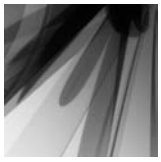

FIRST LANGUAGE

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Influence of language-specific input on spatial cognition: Categories of containment

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ABSTRACT

This study examines whether language-specific input influences children's nonlinguistic spatial cognition as they acquire their first language. Recent research on infant cognition has shown that preverbal infants can make a distinction between tight-fit and loose-fit containment relations. This distinction is systematically made in Korean (*kkita* 'fit tightly'), but not in English (*in*). Using a preferential-looking method, this study tested sensitivity to the distinction in English and Korean learners at different ages: English learners were tested at 18, 24, 29 and 36 months, and Korean learners at 29 and 36 months of age. Results showed that while English learners weaken their sensitivity to the distinction by 29 months of age, Korean learners maintain high sensitivity to the distinction throughout the age periods tested. Language surveys of the English learners indicate that weakening of the sensitivity occurs as the children use the relevant spatial terms and increase their vocabulary level.

KEYWORDS

Development of spatial categories; language and cognition; linguistic input and categorization; spatial categorization; spatial terms

INTRODUCTION

In recent years, the debate on whether and how language influences cognition has been rekindled, and this complex question is once again a central issue in linguistics, psychology and developmental science. In the recent debate, critical data have come from studies on space. This is because space is one of the most fundamental and universal aspects of human experience, and infants begin to explore it virtually from the beginning of their life, and yet it is divided very differently in different languages. Space thus serves as an ideal domain in which one can study the relation between language and cognition, and, in particular, the developmental changes that may occur in cognition before and after language acquisition.

Over the last few decades, predominant views on language and thought have shifted from one end of the spectrum to the other. Until the early 1960s, Sapir-Whorf's 'linguistic determinism' and their 'linguistic relativity' hypothesis argued for language shaping cognition. In particular, Whorf (1956) stressed that there are significant differences in the way languages encode various aspects of the world (e.g., time, space), and argued that language must influence the way we perceive and think about our experiences. Starting in the mid-1960s, however, with Chomsky's (1965) theory on Universal grammar and innate predispositions for language, researchers shifted their focus to the discovery of shared, or universal, features across languages. In the domain of space, researchers found universal semantic features that relate to dimensional, e.g., *high, wide*, and locative terms, e.g., *on, in* (Bierwisch, 1967; H. H. Clark, 1973; Miller & Johnson-Laird, 1976). In the domain of color semantics, Berlin & Kay (1969) showed that there is remarkable uniformity in color naming across languages, and further work tied this uniformity to the physiology of color perception. Findings like these led to the hypotheses that, contrary to the Sapir-Whorf hypothesis, the human cognitive/perceptual apparatus is highly constrained, and that this apparatus both universally shapes language structure and guides language acquisition (e.g., H. H. Clark, 1973; Slobin, 1985; Traugott, 1978).

Following this view, and also influenced by Piaget's work (e.g., Piaget & Inhelder, 1967), researchers in developmental psycholinguistics have proposed a universalist view. According to this view, during the first year of life (i.e., before language production) infants already develop an impressive repertoire of concepts (to do with, for example, objects, actions, causality, space) (Piaget, 1954) that are foundational to language acquisition, and when they begin to acquire words, they map them directly onto those pre-established concepts (E. Clark, 1973; Slobin, 1973, 1985). In the spatial domain, this means that important spatial concepts, such as containment or support, are developed prelinguistically as distinct abstract categories, and when children learn words like *in* or *on* in English, they map those words directly onto the concepts. In this view, then, cognitive development leads or even determines language development.

In recent years, however, this cognitive deterministic claim has been extensively challenged. Major challenges come from findings in crosslinguistic studies on spatial terms: languages differ strikingly in the way they structure space semantically (Levinson, 1996; Talmy, 1975, 1985). In particular, they differ greatly in the way they categorize spatial relations. For example, languages differ in how they group and partition various types of containment and support relations (Bowerman, 1996; Bowerman & Choi 2001;

Bowerman, de Leon & Choi, 1995; Bowerman & Pederson, 1992; see also Brown, 1994). (These studies have convincingly demonstrated that, contrary to previous assumptions, spatial words that had seemed to be translation equivalents often differ in meaning.) Languages also differ in the way they refer to location in space (Levinson, 1996; Pederson, Danziger, Levinson, Kita, et al., 1998). For example, in describing the location of an object in relation to another object, English and Dutch speakers use a relative frame of reference (i.e., X is on the 'left'/'right' of Y) whereas speakers of Tenejapan in southern Mexico use an absolute frame of reference (i.e., X is south of Y). Levinson (1996) and his colleagues (e.g., Pederson et al., 1998) have further demonstrated that language-specific encoding of space influences the speakers' nonlinguistic encoding of space in tasks such as memory and inference tasks. Contrary to the cognitive deterministic view, then, these studies have shown that language influences nonverbal cognition.

Clearly, the relation between language and cognition is a complex one. For one thing, the recent findings suggest that human cognition – at least in the spatial domain – is quite flexible to the extent that it allows for formation of differing semantic systems across languages. More importantly for present purposes, the magnitude of crosslinguistic differences in spatial semantics points to significant flexibility in infant cognition that enables them to learn language-specific systems. In fact, recent crosslinguistic studies have shown that, from virtually the beginning of language development, children's semantic organization is shaped by the language-specific system. In particular, Choi and her colleagues have studied children learning English and Korean, two languages that differ significantly in the way they categorize spatial relations involving containment and support (see below). In their crosslinguistic studies examining acquisition of two spatial terms in English and Korean (the preposition/particle *in* in English, and the verb *kkita*[1] 'to tight(ly) fit or interlock' in Korean), Choi and her colleagues have shown that 2-year-olds learning English and Korean already use spatial terms in a language-specific way, and that 18- to 23-month-olds understand spatial terms according to the semantic principles of the target language (Bowerman & Choi, 1994; Bowerman et al., 1995; Choi, McDonough, Bowerman & Mandler, 1999).

The finding of early acquisition of language-specific semantics was unexpected under previous cognitive determinist accounts of lexical development and raised a set of intriguing questions on the relation between spatial cognition and language: (1) What is the nature of preverbal spatial cognition that allows such rapid learning of language-specific semantics? (2) What are the cognitive consequences of such early acquisition of language-specific semantics? More specifically, does language-specific semantics, once acquired, influence speakers' nonlinguistic sensitivity to spatial relations in any way? (3) If so, when does that process begin? And what are the nature and extent of the influence?

Different theories would predict different answers to these questions. A cognitive determinist view would hold that conceptual categories are universal and foundational to linguistic structures, and that language-specific semantics do not affect children's conceptual structure of space. In sharp contrast, a strong-Whorfian hypothesis would hold that nonlinguistic cognition would be influenced by the language-specific semantic categorization as children master their first language. Between these two extremes there is a 'thinking for speaking hypothesis' (Slobin, 1996) which argues that cognition is influenced by language when it is mediated by linguistic thinking.

McDonough, Choi & Mandler (2003) investigated questions (1) and (2) with the category of containment in preverbal infants (being raised in English- or Korean-speaking environments) and adult speakers of English and Korean. Their study with 9-, 11- and 14-month-old infants showed that during the preverbal period, infants develop a large set of spatial concepts that includes certain distinctions not made in the ambient language. More specifically, 9- to 14-month-old preverbal infants (whether being raised in English or Korean environments) have fine-grained concepts of containment based on tight-fit feature: they can distinguish categorically between tight-fit containment and loose-fit containment relations. This distinction is not grammatically made in English spatial semantics, i.e., the spatial prepositional system in English. The data thus suggest that infants develop an extended set of concepts prelinguistically and then identify which ones are relevant in the target language as they begin their semantic learning. This finding has been corroborated by Hespos & Spelke (2002). Using a habituation paradigm with simple objects, they found that even 5-month-olds in English environments could distinguish between tight- and loose-fit containment.

McDonough et al. (2003) also tested adult speakers of English and Korean on their sensitivity to the distinction between tight-fit vs. loose-fit containment. They found that language-specific semantics do influence adult speakers' nonlinguistic sensitivities: English speakers could *not* attend to the difference between tight vs. loose-fit containment whereas Korean speakers could.[2] These findings, together with the finding of early acquisition of language-specific semantics, suggest that preverbal infants develop sensitivity to a large repertoire of spatial features, but that as they become fluent speakers, the language they have learned selectively channels their attention to linguistically relevant features. (This developmental pattern has some striking resemblance to the pattern reported on phonetic perception studies, e.g., Werker & Lalonde (1988), but see Discussion for important differences.)

The findings in the study by McDonough et al. (2003) raise some specific questions that relate to question (3) above. The specific questions are: When do learners of English begin to weaken their sensitivity to tight- vs. loose-fit distinction? And what are the nature and extent of the influence of their own language? The present study investigates these questions but, before reporting on this, it is necessary to provide some background data on language-specific spatial semantics in English and Korean and preverbal spatial categories of the containment relation.

Spatial semantic categories in English and Korean

The current study focuses on spatial terms in English and Korean that refer to spatial relations resulting from causal actions of placing one object in relation to another. The two languages differ significantly and interestingly in the way they categorize these relations. In our studies, we have been examining the following language-specific spatial semantic categories: *put in* and *put on* in English, and *kkita* 'put into/onto a tight-fit relation' and *nehta* 'put into(/onto) a loose-fit relation' in Korean. These semantic categories involve at least four distinct features that are packaged differently in the two languages: loose containment, tight containment, loose support, tight support.

In English, the semantic contrast between the spatial particles *(put) in* and *(put) on* is based on whether the relation involves containment or support (Fig. 1). The spatial

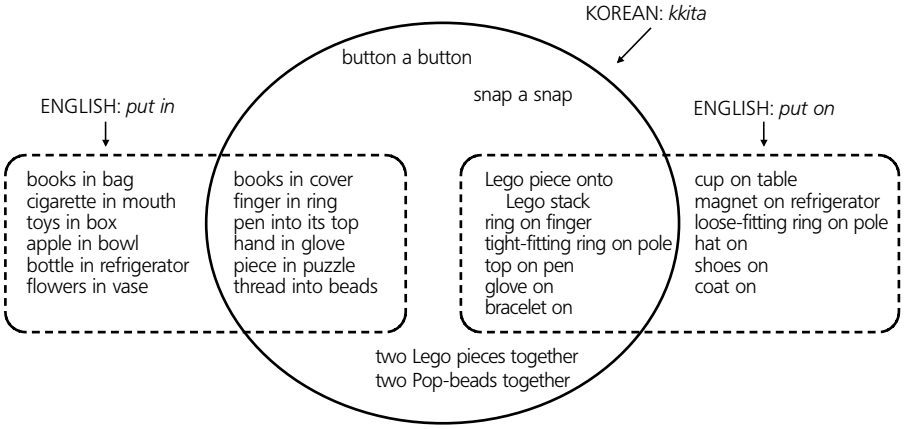

Figure 1 Cross-cutting categories in Korean and English: Korean *kkita* 'fit tightly/interlock' vs. English *put in* and *put on*

word *in* is used when the figure (= the moving object) ends up contained in or encircled by the ground (= the reference object). Note that *put in* is used regardless of whether the containment is tight (e.g., putting a book tightly into a box-shaped cover) or loose (e.g., putting a book in a bag). The semantic category of *in* in English contrasts with that of *on*. The spatial word *(put) on* is used when the figure ends up being supported by or attached to the ground, or when it covers or encircles the ground. And again, the meaning of *on* is irrelevant to whether the relation is tight or loose, e.g., putting a Lego piece on another (tight support) and putting a cup on the table (loose support).

The same semantic space is partitioned differently in Korean. In particular, *kkita*, an early-learned verb, picks out a category to do with bringing three-dimensional objects with complementary shapes into an interlocking, tight-fitting relationship. The *kkita* category cross-cuts the categories of *put in* and *put on*, and extends to some situations that are considered neither 'putting in' nor 'putting on'. This everyday verb has no English counterpart. The cross-cutting of the domain of *put in* by *kkita* means that what English treats as a unified category of 'containment' events is, for speakers of Korean, subdivided: 'tight-fitting' containment events like putting a book into an exactly matching box-cover, described with *kkita*, are treated as a different class of actions from 'loose-fitting' containment events like putting an apple into a bowl or a book in a bag, described with *nehta*. The category of *nehta* encompasses not only loose containment events but also loose encirclement events, e.g., putting a loose ring on a pole. Just as Korean breaks down the category of English *put in*, it also breaks down the domain of *put on*. Here, the partitioning is quite extensive: attaching a figure to the exterior surface of a ground object with a complementary three-dimensional shape (e.g., putting a top on a pen or a Lego block on a stack of Legos) falls into the 'tight fit' category of *kkita*, while juxtaposing objects with flat surfaces (e.g., magnet on refrigerator) is *pwuthita*, depositing a figure on

a roughly horizontal surface (e.g., cup on table) is *nohta*, and putting a clothing item on the head is *ssuta* (distinguished from putting clothing on the trunk, *ipta*, and feet, *sinta*).

In summary, *put in* in English requires the figure to end up in an interior space or volume of the ground, but is indifferent to whether the fit between figure and ground is tight or loose.[3] *Kkita*, in contrast, cares centrally about the fit between a figure or a ground with complementary shapes, but is indifferent to whether this fit is obtained by insertion, covering, surface attachment or encirclement.

Distinction between tight-IN vs. loose-IN relations in preverbal infants and adult speakers

McDonough et al. (2003) tested preverbal infants (9, 11 and 14 months old) and adults on their sensitivity to one type of distinction: tight containment (abbreviated to tight-IN) vs. loose containment (loose-IN). As explained above, Korean distinguishes these types of containment semantically, using *kkita* for tight-IN and *nehta* for loose-IN, but in English they are both routinely denoted by the path particle *in* (see Fig. 1).

In McDonough et al. (2003), a modified version of the preferential-looking paradigm (Choi et al., 1999[4]) was used. The basic method was first to familiarize infants with one type of spatial relation (either a tight-IN or a loose-IN relation) with several different scenes and then, during the test trials, present them with two scenes, one depicting the same tight-IN and loose-IN relation (but a new picture) that they were familiarized with, and the other depicting the opposite (loose-IN or tight-IN) relation. If infants show a systematic difference during these test trials in the time spent looking at the familiar versus the novel relation, this would suggest that they are able to distinguish between the two relations. Thus, the key measurement is the duration of eye gaze to familiar vs. novel relations during the test trials. Figure 2 shows the results. There was a systematic looking preference for the familiar relation during the test trials. That is, regardless of the relation with which they had been familiarized, infants in all three age groups looked longer at the familiar relation than the novel relation (i.e. 'familiarity' effect). So the infants who were familiarized with the tight-IN relation looked longer at the tight-IN test scenes (than the loose-IN test scenes), and those who were familiarized with the loose-IN relation looked longer at the loose-IN test scenes (than the tight-IN test scenes). What the data suggest is that infants in monolingual English environments can make a distinction between tight-fit and loose-fit containment relations. Thus, they show an ability to differentiate between these two categories, which are not systematically distinguished in their target language.

The same test was conducted on infants (9, 11 and 14 months old) being exposed to Korean. Recall that in Korean, tight-fit and loose-fit containment relations are semantically distinguished. Like the infants being raised in a monolingual English environment, Korean infants looked significantly longer at the familiar relation than at the novel relation during the test trials. From these results, it was concluded that during the preverbal stage, regardless of linguistic environment, infants between 9 and 14 months of age can distinguish between tight-fit and loose-fit containment.

Using the same design, McDonough et al. (2003) also tested adult speakers of English and Korean on their sensitivity to the distinction between tight-IN and loose-IN. The results were striking: as shown in Fig. 2, unlike the infants in English-speaking

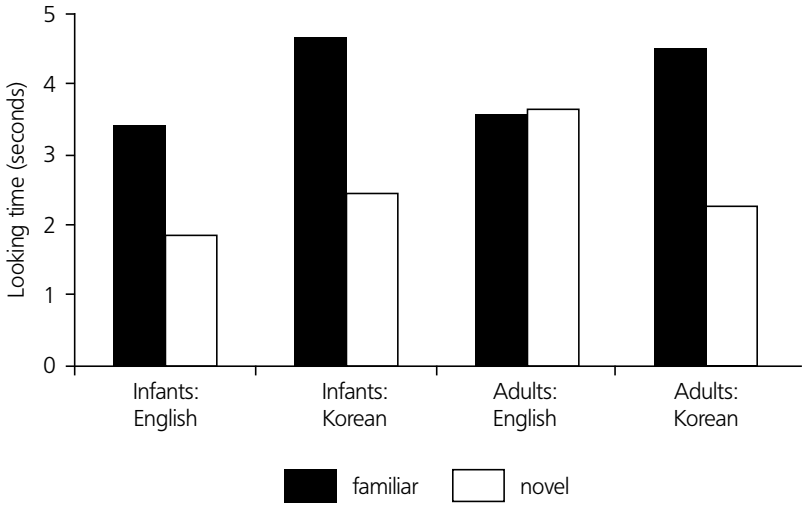

Figure 2 Tight-IN vs. loose-IN relations: preferential looking patterns in preverbal infants (raised in English- vs. Korean-speaking homes) and in adult speakers (from McDonough et al., 2003)

environments, adult speakers of English were not sensitive to the difference between the two types of relation in their looking behavior, regardless of whether they were familiarized with tight-IN or loose-IN. In contrast, the Korean adults clearly distinguished between the two relations. The looking behavior of Korean adults was quite like that of the preverbal infant: the Korean adults looked significantly longer at the familiar test scenes than at the novel test scenes.

The McDonough et al. (2003) study suggests that the difference between tight and loose containment is salient during the preverbal stage, but that the saliency weakens as learners become fluent speakers of a target language that does not systematically encode this distinction. This influence of language may begin much earlier than the highest age range tested by McDonough and colleagues, namely, adults. In fact, the influence may begin as early as 18 months when children begin to comprehend the target semantic system in a language-specific way (Choi et al., 1999). We explore this question in the current study.

METHOD

The current study tests young learners of English and Korean on the distinction between tight-IN and loose-IN. For both languages, the same design as in McDonough et al. (2003) was followed for a systematic comparison. It is described in detail in the 'Design and procedure' section below.

Participants

All participating children for English were recruited in southern California, and those for Korean were recruited in Seoul, Korea, through announcements and personal contacts. The children were acquiring their respective target language in monolingual environments. Each child was given a toy or a book as a reward for participation.

Twenty-four English-learning children participated in each of the following four age groups: 17–19 months (mean: 18 months 11 days), 23–25 months (mean: 23 months 26 days) 28–31 months (mean: 29 months 6 days) and 35–37 months (mean: 36 months 1 day). Henceforth, the four groups will be labeled 18, 24, 29 and 36 months. Equal numbers of male and female children participated in each age group. Due to scene bias, a total of 7 children were excluded from data analysis: two 18-month-olds, two 24-month-olds, one 29 month-old and two 36-month-olds.

Seventeen Korean-learning children aged 29 months (mean: 29 months 21 days; 10 male and 7 female), and 24 aged 36 months (mean: 36 months 18 days; 12 male and 12 female) participated. One 29-month-old and two 36-month-olds were excluded from data analysis because of scene bias. (A smaller sample size for the 29-month-old Korean group is due to lack of availability of children in that age group while the author was collecting data in Korea for a limited period of time.)

Design and procedure

Preferential-looking paradigm

To assess categorization of spatial relations, a familiarization technique followed by a preferential-looking test was used. The basic organization of stimuli was adapted from Behl-Chadha & Eimas (1995) and Quinn (1994). We first familiarized infants with one type of spatial relation (either tight-IN or loose-IN) over six presentations (see 'Familiarization trials' below). Then, during the test trials, we presented the infants with a pair of scenes, one depicting the same relation that they were familiarized with, the other depicting a novel relation. Extending the design used by Behl-Chadha & Eimas (1995), stimuli scenes were made up of a wide variety of objects that were not only *perceptually dissimilar* but also drawn from *different classes* of objects (see below). Unlike the Behl-Chadha & Eimas and Quinn studies, however, which used static scenes, our scenes were dynamic scenes of causal actions of 'putting x in y'. It was assumed that, if infants respond systematically to the relational similarities across dynamic events involving widely varying objects, then they must have analyzed and abstracted these relations.

Familiarization trials

Six distinct dynamic scenes were prepared as familiarization stimuli for each type of relation. Perceptual qualities such as the size, color, shape, form and texture of the objects changed from scene to scene. The stimuli for tight-IN and loose-IN are shown in Figs 3 and 4, respectively. All relations were filmed in dynamic actions performed by a person. In each scene, the person demonstrated the same spatial relation three times. For example, in the first tight-IN familiarization scene from the list below, three geometric shapes (a square, a triangle and a rectangle) were placed one at a time into

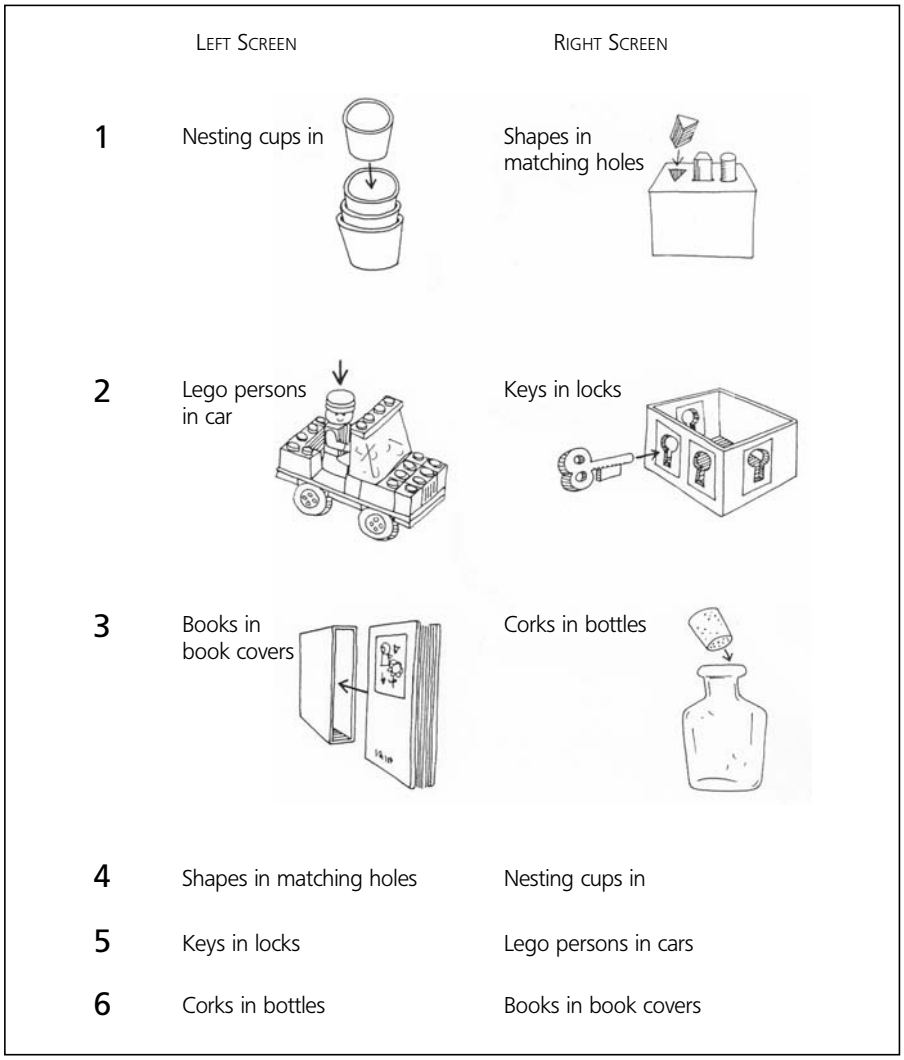

Figure 3 Familiarization scenes for tight-fit containment

their matching slots. Only the performer's hands and torso were shown, to minimize distraction. The six familiarization scenes for tight-IN were: (a) putting nesting cups in the next larger cup, (b) putting plastic geometric shapes in the matching slots, (c) putting Lego persons in Lego cars, (d) putting toy keys in keyholes, (e) putting books in matching box covers, and (f) putting corks in semi-transparent bottles. The six familiarization scenes for loose-IN were: (a) putting Lego persons in the back of a toy truck, (b) putting geometric shapes in oval jewelry boxes, (c) putting plastic pompoms in differently shaped cooking tins, (d) putting pencils in a pencil cup, (e) putting geometric wooden blocks in a plastic basket, and (f) putting Bristle blocks in a cloth bag.

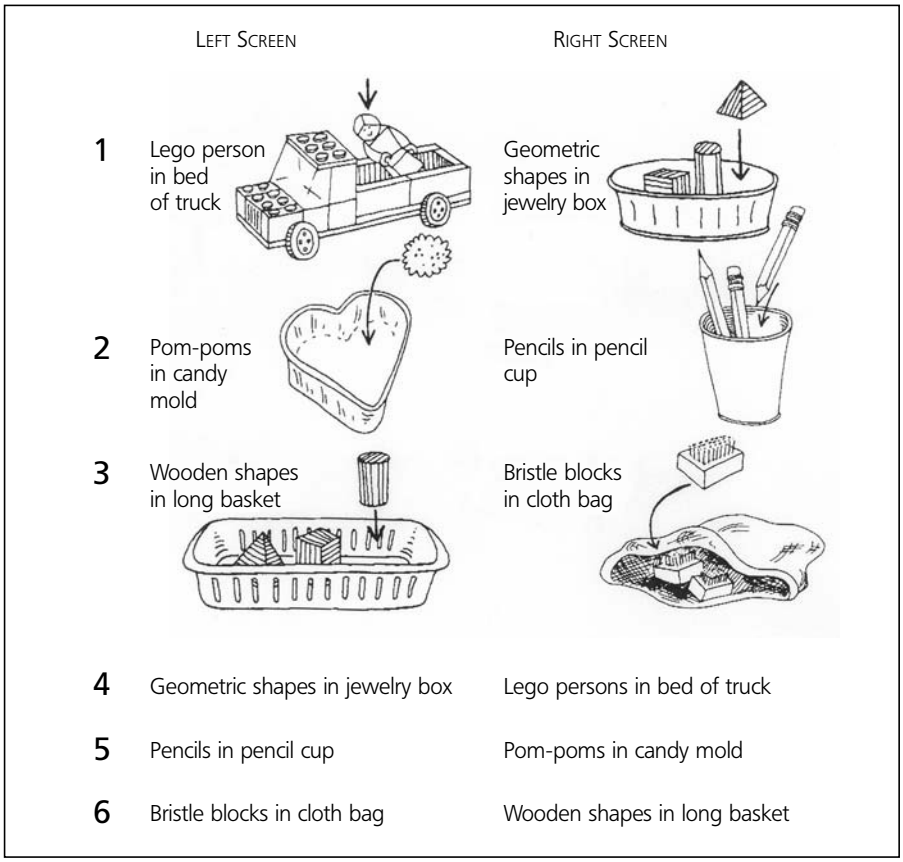

Figure 4 Familiarization scenes for loose-fit containment

The six scenes depicting a given relation (tight-IN or loose-IN) were presented in three pairs, such that on any given trial, two scenes appeared simultaneously, one on each side of the screen. After showing the three pairs (trials 1–3), we showed the same three pairs again in the same order (trials 4–6), but this time with the side (of presentation) reversed (see Figs 3 and 4). Each trial lasted 8 s with 2-s intervals between trials. (During the interval, flickering lights were shown in the middle of the screen to draw children's attention to the center before the next trial.) Half the children were familiarized with the tight-IN and half with the loose-IN relation.

Test trials

Immediately after the six familiarization trials, the children saw two test pairs, one after the other. All participants saw the same two pairs of test trials. Each test pair showed one tight-IN relation and one loose-IN relation with new objects, i.e., objects that had not been used in the familiarization scenes. As shown in Fig. 5, the first test pair consisted

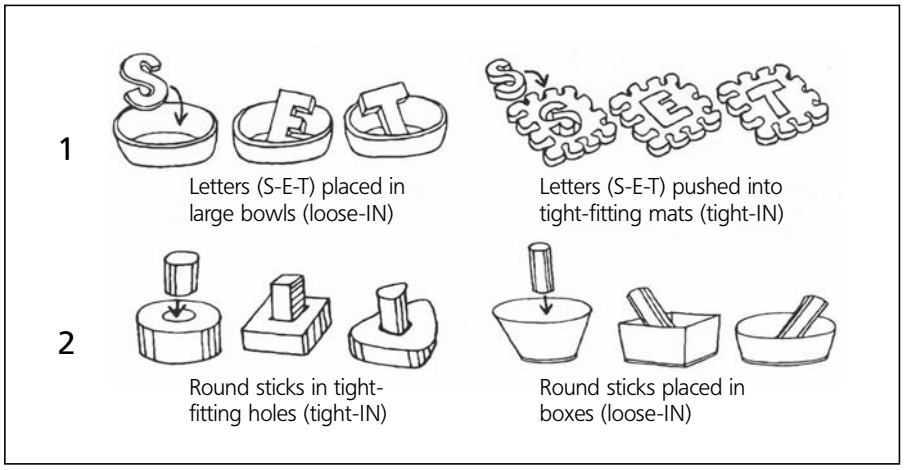

Figure 5 Test pairs: tight-IN vs. loose-IN

of putting foam letters (S, E, T) in large containers (loose-IN) and putting foam letters (S, E, T) tightly in cut-out sections in mats (tight-IN). The second test pair consisted of putting wooden pegs in the holes of various shapes made of plastic (tight-IN) and putting wooden pegs in containers of various shapes (loose-IN). For children familiarized with the tight-IN relation, the loose-IN scenes would be novel, and for those familiarized with the loose-IN relation, the tight-IN scenes would be novel. Notice that in each pair, the same figure objects were used. This was to minimize the possibility that children would look longer at one scene because of their preference for one kind of figure over the other, rather than the relation depicted.

Within each familiarization group, half the participants were tested so that the novel relation in the first test trial was presented on the right side and the novel relation in the second test trial was presented on the left side. The remaining half were shown the novel relation on the left and then on the right side for the first and second test trials, respectively.

Audio

Throughout this experiment, music (instrumental children's songs) was played through the speaker that was centrally located behind a black paneling (see below): one melody during the familiarization period and a new melody during the test period. The music kept infants from becoming restless during the experiment, and the change in music during test trials alerted them to attend closely to the scenes.

Apparatus

The lab set-up was adapted from Naigles (1990) and Hollich, Rocroi, Hirsh-Pasek & Golinkoff (1999). All stimuli scenes were digitized, and pairs of stimuli were imported onto the split-screen frame developed by Hollich et al. (1999). In this way, pairs of scenes were perfectly synchronized in presentation. The whole set of stimuli (six familiarization

trials and two test trials) was digitized as a single movie on a computer. The computer was connected to an LCD projector that projected the movie onto a white screen (68 x 45 in.) mounted (42 in. from the floor) on a black panel.

The infant sat on a parent's lap facing the white screen at 42-in. distance. The parent wore opaque glasses during the session so that she or he could not inadvertently cue the infant to look longer at one scene than another. Just below the white screen, behind the black panel and at the center, was a camera for videotaping eye movements. Above the camera, a speaker was also mounted for playing music during the trials. The whole set-up could be easily transported. Thus, in Korea, the same apparatus could be set up in a quiet room in a childcare center.

Language survey

To assess the child's developmental stage in lexicon, mothers were asked to fill out a standardized language survey for each child participant. The survey questionnaire in both English and Korean was an extended version of that used in Choi & Gopnik (1995) and was based on the author's prior studies on early lexical development in English and Korean learners. Both the English and Korean versions contained a total of 139 words: 67 nominals (animal and object names, food labels, body part names, kinship terms), 52 predicate/relational words (action words, spatial words), 20 social and 'other' early words. The relevant spatial words were included in the predicates section: *in/out* and *on/off* in English, and *kkita, nehta* and *nohta* in Korean. Mothers were asked to check the words their children produced spontaneously (i.e., not imitation). (Comprehension of the words was not systematically examined.) If mothers reported that their children produced spatial words, they were asked to provide specific contexts as examples.

Data analysis

Coding and reliability All videotaped eye movements were imported onto a computer. Each child's eye movements were then coded frame by frame (30 video frames in a second) using the Coder program developed by Hollich et al. (1999). All eye movements were coded as 'looking left', 'looking right' or 'looking away'. A second coder randomly selected and checked 20% of the data to check reliability of the first coder's results; overall, the reliability was 96.5%.

Analyses of variance Following the findings in McDonough et al. (2003) in preverbal infants and adults, it was predicted that if the participant recognized the contrast between the familiarization trials and the novel test scenes, this recognition would be reflected in their preference for the familiar test scenes over the novel test scenes (i.e., familiarity effect). Thus, the key measurement is the amount of looking time at each scene (familiar vs. novel relation) during each test trial.[5] ANOVAs were conducted with Familiarization condition (loose-IN vs. tight-IN) and Age (and Language when appropriate; see the results sections below) as the between-subjects variables, and Scene (Familiar vs. Novel relations in test trials) and Trial (Test pair 1 vs. Test pair 2) as the within-subject variables. (Gender was not entered into the main ANOVAs as preliminary analyses showed no gender differences on Scene preference, and did not interact with Age or Language.) The proportion of participants looking at the familiar relation was

calculated to see whether these results are consistent with the patterns found in the analysis of mean looking times to familiar vs. novel test scenes.

In addition, the looking data for the familiarization trials were analyzed to measure the children's attention level to the familiar relation. For this analysis, averages of looking time at the scenes during the first set (i.e., familiarization trials 1–3) and the second set of presentation (familiarization trials 4–6) were compared. Overall, in all three parts of the experiment, the children maintained their interest to the scenes throughout the familiarization period: their average looking times for the two sets of familiarization ranged from 6.38 to 6.77 s (out of the 8-s scene length). (For the remaining time, the children were looking away.) ANOVAs with Familiarization set (trials 1–3 vs. trials 4–6) as a within-subject variable, and Age and Language as between-subject variables showed no main effects and no interactions. Thus, the children maintained high attention and interest to the scenes during the familiarization period.

Following McDonough et al. (2003), I excluded from data analysis those children who looked at either side of the screen for less than 0.10 s during a test trial. Given that preferential looking is based on the assumption that infants examine both scenes and make a choice as to what they prefer to examine, near exclusive looking at one scene (henceforth called 'scene bias') cannot be meaningfully interpreted.

Analysis of language survey Language survey was analyzed in terms of the number of productive words reported by the mothers. In addition, it was noted for each child whether he/she reportedly produced the spatial words relevant to the current study: *in* in English and *kkita* in Korean.

RESULTS

Preferential-looking data

English learners

Figure 6 shows the durations of looking times to familiar and novel relations by age group. An ANOVA was conducted with Familiarization condition (loose-IN vs. tight-IN), and Age (18, 24, 29, 36 months) as the between-subjects variables, and Scene (familiar vs. novel relations in test trials) and Trial (test 1 vs. test 2) as the within-subject variables. The dependent scores were the durations of looking time to the familiar and the novel relations during the test trials. There was a main effect for Scene (F (1,81) = 18.59, $p <$ 0.001). Overall, children looked at the familiar relation longer than the novel relation. More importantly, however, this effect was qualified by Age and by Familiarization condition (i.e., an interaction of Scene x Age x Familiarization) (F (3,81) = 4.02, $p < 0.05$). This means that the scene preference differed as a function of age as well as the familiarization condition.

To find the locus of the interaction, ANOVAs (with Familiarization condition and Age as the between-subject variables and Scene and Trial as the within-subject variables) were conducted comparing each age group with each of the other three age groups. As can be expected from Fig. 6, the follow-up analyses revealed that 18- and 24-month-olds differed from 29- and 36-month-olds: while 18- and 24-month-olds in

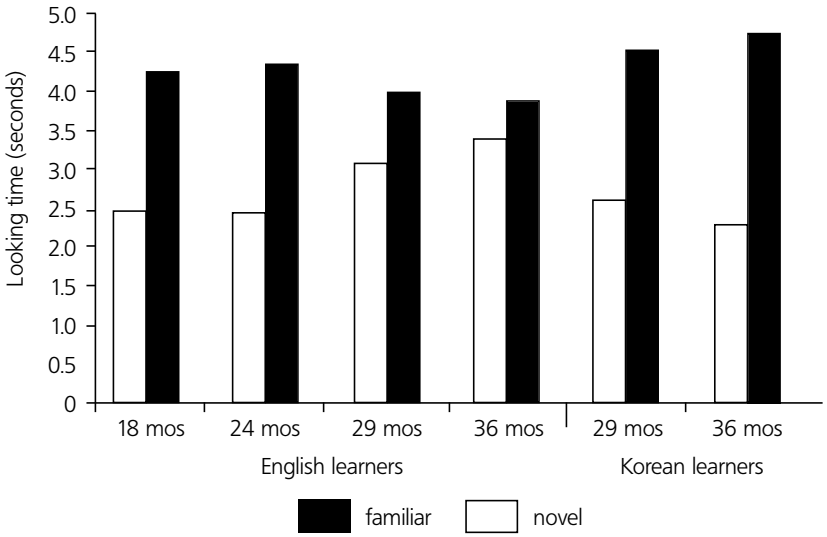

Figure 6 Tight-IN vs. loose-IN relations: preferential looking patterns, by language and by age group

both familiarization conditions looked consistently at the familiar relation longer than the novel relation, 29- and 36-month-olds showed a much weaker preference to the familiar relation. Furthermore, the two older groups showed an interaction of Scene by Familiarization condition. I will now describe the specifics of these patterns.

First, the 18- and 24-month-olds showed a main effect for Scene (F (1,40) = 14.24 p = 0.001). Children in both age groups looked significantly longer at the familiar than the novel scenes. As shown in Fig. 6, the mean looking times to the familiar scenes were 4.27 s for 18 months and 4.36 s for 24 months (mean SD for both ages combined was 1.77). In contrast, the mean looking times to the novel scenes were only 2.49 s and 2.45 s, respectively (mean SD = 1.59). No other main effects or interactions were found (e.g., no Age effect). Thus, both 18- and 24-month-old English learners showed a significant familiarity effect regardless of whether they were familiarized with loose-IN or tight-IN.[6] This suggests that they distinguished between loose-IN and tight-IN relations.

The looking patterns of the two older age groups (29- and 36-months) were different from those of the two younger groups (18- and 24-months). Overall, the former did not show scene preference. (There were no main effects found for these age groups, and no differences involving Age.) Although these children looked at the familiar relation (M = 3.97, SD = 1.63; 29 months: M = 4.01; 36 months: M = 3.91) slightly more than the novel relation (M = 3.23, SD = 1.64; 29 months: M = 3.08; 36 months: M = 3.40), the difference did not reach significance (F (1,41) = 3.78, p = 0.061). Comparing the two age groups, the 29-month-olds tended to look more at the familiar relation and less at the novel relation than the 36-month-olds did (see Fig. 6). However, these differences between the two age groups were not significant (i.e., Scene x Age,

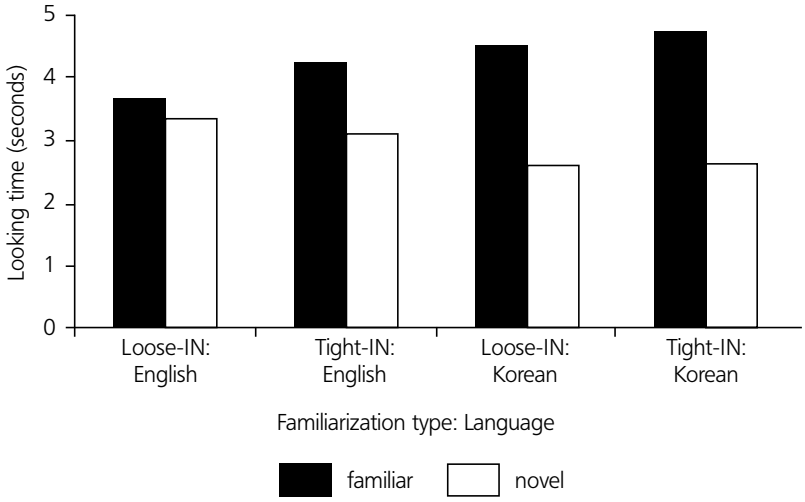

Figure 7 Tight-IN vs. loose-IN relations by familiarization type in 29- and 36-month-old English and Korean learners

F (1,41) = 2.09, p = 0.157). In sum, overall, both 29- and 36-month-olds did not distinguish between the two types of relation.

Importantly, however, the 29- and 36-month-olds showed an interaction involving Scene and Familiarization (F (1,41) = 4.17, $p < 0.05$). As displayed on the left side of Fig. 7, the English-learning children in the two Familiarization conditions showed differential looking patterns: those familiarized in the loose-IN relation did not show any looking preference (M = 3.67 for familiar test scenes vs. M = 3.36 for novel test scenes), whereas those familiarized in the tight-IN relation showed a preference for the tight-IN test scenes (M = 4.23 for familiar test scenes vs. M = 3.12 for novel test scenes). These data suggest that tight-IN was a salient relation for the children who were familiarized in the tight-IN relation, but that loose-IN was not a salient relation for the children who were familiarized with loose-IN.[7] I will discuss this finding in detail in the 'Discussion' section.

To summarize, overall, the looking preference for the familiar relation decreased from the 18- & 24-months to the 29- and 36-month age groups. ANOVAs comparing each of the younger age groups (18 and 24 months) with each of the two older groups (29 and 36 months) also resulted in interactions involving Scene and Age. That is, 18- as well as 24-month-olds differed significantly (at the 0.05 level) from 29-month-olds and from 36-month-olds in their preferential-looking behavior. All these results lead to the conclusion that whereas 18- and 24-month-olds distinguished the two relations, 29- and 36-month-olds did not do so.

One can hypothesize that the significant decrease in the distinction between the two relations may be due to language-specific input (see 'Vocabulary data' section below for relevant analyses). If this is indeed the case, we expect Korean children to

continue their sensitivity to the distinction between tight-IN and loose-IN. I investigated this in the next part of the study.

Korean learners

ANOVAs similar to those performed for the English learners were used to analyze the Korean data. There was a main effect for Scene (F (1,34) = 15.72, $p < 0.001$). As displayed on the right side of Fig. 7, the Korean children looked at the familiar relation significantly longer ($M = 4.65$, $SD = 1.51$; 29 months: $M = 4.54$ s; 36 months: $M = 4.75$ s) than the novel relation ($M = 2.56$, $SD = 1.52$; 29 months: $M = 2.63$ s; 36 months, $M = 2.29$ s).[8] There were no other significant effects.

Comparison between English and Korean learners: 29- and 36-month-olds

A crosslinguistic comparison was conducted between English and Korean with Familiarization condition (tight-IN vs. loose-IN), Age (29, 36), and Language (English, Korean) as the between-subject variables, and Scene and Trial as the within-subject variables. The results showed an interaction of Scene by Language by Familiarization (F (1,75) = 7.04, $p = 0.01$). The previous analyses have already shown that English-speaking children at these ages differed significantly by Familiarization, and the Korean-speaking children did not. As shown in Fig 7, whereas English learners showed some preference for the tight-IN relation only in the tight-IN condition, Korean learners showed a systematic preference for the familiar relation regardless of the Familiarization condition: those familiarized with the loose-IN relation kept looking at the loose-IN scenes and those familiarized with the tight-IN relation kept looking at the tight-IN relation during the test trials. Thus, the Korean 29- and 36-month-olds systematically distinguished between loose and tight containment, whereas English 29-/36-month-olds only respected the tight-IN category.

These crosslinguistic differences are consistently shown in the analysis of the proportions of children who showed the preference for the familiar relation. In English, 60% (27 out of 45) of the children looked longer at the familiar relation, whereas in Korean 82% (31 out of 38) looked longer at the familiar relation. The crosslinguistic difference was significant (χ^2 (1) = 6.22, $p < 0.05$). These data suggest that 29-/36-month-old Korean children distinguish categorically between tight-IN and loose-IN, whereas English-learning children make a distinction only in certain contexts.

Vocabulary data

As described in the 'Method' section, the present study included a language survey to examine a possible relation between productive language and nonlinguistic spatial categorization. Table 1 presents a summary of the language surveys filled out by the mothers of the participants. According to the surveys, of the 139 total words on the questionnaire, the 18-month-old English learners had an average of 36 words in their productive lexicon. Only 6 of 22 children in this group were reported to be producing the spatial word *in*. The 24-month-olds had an average of 82 words in their lexicon; 12 of 22 children were reported to be producing the spatial word *in*.

There was a sharp increase in vocabulary level and production of *in* in 29-month-olds. They had an average of 125 words in their productive lexicon out of 139 total words in the questionnaire. All 23 children were reported to be producing the spatial

Table 1 Summary of language surveys and the number of children producing *in/kkita*

			Presence/absence of in/kkita *production*	
Language	*Age, in months*	*Average no. words produced*	*Present*	*Absent*
English	18 (N = 22)	**36**	**6 (28%)**	**16**
	24 (N = 22)	**82**	**12 (54%)**	**10**
	29 (N = 23)	125	23 (100%)	0
	36 (N = 22)	133	21 (95%)	1
Korean	29 (N = 16)	114	13 (81%)	3
	36 (N = 22)	127	21 (95%)	1

Note. Bold numbers: the children aged 18 and 24 months were entered into the analysis to examine their preferential-looking patterns as a function of their production of *in* and their vocabulary level.

word *in*. The 36-month-olds had an average of 133 words in their lexicon. All 22 children except one were reported to be producing the spatial word *in*.

A comparison of the number of productive words shows a significant difference between the two age groups (18/24 months vs. 29/36 months) in total words as well as predicate/relational words ($p < 0.001$ for both). This is expected. The two groups also differed significantly in terms of the number of children producing the relevant spatial word (*in*) in the children's lexicon.

For the Korean children, the language survey shows that the 29-month-olds had an average of 114 words in their productive lexicon out of 139 total words in the questionnaire; 13 of the 16 children were reported to be using *kkita* productively. The 36-month-olds had an average of 127 words in their lexicon; all except one in this group were reported to be producing the spatial word *kkita*.

Preferential-looking pattern, vocabulary growth and production of *in/kkita*

The present study found an overall weakening of differentiation between tight-IN and loose-IN relations in English from 18-/24-month-olds to 29- and 36-month-olds. This raises a question about whether this phenomenon is related to the vocabulary growth and the acquisition of the spatial word *in*. In the current study, this hypothesis can be tested with the 18- and 24-month-olds' data. This is because the children in these age groups were in the process of acquiring the spatial word *in* as some produced the word while others did not (see bold numbers in Table 1). These children also differed

Table 2 Production of *in* in High vs. Low vocabulary groups in English-speaking 18- and 24-month-olds

	High			*Low*		
	No. children producing in	*No. children not producing* in	*Average no. predicates*	*No. children producing* in	*No. children not producing* in	*Average no. predicates*
18 months	6	4	15.60	0	12	2.33
24 months	9	3	36.42	3	7	10.40
Total	15	7		3	19	
Average			26.01			6.36

in vocabulary level as they were still learning many of the words in the language survey. (In contrast, most of the 29- and 36-month-olds almost reached ceiling level in the language survey.) We can thus analyze the children's looking patterns in these two age groups (18 and 24 months) as a function of their production of the word *in* and their vocabulary level.

For this analysis each child in the two age groups was coded for two variables: the presence or absence of the word *in* in their productive vocabulary and the overall vocabulary level (high or low). Table 2 presents a summary of these data. The vocabulary level was determined within each age group by taking the average number of words produced by each group (i.e., 36 words for the 18-month-olds, and 82 words for the 24-month-olds) and those who were above the average of her/his age group were coded as high, and those who were not were coded as low. It should be noted that all six 18-month-olds who produced *in* were in the high vocabulary group. For 24-month-olds, nine of the 12 children who produced *in* were in the high vocabulary group and three were in the low vocabulary group. (On the other hand, in the high vocabulary group ($N = 22$), a total of seven children did not produce *in*.)

Two ANOVAs were performed with Scene (Familiar vs. Novel) as the within-subject variable. (Trial and Gender did not enter into the analysis, as they were not significant factors in the analyses of looking times.) First, an analysis with 'Production-of-*in*' (presence of *in* ($N = 18$) vs. absence of *in* ($N = 26$)) and Age (18, 24 months) as the between-subject variables showed a marginal interaction of Scene by Production-of-*in* ($F(1,40) = 3.32$, $p = 0.075$). This suggests a strong tendency for the two groups (those who produce *in* and those who do not) to differ in their scene preference. That is, the children who produced *in* (henceforth, the '*in*' group) showed less preference to the familiar relation, and less differentiation between the two relations (tight-IN and loose-IN) than the children who did not produce *in* (henceforth, the 'no-*in*' group). In terms of difference scores in looking time (i.e., looking time to the familiar relation minus looking time to the novel relation), the score for the '*in*' group was 1.04 s (familiar

relation = 3.83 s; novel relation = 2.79 s), while the score for the 'no-*in*' group was 2.31 s (familiar relation = 4.57 s; novel relation = 2.26 s). Thus, children who produced *in* were less likely to attend to the Korean-based loose- vs. tight-fit distinction than those who had not yet learned *in*.

A second ANOVA was conducted taking the vocabulary level as a variable. An ANOVA with Vocabulary level (High, Low) and Age (18, 24 months) as the between-subject variables, and Scene (Familiar vs. Novel) as the within-subject variable showed an interaction of Scene and Vocabulary level (F (1,40) = 5.05, $p < 0.05$). This means that there was a significant difference between the High and Low vocabulary groups in their preferential-looking patterns: those children who had high vocabulary level showed much less differentiation between the two relations (tight-IN vs. loose-IN) than those who had low vocabulary level. In terms of difference scores, the high vocabulary group was only 0.97 s (familiar relation = 3.88 s; novel relation = 2.91 s) whereas the low vocabulary group was 2.53 s (familiar relation = 4.63 s; novel relation = 2.10 s).

As shown in Table 2, many of the children in the high vocabulary group produced *in* (15 out of 22), whereas only a few in the low vocabulary group did (3 out of 22).[9] Furthermore, the high vocabulary group produced significantly more predicate/relational words than the low vocabulary group. This suggests that children in the high vocabulary group not only were likely to know the word *in* but also to have many relational words in their mental lexicon to make semantic contrasts among a number of relational concepts.

Summary

The results of the two analyses, taken together, strongly suggest that there may indeed be a relation between learning the word *in* and vocabulary level on the one hand and weakening of attention to the tight-loose distinction (at least within the containment relation) on the other. More generally, the results suggest that acquisition of language-specific semantics influences nonlinguistic sensitivity in the relevant cognitive domain.

DISCUSSION

This study examined young children's nonlinguistic sensitivity to the distinction between two types of containment relation: tight-fit vs. loose-fit containment. The two relations are semantically distinguished in Korean in a systematic way but not in English. In Korean, the spatial word *kkita* refers exclusively to causal actions resulting in a tight-fitting relation (containment or support) – and does not include a loose-fit relation. In contrast, in English the spatial word *in* refers to both tight- and loose-fitting containment relations.

A prior study (McDonough et al., 2003) using a preferential-looking method found that preverbal infants distinguish the two types of containment relation as two different categories (see also Hespos & Spelke, 2002). In contrast, adult speakers of English and Korean showed different levels of sensitivity: whereas Korean speakers could distinguish the two relations, English speakers could not. This crosslinguistic difference was interpreted to be an effect of language-specific semantic categorization.

The present study examined when the influence begins and what the extent of the influence is in young learners. The same preferential-looking method as in the prior study was used to examine English learners aged 18, 24, 29 and 36 months. Children in both 18- and 24-month age groups distinguished between the two types of containment. However, children in the 29- and 36-month age groups showed a much weaker sensitivity to the differential feature (i.e., degree of fit) of the two relations. Specifically, there was an asymmetry in the preferential-looking behavior between the two familiarization conditions: only the children in the tight-IN condition looked significantly longer at the familiar relation (i.e., tight-IN test scenes). The children who were familiarized in the loose-IN relation did not show any preference between the two relations. The asymmetry is intriguing: it suggests that for young English learners, only the feature of tight-fit is salient. That is, when they are presented with a number of tight-IN scenes (during the familiarization phase), they could pick out the tight-fit feature and thus continued to look at the scenes with the same feature during the test trials.[10] In contrast, the non-distinction in the loose-IN condition suggests that the feature of loose-fit is not something that the older children can abstract from spatial scenes and contrast against the tight-fit feature. In fact, the non-distinction suggests that, when 29- and 36-month-old learners watch a number of loose-IN containment scenes, what they pick out is the containment feature. This would lead to no preference to either familiar (loose-IN) or novel (tight-IN) scenes because both depict containment. Picking out the containment feature is consistent with the English semantic system: *in* refers to containment regardless of tight- or loose-fit.

In contrast to English learners, 29- and 36-month-old Korean learners distinguished between the two relations in a categorical fashion as they showed the familiarity effect whether they were in the tight-IN or the loose-IN familiarization condition. This is consistent with the Korean semantic system: *kkita* refers to a tight-fit relation and contrasts with *nehta,* expressing a loose-fit relation.

The significant decrease in English learners in their attention to the difference in degree of fit from 18-/24-months to 29-/36-months of age, together with the maintenance of the distinction (between tight-IN and loose-IN) in Korean learners, suggests that the language-specific spatial semantics begins to affect nonlinguistic sensitivity in the relevant domain some time between 24 and 29 months of age. Indeed, the language surveys filled out by the mothers show a significant increase between 24- and 29-month-olds in the number of words, as well as in the percentage of children who productively used the spatial word *in*.

It is possible that the weakening of nonlinguistic sensitivity occurs as children master the relevant spatial term. In the present study, this hypothesis was tested with 18- and 24-month-olds learning English. The results showed a significant effect of language on preferential-looking pattern. More specifically, English-speaking children who produced *in* or had a high vocabulary level showed much less sensitivity to the difference between tight-IN and loose-IN than those who did not yet produce *in* or had a low vocabulary level. These results strongly suggest that there is an intimate relation between vocabulary learning and nonlinguistic sensitivities of the relevant domain (Choi & Gopnik, 1995). As pointed out earlier, children in the high vocabulary group not only were more likely to produce the word *in* but also had significantly more predicate/relational words than those in the low vocabulary group. Having many

predicate words in their mental lexicon may mean that they are able to make semantic contrasts among a number of relational concepts. In other words, they are building a semantic system classifying many events and relations into contrastive categories for purposes of talking about them. This process seems to influence the degree to which children nonlinguistically attend to the relevant relational features.

The present study suggests that there may even be a specific relation between production of a specific spatial word, e.g., *in*, and nonlinguistic sensitivity to the relevant spatial categories, e.g., containment (cf. the specificity hypothesis proposed by Gopnik & Meltzoff, 1986, 1993), as a tendency was found in children who produce the word *in* to focus more on the containment feature and less on the tight-loose distinction. Further studies that include comprehension of the relevant words should be able to examine the specificity hypothesis more systematically.

The findings reported here are in line with a recent emergentist view that as children learn words of the same class (e.g., nouns) they attend selectively to the properties that are particularly relevant to those words. For example, Smith (1999; see also Yoshida & Smith, 2003) shows that as English learners increase their noun vocabularies, they pay more attention to the shape of an object when learning a novel noun (but not when learning an adjective). The present study suggests one step further, namely, that such biased attention spills over to nonlinguistic sensitivities in the relevant domain.

There are certain similarities between the developmental patterns found in this study and those in phonetic perception studies. In the literature on the development of phonetic contrasts, studies have consistently found that infants can initially make a number of distinctions including those not phonemically contrasted by the ambient language, e.g., infants' distinction between /ra/ and /la/ regardless of language environment (Kuhl, Kiritani, Deguchi, Hayashi, et al., 1997; Werker & Lalonde, 1988; Werker & Tees, 1984). These studies have also found that, by 10 to12 months of age, the ability to distinguish those sounds that are not phonemically contrasted in the ambient language weakens considerably. Thus, Japanese children lose their sensitivity to the distinction between /ra/ and /la/ by the end of their first year (Kuhl et al., 1997). The parallels between the present study (along with McDonough et al., 2003) on spatial categorization and the phonetic perception studies are impressive. Together, these studies suggest that both at the perceptual and conceptual levels, infants preverbally develop a large set of distinctions that include those not made in the ambient language. In this way, during the preverbal stage, infants develop a substantial level of flexibility that allows them to home in on the language-specific properties quite rapidly.

However, although the general developmental patterns may be similar, influence of language on spatial categorization is distinct from that on speech perception in important ways. First, unlike the case in speech perception, the early distinction of spatial categories is maintained for quite some time, and the weakening of nonlinguistic sensitivity in the relevant domain does not begin until children's third year of life when they produce the relevant words productively. Second, the present study shows that learners maintain some sensitivity to a distinction even though the language they are learning does not reinforce it, i.e., some level of sensitivity to the tight- and loose-fit containment by English learners.

This raises the question of how extensive the influence of language-specific semantics

is to nonlinguistic cognition. More concretely, does language influence cognition so strongly that, by the time English learners become fluent speakers, they completely lose sensitivity to the tight- vs. loose-fit distinction? Although the adult data from McDonough et al. (2003) suggest that to be the case, my current studies with adult speakers of English suggest that they can distinguish between tight- and loose-fit relations in certain contexts. In these studies, adults are asked to examine each target spatial scene (e.g., putting a key tightly into its lock) against a pair of spatial scenes (e.g., putting a book tightly into its matching box-cover vs. putting a Lego loosely in a container) that are only partially similar to the target scene. The participant's task is to determine which of the alternate scenes is more similar to the target. Our preliminary results suggest that English adult speakers can differentiate spatial relations on the basis of degree of fit when it is the only differential feature between the two scenes (e.g., tight-fit vs. loose-fit containment) but not when other spatial variables are also involved. These data suggest that as English learners become fluent speakers their sensitivity to the tight-fit feature decreases to a context-dependent level. This suggests that both a strong version of the Whorfian Hypothesis (Levinson, Kita, Haun & Rasch, 2002; Lucy, 1992; Pederson et al., 1998) and a strong version of cognitive determinism (Li & Gleitman, 2002) presented in recent literature are too extreme. The present findings support a weaker version of Whorf's hypothesis where language influences cognition but only to a certain level.

The present study provides evidence that there is a dynamic interaction between language-specific semantic learning and spatial cognition. More specifically, preverbal infants develop a sophisticated level of spatial cognition (see also Baillargeon, 1995, 2000; Quinn, Adams, Kennedy, Shettler & Wasnik, 2003) that allows them to learn the target semantic system rapidly. As children acquire the spatial semantics of the ambient language, the language-specific system in turn influences their spatial cognition: children's nonlinguistic sensitivity for the semantically relevant categories is well maintained, whereas their sensitivity to other categories gets much weaker.

The present study is limited, however: the categories studied here – tight-fit and loose-fit containment relations – are not lexicalized in either Korean or English as full-fledged semantic categories. For example, the relation of tight-fit containment makes up only a subset of the *kkita* category in Korean (see Fig. 2 above). To understand fully the relation between spatial semantics and cognition, we need to examine how the full-fledged categories of *kkita* and *in* are acquired and how they influence spatial cognition. Further studies are also needed to understand the details of the influence of language-specific categories in the minds of adult speakers.

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NOTES

1. *Kkita* is a spatial verb. In Korean, information about Motion and Path is systematically encoded by a set of spatial verbs, whereas in English it is encoded by Motion verbs plus Path particles, e.g., 'put in' (Choi & Bowerman, 1991; Talmy, 1985).
2. Of course, it is possible that English speakers can distinguish between tight-IN and loose-IN in other contexts. That is, they may not have completely lost the ability to distinguish between containment based on the tight-fit feature. See 'Discussion' section.
3. English has words that express tight fit, e.g., *fit*, *tight*. However, their use is not as 'grammaticized' as the Korean spatial verbs (e.g., *kkita*) in describing spatial relations: whereas the use of *fit* and *tight* is optional in English, the use of spatial verbs is obligatory in Korean. Furthermore, *fit* and *tight* do not have the same meaning as *kkita* in Korean. *Fit* doesn't always mean 'tight', as one can say 'this bed *fits* my size' or 'these shoes *fit* loosely and comfortably'. *Kkita* cannot be used in those contexts as it typically has to do with objects having complementary shapes that interlock tightly in a 3-dimensional way. Also, *tight* in English can be used in broader contexts (including non-spatial contexts) than *kkita*.
4. The preferential-looking design used in Choi et al. (1999) was an adaptation of the paradigm designed by Naigles (1990) and Hirsh-Pasek & Golinkoff (1996).
5. The looking time to the familiar relation is not necessarily related to the looking time to the novel relation, as the child had a third option, i.e., looking away.
6. It is possible that the significant effect in the looking time analyses may be due to a strong preference for the familiar relation in just a few children. Thus, it is useful to look at the proportion data, i.e., the number of children who exhibited such a preference. The proportion data show that the familiarity effect was a general pattern among the children aged 18 and 24 months: 17 of the 22 children (77%) at 18 months and 18 of the 22 children (82%) at 24 months preferred familiar test scenes ($\chi^2(1) = 12.60$, $p < 0.01$). Thus, like preverbal infants, 18- and 24-month-olds learning English distinguish between tight-fit containment and loose-fit containment.
7. The proportion data for the 29- and 36-month-olds were consistent with the looking time data: overall, across the two familiarization conditions, there was no predominant pattern: a little over half (27 out of 45, i.e., 60%) of the children looked longer at the familiar relation and a little less than half (18 out of 45, i.e., 40%) looked longer at the novel relation. However, examining each familiarization condition separately, the proportion of the children who looked longer at the familiar relation differed between the loose-IN and the tight-IN conditions: in the loose-IN condition, half of the children looked longer at the familiar relation, whereas in the tight-IN condition, 18 out of 24 (75%) looked longer at the familiar relation. The number of children who showed the familiarity effect was greater than the chance level ($\chi^2(1) = 4.16$, $p < 0.05$).
8. Consistent with this preferential-looking pattern, an overwhelming majority of the children (31 out of 38, i.e., 82%) looked longer at the familiar relation whereas only 7 out of 38 (18%) looked longer at the novel relation.
9. Unfortunately, our language survey for this experiment did not consistently assess language

comprehension. The comprehension measure was included in the language survey only halfway through the experiment. For three of the seven children (who had the high vocabulary level but didn't produce *in*), we have their comprehension data: all three are reported to comprehend *in*.

10. It is possible that English-speaking children continue to pay attention to the tight-IN situations more than the loose-IN situations because the tight-fit feature can easily be referred to with the verb *fit* or the adjective *tight*. In contrast, there is no common way to express the feature of loose-fit.

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