-fit support event paired with a tight-fit containment event. A control trial presented general linguistic input with the events (e.g., "Oh, look"), whereas two test trials presented the novel label with the events (e.g., "Where does she put it keet?"). Only the toddlers who had been trained with the novel spatial word looked significantly longer at the tight-fit spatial relation, for both containment and support events, when hearing the novel word than when hearing only general linguistic input. The results indicate that the toddlers trained with the novel word had learned to map the word

onto a tight-fit spatial relation, demonstrating that a novel word not only motivates toddlers to attend to a spatial relation they normally disregard in their descriptions of spatial events but also to organize spatial events into a semantic category on the basis of this spatial relation.

The results reported by Landau and Stecker (1990) and Casasola et al. (in press) show how linguistic input can direct young children to map a novel word onto a particular spatial relation. The preschool-age children tested by Landau and Stecker clearly used syntax to disambiguate the referent of a novel word, a cue that the toddlers tested by Casasola et al. may have also used in mapping the novel word onto the tight-fit relation. However, both studies were conducted in naturalistic settings with an experimenter, raising the possibility that children used other cues from their interactions with the experimenter to map the novel word onto the spatial relation. Thus, in the few studies that have presented children with novel words for spatial events, none have explored whether or not children can map a novel word onto a spatial event in the absence of any cues provided by an experimenter. Consequently, it is difficult to pinpoint the role that information from the linguistic input itself plays in leading children to map words onto spatial events. In particular, it is uncertain whether information from the linguistic input as well as the co-occurrence of the word with the relation, without an experimenter, are sufficient for young children to map a novel word onto a spatial relation.

One purpose of this study is to explore whether infants as young as 14 months can learn to associate a novel word with a spatial relation when tested without an experimenter. The results of this experiment would provide insight into whether the linguistic input and the co-occurrence of a novel word and a spatial relation are sufficient sources of information for infants to link a novel word with a spatial event. A second purpose is to document how much experience is needed for infants to learn to associate a novel word with a particular spatial relation. The study by Casasola et al. (in press) was the first to explore toddlers' ability to map a novel word onto a spatial relation, and consequently, no effort was made to limit toddlers' exposure to the novel word across the 20-min training session. Their results raise the question of whether young children can map a novel word onto a spatial relation when given less experience with a novel word and a spatial relation. Infants of 14 months have demonstrated the ability to form word-object associations with only a few minutes of experience with two word-object pairings (Werker et al., 1998). Hence, a goal of this experiment was to explore if infants of 14 months can also map a novel word onto a spatial relation given limited experience to two novel word-spatial relation pairings. Given that 15-month-old infants are beginning to comprehend the spatial terms of their language (Meints et al., 2002), it seemed reasonable to test whether some of the cognitive abilities for developing a receptive spatial vocabulary are in place by 14 months of age.

Infants in this study were tested using a modified habituation procedure known as the switch design (see Werker et al., 1998). Infants were habituated to one novel word (e.g., *teek*) paired with one spatial relation (e.g., containment) and another novel word (e.g., *blick*) paired with an alternate spatial relation (e.g., support). *Teek* and *blick* were chosen as the novel words because they are easily discriminable, abide by English phonemic rules, and do not resemble any English locative terms. Containment (i.e., *in*) and support (i.e., *on*) were chosen as the spatial relations because infants discriminate between these two relations by 6 months (Casasola, Cohen, & Chiarello, 2003). The spatial relations also were presented from a front angle as well as a high angle to prevent infants from associating the words to perceptual differences in the object when in a containment versus a support relation. After habituation, infants were presented with two test trials: The same trial maintained the pairing between word and relation (i.e., *teek*-containment), and the switch trial violated this pairing (i.e., *teek*-support). If infants learned to form an association between each word and the

relation with which it had been paired during habituation, they should look significantly longer at the switch than at the same trial. If infants attend only to the objects or if they attend to the words and spatial relations independently, they should not demonstrate any difference in looking time to the switch versus same trial because the only novel element in the switch trial is the novel pairing of word with spatial relation.

Every effort was made to provide infants with information in the linguistic input to facilitate their mapping of the word to the spatial relation. The novel words were presented in a sentence to provide a syntactic context for the novel words (e.g., “She put Big Bird *blick* the box”). The verb *put* was likely to be familiar to infants, is often used with prepositions, and would signal to the infants that the action was important. In addition, infants viewed objects with which they were likely to have had experience—Big Bird and a box—and labels for these objects were introduced in a pretest trial. Thus, the linguistic input provided both lexical information (i.e., *put*, *Big Bird*, and *box*) and a syntactic context for the novel words. The results of this study were expected to indicate if 14-month-old infants can learn to link novel words to spatial relations when provided only with the co-occurrence of novel word and spatial relation and the linguistic input as sources of information.

METHOD

Participants

Thirty-two 14-month-old (± 2 weeks) infants participated (16 girls and 16 boys). All infants were at least 37 weeks gestational age, of normal birth weight, had no reported history of visual or auditory problems, and were exposed to only English. According to parental report, 17 infants comprehended *in* and 14 comprehended *on*. Twenty-six additional infants were excluded: 5 were fussy, 11 did not meet the habituation criterion (described later), 3 were exposed to languages other than English, and 7 demonstrated extremely long looking times to the same test trial, suggesting that these infants had not habituated to the events seen during habituation.¹

The participants were recruited via a letter given to parents at a local hospital at the time of their child's birth. If the parents expressed interest in participating, they were contacted when their infant was the appropriate age. The participants were given a t-shirt or small toy in appreciation.

Stimuli

The visual stimuli were videotaped, dynamic events with a yellow plastic Big Bird® and a red cardboard box. The auditory stimuli were recorded sentences, spoken by a female in infant-directed speech. A pretest event was created to introduce infants to each object. In this event, Big Bird was to the left of the box. A hand then entered from the left of the screen, lifted and set down Big Bird, then lifted and set down the box, while the recorded voice described each object (i.e., “See? It's Big Bird and a box! Big Bird and a box!”). All habituation and test events also began with Big Bird to the left of the box. A hand entered, lifted Big Bird, and placed him either in the box or on the overturned box. Each event was filmed at a front and high angle (see Figure 1). The auditory stimuli with a novel spatial word, either *teek* or *blick*, began as the hand placed Big Bird in his spatial relation to the box (e.g., “Look! She's putting Big Bird *teek* the box!”) and continued after Big Bird was in his spatial relation to the box (e.g., “Big Bird is *teek* the box! *Teek!*”). Four events were created to allow the pairing of a specific spatial word with a particular relation to be

¹Although an attrition rate of 26 infants may seem high, it is not uncommon with the switch design. Casasola and Cohen (2000), who used the switch design with 18-month-old infants, reported a similar attrition rate.

counterbalanced across participants. A posttest trial, used to test for fatigue at the end of the experimental session, began with the box to the left of Big Bird. The hand then entered and placed the box over Big Bird while the auditory stimuli played: “She’s putting the box zop Big Bird. The box is zop Big Bird! Zop!” Each visual–auditory event was 10 sec in duration and was looped three times without pauses to create trials that were 30 sec in duration.

Apparatus

Each infant was tested in an experimental room with a 20-in. (50.8 cm) color monitor and audio speakers. Infants sat on their parent’s lap approximately 127 cm from the monitor. A camera located under the monitor was connected to a Panasonic VCR and 15-in. (38.1 cm) color monitor in an adjoining control room and allowed the experimenter to observe infants’ looking during each trial. The experimenter used a Macintosh G4 computer and a specially designed software program, Habit 2000 (Cohen, Atkinson, & Chaput, 2000), to present the stimuli, record infants’ looking during each trial, and calculate the habituation criteria (described later).

Procedure

After obtaining parental consent, infants were seated on their parent’s lap in the experimental room. Parents were asked to remain neutral and not to speak to their infant during the testing session. Prior to each trial, an attention-getter, a green chiming expanding circle, directed infants’ attention to the monitor. The experimenter began a trial by depressing a computer key and then depressed a different key to record infants’ looking during a trial. A trial played until infants looked away for more than 1 continuous sec or until the 30-sec trial ended. The pretest trial, designed to introduce infants to each object, was presented first. Next, infants viewed sequential habituation trials of one relation (e.g., containment) paired with a novel word (e.g., *teek*) and the alternate relation (e.g., support) paired with the other novel word (*blick*). Which word was paired with which relation was counterbalanced across participants. Infants viewed the high-angle and front-angle version of each relation and its corresponding label in semirandom order across blocks of four habituation trials. The habituation trials continued until infants’ looking across four consecutive trials decreased 50% of their looking during the first four habituation trials, or until 20 habituation trials were presented. Following the habituation trials, two test trials were presented: (a) the same trial that maintained the word–relation pairing viewed during habituation (e.g., *teek*–containment), and (b) the switch trial that violated the habituation word–relation pairing (e.g., *blick*–containment). The presentation order of the same and switch trials and which pairing was switched was counterbalanced across participants. A final, posttest trial was used to test for fatigue. Half of the infants viewed the front-angle versions of the test and posttest trials, and half viewed the high-angle versions of these trials. A second observer recorded the looking time of 8 randomly chosen infants offline. The average correlation between online and offline looking times was .997 (range = .995–.999), demonstrating high interobserver reliability.

RESULTS

Habituation Phase

Infants viewed an average of 10 habituation trials (range = 6–19 trials), for an average of 160.20 sec (range = 74.6–330.0 sec). The first analysis compared infants’ looking time during the first versus last four trials of habituation. A 2 (sex: male vs. female) $\times$ 2 (trials: average of the four habituation trials vs. average of the last four habituation trials) mixed-model analysis of variance (ANOVA) yielded a significant main effect for trials, $F(1, 30) = 168.90$, $p < .001$. Infants looked significantly less during the last four trials ($M = 9.14$ sec, $SD = 3.83$ sec) than during the first four habituation trials ($M = 21.94$ sec, $SD = 8.46$ sec).

To ensure that infants did not meet the habituation criterion as an artifact, infants' looking to the first four habituation trials was compared to the same test trial in a 2 (sex) $\times$ 2 (trials: average of the four habituation trials vs. the same test trial) mixed-model ANOVA. Infants did look significantly less at the same trial ($M = 6.45$ sec, $SD = 1.67$ sec) compared to the average of the first four habituation trials, $F(1, 56) = 84.99$, $p < .001$. A third analysis indicated that infants looked significantly longer during the posttest trial ($M = 14.68$ sec, $SD = 8.73$ sec) than at the same test trial, $F(1, 56) = 18.66$, $p < .001$. Hence, infants were not fatigued by the end of the experimental session.

Test Phase

The next analysis explored whether infants discriminated an event with a novel pairing between the word and spatial relation (i.e., the switch trial) from one that maintained the habituation word–relation pairing (i.e., the same trial). Preliminary analyses reported no significant difference in looking times of infants whose parents reported that their infant comprehended *in* or *on* and those who did not yet comprehend these spatial terms. For this reason, infants' comprehension of *in* and *on* was not included in the analyses. Infants' looking time to the same versus switch test trials was examined in a 2 (sex) $\times$ 2 (test angle: front vs. high) $\times$ 2 (test trial: same vs. switch) mixed-model ANOVA. The analysis yielded a significant main effect for test trial, $F(1, 28) = 10.39$, $p < .01$. Infants looked reliably longer to the switch trial ($M = 10.14$ sec, $SD = 6.61$ sec) than to the same trial ($M = 6.45$ sec, $SD = 1.67$ sec). Therefore, infants discriminated the trial that maintained the word–relation pairing seen during habituation from the trial that presented a novel word–relation pairing. The analysis did not yield any other significant main effects or interactions. In particular, the Trial $\times$ Angle interaction was not significant, $F(1, 28) < 1$, *ns*, indicating that the viewing angle during the test trials did not influence infants' discrimination of the same versus switch trial (see Figure 2).

DISCUSSION

Infants in this study were tested in a modified habituation paradigm that required them to attend to and form an association between the co-occurrence of a novel word and a spatial relation. The results show that 14-month-old infants can link one novel word with a containment relation and a second novel word with a support relation using only the co-occurrence of word and relation and the linguistic input as sources of information. Infants also formed these associations rapidly, receiving an average of 2.6 min of experience with the two word–relation pairings. Could infants have associated one word with Big Bird and another word with the box? This explanation seems unlikely. None of the objects in the switch trial were novel. Hence, if the infants were only attending to the objects, there would be no reason for them to look significantly longer at the switch than at the same trial. The results also rule out the possibility that infants associated one word with Big Bird when he was partly occluded in the front-angle containment event and the second word with Big Bird when he remained visible in the front-angle support event. During habituation, infants viewed both the front- and high-angle versions of each relation, hearing the same word presented with each version of a specific relation (e.g., *blick* with containment and *teek* with support). Infants tested with the high-angle trials, in which Big Bird never became occluded in the containment event, responded in the same manner as infants tested with the front-angle trials, a pattern that would not have emerged if infants relied solely on Big Bird's appearance to discriminate between the relations. Rather, the most plausible interpretation for the results is that infants were associating each novel word with the spatial relation with which it had been paired during habituation.

These results also demonstrate that 14-month-olds can form novel word–spatial relation associations within a very brief time period. These results are particularly impressive given

the absence of an experimenter to facilitate the associations or direct infants' attention to the relevant referent (i.e., the spatial relation). Of course, there were numerous other cues that might have facilitated infants' ability to form the associations. In particular, using a hand to depict the actions with a single pair of objects, the use of infant-directed speech, and embedding the novel word in a sentence to provide a syntactic context rather than presenting the novel words in isolation very likely aided infants in narrowing the possible referents for the novel word to the spatial relation, as did presenting familiar objects, the verb *putting*, and including the front- and high-angle examples of each relation. In fact, infants may have relied on all these sources of information in mapping the word onto the relation. Nonetheless, they still had to be sensitive to the co-occurrence of the spatial relation and the novel word to form the word–relation associations. Infants' ability to do so, especially given such limited experience with each arbitrary word–relation pairing, reveals that they possess a keen sensitivity to the co-occurrence between specific words and specific spatial relations. The results also demonstrate that the cues provided by an experimenter are not needed to facilitate infants' mappings between word and spatial relation. They can do so given other sources of information.

Given that there were a number of cues available to infants, these results cannot address the degree to which sensitivity to the co-occurrence of a novel word and a spatial relation versus other factors, such as the linguistic input and the use of a single pair of objects, contributed to infants' ability to form word–relation associations. For example, infants may not have formed the associations if the words had been presented in isolation. The inclusion of the familiar verb *putting* may have been particularly pivotal in signaling to infants that the novel word referred to the action of placing Big Bird in his spatial relation to the box. Similarly, given that many infants have had experience with the objects presented, infants may have failed at the task had novel objects been used. Infants also may have had difficulty if various object pairs had been presented during habituation or if infants had been tested with novel objects. Possibly, infants can associate each label with a specific instance of containment and support but may not have the ability to extend the labels to novel instances of the relations. However, additional investigations can now begin to explore the relative contribution of each of these sources of information as necessary and sufficient cues for forming word–relation associations.

This study reveals that infants of 14 months are equipped with the cognitive skills to begin to map novel words onto particular spatial relations and that infants of this age are not restricted to associating novel words with only objects or object properties (Booth & Waxman, 2003; Waxman & Booth, 2001; Werker et al., 1998). Although it is clear that infants can recruit sensitivity to co-occurrence and information in the linguistic input to begin to comprehend spatial language, certainly other factors not included in this study also contribute to the acquisition of spatial language and aid infants in attending to linguistically relevant spatial relations. However, sensitivity to co-occurrence may aid infants in this process as well. The co-occurrence of a specific spatial morpheme with a specific relation may heighten infants' attention to the relation, providing one mechanism by which language directs infants to form particular semantic spatial categories over others (Choi & Bowerman, 1991). In sum, when used in combination with other sources of information, co-occurrence and linguistic input provide one venue through which infants can begin to acquire a spatial lexicon in a fast and efficient manner.

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FIGURE 1. Selected frames of the front- and high-angle containment and support events used in the habituation and test phase of the experiment.

FIGURE 2. Looking time with standard error to the same versus switch test trials of 14-month-old infants tested with the front-angle versus high-angle events.