Exploring the relationship between language-specific semantic spatial categories and infants' nonlinguistic spatial categories

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During the early stages of word learning, infants face the task of coordinating their existing concepts of the world with the morphemes of their language. In the case of the acquisition of spatial language, this task seems to be particularly challenging because languages differ in how they organize spatial events into semantic (i.e., meaning) categories (e.g., Bowerman, 1996). For example, English speakers linguistically sort some spatial events on the basis of containment (e.g., ball in box) and support (e.g., ball on table) whereas Korean speakers focus instead on the fit between two objects (Choi & Bowerman, 1991). The Korean spatial morpheme "kkita" refers to those dynamic events in which one object is fitted tightly or interlocks with another object and is used to describe both containment and support. Hence, a peg that is seen being fitted exactly in a hole and a Lego block that is viewed being placed tightly on another Lego block are both described as "kkita" in Korean. Consequently, the spatial relation to which infants must attend and the basis upon which infants must group events into a spatial category for linguistic expression (i.e., containment or tight-fit) will vary depending on which language a child is learning (Bowerman, 1996).

Despite cross-linguistic differences in the description of spatial events, English- and Korean-speaking toddlers display little difficulty in acquiring the semantic categories specific to their language. Choi and Bowerman (1991) report that toddlers acquiring English describe both tight- and loose-fit containment events as "in" and tight- and loose-fit support events as "on." In contrast, toddlers acquiring Korean describe tight-fit containment and tight-support events as "kkita." Similarly, English-learning infants' comprehension of "in" and Korean-learning infants' comprehension of "kkita" is language specific. Choi, McDonough, Bowerman and Mandler (1999) presented 18- to 23-month-old English- and Korean-speaking infants with pairs of scenes that consisted of either a tight-fit containment event paired with a loose-fit support event or a loose-fit containment event paired with a tight-fit support event. In a control trial, infants did not demonstrate a preference of either event in a pair. However, when hearing the word "in," the English-learning infants looked longer at the containment rather than at the support event in the pair and did so regardless of whether the containment event was tight- or loose-fit containment. In contrast, the Korean children looked longer at the tight-fit event when hearing "kkita," regardless of whether the tight-fit event was that of containment or support. Both sets of findings demonstrate that young word learners group spatial events into language-specific semantic spatial categories, even during the earliest stages of acquiring spatial language.

One question inspired by the above findings centers on the extent to which language-specific semantic categories are based on infants' nonlinguistic categories of spatial relations. Recent experimental findings

have demonstrated that infants raised in an English-speaking environment can discriminate between tight- versus loose-fit containment events, a spatial relation that is linguistically relevant for Korean but not English speakers. Using a habituation-dishabituation paradigm, Spelke and Hespos (2001) habituated 5-month-old infants to either a tight- or a loose-fit containment event (i.e., repeatedly presented infants with one of these events until their looking time to the event decreased to a set criterion). Following habituation, infants viewed both a tight-fit as well as a loose-fit containment event. Infants looked significantly longer at the event that presented a different fit than the habituation event (e.g., from tight to loose), indicating that by 5 months of age, infants could discriminate between tight- versus loose-fit containment. Similarly, Choi, McDonough, Mandler, and Bowerman (2001) familiarized Korean- and English-learning infants of 9, 11, and 14 months to either a tight- or a loose-fit containment relation depicted across six pairs objects. Following familiarization, infants viewed new examples of both types of relationships. Infants from both language groups demonstrated a significant preference for the event with the familiar relation, indicating that infants were able to form a category of one type of containment (e.g., tight-fit) that excluded the other type of containment (e.g., loose-fit). Hence, tight-fit versus loose-fit within containment is a spatial relation to which all infants are sensitive, regardless of linguistic environment.

However, when forming language-specific semantic categories, it is not sufficient for infants to discriminate between two spatial relations. Rather, infants must be able to group spatial events on the basis of one type of spatial relation while ignoring other types of spatial relations that may be present. For example, infants learning the English semantic category of "in" must learn to form a spatial category on the basis of containment while ignoring the distinction between tight- versus loose-fit containment. Likewise, infants learning "kkita" must form a spatial category on the basis of tight-fit while ignoring the distinction between containment and support. Can infants form a spatial category consistent with the English semantic categories of "in" and "on" and the Korean semantic category of "kkita?" To explore this question, Casasola and Cohen (2002) examined the ability of 10- and 18-month-old English-learning infants to form a spatial category of either containment, support, or tight-fit spatial relations. More specifically, we tested infants' ability to form a category of containment that included both tight- and loose-fit containment, a category of support that included both tight- and loose-fit support, and a category of tight-fit that included both tight-fit containment and tight-fit support. Using a standard infant categorization task, infants were habituated to four dynamic events depicting the same spatial relation between two objects (i.e., either containment, support, or tight-fit). For example, infants in the containment condition viewed a hand insert a candle <u>in</u> a cookie cutter of the same shape, a peg <u>in</u> a yellow block, a car <u>in</u> a larger, inverted car, and a stuffed animal <u>in</u> a basket (see Table 1). For infants in the containment and support conditions, half of the examples they viewed during habituation were tight-fit and half were loose-fit examples of the relation. Thus, in order to form the spatial category, infants had to disregard the tight- versus loose-fit relation in the spatial events and instead focus on either the containment or support relation depicted across all four pairs of objects. Likewise, infants who viewed the different examples of tight-fit events viewed two tight-fit containment events (e.g., candle in cookie

cutter, peg in block) and two tight-fit support events (e.g., turtle on pole, Lego man on Lego car) during habituation. To form a category of tight-fit, infants had to disregard the containment and support relations in the events and focus instead on the tight-fit relation seen in all four habituation events. Following habituation, infants were tested with four dynamic events: one from habituation (both objects and spatial relation were familiar), an event with familiar objects in a novel spatial relation, an event with novel objects in the familiar habituation relation, and an event with novel objects in a novel relation. In all conditions, half of the test events were containment events (one tight-fit and one loose-fit containment) and half support events (one tight-fit and one loose-fit support). The design of the experiment is presented in Table 1 and the final frame of the each dynamic event is presented in Figure 1.

If infants could form a category of the spatial relation viewed during habituation, they were expected to look significantly longer at the test events with the novel relation than at the test events with the familiar spatial relation. If infants were not able to attend to the spatial relation in the events, they were expected to attend only to changes in the objects. The results indicate that the 10-month-old infants discriminated reliably between the familiar objects (i.e., seen during habituation) and novel objects (i.e., seen for first time in the test trials). However, only the 10-month-old infants who were habituated to the various examples of containment discriminated reliably between the familiar containment and the novel spatial relation (i.e., support). As can be seen in Figure 2, infants did so both when the objects depicting the relations were familiar and when they were novel. This pattern of response suggests that infants could generalize the containment relation to novel instances of the relation and thus, had formed a spatial category of containment. Those infants who were habituated to the support or tight-fit relations provided no evidence that they attended to these spatial relations, although they did discriminate reliably between the familiar and novel objects in the events.

Similar to the younger infants, the 18-month-old infants in the containment condition discriminated reliably between the familiar containment and the novel spatial relation and did so both when the objects were familiar and when they were novel (see Figure 3). That is, infants generalized their habituation of the containment relation to novel objects in this spatial relation. However, the 18-month-old infants in the support and tight-fit conditions only discriminated reliably between the familiar and unfamiliar relation when depicted by familiar objects (see Figure 4). When the familiar and unfamiliar relations were viewed between novel objects, infants provided no evidence that they could discriminate between the spatial relations. Consequently, these infants did not respond in a manner consistent with having formed a category of either support or tight-fit spatial relations.

The results indicate that infants learn to categorize containment relations prior to support or tight-fit relations. Infants at both ages demonstrated the ability to generalize containment to a novel example of the spatial relation. The results also suggest a developmental progression by which infants acquire the ability to form a categorical representation of a spatial relation. From the obtained results, it seems that infants first have the ability to attend to the objects in the events prior to the time that they can attend to the spatial relation between these objects. Across all conditions, infants were able to discriminate reliably between the familiar and novel objects, even when they provided no evidence that they were able to

attend to the spatial relation presented. In addition, infants appear to attend to the spatial relation between familiar objects prior to the time that they can generalize the relation to novel objects. This specific-to-abstract developmental progression is consistent with findings reported by Quinn et al. (1996) who found that 3-month-old infants can form a category of above versus below between specific objects but do not generalize the spatial relation to novel objects until 6 months of age.

The results reported by Casasola and Cohen (2002) appear to conflict with those findings demonstrating that English-learning infants are sensitive to the distinction between tight- and loose-fit containment (Spelke & Hespos, 2001) and can form a category of tight-fit containment that excludes loose-fit containment (and vice versa, Choi et al. 2001). If infants are sensitive to tight- versus loose-fit, why did infants in Casasola and Cohen (2002) form a category of containment that included both tight- and loose-fit containment? Findings from infants' categorization of objects can be used to resolve these seemingly discrepant findings. Oakes, Coppage and Dingel (1997) found that 10-month-old infants who were habituated to perceptually similar land animals were able to form a category of land animals that excluded sea animals. That is, these infants demonstrated the ability to form an exclusive category of land animals. However, infants habituated to perceptually diverse land animals did not form a category of land animals that excluded sea animals. Rather, these infants formed a more inclusive category of land animals, one that included both land and sea animals (see also Quinn, Eimas, & Rosenkrantz, 1993, for similar results with young infants' categorization of dogs versus cats). Infants' categorization of spatial relations may be similarly influenced by the perceptual similarity of the exemplars presented during familiarization. When familiarized to only one type containment event (e.g., tight-fit), infants form a more exclusive category of containment, one that includes only tight-fit or only loose-fit containment. However, when habituated to both tight-fit and loose-fit containment events, infants form a more inclusive category of containment, one that includes both types of containment events. The results of Casasola and Cohen demonstrate that, under some circumstances, infants can combine tight- and loose-fit containment into a single spatial category. That is, they can treat tight-fit and loose-fit containment as equivalent. Given that infants did not form a category of tight-fit, infants do <u>not</u> demonstrate the same facility in grouping together tight-fit containment and tight-fit support into a single category of tight-fit. Thus, certain spatial distinctions (such as tight-fit versus loose-fit) are easier for infants to group together into a single category than other spatial distinctions (such as containment versus support).

Hence, despite infants' sensitivity to an array of spatial relations, they cannot necessarily combine these relations to form spatial categories consistent with the semantic categories of different languages. How then do toddlers acquire the semantic spatial categories specific to their language? One hypothesis, similar to the argument advanced by Bowerman (1996), is that experience with a particular language teaches infants to group spatial events on the basis of one spatial relation while ignoring other spatial relations that may be present. Preliminary results with 10- and 18-month-old Korean infants provide support for this view. Korean infants of 9 to 11 months and those of 17 to 19 months are being tested in the same tight-fit spatial categorization task as the English-learning infants in Casasola and Cohen (2002). Although the 10-month-old Korean infants provide no evidence that they can discriminate

between the tight- and loose-fit events (similar to the English-learning infants), the 18-month-old Korean infants discriminate reliably between the familiar tight-fit and the unfamiliar loose-fit relation (see Figure 5). Moreover, infants do so both when the objects are familiar as well as when the object are novel (see Figure 6). Thus, 18-month-old Korean infants seem to be forming the spatial category of tight-fit that English-learning infants do not form. Although these results are preliminary (additional Korean infants still need to be tested), the data suggest that Korean infants learn to group tight-fit containment and tight-fit support into a single spatial category between 10 and 18 months and acquire the ability as result of their experience with Korean. If the final results demonstrate the same pattern as these preliminary data, they would support the notion that infants learn to form particular types of spatial categories as a result of their experience with the semantic structure of their language.

As additional research is conducted, the relation between language-specific semantic spatial categories and infants' nonlinguistic spatial categories will become clearer. The evidence thus far suggests that infants' perceptual and cognitive abilities provide them with a sensitivity to an array of spatial relations (Hespos & Spelke, 2001; Choi et al. 2001). Thus, linguistic input is not required for infants to discriminate among various types of spatial relations. However, language may play a critical role in teaching infants how to group various spatial relations into a single category for the formation of particular semantic spatial categories. In other cases, infants can rely on nonlinguistic spatial abilities to form language-specific semantic categories.

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Table 1

The experimental design of Casasola and Cohen (2002): The habituation events are presented in italics and the test events are presented in normal print. Events presented in bold print have a tight-fit between the objects.

	Condition		
	Containment	Support	Tight-fit
Habituation Event 1: *Habituation Event 2:* *Habituation Event 3:* *Habituation Event 4:*	*Animal in* *Car in* ***Candle in*** ***Peg in***	*Car on* *Cup on* ***Round man on*** ***Turtle on***	***Candle in*** ***Lego on*** ***Peg in*** ***Round man on***
Test Event 1: Familiar Objects-Familiar Relation	**Candle in**	**Turtle on**	**Candle in**
Test Event 2: Novel Objects-Familiar Relation	Cup in	Peg on	**Turtle on**
Test Event 3: Familiar Objects-Novel Relation	Peg on	Cup in	Peg on
Test Event 4: Novel Objects – Novel Relation	**Turtle on**	**Candle in**	Cup in

Figure 1: The final frame of the dynamic events used to test infants' ability to form a category of containment (top circle), support (bottom circle) or tight-fit events (middle square). Loose-fit containment events are shown in the first row and tight-fit containment events in the second row. Tight-fit support events are shown in the third row and loose-fit support events are shown in the last row.

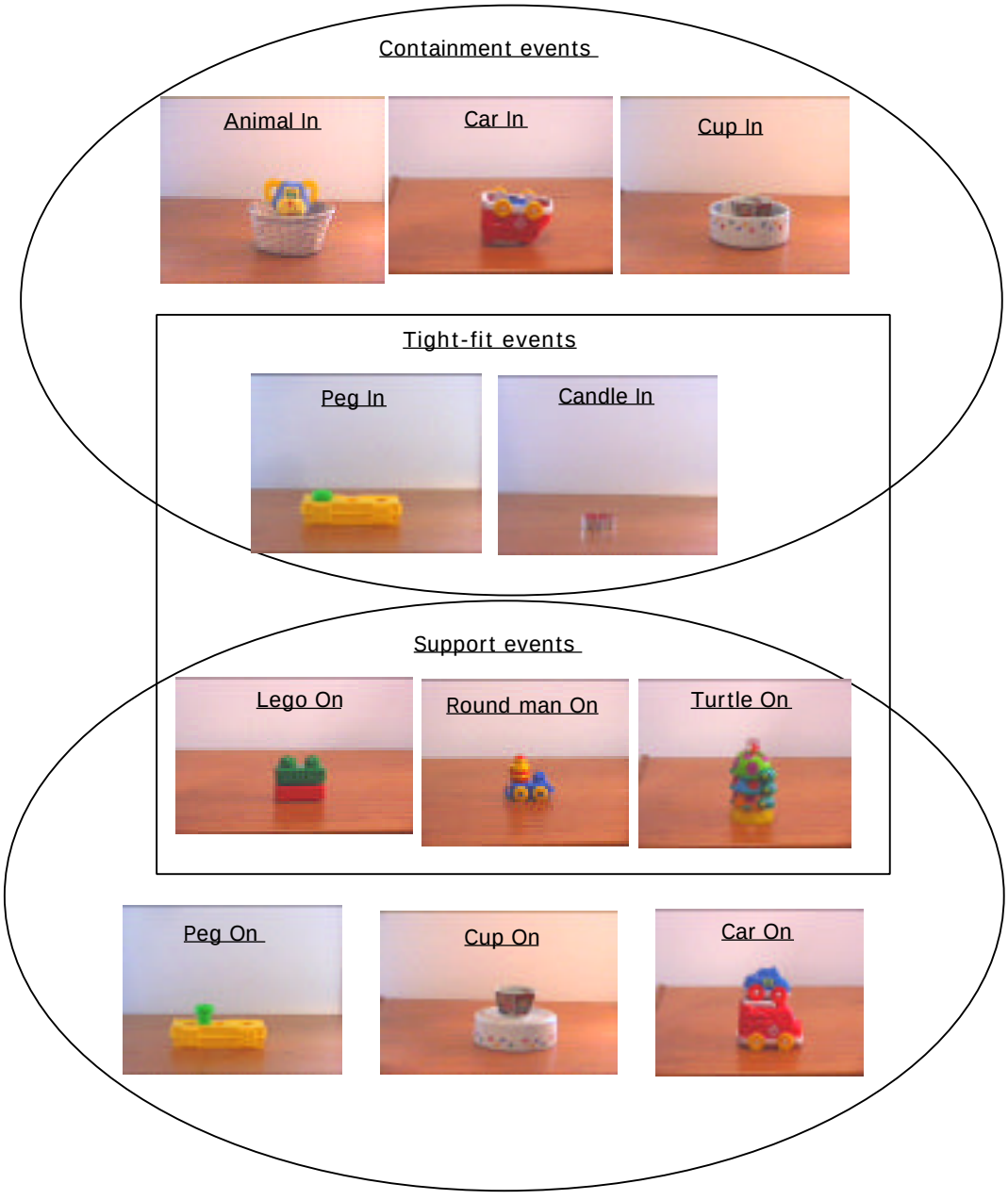


Figure 2

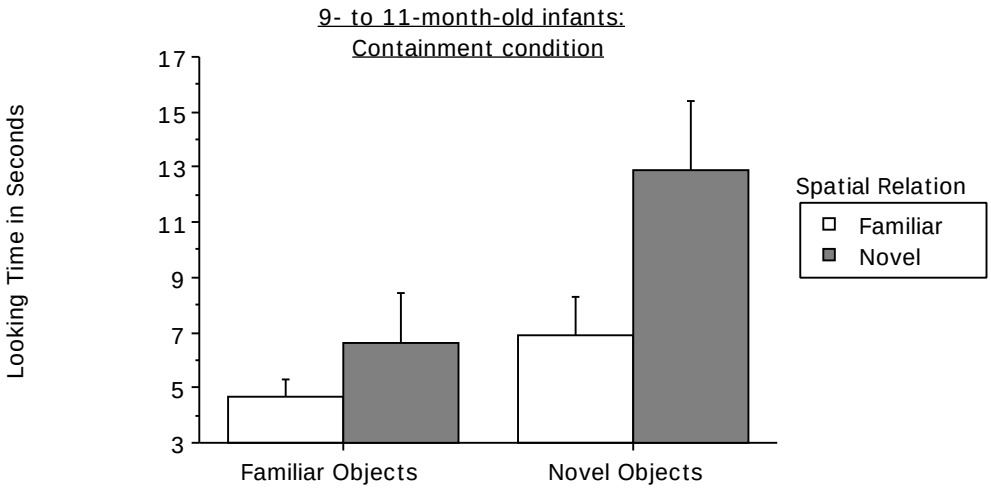


Figure 3

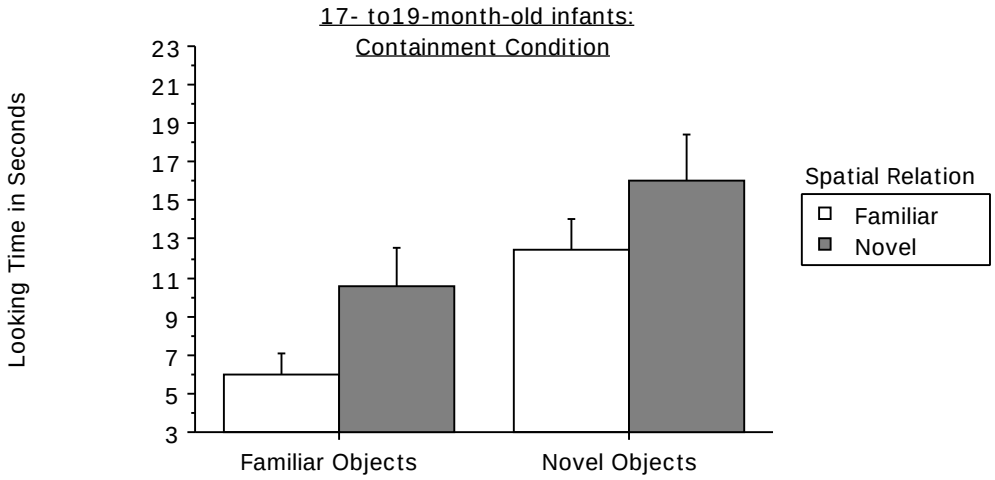
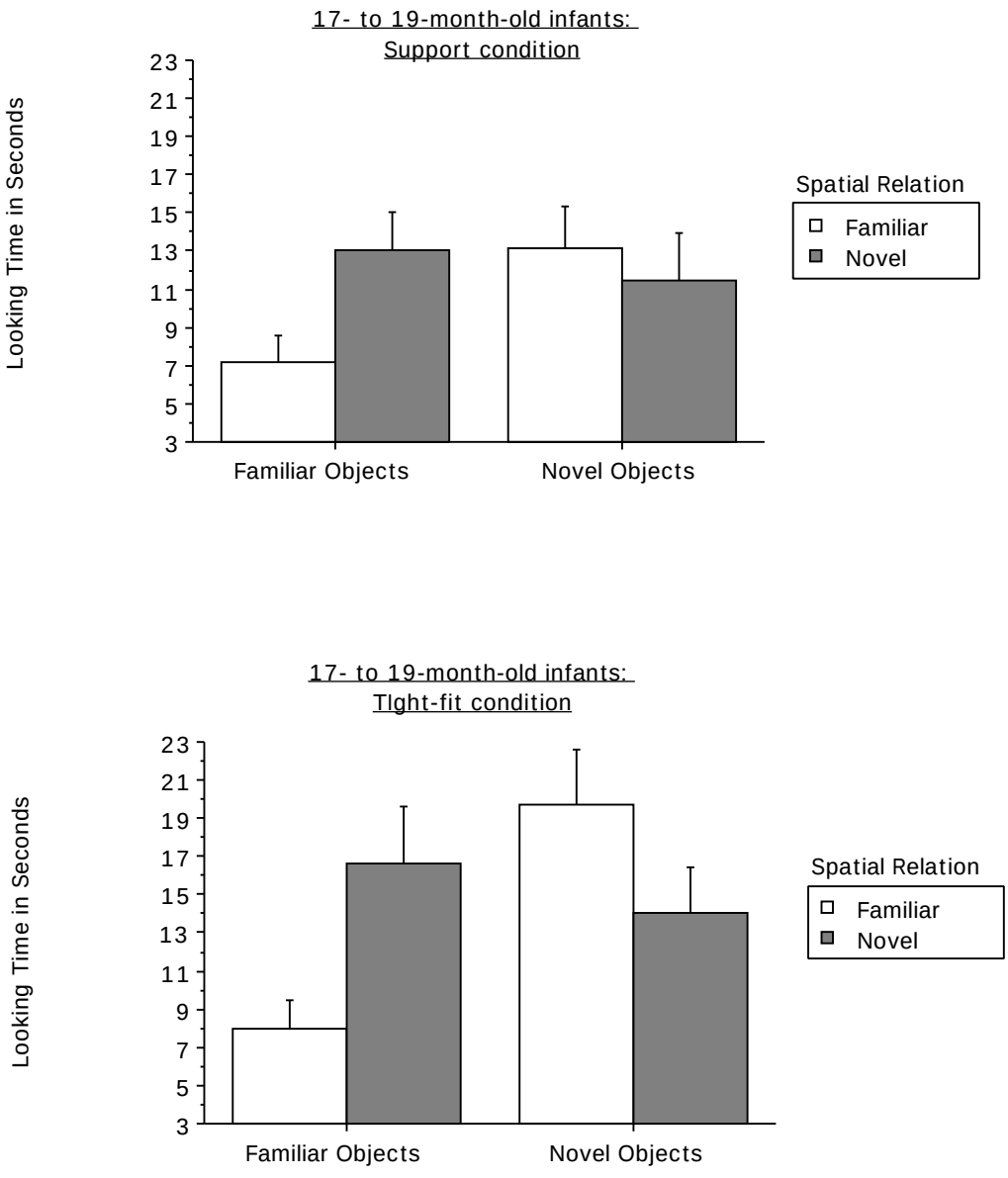


Figure 4


17- to 19-month-old infants:
Support condition
Looking Time in Seconds
23
21
19
17
15
13
11
9
7
5
3
Familiar Objects
Novel Objects
Spatial Relation
Familiar
Novel
17- to 19-month-old infants:
Tlght-fit condition
Looking Time in Seconds
23
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19
17
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11
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7
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Familiar Objects
Novel Objects
Spatial Relation
Familiar
Novel

Figure 5

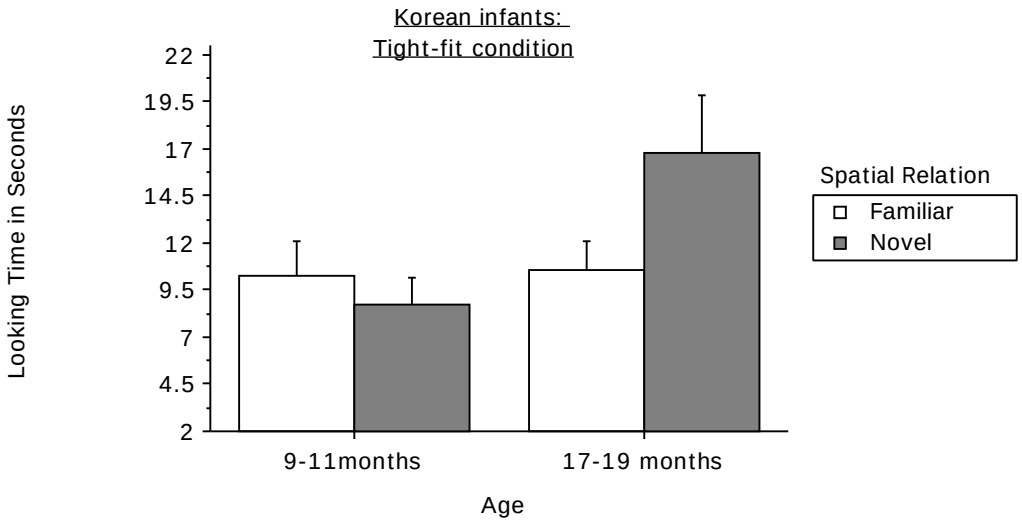

Figure 6