

Running head: NOVEL SPATIAL CATEGORIES

Young Children's Learning of Novel Semantic Spatial Categories

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Abstract

According to linguistic relativity theory, language exerts a strong influence on the development of our minds, particularly during childhood (Whorf, 1956). One area in which this influence can be observed is that of spatial relations. For example, in Dutch, the English category of support (“on”) is further subdivided into two categories, the distinction between which roughly corresponds to the difference between vertical (“aan” in Dutch) and horizontal (“op”) (e.g., Bowerman, 1996). The linguistic relativity theory would predict that this dichotomy would be more easily perceivable to children who were being raised speaking Dutch than to children who were being raised speaking English. This experiment attempts to test the ability of English-speaking two-year-olds to learn the spatial category. Twenty-two children between 25 and 30 months of age first underwent a short training session in which toy models demonstrating each of the spatial relations were presented along with a novel word. Children were then tested for comprehension in a preferential looking paradigm. Children provided no evidence that they learned either of the two possible novel spatial categories (*aan* and *op*). The results suggest that learning novel semantic spatial categories may be challenging.

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Linguistic Relativity

The current study examines the possibility that the spatial categories encoded in a language may influence the ability of children who are native speakers of that language to perceive and form those spatial categories relative to their ability to form spatial categories not encoded in their native language. The theory of Linguistic Relativity, originally posited by Edward Sapir and Benjamin Whorf in 1956, proposes that thought and cognitive development are influenced by the language one learns as a child and that the intrinsic differences across various languages could therefore cause divergences in the developmental paths of children growing up with different languages. One incarnation of the theory is the possibility that, although children may initially be able to attend to numerous ways of perceiving and mentally organizing the world around them, the language they learn as they grow and develop will influence which of these organizational patterns remains salient for them to the exclusion of any that are not encoded in their language (McDonough, Choi & Mandler, 2003).

Languages can differ in the distribution of terms for color that they possess, the way in which they describe spatial location and the spatial relationship of two objects to one another, the classifications they assign to different types of motion events (Munnich, Landau, & Doshier, 2001), and the relationship they assign to time and space as well as the metaphors that are used to link the two concepts (Munnich & Landau, 2003). A particularly striking finding in support of this theory is the fact that, when similar tasks involving naming and describing a variety of different objects and spatial events were presented to children of several different ages as well as adults, children gave descriptions and made mistakes more similar to those of adults with whom

they shared a native language than to those of children of similar ages but of different linguistic backgrounds (Bowerman, 1996).

Another area in which linguistic differences appear to influence perceptions of one's environment is that of motion, and the manner and path it takes. For example, while, in English, verbs usually incorporate the manner of motion and encode the path separately, in Spanish, the opposite is true: the path is included in the verb and manner is encoded separately. In discussing a motion event, an English speaker would likely say "he ran out of the room" (the verb, "ran", encodes the manner of movement while the path, "out", is separate), while a Spanish speaker would say "saliò corriendo", which could be translated as "he exited the room running", with the verb ("saliò") encoding the path ("exit") and the manner being described separately, in an adverb ("corriendo") (Naigles, Eisenberg, Kako, Highter, & McGraw, 1998). It has been found that children as young as 3 years of age reflect these linguistic differences in their attention to different aspects of motion events: speakers of Spanish focus more on path while speakers of English focus more on manner (Berman & Slobin, 1994).

Cognitive Priority

A second theory involving both early language learning and cognitive development is the Cognitive Priority theory, which proposes an opposite viewpoint: that perception of one's environment and cognitive development occur, if not independently of, then without any overly significant influence of language. This theory suggests that children of similar ages should perceive things more or less similarly, regardless of what language they are learning. Evidence for this theory includes the fact that there is a sequence of development of certain spatially-related concepts that is fairly well conserved across many languages; the fact that similar concepts are acquired at the same stage of development regardless of language lends support to

the idea that the acquisition of such concepts is universal and is therefore not dependent upon the language one learns (Bowerman & Choi, 2003). For example, children across many languages have been found to develop the concept of containment first, followed by support, and occlusion (Bowerman & Choi, 2003).

Similarly, despite the cross-linguistic differences for concepts like color, it has been found that the influence of such differences on one's actual memory of colors is not significant. In a study examining the ability of participants whose native languages used vastly different systems of categorization for color (speakers of English and speakers of Dani, a language native to Indonesian New Guinea) to classify and remember chips of different colors, there was no difference in memory ability for the two groups, despite the large difference in the availability of specific color terms across the two languages (Heider & Oliver, 1972).

Another set of observations that supports this theory involves the fact that children, at early stages of development and language learning, have a tendency to over-extend their use of certain spatial words (i.e. to use them for the concepts to which they actually correspond as well for additional related concepts that are not usually described with the same word) and to under-extend others. For example, at early stages of development, words for *behind* and *in front of* are often used solely to describe the position of other objects with respect to the child's own body (Johnston, 1984). Meanwhile, *open* is used not only for events that adults would describe with *open* but also for a variety of other events, both spatial and non-spatial, like taking a piece out of a puzzle and turning on a typewriter (Bowerman, 1978). These findings suggest that children have classified the various spatial relations in their mind independently of language, using some other mechanism or schema.

Additionally, studies have shown that the perceptions and categorizations so often cited as examples of language's effects on cognition can actually be altered so that subjects behave differently from what one would expect based on their native language. Li and Gleitman (2002) used the concept of frame of reference in order to demonstrate this phenomenon. In general, the frame of reference one uses to describe objects' positions in relation to one another can be either allocentric (i.e. characterized by the use of absolute directional terms like 'north' and 'west') or egocentric (i.e. characterized by the use of relative spatial terms like 'left' and 'in front of'). Tzeltal, the Mayan language native to a region in Mexico, uses the former frame of reference while Dutch uses the latter. This difference was studied in an experiment by Pederson et al. (1998) in which participants were asked to recreate an arrangement of model animals on a table from their point of view, which was directly opposite that of the experimenter modeling the arrangement. Speakers of Dutch arranged their animals in an arrangement that was the mirror image of that of the experimenter, thereby demonstrating the fact that they were using an egocentric frame of reference, while speakers of Tzeltal arranged their animals parallel to those of the experimenter, thereby exhibiting an allocentric frame of reference. These results seem to support the theory of Linguistic Relativity. However, in the experiment conducted by Li and Gleitman, English speakers were tested and conditions were further manipulated so that in one condition, participants were tested outside and in another, they were tested indoors. Participants who were tested outside behaved similarly to the Tzeltal speakers in the original experiment, while participants who were tested inside behaved more similarly to the speakers of Dutch, thereby demonstrating that the fact that English typically uses an egocentric frame of reference does not render it completely impossible for English speakers to make use of an allocentric frame of reference in certain situations (Li & Gleitman, 2002). This supports the idea that

language does not direct cognitive development, but that instead the two develop in tandem, without any particular influence on one another. One conceptualization of this theory is the idea that after cognitive categorizations have developed, language is used to package them into the semantically varying categories that are seen cross-linguistically, as opposed to the semantic differences dictating what is learned (McDonough et al., 2003). It is clear that further investigation is needed to continue to explore this area of research.

Cross-Linguistic Differences in Spatial Categories

Spatial relations as an aspect of cognitive development are particularly well suited to the study of these two different possibilities because of the inherent cross-linguistic differences in the description of spatial relations. For example, in English, a clear dichotomy exists between the semantic concepts of containment (“in”) and support (“on”). The difference between the “reverse” of these two spatial relations (“out” and “off”) is also clearly defined (Bowerman & Choi, 2003).

In other languages, however, these spatial relations are categorized differently. In Spanish, for example, the same word, “en”, is used in many cases of both support and containment. In Spanish, an apple could be said to be *en* a bowl, but a cup could also be said to be *en* a table. While other words exist for both of these spatial relations, the (fairly common) use of the same word for both containment and support makes it likely, if the Linguistic Relativity Theory holds true, that speakers of Spanish presented with the task of sorting examples of containment and examples of support into two different categories would have difficulty doing so and might even sort them according to some other criterion (Bowerman, 1996).

Another example of languages differing in their treatment of spatial relations is seen in Finnish, where a radical departure from the indication of spatial relations in general by the use of

prepositions exists and where suffixes indicating different cases are used instead. The *inessive* case, denoted by the suffix *-ssa*, corresponds roughly to the English concept of “in” (e.g. in a house), while the *adessive* case, denoted by *-lla*, incorporates both concepts of “on” (on a house) and of “at” (at a house), as well as certain situations that would be called “in” in English (Bowerman, 1996). The use of a completely different grammar system makes it likely that, in the context of the Linguistic Relativity theory, native speakers of Finnish and native speakers of English would have difficulty understanding each other’s systems of expressing spatial relations at all. The spatial categories themselves are also not as neatly cut across or subdivided as in any of the other languages discussed so far, thereby making it likely that it would be difficult for native speakers of either language to understand the categories of the other language even without grammatical considerations (Bowerman, 1996).

German presents a different sort of contrast in spatial categorization: the concept of containment is treated in largely the same manner as in English, but the concept of support is further divided into two categories, one in which there is support with attachment (e.g. leaves on a tree) and another in which there is support but where the two objects are not necessarily attached (e.g. a cup on a tray) (Bowerman & Choi, 2001). This provides another possibility in terms of testing the tenets of the Linguistic Relativity Theory, in that it seems likely that native speakers of German would be more likely to recognize the support/containment dichotomy than native Spanish speakers. Native speakers of English, on the other hand, might have difficulty accurately identifying the difference between the two types of support that exist in German.

One way in which the divergences between these two theories can be studied is by choosing spatial categories that are unique to specific languages and attempting to determine whether children who are native speakers of another language are able to form those categories

as well. The principles of the Linguistic Relativity Theory suggest that children who are learning one language should find it difficult to adopt the spatial categories native to another language, while those of the Cognitive Priority theory would be supported if children learning any language found it fairly easy to learn the spatial categories commonly used in any other language.

This sort of investigation has already been conducted using the cross-linguistic differences between English and Korean. In Korean, two objects that are placed in a relationship of “tight fit”, in which the two objects are perceived to fit exactly and possibly even to have been specifically made for each other, as in the case of a peg fitting into a hole, are grouped into a single semantic spatial category. On the other hand, objects placed in relationships of “loose fit”, in which there is no particular specificity of fit between the two objects, as in the case of an apple that has been placed in a bowl, are lexically distinguished from those resulting in a tight-fit relation and are thus placed in a separate semantic spatial relation. These two semantic categories cut across the English ones of “in” and “on”: for example, both the case of one Lego toy being on another Lego toy and the previously mentioned case of a peg fitting into a hole would be considered tight fit in Korean, and would be labeled with the same spatial term (“kkita”), while in English the former would be labeled as “on” while the latter would be labeled as “in”. Similarly, both an apple in a bowl and a cup on a tray would be examples of loose fit in Korean while in English these again would be classified as “in” and “on”, respectively (Bowerman, 1996). Choi et al. (1999) found that by 18 to 23 months, English speaking children were able to understand the word “in” and the accompanying spatial category while Korean speaking children were able to understand the word “kkita” (tight fit) and the accompanying spatial category. Children were shown pairs of scenes while listening either to sentences that included the target

word or sentences that were linguistically neutral. The sentences that included the target word caused them to look at the corresponding scene, thereby demonstrating that children are able to understand certain spatial words and the corresponding spatial categories in their native language and that this can be observed during a preferential looking task (Choi et al., 1999).

In a later study, McDonough et al. (2003) found that children from 9 to 14 months of age are still flexible in their formation of spatial categories, while adults are not. The infants in this study were still at a preverbal stage of development, which appears to have reduced the potential negative effects of their native language on their ability to form non-native spatial categories. Both infants being raised with English as their native language and infants being raised with Korean as their native language showed evidence of having distinguished between tight containment and loose support as well as between tight and loose containment, which demonstrates that preverbal infants show evidence of being able to categorize contrasts that do not exist in their native languages (McDonough et al., 2003). However, English speaking adults showed no evidence of forming the contrast between tight and loose containment; this is in line with the expectations of the Linguistic Relativity Theory in that English does not encode the contrast between tight and loose fit and so as speakers of English age, they become less sensitive to this contrast as it is pushed to the background by other concepts that are rendered more salient by the fact that their language specifically encodes them. Korean speaking adults, in contrast, were able to identify both categories (McDonough et al., 2003).

A similar study conducted by Casasola, Wilbourn and Yang (2006) demonstrated that, at 21 and 22 months of age, children are able to map a novel word onto a new spatial category, which indicates that they are able to associate a new word with a new concept fairly quickly and also that they are still relatively flexible in their ability to learn new spatial relations. The novel

spatial category in this case was again that of tight fit (Korean “kkita”), and toddlers were exposed to four examples of tight fit spatial relations (two were containment and two were support) during a training session before their comprehension of the new category was tested in a preferential looking session. Some children were taught a new word to go with the spatial relations demonstrated during the training session while others were not; those who were exposed to the novel word and had a chance to associate it with the spatial relations being demonstrated showed evidence of having successfully formed the spatial category of tight fit and looked longer at these scenes during the preferential looking trials, while children who were not exposed to the new word did not seem to have formed the tight fit spatial category (Casasola et al., 2006). This suggests that children are still flexible in accepting “foreign” spatial categories at this age, and also that the use of a novel word is essential to their ability to learn a new spatial category.

The Current Experiment

The differences between Dutch spatial categories and those native to English lend themselves to a similar sort of experiment that could address the spatial categorization aspect of the two theories regarding the possible effects of language on cognitive development. Dutch, similarly to German, presents a situation of subdivision of one of the spatial categories common to English: while concepts of containment are relatively conserved across both languages, the English concept of support is divided into two separate categories in Dutch. *Op* is used for a category that includes objects that are placed in a relationship of support that is horizontal or, as in German, comparatively un-attached, while *aan* is used for a category that describes objects that are often in a more vertical relationship to one another and must be held in place by some sort of attachment in order to counteract outside forces like gravity (Choi et al., 1999). The

current experiment, therefore, attempted to teach the categories that exist in Dutch to young children who are native speakers of English before assessing their ability to form the novel categories through their performance in a preferential looking task.

In order to teach the new spatial category to children, the experimenter used two examples from each category to demonstrate the novel spatial distinction, because it has been shown that having fewer object pairs, rather than many, as examples of a novel spatial category can help infants to form the category (Casasola, 2005b). This experiment was done with younger children (14 months of age) and a familiar spatial category (support), but it seems possible that the same results would hold true for older children. More than two examples of each category might also make the training session too long for toddlers. While younger children can only draw parallels and form categories when presented with very similar exemplars, beginning at 13 months of age, children seem to be capable of generalizing concepts more abstractly, both in terms of forming the category with examples that differ more widely and in terms of later accepting additional equally differing examples (Chen, Sanchez & Campbell, 1997).

Furthermore, by approximately two years of age, children have had considerable experience with spatial words in their own language and are able to understand basic spatial categories, such as containment and support (Choi et al., 1999), and so this age group was chosen for the current study.

During the training session of the present study, the experimenter labeled the target spatial category with a novel nonsense word, “eck”. This word was chosen because it follows the pattern of most English prepositions (i.e. a monosyllabic word beginning with a vowel and ending with a consonant) and because it has been shown that labeling novel concepts helps infants and young children to learn them (Casasola, 2008). For example, in a study assessing the

effects of linguistic input on infants' ability to form a category of support, it was found that hearing the familiar word "on" helped participants attend to the spatial relation while linguistically neutral phrases had no effect (Casasola, 2005a). It was also found that a novel spatial word assisted 18-month-old children in forming an abstract category of support, compared to children in a silent condition, despite the fact that it was not a familiar word (Casasola & Bhagwat, 2007). Additionally, it has been shown that even at 14 months of age, children are able to form word-relation associations relatively quickly, needing only minimal exposure to the word in conjunction with the relation to link the two (Casasola & Wilbourn, 2004). Therefore, a novel word was used to facilitate children's learning of the novel category in the current experiment as well. In both the training and the testing portions of the study, the novel word was used in the context of several phrases in which it was used as a preposition (e.g. "she's putting it *eck*") because previous studies have shown that children (as well as adults) use the syntactic frameworks in which they encounter new words to make inferences as to the words' meaning (Gleitman, 1990; Landau & Stecker, 1990). By two to three years of age, children consistently define the boundaries of semantic categories by making use of labeling patterns (Landau & Shipley, 2001).

The testing portion of the experiment was conducted using the preferential looking paradigm first introduced by Spelke in 1976 and later adapted for use with linguistic stimuli (Spelke, 1976; Golinkoff, Hirsch-Pasek, Cauley, & Gordon, 1987). It has been shown that by 18 months of age, children being tested using preferential looking will consistently look at the scene being described (McDonough et al., 2003); there is also evidence that the procedure works with still younger infants.

Methods

Participants

The participants were 22 normally developing toddlers (10 males and 12 females) who ranged in age from 25.5 to 31 months ($M = 27.97$, $SD = 1.28$). The children were full term at birth, were reported by their parents to have normal vision and hearing, and were monolingual English speakers. An additional 5 (4 male, 1 female) children were tested but were excluded because they did not finish the study.

The children were recruited from a database shared among several infant laboratories on the Cornell campus. Children's names were placed in the database when their parents signed them up at the time of their birth. Participants' parents were sent a letter describing the study and were then called to schedule an appointment. All participants were given a t-shirt in appreciation of their participation.

Stimuli

During both the training and testing portions of the experiment, a series of object pairs were used to demonstrate the two possible target spatial categories as well as that of *in*, which was used during two of the test trial scenes as a control. The object pairs were chosen based on input from five native speakers of Dutch: a series of photos of possible object pairs was given to them and they were told to describe the spatial relation depicted in each, either with a phrase or a whole sentence (the example they were given was that of a computer on a desk, and the possible answers were given as “computer on desk” and “the computer is on the desk”). From their responses, six object pairs were chosen for the *op* and *aan* categories and five object pairs were chosen for the *in* category, which corresponds to English *in* (see Appendix A for the survey filled out by the native Dutch speakers).

The *op* pairs were as follows: a toy pot with its lid, two plastic blocks one on top of the other, a toy piece of butter on a wooden slice of bread, a small toy panda on an overturned bowl, a Brio train on a piece of wooden tracks, and a small plastic cup on a tray. The *aan* object pairs were a ceramic Cornell magnet on a magnetic dry-erase board, a pig-shaped magnet on another magnetic dry-erase board, a Post-It note on a vertically held plastic board, a suction cup on another vertically held plastic board, a Playmobil tree with removable branches, and an article of doll clothing hung on a hook attached to a wooden stand. Four of these object pairs (the four involving some form of board) were considered substantially similar to one another while the other two (the toy tree and the doll clothes on the hook) were considered less similar to the other four; this was taken into consideration in assigning stimuli pairs to children for the testing and training sessions. The *in* pairs consisted of a Playmobil person in a Playmobil car, a toy tiger in a plastic bowl, a small rubber ball in the drawer of a doll-sized piece of furniture, a pair of glasses in a glasses-case, and a toy key in the matching lock on the side of a plastic box. (See Figure 1 for photos of each object pair). A sixth native speaker of Dutch validated the final list of object pairs and the spatial relations they represented.

The stimuli for the training session were the actual objects that the child could view and manipulate, while the stimuli for the comprehension preferential-looking paradigm were six-second videos of the experimenter's hand placing each object pair into the desired spatial relation. The videos were looped once so that the total duration of each was twelve seconds. An audio soundtrack was added to each video and was played from the center monitor, regardless of where the visual stimulus was located. The audio track for the first of the four scenes of each testing session (the testing sequence is described in detail in the procedure section) was as follows: "Look! Watch what happens. See? Where does she put it? Look! Watch what happens.

See?” The soundtrack for the second scene, the familiarization for the second object pair, was “This one is different. Where does she put it now? Watch what happens. This one is different. Where does she put it now?” The third portion of each scene was the baseline control trial and consisted of both videos presented simultaneously, each on its respective screen, with a background audio encouraging the child to look at both of them (“Look! Both of them. See? Both of them. Do you see where she puts each? Look, both of them. See? Both of them,”). The fourth and final portion of the scene was the test trial, which consisted of a second instance of both spatial relations presented simultaneously, each on its respective screen with the following audio track: “Where is she putting it *eck*? Find it! She’s putting it *eck*. Look! Where is she putting it *eck*? Find it!” See Figure 3 for a schematic diagram of a sample testing scene; for this sample, *op* is the target spatial category and the first target location order is used (left, right, right, left).

Apparatus

Participants were trained in a room of 4.72 by 3.48 meters while sitting around a 91.44 by 61 centimeter wooden table. A Canon ZR80 camera was placed on a tripod 1.65 meters away from the participant to record the training session.

Participants were tested on their comprehension of the target spatial word in another room of 2.2 by 2.64 meters. The room contained three Dell monitors placed side-by-side on a table with a black framework obscuring all but the screens of the monitors themselves. The center monitor was approximately 1.27 meters away from the participant and the monitors were placed 25 centimeters from each other. A Panasonic camera was located directly under the center monitor and was used to record the testing session so that participants’ looking times to the videos presented on the two side screens could later be measured. A Sony VCR and Panasonic

television as well as the control computer, a Macintosh G5, were located in a control room adjacent to the testing room so that the experimenter could monitor and control the testing session by initiating each trial when the participant's attention was focused on the center monitor (see Figure 2 for a diagram of the rooms in which the study was conducted).

Procedure

Participants were randomly assigned into one of two groups: a group whose target spatial category was *op* and one whose target spatial category was *aan*. Within the *aan* category, six children were assigned to be trained with two object pairs that were considered similar to one another and the remaining five were trained with one of the four similar object pairs and one of the two less similar ones. The children in the "similar" condition were then tested with other examples of the similar target object pairs during scenes 1 and 3 of testing, and with less similar object pairs during scenes 2 and 4. This distinction between similar and different examples of the target spatial category was not relevant in the *op* condition, as all of the object pairs used to demonstrate this category were judged to be of roughly equivalent visual similarity.

Children in each group underwent a training session as well as a testing session. Parents also completed the short form version of the MacArthur Communicative Development Inventory (Fenson et al., 2000) so that the sample's vocabulary-related development could be compared to established norms.

Training session While the parent completed the language inventory, the experimenter played with the child until the child seemed comfortable interacting with her. When the parent was finished with the MCDI and the consent form, the experimenter invited the parent and child to play with her in another room (see Appendix B for consent form).

The child, parent and experimenter sat around the wooden table described above with the child sitting at the center of the longer side and the experimenter and parent each sitting on one of the shorter sides of the table. The experimenter began by demonstrating the first example of the target spatial relation, saying “Watch! I’m going to put this *eck*. Yay! I put it *eck*. See? I put it *eck*!” The experimenter then removed the object from the spatial relation and offered it to the child, saying, “Do you want to try? Can you put it *eck*?” The experimenter helped the child if necessary and clapped enthusiastically when the spatial relation had been produced, saying “Yay! You put it *eck*! Good job! You put it *eck*.” For half of the children, the target relation was Dutch *op* while for the remaining children, the target relation was *aan*. If the target relation was *op*, then the children also viewed non-target relation *aan*, and vice versa, in order to be given a contrasting sample.

The experimenter then demonstrated the first example of the non-target spatial relation (e.g. *aan* if the target relation was *op*), saying “Watch where I’m going to put this. Uh-oh, that’s not *eck*. See where I put it? Not *eck*. That’s not *eck*,” while shaking her head back and forth. The experimenter did not encourage the child to reproduce this spatial relation, since the negative tone of voice used with the non-target relation might have discouraged children from further participation in the experiment.

The experimenter then demonstrated another example of the target relation, followed by another example of the non-target relation, using the same script, before inviting the child and his or her parent(s) to come watch a video.

Testing Session. Following this training session, the child and parent were taken across the hall to the testing room with the three monitors. The child was seated on the parent’s lap in the chair facing the center of the three monitors and the parent was encouraged to remain as

neutral as possible for the duration of the testing session so as not to influence the child's response to the stimuli.

Four pairs of examples of spatial relations were shown to each child, in the following order: two instances of the target and non-target relations shown together (hereafter scene 1 and scene 2), and two instances of the target and *in* shown together (scenes 3 and 4). This order did not change across children. The left and right monitors were used for this portion of the experiment, and each child was randomly assigned to one of two orders for the location of the target spatial relation: left, right, right, left or right, left, left, right. This ensured that a preference for one side over the other would not bias the results and that the child could not predict the location of the correct spatial relation based on the location. Which stimuli videos each child saw was randomized so that the order of the specific object pairs used to represent each spatial category was different for each child; no child ever saw the same object pairs in the testing session as he or she had seen in the training session.

Each of the four scenes was, in turn, comprised of a sequence of four parts with an attention getter before each individual part. The attention getter consisted of an expanding and contracting green circle that was accompanied by chiming. This attention-getter appeared on the center screen and served the purpose of centering the child's gaze prior to the presentation of each scene. The first part of each scene was a familiarization to each of the spatial relation videos individually, accompanied by the off-screen audio track of linguistically neutral phrases described above. First, one stimulus video appeared on the left screen with the first audio track described. Next, the second video appeared on the right screen with a slightly different audio track, also described above, followed by the baseline control and test trials.

Coding

The videotapes generated during the testing session were used to record participants' frame-by-frame looking time to each screen with an offline coding program, SuperCoder for X (Hollich, 2003). For each scene, the two individual familiarization scenes were not coded because these stimuli were presented only for the purpose of accustoming toddlers to each new event to reduce the effects of novelty on their looking times during the more important baseline control and test trials. The toddlers' looking time to each screen during the control and test trials of each scene, however, was measured. Their total looking time and their looking time to each screen were used to calculate the proportion looking time to the target spatial relation of each pair by dividing their looking time to the target by their total looking time for the trial, and it is these data that were analyzed.

Results

While the original number of participants was 27, five were excluded for not finishing the study, leaving a final sample of 22 children (10 male, 12 female). Prior to participating in the study, the children's verbal development was assessed with the MacArthur CDI short form. On average, they had a production score of 80.36 words, which, for their age group (approximately 28 months), is close to the 50th percentile, indicating that their verbal development was normal. Furthermore, a Univariate Analysis of Variance was conducted to determine if there was any difference in vocabulary production between the two groups (those whose target spatial category was *aan* and those whose target spatial category was *op*). The groups did not differ significantly in total vocabulary production, $F(2,20) = 2.104, p = .148, ns$, nor did they differ in production of spatial words (prepositions and other words indicating location), $F(2, 20) = .716, p = .501, ns$. A Univariate Analysis of Variance was also conducted to test for effects of gender, and these were found not to be significant, $F(1,18) = 1.750, p = .202, ns$.

Children’s proportion looking time to the target (regardless of which spatial category was the target) was analyzed in a 4 (Scene: 1, 2, 3, and 4) x 2 (trial: control and test) Analysis of Variance and no significant differences were found, $F(3, 54) = .999, p = .400, ns$, (see Figure 4). The results for scenes 1 and 2 and scenes 3 and 4 were then combined by averaging their values and the results for the two possible target spatial categories (*op* and *aan*) were considered separately (see Table 1).

Table 1. Mean proportion looking time to target (Standard Error) during control and test trials for target vs. non-target and target vs. in comparisons

	<u>Target vs. Non-target</u>		<u>Target vs. In</u>	
	Control	Test	Control	Test
Op	.532 (.039)	.518 (.025)	.419 (.047)	.385 (.051)
Aan	.454 (.040)	.509 (.027)	.328 (.050)	.357 (.054)

Proportion looking time to the target with these data was then analyzed with a 2 (scene: target vs. non-target, target vs. in) x 2 (trial: control, test) x 2 (target: *op*, *aan*) mixed methods Analysis of Variance and no significant differences were found, $F(1, 19) = .004, p = .950, ns$.

During the first two scenes (target vs. non-target), children in the *aan* group showed a slight trend in the direction of having learned the spatial relation: their looking time to the target spatial relation increased from the control trial to the test trial, though the difference was not significant. Children in the *op* condition showed a negligible difference in looking time to the target spatial relation during the control and test trials (see Figure 5). During the second set of scenes (target vs. in), children in the *aan* condition again showed a slight trend that could indicate having learned the spatial relation while children in the *op* category showed an opposite trend, looking for a larger proportion of time at the *in* spatial relations than at *op* (see Figure 6).

Additionally, it was found that the six children who were in the *aan* condition and who were trained with similar object pairs as examples of the target category showed an increased proportion looking time to the target spatial category in scenes 1 and 3, which were the scenes where they were tested with other similar object pairs. In scenes 2 and 4, they showed a smaller mean proportion looking time to the target (see Figure 7). A 4 (scenes 1 through 4) by 2 (similarity) by 2 (trial: control and test) Analysis of Variance was performed and it was found that the difference in mean proportion looking time to target between the control and test trials for children who were trained with similar object pairs in the *aan* condition was approaching significance, $F(1,9) = 4.19, p = .071, ns$. This effect did reach significance when only the first and third scenes were considered, $F(1, 9) = 9.708, p < .05$.

During the third and fourth scenes of each testing session, those involving a comparison of the target spatial category with containment, children displayed a tendency to look at the containment events more than would be predicted by chance; this was analyzed with a paired t-test and it was found that during the control trials of these two scenes, children tended to look at the containment events more than would be predicted by chance at a rate that approached significance, $t(21) = 1.929, p = .067, ns$ for the third scene and $t(21) = 1.916, p = .069, ns$ for the fourth scene. This pattern was less evident for the test trials of each of these scenes, $t(21) = 1.364, p = .187, ns$ and $t(21) = 1.608, p = .123, ns$ for the third and fourth scenes respectively.

Overall proportion looking time to the target spatial category declined precipitously from the first scene to the last, suggesting that fatigue had an effect on the children's performance as the testing session went on. This decline in proportion looking time was significant, $F(3, 54) = 3.495, p < .05$, while overall looking time declined as well, though without reaching significance $F(3, 54) = 1.385, p = .257, ns$. Additionally, there was a marginally significant difference in

looking time between the control and test trials of each scene, $F(1, 18) = 4.372, p = .051, ns$.

Discussion

The fact that there were no significant differences in children's looking time to the target spatial relation across the control and test trials throughout the testing session suggests that they did not form the target category, whether it was *op* or *aan*. Children in the *aan* condition demonstrated a slight trend towards looking longer at the target spatial relation during the test trial than during the control trial, indicating that some children did show evidence of forming the category. Perhaps, had a greater number of children been tested in this condition, it would have been found that they had, in fact, formed this spatial category.

Children in the *op* condition, however, did not display this trend, which suggests that there might be something inherently more difficult about forming the category of *op*. It seems possible that, since *op* is very similar to many of the examples that form the more general category of support that English-speaking children acquire fairly early on (Casasola, 2008), they were unable to conceive of the novel word, 'eck' as pertaining solely to the horizontal examples presented in the training session and thus showed no evidence of having formed the category. The examples used for *aan*, in contrast, may not have been as similar to any typically salient examples in the children's environment, and so their lack of prior experience with these examples may have made it more feasible for them to map the novel word 'eck' onto the category being illustrated with them.

Related to this possibility is the finding that children in the *aan* condition who were trained with two *aan* object pairs considered perceptually similar to one another seemed to find it easier to identify the target spatial relation during testing when the example used in testing was also perceptually similar to those used during training (i.e. test trials 1 and 3). The higher mean

proportion looking time to the target spatial relation during these trials for children in the *aan*/similar condition suggests that, in this study, children had more difficulty forming the spatial category with dissimilar examples and, conversely, showed more evidence of forming the category when trained and tested with perceptually similar examples. This pattern held true in both the *target vs. non-target* scenes (scene 1, which contained another similar object pair showed better results than scene 2, in which an object pair not considered perceptually similar to those used in training represented the target category) and the *target vs. in* scenes (scene 3, again containing a similar object pair, showed better results than scene 4, in which a dissimilar object pair was used).

While the pattern showing no difference between the control and test trials in the *target vs. non-target* scenes suggests the possibility that children did not form the distinction between the novel spatial categories presented in this experiment (*op* and *aan*), the lack of difference between the control and test trials in the *target vs. in* scenes suggests a problem with the methodology. Children of this age have been found to have developed the category of containment (*in*) already (Casasola, 2008), and so should have no trouble distinguishing it from the target spatial category (which is a form of the general English *on* category of support with which they are already likely to be familiar, regardless of its subdivision into *aan* and *op* in Dutch). The fact that this pattern in looking times occurred despite children's supposed knowledge of the distinction between containment and support at this age suggests that the methodology should be improved upon in order to provide more conclusive results.

In addition to the likelihood that the methodology needs to be improved upon, the fact that children are generally highly attracted to containment events must also be considered. Clark (1973), for example, found that when children were allowed to play freely with a set of toys, they

were more likely to produce relations of containment than relations of support or any other kind. Therefore, it is possible that the children in the current experiment did, as expected, understand the concept of the distinction between containment and support, but did not feel that the audio track asking them to find 'eck' was compelling enough to distract them from the more alluring containment relations. This possibility is further supported by the fact that the children's looking time to the containment events during the control trials of each scene tended towards being greater than chance, though this tendency failed to reach significance. The fact that this tendency was reduced during the test trials of each scenes suggests that the directions to find 'eck' that the children heard were at least marginally effective in reducing the proportion of the children's looking time that was to the containment events, indicating that, with some alterations, these verbal directions could possibly produce the desired effect.

Prior to conducting a similar study looking at cross-linguistic differences in Korean and English, McDonough et al. (2003) had verified in a previous study that English and Korean speaking children could indeed reliably identify the correct spatial relation from among those encoded in their respective languages. A similar study might be advisable in this case: using a methodology similar to that of McDonough et al., English speaking children could be tested for their ability to identify *in* and *on* in the context of a preferential looking paradigm and Dutch speaking children could be tested for their ability to distinguish between *aan* and *op*. If Dutch speaking children truly are able to identify the two support categories during a preferential looking session but English speaking children show no evidence of doing the same, this would provide stronger support for the Linguistic Relativity Theory than the simple possibility that English speaking children have difficulty doing so, for it is possible that there is simply something about the procedure that is too difficult for children rather than the difficulty

stemming from the formation of the spatial categories themselves.

Another possible complication is that of the range of examples used both during testing and during training. While young children have been found to be able to generalize a spatial term across a variety of exemplars of a spatial category, their ability to abstract the concept and the accompanying term to new instances of the relation depends on the degree of variation of the examples presented during the training session (Gentner & Loewenstein, 2002). In the present study, however, children appeared to form the category only when they were both tested and trained with similar examples of the target spatial relation. It is possible that the examples demonstrated during training were not illustrative enough of the spatial category to allow for the children to abstract the concept being presented to the less similar instances that were used during portions of the testing session; that is, perhaps the spatial relations themselves were not salient enough compared to other aspects of the examples (e.g. the objects used to demonstrate the spatial relations). In future studies, steps should be taken to address this problem.

An additional issue pertaining to the training session is that of the syntactic context in which the novel word was presented. While the word was meant to be used as a preposition (e.g. “I’m putting it *eck*”), in reality, English prepositions are not found at the end of sentences or phrases but are instead followed by the referent object. For example, one would not say “I’m putting the cup on” but rather “I’m putting the cup on *the table*”. At the age reached by the children who participated in this study, children are already quite linguistically aware and, through syntactic bootstrapping, actively make use of syntax to determine the meaning of new words. Therefore, the fact that the novel word in this experiment was not used entirely correctly (as a preposition) in terms of syntax could have prevented children from successfully mapping the novel word onto the spatial category being presented. The brief exposure to the novel word

that was provided during the training session should also be taken into consideration – it may not be feasible for young children to map a novel word onto a spatial category (or any other referent) with such limited exposure. The extent to which children are able to “learn” a word and the depth of understanding of a word that is necessary for them to begin to apply it to new situations should be considered in future use of this methodology. Instead of a novel word, perhaps future experiments could include an interactive task in which children are asked to decide which examples most resemble the ones they have already seen.

Also related to the children’s ability to map the word onto the novel spatial category is the issue of the wide age range of the participants. Children in this age group are constantly learning many new words and concepts and making rapid progress in their understanding of the world. This means that the wide range in age of the participants, which spanned more than six months, may have caused some variation in the children’s pre-existing knowledge of both spatial categories and the words used to describe them, as well as of syntactic frameworks, as mentioned above.

Furthermore, there was, on average, a significant decrease in proportion looking time to the target from the first scene to the last (see Figure 2), as well as a decline in overall looking time. The decline in proportion looking time to target suggests that children were becoming progressively less engaged in the task and therefore less interested in focusing their attention on the directions being given through the audio track. The decline in overall looking time, though not significant, further supports this possibility, suggesting a fatigue effect: though the testing portion of the experiment was only four minutes in total, perhaps its repetitive nature was not sufficiently engaging, causing the participants’ interest to have waned by the last scene. The fact that looking time declined from the control to the test trial of each scene suggests that the

children were only engaged the first time they saw both stimuli videos together and that the second instance of this set of stimuli was no longer as interesting for them, despite the audio track directing them to find ‘eck’. Perhaps in future experiments of a similar nature, the audio tracks could be varied to counteract the effects of boredom induced by the repetitive nature of the task. As long as the phrases used are roughly equivalent linguistically, this might help to sustain subjects’ attention without compromising the controlled nature of the experiment. Additionally, the stimuli videos themselves could be made more exciting; simply using better quality videos with brighter lighting might help in achieving this. For example, in the preferential looking portion of their study, Choi et al. (1999) started the audio track several seconds prior to the beginning of each video in order to ensure continued engagement with the children and to prime them to the spatial relation they were meant to be looking for so that they could begin to do this as soon as the video appeared; a similar technique could easily be employed in this study to attempt to achieve better results.

In sum, while the results of the current study show little evidence that English speaking toddlers are readily able to learn the distinction between the Dutch semantic spatial categories *op* and *aan*, the small sample size and imperfect methodology make these results far from conclusive. The study serves to illuminate several areas in which the methodology could be improved upon for similar experiments in the future, and to raise several points for consideration in future research. It is clear that additional research is needed to truly discern whether English-speaking toddlers are still linguistically flexible enough to learn Dutch spatial categories not encoded in English or whether their native language exerts such a strong influence on their perceptions of their environment that they find it difficult to form foreign spatial categories.

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Appendix A: Dutch Native Speaker Spatial Relation Survey

Each photo depicts two objects somehow related to each other spatially – the two objects being focused on are listed (in English) above the photo. Please write on the line a description in Dutch of the spatial relation that you feel fits the two objects most accurately. Answers similar to either of the examples given below (in English) are acceptable:

0. Computer & table



Computer on table

Or

The computer is on the table.

1. Painting & wall



2. Pencil & drawer



3. Coat & hook



4. Shirt & person



5. Glasses & case



6. Card & wallet



7. Photo & refrigerator



8. Hook & wall



9. Shoe & foot-



10. Block & block



11. Cup & cabinet



12. Disc & case



13. Ring & pole



14. Leaf & branch



15. Water & bottle



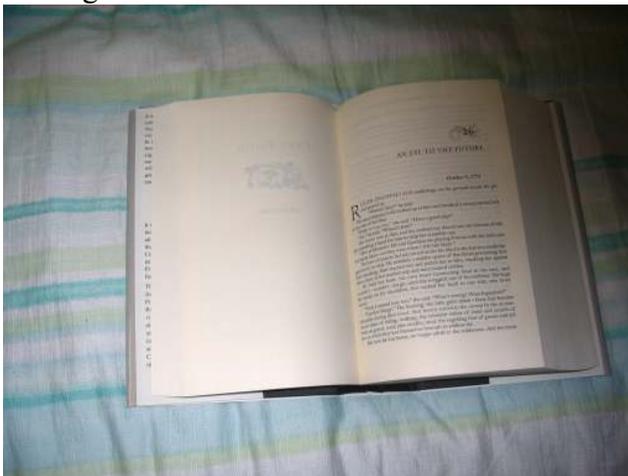
16. Butter & bread



17. Key & lock



18. Page & book



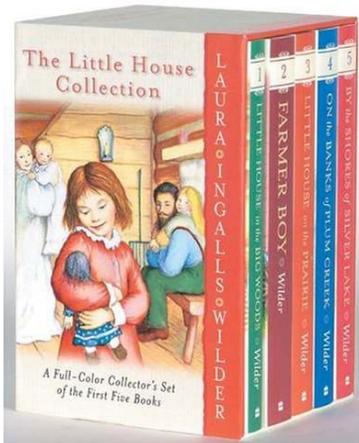
19. Cup & tray



20. Bandaid & arm



21. Cover & book



22. Picture & frame -



23. Lid & pot



24. Soup & bowl



25. Person & car



26. Train & rails



27. Snow & branch



28. Paper & folder



29. Stapler & table



Thank you so much for your help – I truly appreciate it!

Appendix B: Parental Informed Consent Form

Parental Informed Consent to Participate in Research

We invite your child to participate in a research study of infant language development being conducted by Dr. Marianella Casasola, a faculty member in the Department of Human Development at Cornell University and Christen Kisch, an undergraduate student also in the Department of Human Development. Funding for this study is provided by the National Science Foundation. We hope to learn how infants' and toddlers' concepts of spatial relations are influenced by their native language. Your child was selected as a possible participant because your child is in the age ranges we are interested in studying. Your child will be one of approximately 24 children selected to participate in this study. We ask that you read this form and ask any questions you may have before agreeing to allow your child to participate in this study.

Purpose of the study

The purpose of this study is to explore whether infants who are being exposed primarily to English are able to learn spatial relations that are not common to the English language. To this end, we will spend several minutes demonstrating a novel set of spatial categories to your child through modeling with toys and observing your child while he or she plays with the same toys. We are recruiting 24 normally-growing children who are being raised in an English monolingual environment between the ages of 24 and 36 months.

Description of the study

If you decide to participate, your child will first be tested for comprehension of the English spatial categories of "in" and "on" through the use of toys. Your child will then be taught a new spatial category (common to another language) by an experimenter. Following this interaction, your child will view short, videotaped pairs of events and their looking time to each event in the pairs will be recorded. The testing session lasts approximately 7 minutes. You will not be separated from your child at any time during the testing session. In addition, if for any reason your child becomes too fussy to continue, we will stop the session. You, also, may stop the session at any time, for any reason, without penalty.

Prior to the testing sessions, you may be asked to complete a vocabulary survey form that assesses what words your child comprehends and/or produces. Your child will be videotaped during both the play session and the video session so that his or her responses to the various stimuli can be recorded later.

Benefits, Risks and Possible Discomforts

Although participation in this research study provides no direct benefit to you or your infant, it will help us learn how children and toddlers learn to comprehend language. It has been our experience that infants enjoy our language play session and are interested in the video scenes we show. Importantly, the procedure involves no risks beyond those you or your child would have in everyday life. We will make every effort to ensure that you and your infant enjoy the session. If your infant is tired, or clearly not interested in the session, we will stop the session. Also, you may discontinue participation, either temporarily or permanently, at any time.

Confidentiality

Any information in this study that is identified with you or your child will remain confidential. In any sort of report we might publish, we will not include any information that will make it possible to identify you or your child. These records will be kept in a locked room in our laboratory, and only the researchers in our laboratory will have access to them. Confidentiality will be maintained to the extent allowed by law.

With your consent, audio and/or video recordings will be made of your child's testing session, in order to allow us to check the data recorded for accuracy at a later point in time and so as to provide us with a permanent record of the data obtained. Again, these records will be kept in our laboratory, and only the researchers will have access to them. Your child's audio and video recording may be used for teaching or training purposes, but all of his/her information will be blocked out so as to not reveal his/her name. Only if you agree, your child's audio and video recording may be used for teaching or training purposes, but all of his/her information will be blocked out so as to preserve his/her identity. Please note that someone who knew your child at the time may be able to recognize him/her on these audio and videotapes. You may contact us at any time and request that we remove his/her videotaped data from the archive. Also, your child may still participate in the study without being audio or video taped.

The tapes will be stored in our research laboratory, which is locked and to which only members of the research team have access. The Principal Investigator will be the primary person to have access to your child's recordings. Research assistants may be asked to transcribe and code the data. In that case, they will listen or look at the recordings, but will not know your or your child's full names.

The aim of the study is to obtain average data: We are interested in finding out how infants of the same age learn novel spatial categories. Therefore, at the end of the study, your child's data will be averaged and reported as group.

At your request, we will be happy to give you copies of the tapes. Furthermore, if you should discontinue your participation, and request that the tapes made so far be erased, we will do so.

Compensation

We would most appreciate it if you and your child participate in this study. As a token of appreciation, your child will be given a bib, t-shirt, or a spill-proof cup.

Voluntary nature of participation

Participation in this study is voluntary. Your decision of whether or not to participate will not prejudice your future relations with Cornell University. If you decide to participate, you are free to withdraw your consent and to discontinue your participation at any time without penalty or loss of benefits to which you are otherwise entitled.

Questions about the study

If you have any questions about the research now, please ask. If you have questions later about the research and/or research-related injuries, you may contact Dr. Marianella Casasola at 607-255-4133 or via email at mc272@cornell.edu or Christen Kisch at 908-892-9549 or via email at cmk45@cornell.edu.

If you have questions regarding your rights as a human subject and participant in this study, you may contact the Cornell Institutional Review Board at (607) 255-5138, or access their website at <http://www.irb.cornell.edu>

Agreement

Cornell University Institutional Review Board has approved this consent form. The consent form must be reviewed annually and on the date that appears below.

Your signature below indicates that you have read the information in this agreement and have had a chance to ask any questions you have about the study. Your signature also indicates that you agree to allow your child to be in the study and have been told that you can change your mind and withdraw your consent to participate at any time. You have been given a copy of this agreement.

Child's name (please print)

Parent's name

Signature of Parent

Date

Signature of Investigator

Date

I consent to allow my child and myself to be audio or videotaped during the study.

Yes No Signature: _____ Date: _____

I consent to allow the experimenters to share the audio and videotapes for teaching, training, and possible future research purposes and understand that my child's recording may be used. I also understand that my child's name will not be revealed on the tape. However, someone who knew my child or me at the time may be able to recognize us on the videotape. I understand that I can still participate in the study if I do not want our recordings to be used for training, teaching, or possible future research purposes.

Yes No Signature: _____ Date: _____

This consent form was approved by the Cornell IRB on 8/27/07

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Figure Captions

Figure 1. Stimuli: object pairs used to depict *op*, *aan*, and *in*.

Figure 2. Layout of the training, control and testing rooms.

Figure 3. Sequence of a sample testing scene.

Figure 4. Mean proportion looking time to target by scene (scenes 1 and 2 represent target vs. non-target events; scenes 3 and 4 represent target vs. in events).

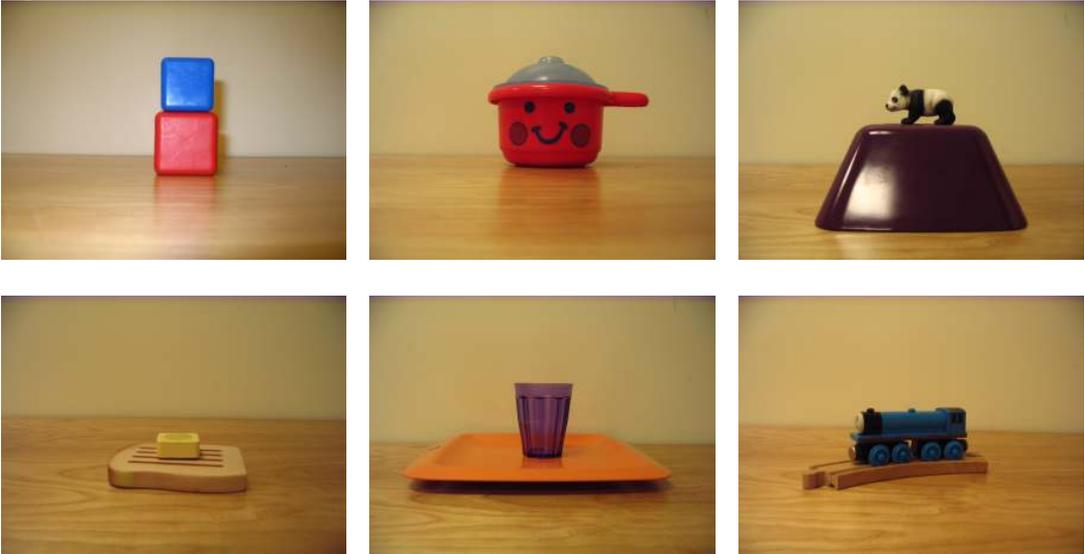
Figure 5. Mean proportion looking to target during *target vs. non-target* scenes.

Figure 6. Mean proportion looking to target during *target vs. in* scenes.

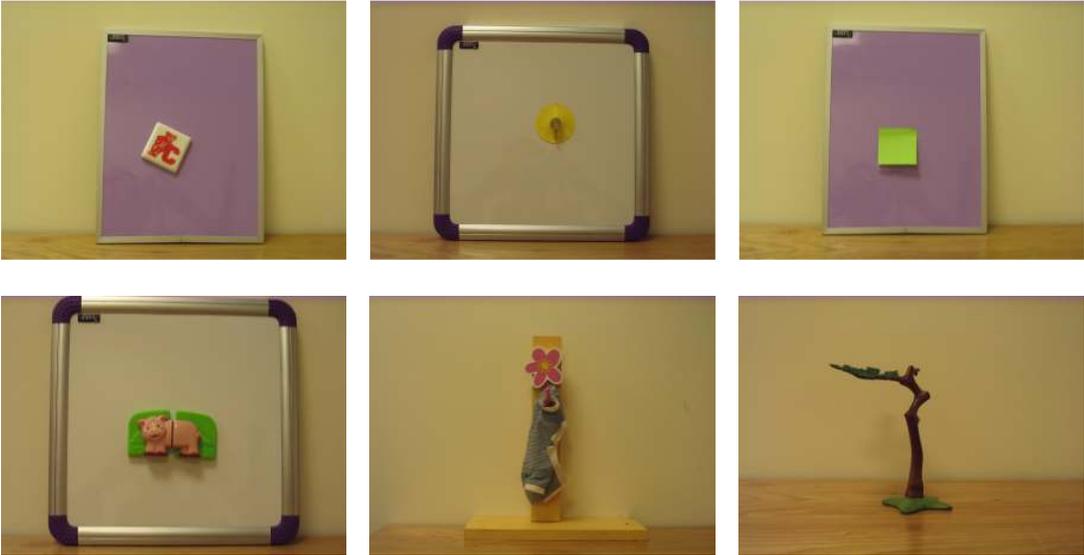
Figure 7. Mean proportion looking time to target during *target vs. in* scenes in *aan* condition, by similarity of object pairs used in training.

Figure 1.

Op



Aan



In

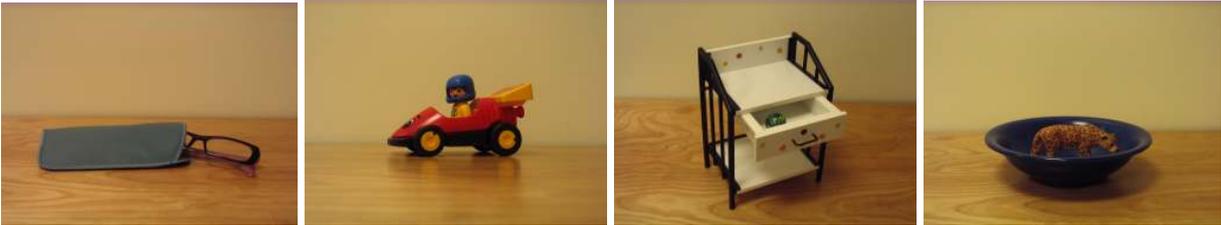


Figure 2

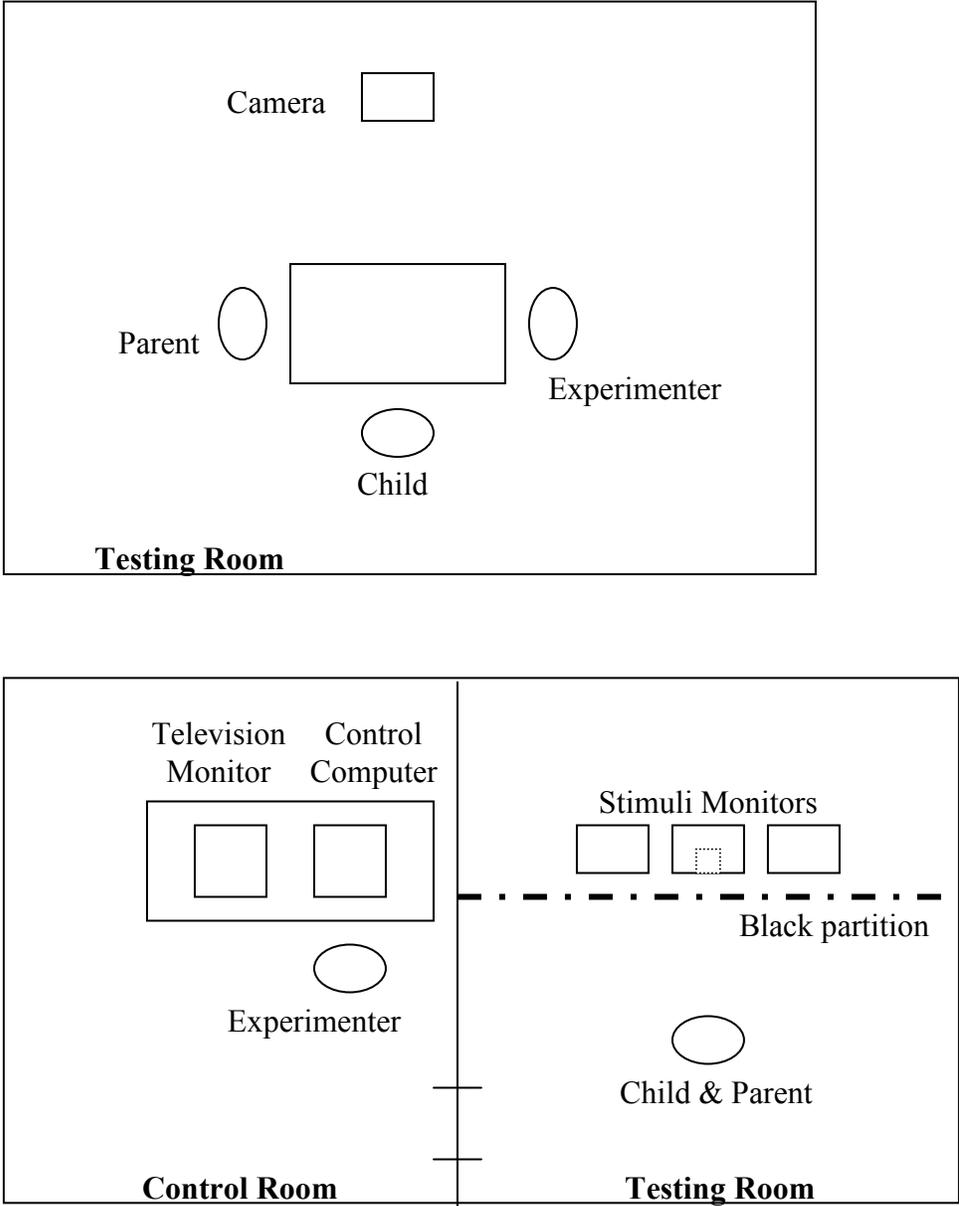


Figure 3

Cup on table	Familiarization 1: <i>Look! Watch what happens. See? Where does she put it? Look! Watch what happens. See?</i>	Blank screen
Blank screen	Familiarization 2: <i>This one is different. Where does she put it now? Watch what happens. This one is different. Where does she put it now?</i>	Branch on tree
Cup on table	Control: <i>Look! Both of them. See? Both of them. Do you see where she puts each? Look, both of them. See? Both of them.</i>	Branch on tree
Cup on table	Test: <i>Where is she putting it eck? Find it! She's putting it eck. Where is she putting it eck? Find it!</i>	Branch on tree

Figure 4

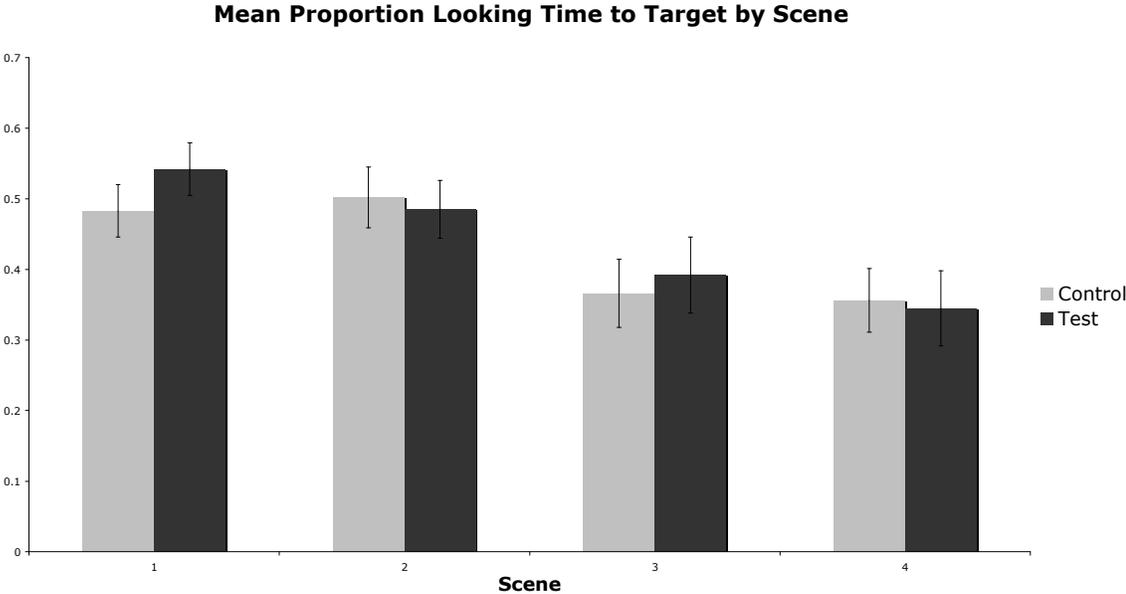


Figure 5

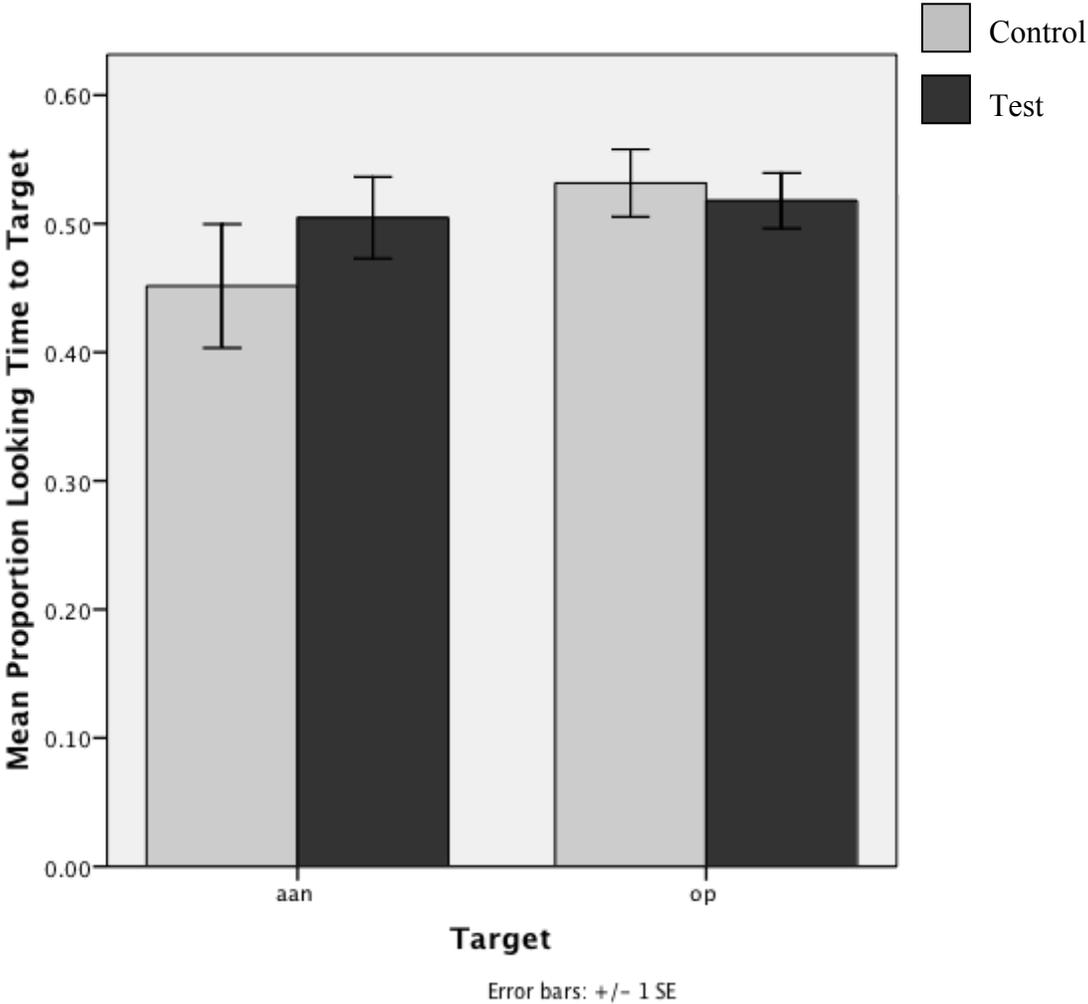


Figure 6

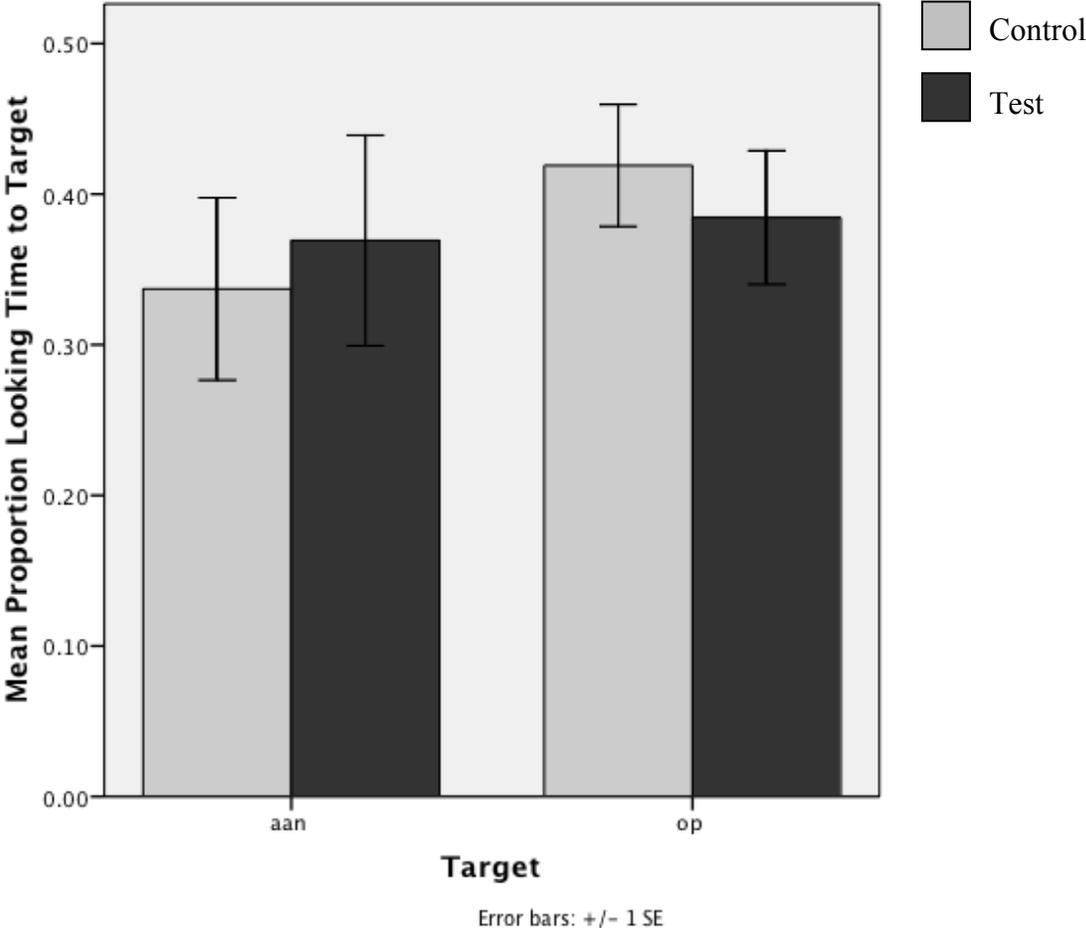


Figure 7

