Object Similarity Bootstraps Young Children to Action-Based Verb Extensions

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Abstract

Young children often fail to generalize a novel verb based on sameness of action since they have difficulty focusing on the relational similarity across events while at the same time ignoring the objects that are involved. We hypothesized that similarity of objects involved in action events plays a scaffolding role in children's extraction of relational commonality across events, which they use to extend a verb. This hypothesis was supported by two studies. In Study 1, with Japanese-speaking 3- and 4-year-olds (N = 28 in each age group), novel-verb generalization was fostered if the objects used in the same action were similar to each other. Study 2, with 45 4-year-olds, further showed that repeated experience of action-based verb extension supported by object similarity leads young children to be better able to extend a novel verb based on sameness of action, even without support from object similarity.

Verbs refer to kinds of relations, whereas nouns, especially concrete nouns, denote kinds of objects. Thus, in order to learn a novel word, children need to identify the word's form class and map the word to a meaning that is characteristic of the form class. When children hear a novel noun, their task is to find the referent object and generalize the word to other like objects. In contrast, when the novel word is a verb, children must map the word to the relation they find in the present scene and extend the word based on the sameness of the relation. However, it is not a trivial task to figure out which relation that is observed in the scene should be incorporated into the meaning of a novel verb. For example, when we hear a novel verb in association with a scene in which someone is rolling a ball, the verb could mean the agent's action of releasing the ball, the rolling motion of the ball, or the departure of the ball from the agent. Thus, researchers have argued that verb learning is more difficult for young children than noun learning (e.g., Childers & Tomasello, 2002, 2006; Hirsh-Pasek & Golinkoff, 2006; Gentner, 1982; Imai, Haryu & Okada, 2005; Imai, Li, Haryu, Okada, Hirsh-Pasek, Golinkoff & Shigematsu, 2008; Kersten & Smith, 2002; Maguire, Hennon, Hirsh-Pasek, Golinkoff, Slutzky & Sootsman, 2002).

Supporting this view, Kersten and Smith (2002) introduced a novel verb for a scene in which a novel bug-like creature moved in a distinctive way, and found that three-year-olds were not willing to apply this verb to a different creature that was moving in the same way. In contrast, children of the same age readily applied a novel noun introduced for the same scene to the same creature moving in a different way. Maguire et al. (2002) found that 18-month-olds who were introduced to a novel verb during a video of an intransitive action failed to generalize the verb to the

same action performed by a new agent, even after they heard the verb repeatedly in association with the identical action performed by four different people. Other studies also showed that young children were reluctant to generalize a novel verb associated with a novel transitive action to the same action performed with a different object (Behrend, 1990; Forbes & Farrar, 1993; Imai et al., 2005, 2008).

Young children have difficulty in extending a novel verb based upon sameness of action, especially when the action is performed by a different agent (Kersten & Smith, 2002; Maguire et al., 2002) or with a different object (Behrend, 1990; Forbes & Farrar, 1993; Imai et al., 2005, 2008). However, it is not the case that children of this age assume that verbs can refer to objects. For example, in Imai et al. (2005), three-year-olds who were introduced to a novel verb in association with a novel action performed by a woman with a novel object would not extend the verb to another video showing the same object lying still on a table. Young children do understand that verbs should be extended by a different principle than for noun extension, but they have difficulty in identifying the core meaning of a novel verb, i.e., the common relation between objects.

Young children's difficulty in extracting relational commonality across events has also been reported in previous studies of analogical reasoning (Gentner, 1988; Gentner & Ratterman, 1991; Lowenstein & Gentner, 2005). For example, when asked to interpret a metaphor such as "Plant stems are like drinking straws," young children were likely to say, "They are both long," focusing on lower-order surface similarity. In contrast, older children would say, "They are both used for drawing water," attending to higher-order relational similarity (Billow, 1975; Gentner, 1988). Furthermore,

when relational similarity was pitted against object similarity in a task in which one of the test items was to be matched to the standard item, young children tended to select on the basis of object similarity rather than on the basis of relational similarity (Gentner & Ratterman, 1991). Thus, focusing on relational commonality, especially when there is competing lower-order surface similarity, is very difficult for young children, not only in verb extension but also in analogical reasoning.

Studies of analogical reasoning have also suggested that young children are better able to make relational mappings when the objects involved in the base and the target are perceptually similar (DeLoache, 1989, 1990; Gentner & Toupin, 1986; Holyoak, Junn & Billman, 1984; Loewenstein & Gentner, 2001). For example, Gentner and Toupin (1986) asked young children to act out stories with new toy characters and found that the children could more successfully map a plot structure from one set of characters to another when the corresponding characters (i.e., the characters with the same role in the stories) were similar (e.g., a squirrel and a chipmunk) than when they were dissimilar (e.g., a squirrel and a moose). DeLoache (1989, 1990) examined preschoolers' ability to map between a regular-sized, ordinary room and its 3-D miniature and found that 38-month-olds' performance was affected by object similarity between the two rooms.

Based on these findings, Gentner and her colleagues (Gentner & Ratterman, 1991; Kotovsky & Gentner, 1996) argued that lower-order concrete similarity leads young children to find higher-order relational similarity, by heightening the overall similarity of the entities (scenes, stories, and so on) to be compared and providing a scaffold for aligning the representations of those entities.

They further proposed that the repeated experience of making relational mappings by being guided by lower-order concrete similarity prepares young children to easily find relational similarity even when it is not supported by lower-order similarity. Gentner and her colleagues called this process *progressive alignment*. For example, in a task that required children to find a hidden toy in a target room after being shown its location in a model room, Loewenstein and Gentner (2001) found that children who were given an opportunity to simply compare the initial model (Hiding Room 1) with another highly similar model (Hiding Room 2) became better able to find the toy in the target room subsequently.

The process of alignment is also critical to the extraction of relational similarity across events. In this regard, verb learning requires analogical reasoning. Based on the finding that lower-order similarity helps young children identify higher-order relational similarity in analogical reasoning tasks (Gentner, Loewenstein & Hung, 2007; Kotovsky & Gentner, 1996), we predict that young children's verb extensions may also be fostered if relational similarity is highlighted by lower-order similarity. Here, we consider the similarity of objects involved in action events, because previous studies have demonstrated that young children have great difficulty in separating the action itself from the involved object in extending verbs (Behrend, 1990; Forbes & Farrar, 1993; Imai et al., 2005, 2008). We predict that children's verb extension will be fostered if the objects involved in the same action are similar. We consider this process to be a variation of progressive alignment proposed by Gentner and her colleagues (Gentner et al., 2007; Kotovsky & Gentner,1996), and hereafter we call our prediction concerning children's verb extension the object-similarity bootstrapping

hypothesis.

The primary purpose of the present research was to test the object-similarity bootstrapping hypothesis. Two studies were conducted for this purpose. Study 1 examined whether object similarity would scaffold action-based verb extension. In Study 2, we went one step further and investigated whether repeated experience of action-based verb extension supported by object similarity would lead young children to be better able to extract the same action across events even without support from object similarity.

If we find support for the object-similarity bootstrapping hypothesis, it will provide important insights for theories of children's verb learning. There has been a long debate concerning the mechanisms by which young children learn verb meanings. Some researchers have argued for the importance of domain-specific knowledge of the mapping rules between argument structure and verb meanings (e.g., Fisher, Gleitman, & Gleitman, 1991; Gleitman, 1990). Other researchers, in contrast, have emphasized domain-general mechanisms such as analogical reasoning (e.g., Gentner, 2006) and mindreading (Akhtar & Tomasello, 1996; Tomasello, 2003). If we find that object similarity not only helps young children extend verbs in Study 1 but also bootstraps them to action-based verb extension even without support from object similarity in Study 2, this will highlight the importance of domain-general mechanisms in verb learning, although it does not exclude the possibility that children use domain-specific knowledge about verbs in inferring the meanings.

Study 1

In Study 1, each child was assigned to one of two conditions, the similar-object condition or the dissimilar-object condition. Children in both conditions heard a novel verb while watching a video in which a woman performed a novel action using a novel object. They were then shown two test scenes side-by-side and asked to select the one to which the novel verb could be applied. The two test scenes were an Action-Same/Object-Change test event (henceforth, AS test event) in which the same woman was performing the same action but with a different object, and an Object-Same/Action-Change test event (OS test event) in which the same woman was performing a different action with the same object as that used in the original event. If children selected the AS test event, they could be regarded as having extended the novel verb based on the sameness of the action, and if they selected the OS test event, they must have attended to the sameness of the object in extending the novel verb. In the similar-object condition, the object used in the AS test event was highly similar in shape to the object used in the original action event. In the dissimilar-object condition, the object used in the AS test event was not similar to the object used in the original action. The object-similarity bootstrapping hypothesis predicted that children in the similar-object condition would extend a novel verb to the AS test event more successfully than those children in the dissimilar-object condition.

Method

Participants. Twenty-eight 3-year-olds (*M* age = 3 years 5 months, *SD* = 3.6 months,

range = 3;0 – 3;11), and 28 4-year-olds (*M* age = 4 years 5 months, *SD* = 2.8 months, range = 4;1 – 4;10) participated in this study. All participants were monolingual Japanese. They lived in a suburban city in the greater Tokyo area and were mostly from middle to lower-middle class families. Each child was randomly assigned to one of the two conditions, the similar-object condition or the dissimilar-object condition. There was approximately the same number of boys and girls in each condition.

Stimulus Materials. Six sets of video action events were used as stimulus materials (see Table 1). Each set consisted of a standard event and two test events. In the standard event, a young woman performed a repetitive action with a novel object. The two test events, i.e., the Object-Same/Action-Change (OS) test event and the Action-Same/Object-Change (AS) test event, were variants of the standard event, as described earlier. The similar-object condition and the dissimilar-object condition differed only in the type of object used in the AS test events. In the similar-object condition, the object used in the AS test event was highly similar in shape to the object used in the standard event, but it could be clearly distinguished from the one that appeared in the standard event and could be recognized as a different kind of object. In the dissimilar-object condition, the shape similarity of objects in the standard event and the AS test event was low.

Insert Table 1 about here

In order to verify that the shape similarity of objects within each set was higher in the

similar-object condition than in the dissimilar-object condition, 15 undergraduates were presented with the two objects from each set in each condition and asked to rate the shape similarity between them on a scale of 1 (least similar) to 7 (most similar). The mean rating score for the similar-object condition was 5.3 (range: 3.7 - 5.9), and for the dissimilar-object condition, it was 1.8 (range: 1.5 - 2.5). The scores were significantly higher in the similar-object condition than in the dissimilar-object condition for all the sets.

Procedure. In both the similar-object condition and the dissimilar-object condition, the procedure was the same as that used in Imai et al. (2005), except that the stimuli were carefully constructed so that the shape similarity between the object used in the standard event and the object used in the AS test event would be clearly higher in the similar-object condition than in the dissimilar-object condition. The children were tested individually in a quiet room in the preschool they attended. The stimulus videos were presented using PowerPoint on a laptop computer.

As in Imai et al. (2005), children received four warm-up trials to make sure that they were able to indicate what they thought to be the correct answer by pointing to one of the two test videos. Care was taken so that the warm-up trials would not lead children to have any bias toward objects or actions during the test trials. In the first two warm-up trials, children were shown two familiar objects (e.g., cat vs. dog) on videos and were asked to identify the object the experimenter referred to by saying, e.g., “Where is a doggy?” In the third warm-up trial, they were shown two familiar actions (hand clapping vs. jumping) and the experimenter asked, “In which [movie] is [she] jumping?” dropping the words in brackets since doing that is very natural in Japanese. In the last warm-up trial,

the children heard a novel verb while watching a standard video in which an actor was performing a novel action with a novel object, and then were shown two test events side by side. One of the test events was exactly the same as the standard video; the other was totally different in both the action and the object, although the actor was the same. The children were asked to which movie the novel verb should be applied. Thus, the last warm-up trial was parallel to the test trials except for the structure of the two test events.

After the warm-up trials, the children received the test trials. In each set, the standard event (a 10-second-long clip) was repeated three times in a continuous loop for a total of 30 seconds. While showing the standard event, the experimenter introduced a novel verb by saying, "Mite (Look)! X-teiru (is X-ing)."

In this Japanese sentence, X represents a verb stem that was replaced with a novel word like *neke*, *ruchi*, or *heku*; it was followed by the present progressive suffix '-teiru.' Thus, just saying "X-teiru" in Japanese can be translated into English as "is X-ing," with subject and object dropped. Dropping subject and object from the sentence is neither unnatural nor ungrammatical in Japanese, and these kinds of sentences are as appropriate for transitive verbs as for intransitive verbs. For example, in noting that a rabbit is eating a carrot, Japanese speakers naturally say "tabe-teiru (is eating)" without mentioning the subject (i.e., rabbit) or the object (i.e., carrot). In fact, in a similar verb extension task in previous research (Imai et al., 2008), Japanese preschoolers performed slightly better when the verb was introduced without subject and object than when the verb was introduced with subject and object, unlike their English-speaking age peers. For Japanese children, hearing

arguments of a verb in a situation in which the subject and the object were both obvious from visual information in the video might have impeded their verb generalization. Thus, novel verbs were presented without arguments in this study, as was done in Imai et al (2005, 2008).

After the novel verb was repeated three times while the standard event was displayed, the two test events were shown side by side. The left-right position of the AS and OS test events was counterbalanced within each child. The experimenter pointed to each event in succession and waited so that the children could watch and compare the two videos as long as they wanted. Then the experimenter asked the children to indicate which of the two test events the novel verb should be extended to by saying, "X-teiru (X-ing) nowa (Topic marker) docchi (which)?" This can roughly be translated into English as "In which [movie] is [she] X-ing?," although the words in brackets were omitted. This procedure was repeated for each of the six sets of stimuli, and the presentation order was randomized across participants.

Results

If children can extend a novel verb based on sameness of action, they should select the AS test event. The selection of an AS test event was scored as an AS response and the mean proportion of AS responses was calculated for each condition, as shown in Figure 1.

Insert Figure 1 about here

To test whether children's responses varied across age groups and object similarity conditions, the proportion of AS responses was submitted to a 2 (age: 3- vs. 4-year-olds) by 2 (object similarity condition: similar vs. dissimilar) ANOVA. The main effect of object similarity was significant, $F(1, 52) = 17.4$, $p < .001$, $\eta_p^2 = .25$, indicating that children in the similar-object condition were more likely to extend a verb to the same action than those in the dissimilar-object condition. The main effect of age also approached statistical significance, $F(1, 52) = 4.0$, $p = .052$, $\eta_p^2 = .07$, suggesting that 4-year-olds performed better than 3-year-olds. The interaction between age and object similarity was not significant, $F(1, 52) = .20$, $p = .66$. Thus, both 3- and 4-year-olds showed a benefit of object similarity in novel-verb extension, and the prediction that object similarity scaffolds action-based verb extension was supported.

削除: , $\eta_p^2 = .004$

The 4-year-olds in the similar-object condition successfully extended a novel verb based on the sameness of the action, selecting AS test events 82.1% of the time, which was significantly higher than chance, $t(13) = 5.21$, $p < .001$, $d = 1.39$, two-tailed. In contrast, children of the same age in the dissimilar-object condition made AS responses 39.3% of the time, which was not different from chance, $t(13) = 1.01$, $p > .10$, two-tailed. For 3-year-olds, action-based verb generalization was still difficult even with a scaffold from object similarity. Their performance in the similar-object condition did not differ from chance level. They chose AS test events 59.5% of the time, $t(13) = .87$, $p > .10$, two-tailed. The 3-year-olds in the dissimilar-object condition selected the AS test event only 25.0% of the time, which was significantly below chance, $t(13) = 2.94$, $p < .05$, $d = .79$, two-tailed.

削除: $d = .27$,

削除: $d = .23$,

Insert Table 2 about here

An analysis of individual children's performance converged with the results of the group analysis. Table 2 shows the number of AS-dominant children who selected AS test events four times or more out of six trials, and the number of OS-dominant children who selected OS test events four times or more. An asymmetrical log-linear model was fitted on the 2 (age) by 2 (object similarity condition) contingency table to see whether the ratio of AS-dominant children to OS-dominant children varied across age groups and object similarity conditions. In both age groups, the proportion of AS-dominant children was greater in the similar-object condition than in the dissimilar-object condition, $\chi^2(1, N=56) = 13.26$, $p < .001$, $\phi = .49$. Neither the main effect of age, $\chi^2(1, N=56) = 2.35$, $p > .10$, nor the interaction between age and object similarity condition, $\chi^2(1, N=56) = .01$, $p > .10$, reached statistical significance.

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Discussion

The results supported the object-similarity bootstrapping hypothesis. Children were more likely to extend a novel verb to the AS test event when the object used in the AS test event was highly similar to the object used in the standard event. When the two objects used in the same action events (the standard and the AS test) were similar to each other, the overall similarity across the two events increased, which helped children align the two events and extract the common relation.

In contrast, children were much less willing to extend a novel verb to the same action when

the objects used in the standard and in the AS test event were dissimilar. Three-year-olds in the dissimilar-object condition were especially prone to selecting the test scene in which a different action was performed with the same object, doing so 75% of the time. This result, however, should be interpreted with caution, since there are three possible explanations for it. One possibility is that 3-year-olds may believe that a verb refers to an object. The second possibility is that they believe that a verb can be extended to any action performed with the same object. The third possibility is that 3-year-olds may have understood that a verb should be generalized based on the sameness of action, but they selected the OS test event because they were unable to find the same action in the AS test event and resorted to the sameness of objects.

In order to examine these possibilities, Study 1A was conducted, using a Yes-No paradigm with the stimuli used in the dissimilar-object condition in Study 1. To see if 3-year-olds think that a verb refers to an object, a Still-Object test event (henceforth, SO test event) was included in addition to the AS and OS test events. In the SO test event, the object used in the standard event was shown in a video sitting alone on a table. Three-year-olds were first introduced to a novel verb while watching a standard event. One of the three test events was then presented to the side of the standard event. Children were asked whether the test event could be labeled with the verb.

If 3-year-olds' performance in the dissimilar-object condition in Study 1 reflected their belief that a verb refers to an object, they will extend the novel verb to the SO test event. If they believe that a verb refers to any action performed with the same object, they will be willing to apply the novel verb to the OS test event, but will accept neither the SO test event nor the AS test event as a

referent of the verb. Finally, if they know that a verb should be extended based on sameness of action but have trouble extracting the same action performed with a different object, they will be unwilling to extend the novel verb to any of the three test events.

Study 1A

Method

Participants. Fifteen monolingual Japanese 3-year-olds (*M* age = 3 years 6 months, *SD* = 4.1 months, range = 3;0 – 3;10) took part in this study. There were 6 girls and 9 boys. All children lived in a suburban city in the greater Tokyo area. Their demographic characteristics were the same as those of the children who participated in Study 1. Four additional children were excluded due to failure to complete the experiment (1) or due to a *yes* bias, saying "yes" to all the questions (3). None of the children had participated in Study 1.

Stimuli and Procedure. The six sets of video stimuli used in the dissimilar-object condition in Study 1 were used. In addition to the standard event, the AS test event and the OS test event, a video of a SO (Still-Object) test event was included in each set. In the SO test event, the object used in the standard event was shown in a video lying alone on a table. As in Study 1, the stimulus videos were presented using PowerPoint on a laptop computer. The children were shown a standard event and introduced to a novel verb by saying, "Mite (Look)! X-teiru (X-ing)," dropping subject and object as in Study 1. Then one of the three test events was shown on the right side of the standard event. The experimenter pointed to the test event and asked, "Kocchi mo X-teiru?" This

sentence can be translated into English as “Is [the woman] also X-ing [it] in this [movie]?” Again, the words in brackets were not uttered in the Japanese sentence. The children saw each of the six standard events three times with three different test events for a total of 18 trials. Six verbs were used in this experiment, and a particular verb was always associated with a particular standard event. The order of the 18 trials was randomized with the constraint that no successive trials presented the same standard event.

Results

If children agreed with the extension of the novel verb to the test event, the response was scored as a *yes* response. The proportion of *yes* responses to each test event is shown in Figure 2. A repeated-measures ANOVA revealed a significant main effect of test type, $F(2, 28) = 4.33$, $p < .05$, $\eta^2 = .24$. LSD post-hoc comparisons revealed that the proportion of *yes* responses was greater for the AS trials than for the SO trials, and greater for the AS trials than for the OS trials, all *p*s < .05.

Insert Figure 2 about here

The 3-year-olds extended the novel verb to the SO test event only 17.8% of the time, which was significantly below chance, $t(14) = 3.85$, $p < .01$, $d = .99$, two-tailed. They were also reluctant to generalize the novel verb to a different action performed with the same object. They accepted the OS test event as a referent of the verb 16.7% of the time, which was again significantly less than chance,

$t(14) = 5.29$, $p < .001$, $d = 1.37$, two-tailed. The children were more likely to extend a novel verb to the same action performed with a different object, but the proportion of *yes* responses (43.3%) did not exceed chance level, $t(14) = .70$, $p > .10$, two-tailed.

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The analysis of individual children's responses was consistent with the results from the group analysis. Three out of the 15 children accepted the Still-Object test event as a referent for the novel verb four times or more in the six trials, which was significantly below chance (sign test, $p < .05$). Only one of the 15 three-year-olds extended the novel verb to the OS test event four times or more in the six trials, which was also significantly different from chance, $p < .01$. The number of children who extended the novel verb to the AS test event four times or more in the six trials was five, which was not different from chance.

Discussion

The results suggest that 3-year-olds believe neither that a verb refers to an object nor that a verb refers to any action performed with the same object, even though they selected the OS test event significantly more often than chance level in the dissimilar-object condition in Study 1. Their unwillingness to extend a novel verb to the same action performed with a different, perceptually dissimilar object in Study 1 should therefore be attributed to their difficulty in extracting the common action.

The results from Study 1 indicate that young children's success in verb extension is strongly affected by the similarity of the objects used in performing the same action. This is

presumably because object similarity enhances the overall similarity between the standard event and the AS test event, and this helps the children compare the two events and extract the common relation (i.e., action). As reviewed in the Introduction, a parallel phenomenon has been reported in the literature on children's analogical reasoning (DeLoache, 1989, 1990; Gentner & Toupin, 1986; Holyoak et al., 1984; Kotovsky & Gentner, 1996) as well as in previous research on word learning (Childers, 2008; Childers & Paik, 2009; Klibanoff & Waxman, 2000; Waxman & Klibanoff, 2000).

Thus, evidence for the scaffolding role of object similarity in developing analogical reasoning as well as in word learning is accumulating. Given this, a further interesting possibility is that repeated experience of extending a novel verb to the same action guided by object similarity may bootstrap young children to successful verb extension in situations in which there is no support from object similarity, as predicted by the progressive alignment hypothesis proposed by Gentner and her colleagues (Gentner et al., 2007; Kotovsky & Gentner, 1996)

Study 2

In Study 2, the object-similarity bootstrapping hypothesis was tested in a stronger sense than in Study1. Here, we investigated whether repeated experience of action-based verb extension supported by object similarity would lead children to be better able to extract commonality of action across events even without support from object similarity. For this purpose, 4-year-olds were assigned to either a similar-then-dissimilar-object (henceforth, SD) condition or a dissimilar-then-dissimilar-object (DD) condition. The children in the SD condition were first

examined on their novel-verb extensions with support from object similarity on the first four trials. The last four trials tested whether they could extend a novel verb to the same action without support from object similarity. The children in the DD condition were asked to extend a novel verb without support from object similarity both on the first four trials and on the last four trials. If the object-similarity bootstrapping hypothesis is valid, the children in the SD condition should perform better than those children in the DD condition, not only on the first four trials, where the two groups are tested using different types of stimuli, but also on the last four dissimilar-object trials, where the two groups receive the same stimuli.

Method

Participants. Forty-seven monolingual Japanese 4-year-olds participated in this study (*M* age = 4 years 6 months, *SD* = 3.2 months, range = 4;0-4;11). They lived in a suburban city in the greater Tokyo area and were mostly from middle to lower-middle class families. None of these children took part in Study 1 or 1A. Twenty-four children were assigned to the SD condition, and 23 were assigned to the DD condition. There were approximately equal numbers of boys and girls in each condition.

Stimulus Materials. Eight sets of video action events served as stimulus materials. As in Study 1, each set consisted of a standard event and two test events, the Object-Same/Action-Change (OS) test event and the Action-Same/Object-Change (AS) test event. In the standard event, a woman performed a novel action with a novel object. In the OS test event, the same woman performed a

different action using the same object as in the standard event. In the AS test event, the same woman performed the same action as in the standard event, but with a different object.

On the first four trials, children in the SD and DD condition heard the same novel verb in association with the same standard event. They were then presented with the two test events, as in Study 1. For the first four trials, the OS test event was the same across the two conditions, but the AS test event depended on the condition the children were assigned to. The children in the SD condition saw the similar-object AS test events that were used for the similar-object condition in Study 1, and the children in the DD condition were shown the dissimilar-object AS test events that were used for the dissimilar-object condition in Study 1. Thus, Sets 1, 2, 4, and 6 in Table 1 were used on the first four trials in Study 2.

On the last four trials, children across the two conditions saw the same four sets of stimuli; each set consisted of a standard event, an OS test event, and a dissimilar-object AS test event. Two new sets of stimuli were used in addition to the two dissimilar-object sets from Sets 3 and 5 shown in Table 1. The two new sets were created being modeled after the dissimilar-object sets in Study 1.

Procedure. Children were tested individually in a quiet room at the preschool they attended. Children in both the SD and DD conditions received a total of eight trials. Throughout the session, the instructions and the procedure for each trial were identical to those in Study 1 for both conditions.

As in Study 1, warm-up trials were given prior to the experimental trials. The experimental trials consisted of two blocks, the first four trials and the last four trials. On each of the first four trials, children were first introduced to a novel verb while watching a standard event. They were then

shown the two test events, the AS test event and the OS test event. The type of AS test event they saw depending on the condition they were assigned to. The children in the SD condition were shown the similar-object AS test event, while the children in the DD condition saw the dissimilar-object AS test event. In both conditions, children were asked to indicate to which of the AS and OS test events the novel verb should be applied. This procedure was repeated on each of the first four trials.

The last four trials were conducted without a break after the first four trials were completed. On the last four trials, children in both conditions received the same stimuli. That is, they were first shown the standard event and then tested with the OS test event and the dissimilar-object AS test event. Any set that was used on the last four trials was not used on the first four trials. The order of the four sets within the first four trials and the last four trials was randomized and the left-right position of the AS and OS test events was counterbalanced within each child. No feedback was provided concerning whether the response was correct or not on the first four trials or on the last four trials.

Results

A choice of the AS test event was scored as an AS response. The proportion of AS responses was calculated for the first four trials and the last four trials separately in each condition, as shown in Figure 3. The children in the DD condition selected AS test events 51.1% of the time on the first four trials, and 55.4% of the time on the last four trials, neither of which was significantly different from chance ($t(22) = .13$, $p > .10$, and $t(22) = .54$, $p > .10$, respectively). In contrast, the

削除: $d = .03$,

削除: $d = .11$

children in the SD condition selected AS test events 86.5% of the time on the first four trials, which was significantly greater than chance, $t(23) = 7.67$, $p < .001$, $d = 1.57$. Unlike the children in the DD condition, those in the SD condition also showed action-based verb extension for the last four trials, selecting the AS test events 75.0% of the time, $t(23) = 3.20$, $p < .01$, $d = .65$.

Insert Figure 3 about here

The proportion of AS responses was submitted to a 2 (condition: SD vs. DD) by 2 (block: first four trials vs. last four trials) ANOVA with the factor of trial as a repeated measure. The main effect of condition was significant, $F(1,45) = 7.72$, $p < .001$, $\eta_p^2 = .15$. Neither the main effect of block ($F(1,45) = 0.47$, $p > .10$) nor the interaction ($F(1,45) = 2.32$, $p > .10$,) was significant. Thus, the 4-year-olds in the SD condition performed better than those in the DD condition not only on the first four trials but also on the last four trials, in which there was no support from object similarity. The lack of an interaction effect suggests that the performance of the children in the SD condition did not drop with the change from the similar-object trials to the dissimilar-object trials, whereas the performance of the children in the DD condition did not improve from the first four dissimilar-object trials to the last four dissimilar-object trials.

削除: , $\eta_p^2 = .01$

削除: $\eta_p^2 = .05$

Discussion

The results from the first four trials replicated the findings from Study 1. Specifically,

4-year-olds were able to extend a novel verb based on the sameness of action when the same action was performed with a similar object, whereas they failed without support from object similarity. More important, however, is that the children who experienced similar-object trials on the first four trials also performed very well on the following dissimilar-object trials. A general practice effect could not explain the success on the last four trials for the children in the SD condition, since the performance of the children in the DD condition did not improve after their four dissimilar-object trials. It thus seems legitimate to conclude that the difference in performance on the last four dissimilar-object trials came from the difference in the children's experience on the first four trials. The repeated experience of action-based verb extension supported by object similarity bootstraps children to be better able to generalize a novel verb based on the sameness of action even without support from object similarity.

Object similarity is also reported to be important in young children's adjective extension. Klibanoff and Waxman (2000) found that 3-year-olds could extend a novel adjective successfully from one object (e.g., a bumpy green horse) to another (e.g., a bumpy purple horse) if and only if both objects were drawn from the same basic-level object category. In addition, three-year-olds who had been given an opportunity to extend a novel adjective within the same basic-level category became able to extend the same adjective to other objects from different basic-level categories. Once children successfully extend a particular adjective supported by object similarity, this gives them another chance to discover precisely what property the adjective refers to, which would lead them to generalize the adjective to objects that are less similar to the original. The present study went one

step further, demonstrating that children come to have general expertise in finding common relations across events after they have had repeated experience of extending novel verbs supported by object similarity.

General Discussion

Importance of domain-general cognitive processes for verb learning

Young children were found to have great difficulty in generalizing a novel verb to the same action performed with a different, perceptually dissimilar object, which was consistent with the findings from previous research (Forbes & Farrar, 1993; Imai et al., 2005, 2008; Kersten & Smith, 2002; Maguire et al., 2002). However, this does not mean that young children do not know that verbs should be generalized by a different principle from nouns. In Study 1A, three-year-olds rejected an object as a referent of a novel verb. They do understand that verbs refer to *relations* between objects rather than objects per se.

Then, in what situations can young children extend a verb based on sameness of action? In Study 1, both 3- and 4-year-olds could extend a novel verb to the same action more easily when the objects involved in the original event and the same-action event were perceptually similar to each other than when they were dissimilar, which suggests that object similarity plays a scaffolding role in verb learning. Study 2 further demonstrated that children became better able to extend a novel verb to the same action even without support from object similarity after they had had repeated experience of making action-based verb extension with support from object similarity.

These results provide an insight into the mechanism by which young children learn verb meanings. Initially, young children may be very conservative in generalizing verbs. They limit themselves to extending a novel verb to events that are massively similar to the event they originally experienced. Here object similarity can serve as a scaffold, by heightening the overall similarity across events in which the same action is performed. Once children have chosen the same-action event guided by overall similarity, this in turn provides them with an opportunity to compare the events in more detail and to extract the common action. Repeated experience of extending novel verbs supported by object similarity then bootstraps children to action-based verb extension without scaffolding from object similarity. Thus, the results of the present research highlight importance of the domain-general processes such as comparison and alignment (Gentner, 1982) in the domain of verb learning (Gentner, 1982).

Optimal levels of object similarity for comparison and progressive alignment

An interesting question is the kind and degree of object similarity that are needed to foster progressive alignment in verb (as well as adjective) learning. The object similarity that promoted adjective learning in Klibanoff and Waxman (2000) was the similarity that arose from the same basic-level category. Kersten and Smith (2002) also reported that 3-year-olds could extend a novel verb to the same action performed by a different agent from the same category. In contrast, object similarity in the present research was purely perceptual, since all the similar objects were of different kinds.

On one hand, it is possible that children receive stronger scaffolding when object similarity is both conceptual and perceptual than when it is only perceptual. Thus, we might expect that children may have performed even better if the objects from the same basic-level category were used for the standard action event and the AS test event. On the other hand, it is also possible that if the objects used for the standard-action event and the AS test event were too similar, the children may have thought that the two action events were identical, and hence may not have initiated comparison between the two events. If so, progressive alignment would not take place. In fact, Childers and Paik (2009) found that children who were shown several dissimilar events associated with a particular verb became better able to extend the verb to other dissimilar events than those children who were provided with the same number of similar events that the verb should be applied to. It may be when there are both sufficient similarity and variation across events denoted by the same verb that children initiate comparison and alignment. It is also probable that the optimal level of similarity interacts with the size of children's verb lexicons (see Maguire, Hirsh-Pasek, Golinkoff, & Brandon, 2008, for the possibility that very young children benefit more from the repetition of one exemplar rather than from many different exemplars). This issue is worth pursuing in future research.

Nature of children's verb learning

The present research has demonstrated that young children's verb extension is fostered by object similarity. At the same time, it suggests that children as old as four years of age still need scaffolding from object similarity in verb extension. This fact is striking, since Waxman and her

colleagues (Waxman, Lidz, Braun, & Lavin, 2009) have reported that 24-month-olds are ready to extend a novel verb to a different event involving the same action. However, in our view, their findings and ours should not be taken as contrasting.

In their research, 24-month-olds received four different examples of the same action (e.g., in each example, the same actor was waving one of four different balloons) in association with a novel verb. In addition, the children were shown a completely different action (e.g., the same actor was playing a saxophone) and told that the verb should not be applied to the action. With such rich scaffolding, 24-month-olds could extend a novel verb to a very similar event in which the same actor was performing the same action with another object from the same basic-level object category (e.g., a new balloon that the child did not see in the familiarization phase). Thus, their results suggest that 24-month-olds need rich scaffolding to extend a novel verb to a very similar event. The fact that children at 3- and 4-years of age still need some scaffolding in verb extension indicates that their understanding of verb meanings is not as robust as adults, and still has room for developmental progress.

Even when children understand that verbs should be generalized based on the sameness of relation, finding the ‘same’ relation is not easy. For example, adult English speakers may think that the English verb “carry” refers to fairly concrete actions and its meaning is easy to grasp. However, when we consider the range of events that could be denoted as “carrying” actions, it becomes obvious that extracting commonality across “carrying” actions is not simple. For example, a scene of someone “carrying” a briefcase in the hand is distinctively different from a scene of someone

"carrying" a tennis racket on the shoulder or "carrying" a backpack on the back. For English speakers, these are all the same action to which the verb "carry" is applied, although they look so different. In Chinese, however, these actions are denoted by different verbs. Thus, the semantic invariant for each verb can be very abstract, even though each referent action seems to be concrete.

Furthermore, what counts as a semantic invariant varies depending on the semantic domain of the verb. The current experiments focused on a repetitive action performed with some object, such as "waving a flag" or "twirling a baton." Other verbs, however, can be extended based on the sameness of the result of the action, or based on the sameness of the manner of motion. Given the variety of relations that verbs can refer to, it is not sufficient for children to understand that verbs refer to kinds of relations. Children also need to find out what kind of common relation should be preserved as a core meaning of a verb in the particular domain. In this regard, we should be cautious about concluding that children have abstract understanding of verb meanings even if they show *some* level of understanding. Even when children are able to extend a novel verb to the same action without scaffolding, they may still have a long way to go before achieving adult-like comprehension of verb meaning (Saji, Saalbach, Imai, Zhang, Shu & Okada, 2008, Theakston, Lieven, Pine & Rowland, 2002).

In any case, we emphasize that the results presented in the current research should *not* be taken to suggest that young children lack the ability to extend a novel verb (see Imai et al., 2005, for a similar discussion). Instead, they suggest that it takes children a long time to gain the robust, adult-like representation of verb meanings that allows them to successfully extend a novel verb even

when scaffolding is scant. Our research offers an account of how children go through this long developmental trajectory, and of how they build up expertise in verb learning that requires less and less scaffolding.

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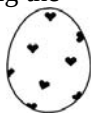
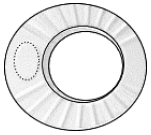
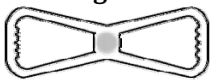
interpretations of novel verbs and nouns in dynamic scenes. *Cognitive Psychology*, **59,** 67-95.

Table 1

Actions and Objects Used in Study 1

	Standard Event	Object-Same Test Event	Action-Same Test Event	
			Similar-Object Condition	Dissimilar-Object Condition
Set 1	A woman is rolling the object (**a foot-ball shaped orange Frisbee with fins**) between the palms of her hands. 	The same woman is lightly tossing and catching with both hands the same object as used in the standard event. 	The same woman is doing the same action as that performed in the standard event with **a Styrofoam egg with heart design**. 	The same woman is doing the same action as that performed in the standard event with **a blue candle holder in the shape of a cup with a long stem.** 
Set 2	A woman is holding the object (**a long blue plastic arch-shaped object**) behind her back, pulling it up and down. 	The same woman is holding the same object, twisting her torso from side to side. 	The same woman is doing the same action as that performed in the standard event with **long sponge**. 	The same woman is doing the same action as that performed in the standard event with **a racket frame**. 
Set 3	A woman is holding the object (**a octagon-shaped rubber Frisbee ring with blue/black stripes**) both hands at chest level, twisting the object so that it bends in the middle. 	The same woman is holding the same object in her right hand and fanning herself with it. 	The same woman is doing the same action as that performed in the standard event with **a Styrofoam yellow visor**. 	The same woman is doing the same action as that performed in the standard event with **a blue rubber dog toy consisting of two large loops**. 

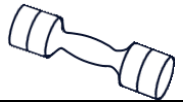
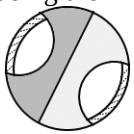
Set 4	A woman is holding the object (**a dark green metal spherical trellis on a long, thin stem**) in her right hand, pushing it out with a stabbing motion. 	The same woman is holding the same object with both hands at chest level, twirling it like a baton. 	The same woman is doing the same action as that performed in the standard event with **a plunger with a plastic handle and a rubber head.** 	The same woman is doing the same action as that performed in the standard event with **a large gray plastic curved pipe**. 
Set 5	A woman is holding the object (**a plastic orange dumbbell**) in her right hand, moving it backwards by bending her arm. 	The same woman is holding the same object in her right hand and moves it in an arc over her head with her arm stretched. 	The same woman is doing the same action as that performed in the standard event with **a bone-shaped wooden toy for dogs**. 	The same woman is doing the same action as that performed in the standard event with **a rope ring with pink and yellow cloth stretched covers**. 
Set 6	A woman is tapping the object (**a donut shaped plastic toy for cats**) against her thigh. 	The same woman is rotating the same object with her forefingers at her chest level. 	The same woman is doing the same action as that performed in the standard event with **a donut-shaped baking mold**. 	The same woman is doing the same action as that performed in the standard event with **a brown plastic drainpipe**. 

Table 2

Number of children who showed AS-dominant and OS-dominant performance in Study 1

	AS-dominant children	OS-dominant children
Three-year-olds		
Similar Object	8	6
Dissimilar Object	2	12**
Four-year-olds		
Similar Object	11*	3
Dissimilar Object	4	10

* p <.05. ** p<.01.

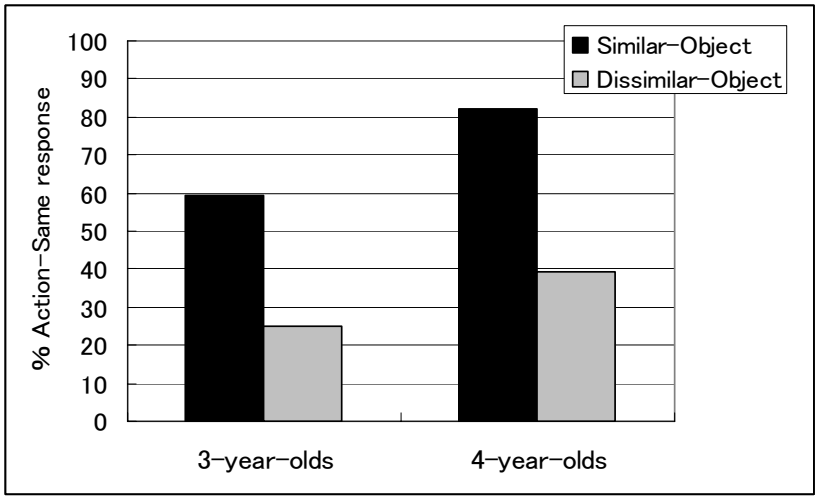


Figure 1. Proportion of Action-Same responses in each condition in each age group in Study 1.

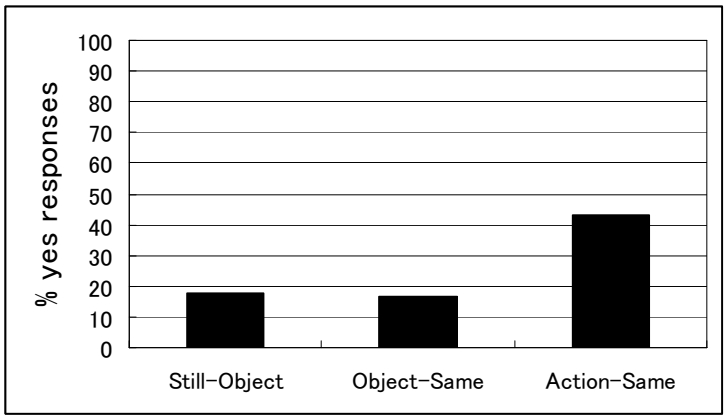


Figure 2. Proportion of children's agreement to extend the novel verb to each test event in Study 1A.

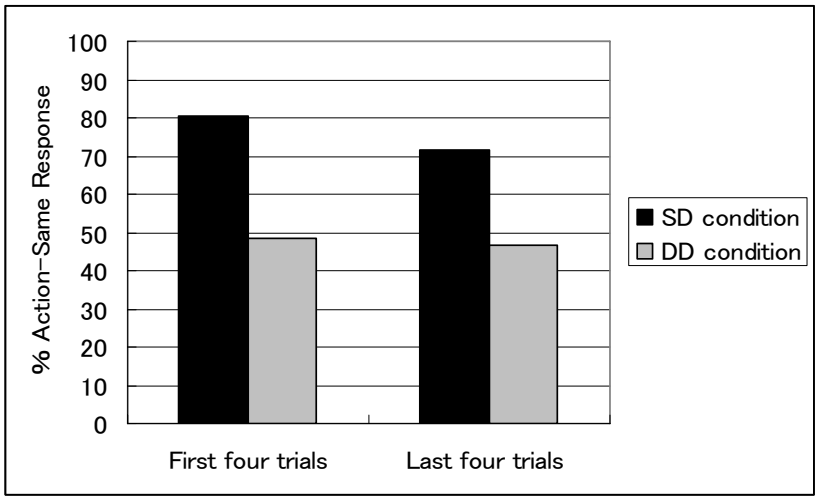


Figure 3. Proportion of Action-Same responses in each condition in Study 2.