Get by With a Little Help From a Word: Multimodal Input Facilitates 26-Month-Olds' Ability to Map and Generalize Arbitrary Gestural Labels

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Get by With a Little Help From a Word: Multimodal Input Facilitates 26-Month-Olds’ Ability to Map and Generalize Arbitrary Gestural Labels

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In the early stages of word learning, children demonstrate considerable flexibility in the type of symbols they will accept as object labels. However, around the 2nd year, as children continue to gain language experience, they become focused on more conventional symbols (e.g., words) as opposed to less conventional symbols (e.g., gestures). During this period of symbolic narrowing, the degree to which children are able to learn other types of labels, such as arbitrary gestures, remains a topic of debate. Thus, the purpose of the current set of experiments was to determine whether a multimodal label (word + gesture) could facilitate 26-month-olds’ ability to learn an arbitrary gestural label. We hypothesized that the multimodal label would exploit children’s focus on words thereby increasing their willingness to interpret the gestural label. To test this hypothesis, we conducted two experiments. In Experiment 1, 26-month-olds were trained with a multimodal label (word + gesture) and tested on their ability to map and generalize both the arbitrary gesture and the multimodal label to familiar and novel objects. In Experiment 2, 26-month-olds were trained and tested with only the gestural label. The findings revealed that 26-month-olds are able to map and generalize an arbitrary gesture when it is presented multimodally with a word, but not when it is presented in isolation. Furthermore, children’s ability to learn the gestural labels was positively related to their reported productive vocabulary, providing additional evidence that children’s focus on words actually helped, not hindered, their gesture learning.

Throughout the typical course of development, children learn new words with relative ease. Although a seemingly effortless task, a number of perspectives have been put forth to describe the various processes by which children learn to link words with referents. For instance, some have proposed that children recruit language-specific biases or constraints to assist them in...
determining correct word–referent mappings (Clark, 1987; Markman, 1989). Others have proposed that children rely on their adept sensitivities to social cues, such as the referential intent of the speaker, eye gaze, and joint attention, to guide them to the correct word–referent conclusions (Akhtar, 2004; Akhtar, Carpenter, & Tomasello, 1996; Akhtar & Gernsbacher, 2007; Baldwin, 1993; Tomasello, 2003). However, the mechanisms driving early word learning appear to change throughout development. A great deal of research has shown that infants initially rely on their general perceptual sensitivities, which results in a greater flexibility in the types of cues they will utilize. Yet, as infants gain more experience with their ambient language, they become more specialized or focused on language-specific cues (Hollich et al., 2000; McGregor, 2008; Namy, Campbell, & Tomasello, 2004; Tomasello, 2003; Werker, Cohen, Lloyd, Casasola, & Stager, 1998; Yeung & Werker, 2005). This type of general-to-specific progression or narrowing has been found in several developmental domains throughout infancy, such as speech and face perception, as well as intersensory integration (Gogate & Hollich, 2010; Lewkowicz & Ghazanfar, 2009; Scott, Pascalis, & Nelson, 2007; Werker & Tees, 1984).

Support for this type of flexible-to-narrow progression has also been provided by research on early symbolic development (Fulkerson & Waxman, 2007; Graham & Kilbreath, 2007; Namy & Waxman, 1998; Woodward & Hoyne, 1999). For instance, several studies exploring infants’ symbolic understanding and early word learning have shown that younger infants are more flexible and seemingly agnostic to the type of symbols (e.g., gestures, sounds, words) they will link to objects. However, as infants progress in language learning, they become increasingly restrictive and focus specifically on words as associates to objects (Fulkerson & Waxman, 2006; Graham & Kilbreath, 2007; Namy & Waxman, 1998; Woodward & Hoyne, 1999). Woodward and colleagues (Woodward & Hoyne, 1999; Woodward, Markman, & Fitzsimmons, 1994) reported that when presented with either a novel word (e.g., “toma”) or a nonlinguistic sound (e.g., sound of a whip) as a label1 for an object, 13-month-olds readily mapped and generalized both words and sounds to familiar and novel objects. However, 20-month-olds did not demonstrate comparable flexibility and only provided evidence of learning the word–object linkages.

Similarly, Namy and Waxman (1998) examined 18- and 26-month-olds’ willingness to interpret arbitrary gestures and novel words as labels for objects. Their findings demonstrated that 18-month-olds readily mapped and generalized both words and the arbitrary gestures. Twenty-six-month-olds, on the other hand, readily mapped and generalized the novel words yet required additional training to learn the arbitrary gestural labels. Namy and Waxman (1998) concluded that 26-month-olds were less willing to interpret the arbitrary gestures as labels because their more extensive language experience created an increased reliance on words, in particular, as associates to objects. Offering additional support for this conclusion, Graham and Kilbreath (2007) found that 22-month-olds relied only on words to make inductive inferences, whereas 14-month-olds relied on both words and gestures. This flexible-to-narrow transition in symbolic openness, occurring around the 2nd year, reveals a developmental period in which children become particularly attentive to the types of symbols (e.g., gestures, words) that are most frequently used in their environments (Graham & Kilbreath, 2007; Namy & Waxman, 1998; Woodward & Hoyne, 1999).

However, research exploring this flexible-to-narrow progression between 18 and 26 months with symbolic gestures has generated conflicting results. For example, recall that Namy and

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1Although a nonlinguistic sound cannot be considered a “label” in the traditional sense, Woodward and Hoyne (1999) use the term “labeled” to describe the target object.
Waxman (1998) found that 26-month-olds did not readily learn arbitrary gestural labels, yet 18-month-olds did. In contrast, Tomasello, Striano, and Rochat (1999) found that both 18- and 26-month-olds readily learned iconic gestures as labels for objects. In considering why 26-month-olds inconsistently demonstrated the ability to learn gestural labels, one important difference between the two studies was that Tomasello et al. (1999) utilized more conventional iconic gestural labels (i.e., bears some resemblance to the referent), whereas Namy and Waxman (1998) utilized less conventional arbitrary gestural labels (i.e., bears no resemblance to the referent). While some contend that iconic gestures are easier for children to learn because they resemble the referent (Acredolo & Goodwyn, 1988; Goodwyn, Acredolo, & Brown, 2000; Striano, Tomasello, & Rochat, 2001; Werner & Kaplan, 1963), Namy et al. (2004) asserted that children’s growing appreciation of the conventions of communicative exchanges rather than iconicity accounted for the differences in the findings across studies. More specifically, Namy et al. (2004) proposed that 26-month-olds more readily learn iconic gestures because they are used more frequently in their day-to-day encounters, whereas arbitrary gestures are not. As 26-month-olds become more aware of the conventional symbols used in their environment, they become focused on those types of symbols (Namy et al. 2004).

To test their claim, Namy and collaborators (2004) examined 18-, 26-, and 48-month-olds’ ability to learn iconic gestures (e.g., hopping gesture for a rabbit) versus arbitrary gestures (e.g., a dropping motion for a rabbit) as labels for objects. Their findings revealed that the 18- and 48-month-olds learned both the iconic and arbitrary gestural labels. As predicted, 26-month-olds only provided evidence of learning the more conventional iconic gestures. Namy et al. (2004) concluded that this U-shaped pattern confirmed that earlier in development, 18-month-olds are somewhat agnostic to and flexible in the types of symbols (conventional or unconventional) that they will interpret as labels. However, around the 2nd year, children become increasingly more sensitive to the conventions of their linguistic environments and will apply only more conventional symbols (e.g., iconic gestures or words) to referents. Yet, as children become more linguistically advanced, this heightened attention to convention is replaced with an increased awareness of the diversity of symbols and intentionality. Namy et al. proposed that by 48 months, this increased awareness ultimately allows children to adjust or override their commitment to convention and learn both the iconic and arbitrary gestural labels.

For 26-month-olds, although this narrowing or focus on conventional symbols may be advantageous, it may also be limiting in that it appears to be challenging to override. For example, to emphasize to 26-month-olds that arbitrary gestures, like words, may be used as labels for objects, Namy and Waxman (1998) conducted a follow-up experiment using a puppet to name objects with either a word or gestural label. Even within the context of a familiar naming routine, the inclusion of a novel interlocutor (i.e., the puppet) did not facilitate 26-month-olds’ willingness to interpret the arbitrary gestural label. In another follow-up experiment, Namy and Waxman (1998) instituted an additional training period during which the puppet invited the children to produce the gestural labels. It was this additional training coupled with the elicited production of the gesture that ultimately facilitated 26-month-olds’ ability to interpret the arbitrary gestures as labels for the objects. These findings underscore that 26-month-olds’ focus on more conventional symbols requires additional information to override.

One possible explanation as to why the gestural labels were more challenging for the 26-month-olds to learn is that the task may have been somewhat ambiguous without the additional information or cues. Given that children in the previous research were tested during
a period of symbolic reorganization (Graham & Kilbreath, 2007), as a result of their increased awareness of communicative conventions (Namy et al., 2004), it is possible that the presentation of the less conventional arbitrary gesture in isolation was particularly confusing. This confusion may have been due to the fact that in naturalistic settings, caregivers’ communicative gestures most often occur with the accompanying verbal labels (Matatyaho & Gogate, 2008; Zukow-Goldring, 1996; Zukow-Goldring & Rader, 2001). More specifically, research has shown that caregivers instinctively and spontaneously coordinate their gestures and speech when labeling objects (Gogate, Bahrick, & Watson, 2000; Matatyaho & Gogate, 2008). Several studies have shown that during naming interactions, when the goal is to draw their infant’s attention to a particular object, mothers’ verbal labels are most often presented with communicative gestures, such as pointing or showing (Gogate, Bolzani, & Betancourt, 2006; Matatyaho & Gogate, 2008; Zukow-Goldring, 1996). Furthermore, Gogate and colleagues (Gogate et al., 2000, 2006; Matatyaho & Gogate, 2008) have repeatedly found in their experimental studies that mothers’ natural tendency to use multimodal labeling not only maintains their infants’ attention but also facilitates their ability to learn and remember word–object relations.

In an attempt to exploit this instinctive coupling, Goodwyn and colleagues (2000) encouraged and trained parents to use symbolic gestures (arbitrary and iconic) as they verbally labeled objects or actions (e.g., ‘‘See the ‘birdie’ + [flap arms]?’’) in naming routines with their preverbal infants. The findings revealed that infants who were exposed to this type of multimodal input (i.e., infant signs) demonstrated a linguistic precocity compared to their peers with respect to building a lexicon. Likewise, Daniels (1994, 1996, 2001) found that preschoolers and kindergarteners, who were presented with similar types of multimodal labels (e.g., English words + American Sign Language signs), demonstrated significantly larger vocabulary gains than children who were not exposed to this type of input. What is particularly interesting about this line of research is that the multimodal input facilitated not only children’s abilities to learn the words but also their ability to learn the gestures/signs (Bates, Thal, Whitesell, Fenson, & Oakes, 1989; Capone & McGregor, 2004; Daniels, 2001; Goodwyn et al., 2000).

In terms of perceptual advantages, multimodal input (e.g., auditory + visual) has been shown to be particularly beneficial because information presented across multiple modalities is more richly encoded and successfully retrieved than information presented in only one modality (Broadbent, 1956; Daniels, 2001; Delogu, Raffone, & Belardinelli, 2009; Gogate, Walker-Andrews, & Bahrick, 2001; Goodwyn et al., 2000; Martin, 1980; Moreno & Mayer, 2002; Paivio, 1986; Penney, 1989; Thompson & Paivio, 1994). This advantage has been noted in both experimental and naturalistic settings exploring the influence of multimodal input on early word learning and various aspects of language development (Booth, McGregor, & Rohlfing, 2008; Daniels, 1994, 1996, 2001; Gogate & Bahrick, 2001; Gogate et al., 2001; Goodwyn et al., 2000; Houston, Ying, Pisoni, & Kirk, 2001; Kelly, McDevitt, & Esch, 2009; Zammit & Schafer, 2011). With auditory labels in particular, multimodal input is thought to enhance memory because retrieval in one sensory modality automatically triggers retrieval in the other (Lewandowski & Kobus, 1993; Mastroberardino, Santangelo, Botta, Marucci, & Belardinelli, 2008; Moreno & Mayer, 2002; Penney, 1989).

In addition to the perceptual benefits of multimodal input, pairing a more conventional type of label (e.g., word) with a less conventional type of label (e.g., arbitrary gesture) may facilitate 26-month-olds’ willingness to learn the arbitrary gestural label. Considering that 20- to 26-month-olds are focused on words as appropriate labels for objects (Graham & Kilbreath, 2007; Namy & Waxman, 1998; Woodward & Hoyne, 1999), pairing a more conventional type
of label with a less conventional gesture may highlight the relevance (and appropriateness) of the
gesture for children, particularly because children may be less familiar with symbolic gestures
presented in isolation. However, the degree to which words can facilitate children’s gestural
learning may be dependent upon where children are in their vocabulary development. To date,
little research has directly examined children’s vocabulary in relation to their performance in
label-learning tasks (Bates et al., 1989; Hollich et al., 2000; Werker, Fennell, Corcoran, & Stager,
2002). Furthermore, the limited research conducted has reported inconsistencies regarding the
direction of this relationship (Werker et al., 2002). These inconsistencies may be the result of
various types of vocabulary assessments (e.g., parental report, standardized tests) and outcome
measures (e.g., continuous vs. categorical) utilized across both experimental and naturalistic
settings (Hollich et al., 2000).

Thus, the purpose of the current study was to determine whether multimodal labels could facili-
tate 26-month-olds’ ability to learn an arbitrary gesture as a label for an object and whether this
ability was influenced by children’s vocabulary. In a controlled experimental setting,
26-month-olds were given a multimodal label (i.e., word + gesture) for an object during training.
Next, we tested children’s ability to map and generalize both the gestural label and multimodal
label to familiar and novel objects. We hypothesized that the presentation of a word with an arbi-
trary gesture would facilitate 26-month-olds’ ability to learn the gestural label. If children adopted
both the word and gestural labels, then they should select the target object regardless of the type of
request (gesture alone or multimodal). On the other hand, if children still more readily adopt words
than gestures, then they should be less likely to make the correct choice with the gesture-only
requests. Furthermore, children’s willingness to accept the gestural label may depend on the size
of their vocabularies. For instance, children with higher vocabularies may be less likely than chil-
dren with lower vocabularies to accept the gestural labels due to their increased experience with
words as labels. Alternatively, this increased experience may enable children with higher vocabul-
aries to focus more on the gestural label as opposed to the word.

METHOD

Participants

Participants were recruited through public birth records and contacted when they reached the
appropriate age range. The final sample consisted of 35 children (18 males, 17 females) ranging
in age from 25 to 27 months \((M = 26.4\) months, \(SD = .48\) months). Fourteen additional children’s
data were excluded from the analyses due to experimenter error \((n = 1)\), failure to make at least a
selection during the introduction phase \((n = 7)\), or failure to complete the session due to fussiness
\((n = 6)\). All children received a T-shirt and a photo keepsake for participation.

Stimuli

Objects

Stimuli used during the interaction paradigm were plush toys. Figure 1 depicts the novel objects
used in the introduction, training, and testing phases. For the introduction phase, the stimuli were
three familiar plush animals: a rabbit, a fish, and a bird. For the training and testing phases, four unique plush toys (two pairs) were used. Each pair was identical except in color.

**Gestures and Words**

Conventional iconic gestures and familiar words were presented simultaneously with the familiar objects during the introduction phase. “Bird,” “fish,” and “rabbit/bunny” were used because they are reported to be part of children’s receptive vocabularies by 18 months of age (Fenson et al., 1993). The “rabbit” gesture was produced with a bent V-hand (e.g., bunny ears) illustrating a rabbit’s hopping movement. The “fish” gesture was produced with the right hand moving back and forth while slowly moving forward to illustrate a fish’s swimming movement. The “bird” gesture was produced with both hands flapping to illustrate a bird’s flying movement.

The novel word “blicket” was paired with an arbitrary gesture during the training and testing phases. The novel arbitrary gesture was derived from the American Sign Language (ASL) sign for yellow. The ASL sign for yellow is articulated with the thumb and pinky finger extended.

<table>
<thead>
<tr>
<th>Phase</th>
<th>Request/label given</th>
<th>Objects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction</td>
<td>“Can you find the ‘bunny’ + &lt;gesture&gt;?”</td>
<td><img src="image" alt="Fish, Rabbit, Bird" /></td>
</tr>
<tr>
<td>Training</td>
<td>“This is a ‘blicket’ + &lt;gesture&gt;!”</td>
<td><img src="image" alt="Yellow, Red" /></td>
</tr>
<tr>
<td>Testing: Mapping</td>
<td>“Can you find the ‘blicket’ + &lt;gesture&gt;?”</td>
<td><img src="image" alt="Yellow, Red" /></td>
</tr>
<tr>
<td>Testing: Generalization</td>
<td>“Can you find the other ‘blicket’ + &lt;gesture&gt;?”</td>
<td><img src="image" alt="Black, Yellow" /></td>
</tr>
</tbody>
</table>

*FIGURE 1 Example of the object pairs and label requests presented during the introduction, training, and testing phases. (Color figure available online.)*
with the middle fingers flat against the palm (i.e., Y-hand). This Y-hand twists twice counter clockwise (Sternberg, 1998). The double presentation was done so the novel gesture matched temporally with the presentation of the two-syllable novel word.

Apparatus

The session occurred in a 3.5 m × 6.5 m room. Children were seated at a child-size table (36-inch diameter) directly across from the experimenter. Two concealed cameras, situated 2 m and 3.5 m away from the table, recorded the testing session. In an adjoining room, a digital video recording system was used to capture the video and audio recordings.

Procedure

After parental consent was obtained, children were seated across from a female experimenter while parents completed the MacArthur-Bates Communicative Development Inventory Short Form-B (MCDI; Fenson et al., 1993, 2000). Parents were asked to remain neutral and refrain from labeling the objects during the session. Which object was labeled (Object A or Object B) and the order of presentation of the objects (labeled first or distracter first) was counterbalanced across participants. Each session was divided into three phases: introduction, training, and testing phases. Figure 1 depicts examples of the object sets and corresponding label requests used during the introduction, training, and testing phases of the experiment.

Introduction Phase

The introduction phase served to familiarize participants with the procedure. First, the experimenter handed a familiar object (bunny, bird, or fish) to the participant and labeled it with both the appropriate word (e.g., ‘‘bunny’’) and the corresponding iconic gesture (e.g., bent V-hand hopping) simultaneously. Each time the experimenter drew the child’s attention to the object, she repeated the multimodal label (e.g., ‘‘This is a ‘bunny’ + <gesture>!’’). After the participant played with the object, it was removed before the next object was introduced. This was repeated until all three objects were introduced. The order of presentation was counterbalanced across participants.

After this initial introduction, all three objects were brought back on the table. The experimenter then made a series of individual requests, which included one of each type of label (gesture alone, word alone, or multimodal), resulting in a total of three trials. For example, the experimenter asked the child to indicate which object was the rabbit toy (e.g., ‘‘Can you point to the <gesture>?’’), which object was the bird toy (e.g., ‘‘Can you hand me the ‘bird’?’’), and finally which object was the fish toy (e.g., ‘‘Can you hand me the ‘fish’ + <gesture>?’’). The pairings between the toy (bunny, bird, or fish) and request (word, gesture, or both) as well as order of the requests were all counterbalanced across participants.

Preference Assessment and Free Play

Following the introduction phase, participants were introduced to one of two novel object pairs (e.g., red and yellow set). Both objects were placed on the table, and the child was invited
to play with them freely (approximately 1 minute). The experimenter then asked the participant to indicate which object was his/her favorite (i.e., “Which toy is your favorite?”). If the child failed to make a selection, the experimenter asked, “Which toy do you like better?” If the child again failed to make a selection, the experimenter put the objects back into the bag and moved on to the training phase. This assessment of initial preference was conducted to ensure that children’s selections during the test trials could not be attributed to their initial preference for one object over the other.

Training Phase

During the training phase, the experimenter brought out one of the previously viewed novel objects. When the target object was presented, the experimenter simultaneously labeled the object with the arbitrary gesture \( \text{YELLOW} \) and the novel word “blicket.” Initially, this object was held near the experimenter’s face to ensure that the children attended to the word, gesture, and object (e.g., “Look at this ‘blicket’ + \(<\text{YELLOW}>\)” . . . “I call this a ‘blicket’ + \(<\text{YELLOW}>\)” . . . “I really like this ‘blicket’ + \(<\text{YELLOW}>\)” ). Then, the experimenter handed the object to the participant and continued to use the multimodal label (i.e., “blicket” + \(<\text{YELLOW}>\) ) to refer to the object (e.g., “Do you play with the ‘blicket’ + \(<\text{YELLOW}>\)?”). The order of presentation between labeled and distracter objects was counterbalanced across participants.

When the distracter object was presented, the experimenter brought attention to the object in a similar manner as the labeled object but did not provide a label. Instead, the experimenter directed the participant’s attention to the object with phrases such as “Look at this one!” and “I like this one!” The child’s attention was drawn to the distracter object about 7 to 11 times (\( M = 9 \)).

Testing Phase

The testing phase consisted of mapping and generalization trials. In both trials, the experimenter made two requests: a gesture only and a multimodal request. The order in which these requests were made was counterbalanced across participants. The decision was made to utilize this type of within-subjects design and request the target object twice to confirm that, at a minimum, the children were able to map and generalize the multimodal label that they were presented with during training. However, children could have easily ignored the gesture, attended to only the word–object relation, and still have been able to correctly select the target object. Therefore, the benefit of having a within-subject comparison is that it allowed for us to determine whether participants had interpreted the gesture as an appropriate label when it was presented independently of the word.

Considering that children may interpret a second request for an object as an indication that they were incorrect in their previous selection, we took several steps to minimize this possibility in the current study. First, we removed the objects from the table after the initial request (e.g., multimodal label). Second, we were careful in selecting the wording that the experimenter used to initiate the second request. More specifically, after the objects were placed back into the bag,
the experimenter exclaimed that ‘‘this was a fun game’’ and that she wanted to ‘‘play it again.’’ Finally, after this statement was made, the experimenter brought back out the objects but switched their left–right position on the table from the previous request and labeled it with the alternate type of label (e.g., gesture only).

**Mapping trials.** For the mapping trials, the experimenter placed both of the objects used during training back onto the table and invited the participants to play a game with her. For the gesture-only request, the experimenter asked the participant, ‘‘Can you point to the <gesture>?’’ Regardless of accuracy, the experimenter consistently gave neutral feedback (e.g., ‘‘That one? OK.’’). Next, the experimenter removed both objects from the table. She then indicated to the participant that she wanted to play the game again and put both objects back out onto the table. Then, the experimenter used the multimodal request, ‘‘Can you point to the ‘blicket’ + <YELLOW>?’’ After the child made a selection or after 15 seconds with no selection, the experimenter removed the objects from the table.

**Generalization trials.** For the generalization trials, the experimenter presented two novel objects that were identical to the previously presented objects but differed in color. The experimenter then asked the participant to find the ‘‘other <label>’’ (e.g., gesture only or multimodal label). After this request, the experimenter removed the objects and then indicated that she wanted to play the game one more time. Once she returned the objects back to the table, she requested the target using the alternate label. Again, the order of requests (gesture first vs. multimodal label first) was counterbalanced across participants.

**Coding**

The experimental sessions were coded offline. Children’s behaviors were coded as: 1) correct selection, 2) incorrect selection, or 3) no or unclear selection. A second independent coder analyzed the sessions of 25% of the sample. Inter coder reliability was $k = .95, p < .01$.

**RESULTS**

The number of times children correctly selected the target object for the gesture-only and multimodal label requests across the mapping and generalization trials is reported in Table 1.

<table>
<thead>
<tr>
<th>Type of request</th>
<th>Gesture-Only (Mapping)</th>
<th>Multimodal (Mapping)</th>
<th>Gesture-Only (Generalization)</th>
<th>Multimodal (Generalization)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Correct</td>
<td>21</td>
<td>31</td>
<td>24</td>
<td>26</td>
</tr>
<tr>
<td>Incorrect</td>
<td>9</td>
<td>1</td>
<td>6</td>
<td>5</td>
</tr>
</tbody>
</table>
A series of chi-square analyses were conducted to determine whether children’s selections (correct vs. incorrect) for the mapping and generalization trials varied depending on their initial preference object selections (Object A vs. Object B), the training set received (Set A vs. Set B), the order in which the gesture-only label was presented (gesture-only first vs. gesture-only second), or by gender (males vs. females). The analyses did not reveal significant results, all \( p > .05 \), indicating that children’s selections did not differ based on these variables for either the mapping or generalization trials.

The next analysis was conducted to determine whether the children were able to map and generalize the multimodal label onto the target object. This analysis was done to confirm that the children understood the task and, at a minimum, were able to attend to and learn the verbal label. Of the participants who made a selection during the mapping trials, 96.9% selected the target object. Moreover, a chi-square test confirmed that the target object was selected significantly more often than the distracter object, \( \chi^2(1, N=32) = 28.13, p < .001 \). Similarly, during the generalization trials, 83.9% of the participants who made a selection selected the target object. Again, a chi-square analysis confirmed that the target object was selected significantly more often than the distracter object, \( \chi^2(1, N=31) = 14.23, p < .001 \). These findings demonstrate that the children not only learned the specific multimodal label, but also were able to extend it to a novel exemplar.

A subsequent analysis was conducted to determine whether children learned the arbitrary gestural label independently of the word. Of the participants who made a selection during the mapping trials, 70% correctly selected the target object. A chi-square analysis revealed that when requested with only the gesture, the children selected the target object more often than the distracter object, \( \chi^2(1, N=30) = 4.80, p < .05 \). When given only this gestural label during the generalization trials, 80% of the participants who made a selection correctly selected the target object. Again, the target object was selected significantly more often than the distracter object, \( \chi^2(1, N=30) = 10.80, p = .001 \). Thus, children provided evidence of mapping the gesture to familiar objects as well as extending this gestural label to a category.

An analysis exploring the relationship between children’s correct selections when presented with the gesture-only requests compared with the multimodal label was conducted. The analysis revealed that more correct selections for the gesture-only requests was significantly related to more correct selections for the multimodal requests, \( r = .41, p < .05 \). A Wilcoxon signed rank test revealed that participants correctly selected the target object significantly more often when they were presented with the multimodal label than when they were presented with the gestural label alone, \( Z = -2.65, p < .01 \).

The relationship between children’s reported productive vocabulary and their overall performance was examined. An initial analysis of children’s reported vocabulary scores on the MCDI revealed that, on average, children were reported to produce 75 words (\( M = 74.8 \) words, \( SD = 17.3 \) words). These scores did not significantly differ between females (\( M = 76.7 \) words, \( SD = 16.9 \) words) and males (\( M = 73 \) words, \( SD = 18 \) words), \( F(1, 34) = 0.48, p > .10 \). A subsequent linear regression revealed that the number of words reported in children’s vocabularies significantly predicted their correct selections on the gesture-only request trials (\( \beta = .37, t(31) = 2.17, p < .05 \). These results indicate that children with higher productive vocabularies were more likely to correctly select the target object when requested with only the gestural label. However, for the multimodal requests, children’s reported vocabulary sizes did not reliably predict performance, \( \beta = .22, t(29) = 1.18, p > .10 \).
Follow-Up Control Study

An additional 14 children were tested using a variation of the English syntactic frame. During test trials, instead of requesting the target objects with the phrase, “Can you point to the \verb<gesture>?\” or “Can you hand me the other \verb<gesture>?\” we used the following syntactic frame: “Which one can you get? \verb<gesture>!\” This was done to ensure that children interpreted both the gesture and word as labels and did not solely rely on the function word “the” to make the appropriate selection (L.L. Namy, personal communication, April 19, 2010). Of the 14 children, 3 did not complete the session due to fussiness and 1 did not participate in any way throughout the session, failing to interact with the experimenter or select any object at any time. Of the remaining 10 participants who made selections on the mapping trials, 80% selected the target object. For the generalization trials, 70% of them correctly selected the target object. Overall, the target object was selected over the distracter object 82% (14 out of 17) of the time, which significantly differed from chance, \(t(16) = 2.14, p < .05\). Therefore, the findings from the main experiment cannot be attributed specifically to the syntactic framing used during test trials.

DISCUSSION

In the current experiment, 26-month-olds were presented with a multimodal label (i.e., gesture + word) for an object. We sought to determine whether 26-month-olds would interpret the arbitrary gesture as an object label, something that they have not previously demonstrated without additional training or physically producing the gesture (Namy & Waxman, 1998). The findings revealed that in a controlled experimental setting, 26-month-olds were able to interpret arbitrary gestures as labels when they were presented multimodally with auditory words. Specifically, children were significantly more likely to select the target object when requested with either the gestural label alone or with the multimodal label. Further, children mapped and generalized these labels to both the familiar and novel objects, indicating that they had extended these labels to an object category. Children’s interpretation of the multimodal label was not related to their productive vocabularies. However, children’s interpretation of the gesture-only labels was related to their productive vocabularies. The more words children were reported to know, the more likely they were to correctly select the target object when requested with only the gestural label. Children’s acceptance of the arbitrary gesture as an appropriate label when it was decoupled from the word indicates that, on some level, they attended to and encoded both labels independently. Therefore, it appears that the multimodal label influenced 26-month-olds’ willingness to accept a gestural label without extensive training or having to physically produce the gesture.

However, we must be cautious in this interpretation in that there are some limitations of the current study. For instance, the initial introductory phase using the iconic gestures (e.g., hands flapping) paired with the familiar words (e.g., “bird”) may have been sufficient in cluing participants into the nature of the task and highlighting importance of the gesture. As a result, children may have come to regard the gesture as meaningful independent of the multimodal

\[^2\]The denominator is 17 instead of 20 because there were 3 trials where children selected both objects simultaneously. Thus, we only used trials where either the target or distracter object was selected.
presentation used during the training phase. Therefore, it is possible that the children simply transferred this knowledge from the introduction phase to the training and testing phases with the arbitrary gestures and novel words. Although this is a plausible explanation, it is unlikely in that previous research has provided compelling evidence to indicate that although 26-month-olds will readily interpret an iconic gesture as an object label, they do not readily interpret an arbitrary gesture as an object label (Namy et al., 2004). Furthermore, given that all of the children in the current study received multimodal labels during both the introduction and training phases, it is not possible to pinpoint the degree to which the presence of the auditory word, in particular, played a part in children’s ability to interpret either the iconic or arbitrary gestural labels. To address these limitations, we conducted an additional experiment and presented 26-month-olds with only a gestural label during both the introduction and training phases.

EXPERIMENT 2

In Experiment 2, we sought to determine whether 1) the exposure to iconic gestures in the introduction phase was enough to facilitate 26-month-olds’ ability to map and generalize arbitrary gestural labels and 2) the pairing of the auditory word with the gestural label was what specifically influenced children’s ability to learn the arbitrary labels in Experiment 1. To explore these questions, we tested 26-month-olds’ ability to map and generalize arbitrary gestures as labels for objects when presented with only a gestural label and not with the multimodal label. Children in Experiment 2 were tested in a similar procedure as the children tested in Experiment 1, except that an auditory word was not paired with the gestural labels.

Based on the nature of the stimuli presented in the current experiment, we made several predictions. First, we predicted that when presented with only the gestural label, as opposed to the multimodal label, 26-month-olds would not interpret the arbitrary gesture as a label for an object, similar to the findings of previous research (Namy et al., 2004; Namy & Waxman, 1998). Secondly, based on the findings of Namy et al. (2004), we predicted that simply being exposed to conventional iconic gestures (e.g., flapping arms) during the introduction phase would not be sufficient in facilitating 26-month-olds’ ability to map and generalize the arbitrary gestural labels to familiar and novel objects.

Lastly, with regard to whether children’s productive vocabularies would predict their ability to learn the gestural labels, we considered two possibilities. The first possibility was that children’s productive vocabularies would be related to their gesture learning, with larger productive vocabularies being related to more correct responses, similar to the findings of Experiment 1. However, a second, and we think more likely, possibility is that children’s productive vocabularies would not be significantly related to their ability to learn the gestural label due to the ambiguity and difficulty of the task. We propose that pairing the conventional label with the unconventional label in Experiment 1 highlighted the nature of the task, which in turn influenced the types of strategies or abilities the children were able to use. In Experiment 2, the presence of only the unconventional label (i.e., arbitrary gesture) may make the task particularly difficult for 26-month-olds, who have become less flexible in the types of symbols they are willing to accept as appropriate object labels (Namy et al., 2004). As a result of this lack of flexibility, children may be less likely to rely on their existing word-learning skills if a task does not present a word as a label.
METHOD

Participants

The final sample consisted of 24 children (10 males, 14 females) ranging in age from 25 to 27 months (M = 26.2 months, SD = .59 months). Nineteen additional children were tested, but were excluded from the analyses due to experimenter error (n = 1), failure to make a selection during the introduction phase (n = 8), or failure to complete the testing session due to fussiness (n = 10). Participants were recruited in the same way as in Experiment 1.

Stimuli & Apparatus

The novel objects, gestures, and apparatus used were identical to those used in Experiment 1.

Procedure

As in Experiment 1, the procedure in Experiment 2 consisted of an introduction phase, a training phase, and a testing phase. The introduction phase was identical to Experiment 1, except that the familiar objects (rabbit, bird, fish) were labeled and requested with only the iconic gestural label. For example, the experimenter handed one of the familiar objects (e.g., rabbit) to the participant and labeled it with an iconic gesture (e.g., bent V-hand hopping) embedded in an English carrier phrase, such as “Look at the <gesture>.” Again, the order of presentation of the three familiar objects with their corresponding iconic gestures was counterbalanced across all participants.

In the beginning of the training phase, the experimenter introduced the two novel objects and asked the participant to indicate which object was his/her favorite (e.g., “Which one is your favorite?”). After this preference trial, the remainder of the training phase was initiated with the experimenter presenting a novel object with the arbitrary gestural label (e.g., “I call this a <YELLOW>”). Again, children were exposed to this gestural label for the target object and had their attention drawn to the distracter object approximately 7 to 11 times (M = 9). The order of presentation (labeled first or distracter first) was counterbalanced across participants.

Similar to Experiment 1, the testing phase consisted of mapping and generalization trials. However in both trials, the experimenter made two gesture-only requests. After the experimenter requested the target object the first time (e.g., “Can you point to the <gesture>?”) and the child made a selection, the experimenter exclaimed, “I really like this game! Let’s play again!” The same procedure was used for the generalization trials with the novel objects (e.g., “Can you point to the other <gesture>?”).

Coding

Three different responses—1) correct selection, 2) incorrect selection, or 3) no or unclear selection—were coded from the videotapes after the testing session. To obtain intercoder reliability, a second independent experimenter coded the sessions of 25% of the sample, $k = .95, p < .01$. 
RESULTS

The number of times that children selected the target object (none, once, or twice) for both mapping and generalization trials as a function of gender is reported in Table 2. As in Experiment 1, preliminary chi-square analyses were conducted to determine whether the number of times children correctly selected the target for the mapping and generalization trials varied depending on their initial preference object selections (Object A vs. Object B), the training set received (Set A vs. Set B), or by gender (males vs. females). The analyses did not reveal any significant results, all \( p > .05 \), except for gender. Chi-square analyses revealed that males and females differed in their selections during the mapping trials, \( \chi^2(2, N = 24) = 9.1, p < .05 \), but not during the generalization trials, \( \chi^2(2, N = 23) = 3.9, p > .10 \). As can be seen in Table 2, for the mapping trials, males were more likely than females to repeatedly select the distracter object for both requests, whereas females were more likely than males to repeatedly select the target object for both requests.

However, a subsequent chi-square analyses conducted within each gender confirmed that neither the males, \( \chi^2(2, N = 10) = 3.8, p > .05 \), nor the females, \( \chi^2(2, N = 14) = 5.3, p > .05 \), reliably selected the target object at above-chance levels. Moreover, across the two requests, only 38% of the children selected the target object above chance (i.e., twice) on the mapping trials, with the remainder of the sample selecting the target at chance (i.e., once) or below (i.e., never). A similar pattern emerged during the generalization trials. As predicted, the findings of the chi-square analyses revealed that the distribution of children’s selections during the generalization trials did not reliably differ from chance, \( \chi^2(2, N = 23) = 1.65, p > .05 \). Furthermore, across the two requests, only 42% of the children selected the target object above chance (i.e., twice), with the remaining children selecting the target object at chance rates or less.

The analysis of children’s reported vocabulary scores on the MCDI revealed that children were reported to produce an average of 71 words (\( M = 71.2 \) words, \( SD = 23.6 \) words). These scores did not significantly differ between females (\( M = 73.8 \) words, \( SD = 26.8 \) words) and males (\( M = 68.0 \) words, \( SD = 22.2 \) words), \( F(1, 24) = 0.36, p > .10 \). Furthermore, these scores did not significantly differ from the children’s vocabulary scores in Experiment 1 (\( M = 74.8 \) words, \( SD = 17.3 \) words), \( F(1, 24) = 0.56, p > .10 \). A linear regression revealed that the number

<table>
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<th>TABLE 2</th>
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<td>Number of Correct Selections Across Two Requests for Mapping and Generalization Trials as a Function of Gender</td>
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<table>
<thead>
<tr>
<th>Test trials</th>
<th>Mapping</th>
<th>Generalization</th>
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<tr>
<td></td>
<td>Males</td>
<td>Females</td>
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<tr>
<td>Zero Correct</td>
<td>6</td>
<td>1</td>
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<tr>
<td>One Correct</td>
<td>3</td>
<td>5</td>
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<tr>
<td>Two Correct</td>
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<td>8</td>
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*For the generalization trials, one female failed to make a selection (\( n = 23 \)).
of words reported in children’s productive vocabularies did not reliably predict their correct selections across the mapping and generalization trials, $\beta = .01$, $t(22) = 1.67$, $p > .10$.

DISCUSSION

In the current experiment, 26-month-olds were presented with an arbitrary gesture as a label for an object. When presented with this gestural label in isolation, 26-month-olds in the current experiment did not provide evidence of learning the gesture–object linkage. More specifically, the 26-month-olds were not more likely to select the target object over the distracter. Furthermore, children’s reported productive vocabularies did not reliably predict their gesture learning.

The findings of the current experiment both replicate and extend the findings of Namy and colleagues (Namy et al., 2004; Namy & Waxman, 1998). The findings of the current experiment highlight that when given only arbitrary gestures as labels for objects, 26-month-olds do not readily interpret these types of gestures as appropriate object labels. These findings also extend the findings of Namy and collaborators by demonstrating that exposure to a more conventional iconic gestural label (e.g., flapping hands for “bird”) during the introduction phase was not sufficient in facilitating 26-month-olds’ willingness to accept the less conventional arbitrary gestural label. It is possible that the differences in conventionality between the iconic and arbitrary gestures made it particularly difficult for the 26-month-olds to transfer their experiences with the iconic gestures during the introduction phase to the training and testing phases with the arbitrary gestures.

The results also reveal that children’s oral vocabularies did not predict the degree to which children learned the arbitrary gestural labels. This finding highlights that presenting an unconventional arbitrary gesture, in isolation, as a label for an object may have added an additional level of complexity and ambiguity to the task for the 26-month-olds, who are particularly in tune with communicative conventions (Namy et al., 2004). As a result, 26-month-olds may not have been able to recruit their existing oral word-learning skills in the service of learning the gestural labels.

GENERAL DISCUSSION

The current set of experiments sought to determine whether presenting a multimodal label (word + gesture) could facilitate 26-month-olds’ ability to map and generalize an arbitrary gesture as a label for an object. The findings revealed that during a period of symbolic reorganization, 26-month-olds were able to map and generalize an arbitrary gesture as an object label when it is presented multimodally with a word (Experiment 1) but not when it is presented in isolation (Experiment 2). The results also demonstrate that children’s reported vocabularies played a role in their ability to learn the gestural labels in Experiment 1 with the multimodal input, but not in Experiment 2 with only the gestural labels. Based on these findings, we contend that the multimodal input 1) highlighted the nature of the task, 2) facilitated children’s ability to richly encode and successfully retrieve both labels, and 3) allowed them to rely on the more conventional label (i.e., word) as the scaffolding upon which they learned the less conventional label (i.e., arbitrary gesture).

The pairing of the gesture with the word in Experiment 1 may have highlighted the nature of the task by making the role of the gesture less ambiguous to children by emphasizing the importance of
both the gesture and the word as communicative tools. This pairing might explain why 26-month-olds in Experiment 1 interpreted the arbitrary gesture as an appropriate object label despite having failed to demonstrate this ability in Experiment 2 as well as in previous studies (Namy et al., 2004; Namy & Waxman, 1998). Children’s willingness to accept (or not accept) the gestural label appears to have been influenced by the demands of the task (Hollich et al., 2000) and the nature of stimuli. For 26-month-olds, who are more familiar with auditory words as labels, the articulation of an unconventional or less familiar type of gesture embedded within a spoken English sentence (e.g., “Can you find another <gesture>?”) might have made the task particularly ambiguous. This ambiguity, when coupled with the cognitive demands intrinsic to learning a new word in an unfamiliar setting, may have overloaded and confused the young learners.

In addition to clarifying the task, the multimodal label may have influenced the way the children processed, encoded, and stored the novel labels. The multimodal input seems to have facilitated the retrieval of both labels, as evidenced by the children’s selection of the target object with both the gesture-only and multimodal requests in Experiment 1. Penney (1989) has long claimed that presenting words both orally and visually enhances memory due to the dual memory store created as a result of perceiving information in two independent yet integrated sensory modalities. Supporting this claim, Kelly and colleagues (2009) reported that English-speaking adults’ ability to learn Japanese words was enhanced when the words were presented with congruent hand gestures. More specifically, participants in the multimodal condition remembered significantly more Japanese words than their nonexposed peers, and this advantage remained evident up to 1 week later (Kelly et al., 2009). Similar facilitative results of multimodal input have been reported with preverbal infants as well (Matatyaho & Gogate, 2008; Zammit & Schafer, 2011). Overall, these findings provide compelling evidence to indicate that the visual gestures aid in the retrieval of the auditory words (Kelly et al., 2009; Mastroberardino et al., 2008; Matatyaho & Gogate, 2008).

In more naturalistic settings, repeated exposure to multimodal labels has also been shown to have long-term implications for memory of words and gestures in both typical and atypical populations (Acredolo & Goodwyn, 2002; Bird, Gaskell, Babineau, & Macdonald, 2000; Capone & McGregor, 2004; Daniels, 2001; Houston et al., 2001; Matatyaho & Gogate, 2008). For instance, Daniels (1994, 1996, 2001) has consistently reported that preschoolers and kindergarteners who were exposed to ASL sign-accompanied speech acquired significantly larger vocabularies relative to their nonexposed same-aged peers. Furthermore, this advantage persisted and was apparent up to 1 year after children’s initial exposure. Interestingly, the effect of this type of multimodal exposure was particularly robust for children who were delayed in their vocabulary development (Daniels, 2001). Similarly, Goodwyn and colleagues (2000) found that preverbal infants who were exposed to gesture-accompanied speech (e.g., infant signs) by caregivers demonstrated a linguistic precocity compared to their peers with respect to building a lexicon. Moreover, this linguistic precocity persisted into middle childhood (Acredolo & Goodwyn, 2002). These findings, in conjunction with the findings of the current study, suggest that multimodal input (e.g., words + gestures) facilitates children’s ability to process, encode, and remember both auditory and gestural labels.

The current study also illustrates that the facilitative relationship between words and gestures is bidirectional in that auditory words can also facilitate the retrieval of visual gestures. Bates and colleagues (1989) reported a similar finding demonstrating that infants were significantly more likely to remember and use a gesture if it was presented with a word than if it was not. In the
current study, when given the gesture-only request in Experiment 1, select participants spontaneously blurted out the word (i.e., “blicket”). These spontaneous vocalizations always occurred prior to selecting the target object, as if saying the word facilitated the children’s retrieval of the gesture–object pairing. Although anecdotal, this type of spontaneous vocalization underscores the manner in which both the gesture and the word were stored.

In addition to the perceptual and cognitive benefits, it is plausible that pairing the word with the gesture enabled children in the current study to use the more conventional type of cue (e.g., a word) in the service of learning the less conventional type of label (i.e., arbitrary gesture). This proposal is supported by previous research exploring the effects of multimodal input on language learning (Capone & McGregor, 2004; Daniels, 2001; Goodwyn et al., 2000; Kelly et al., 2009; Matatyaho & Gogate, 2008). For instance, Bates et al. (1989) found that when the symbolic gestures were unfamiliar, infants were able to rely on familiar words (e.g., “flower”) to aid in their learning. In the current study, although both the word (“blicket”) and the gesture (i.e., ASL sign for YELLOW) were novel, the auditory word was a more conventional type of label than the gesture. This may also be why children with larger vocabularies (or more experience with this type of label) were better able to exploit the presentation of the word to learn the gesture.

Although previous studies have proposed that a growing appreciation for words as a function of greater linguistic experience may hinder children’s abilities to learn other types of symbols (Graham & Kilbreath, 2007; Namy & Waxman, 1998; Woodward & Hoyne, 1999), the findings of the current study offer a more nuanced perspective. We propose that 26-month-olds’ specialization or narrowing toward words may actually facilitate and not hinder their learning of other types of symbols depending on how the symbols are presented. For example, in Experiment 1, instead of supplanting gesture, it appears that higher language skills actually fostered gestural learning during the task because of the presence of the word. Perhaps children with larger vocabularies were more efficient in allocating less attention to the conventional type of label (i.e., word) and allocated more attention to the less conventional gesture. Conversely, children with smaller vocabularies may have adopted a less efficient strategy by attending more to the word at the cost of attending to the gesture. Thus, it is possible that more advanced children were particularly efficient in freeing up attentional resources, which enabled them to attend to the co-occurring gestural label. It is also important to note, however, that regardless of their reported vocabulary size, the majority of children in Experiment 1 correctly selected the target object when requested with the either the gestural label (80%) or the multimodal label (96%). This result demonstrates that even children with smaller vocabularies were able to learn both the gestural and multimodal labels. This pattern was not evident for the children in Experiment 2, providing additional evidence that children’s strategies differed as a function of the stimuli they received during training.

Based on the findings, we propose that multimodal input 1) highlighted the nature of the task, 2) improved children’s ability to process and remember both labels, and 3) facilitated their ability to utilize a more conventional type of label or symbol (e.g., word) to learn a less conventional type of label or symbol (e.g., arbitrary gesture). However, because we did not test children’s ability to learn the arbitrary gestures when presented with a word and a gesture asynchronously, we cannot definitively argue that the synchrony between the word and the gesture is what specifically enhanced children’s learning in Experiment 1. It is possible that simply having two sources of information (words and gestures), even when presented sequentially instead of
simultaneously, was enough to facilitate children’s learning. While this possibility was not examined in the current study, research with preverbal infants has shown that children more readily learn new labels for objects when mothers synchronize their communicative gestures with their words than when their communicative gestures are presented asynchronously (Matatyaho & Gogate, 2008). Although it is likely that the synchrony between the words and gestures played an important role in highlighting the importance of gesture for the children in the current study, future research is needed to pinpoint the degree to which synchrony, as opposed to simply having additional sources of information, impacts children’s learning abilities.

One important implication of the current research is that it provides some insight into the ways in which children’s early symbolic development may be enhanced and extended to other aspects of language learning. For example, multimodal input, in the form of auditory words paired with visual gestures, might facilitate language learning in preliterate children in the same way that auditory words paired with visual words (i.e., written text) facilitate language learning in literate children and adults (Kelly et al., 2009; Moreno & Mayer, 2002). For preliterate children, learning to conceptually and linguistically link one type of visual symbol (i.e., gesture) with an auditory word may subsequently transfer to or accelerate their ability to associate other types of visual symbols (e.g., written words, street signs) with auditory words (DeLoache, Simcock, & Marzolf, 2004). As a consequence, it is possible that 26-month-olds’ ability to learn visual gesture–auditory word linkages could facilitate their ability to form similar written text–auditory word linkages during the early stages of reading development. Thus, a task for future research is to explore whether exposure to multimodal input (synchronous or asynchronous) can facilitate both language learning and literacy throughout development.

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