The Effect of Iconicity Type on Preschool Children’s Gesture Learning:
A Role for Embodiment?

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Abstract

Iconicity, or the similarity between a symbol and its meaning, is found in many languages, especially in sign languages. Children use iconicity to facilitate new word learning, although the age when they seem to reliably leverage iconicity varies from study to study. Previous studies have inconsistently classified iconic gesture type, and this inconsistency may have affected their findings and generalizability. We proposed that children might be differently sensitive to iconic gestures with varying degrees of embodiment. Therefore, we categorized iconic gesture types based on level of embodiment, with gestures differing in terms of action and/or perceptual features. We tested adults \( (n = 20) \) and children \( (n = 81) \) on their baseline recognition of iconic and non-iconic gestures that represented familiar objects. Then, we taught the same participants three different types of iconic and non-iconic gestures to determine which gesture types were more easily learned. Results indicated that adults were at ceiling in recognizing and learning all iconic gesture types. Four- to five-year-old children were less accurate than adults, but learned all iconic gesture types equally well. Three-year-old children recognized and learned iconic gestures that had higher levels of action-based embodiment than gestures that represented perceptual features. Therefore, children attend to different features of iconicity throughout development, suggesting that embodiment does play a role in children’s ability to learn gestures.
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From birth, children possess the impressive ability to map meaning to linguistic form, rapidly adding new words to their vocabulary; by 13 months of age, babies can comprehend novel words for objects they have never seen before (Woodward, Markman, & Fitzsimmons, 1999). Children’s acquisition of new words is especially remarkable given the arbitrary relationship between most words and their meanings. Although arbitrary symbols prevail in most languages, iconic symbols, which resemble their referents, are present in all languages, spoken or signed (Perniss, Thompson, & Vigliocco, 2010). In spoken languages, iconic symbols often consist of onomatopoeic words, such as the English word *woof*, in which the word itself mimics the sound associated with the referent to which the word refers. The format of the word, such as the length or number of repeating units contained within it, can also iconically convey meaning (Dingemanse, Blasi, Lupyan, Christiansen, & Monaghan, 2015). For example, the Siwu word *dzoro* refers to something long, but *dzoroo* refers to something very long. Likewise, the Japanese word *kpata* refers to one drop, whereas *kpata kpata* refers to multiple drops (Dingemanse et al., 2015). However, iconic symbols exist more frequently in sign languages because more concepts can be represented in the visual-manual modality than in the aural-oral modality (van der Hulst & Mills, 1996). Given iconicity’s prevalence across languages, can children recognize iconicity and leverage it in word-learning?

In sign languages, iconic symbols often represent visual features of the referent, such as how one interacts with the referent (Figure 1A), the shape of the referent (Figure 1B), or part of the referent (Figure 1C). For example, the sign “HAMMER” in American Sign Language (ASL) depicts the *use* of a hammer with the hands grasping an imaginary hammer. On the other hand,
signs such as the ASL signs for “HOUSE” and “CAT” depict perceptual *shape* features of the referent.

![Figure 1](image)

*Figure 1.* (a) the ASL sign for HAMMER mimics how one uses the object; (b) the ASL sign for HOUSE traces the outline of a prototypical house; and (c) the ASL for CAT depicts part of the object’s shape. Reprinted from “Iconicity Lends a Hand in Language Learning Only After Children Know It’s There,” by R. W. Magid and J. E. Pyers, 2015, *manuscript submitted for publication.*

**Classifying Iconic Gestures**

Similar variability in types of iconicity exists among gestures, yet researchers vary in how they categorize different iconic gestures. For example, some researchers looking at children’s elicited gesture production divide iconic gestures into two subcategories: *imaginary object gestures* or *body-part-as-object gestures* (Overton & Jackson, 1973; Boyatzis & Watson, 1993). Imaginary object gestures depict how one would typically use an object whereas body part gestures use a part of the body, typically the hand(s), to represent an object. On the other
hand, Stefanini, Bella, Caselli, Iverson, and Volterra (2009) categorized iconic gestures as either action gestures (i.e., enactments) or size/shape gestures. Enactments not only include imaginary object gestures, but they also include fully embodied gestures, such as a gesture for lion in which the hands and fingers are outstretched to form a claw-like shape as if one is pretending to be a lion. Embodied gestures reflect a high level of embodiment, or link between the mind’s language processing system and the body’s motor system. Embodied gestures may call upon motor representations or experiences similar to those associated with imaginary object gestures. In contrast, size/shape gestures highlight the perceptual features of the referent, such as tracing the shape of a triangle to gesture the word roof. Other studies do not distinguish among types of iconic gestures and instead condense them into one category. For instance, Acredolo and Goodwyn (1988) defined object gestures as gestures that indicate the presence of an object, without distinguishing between embodiment and body-part-as-object gestures. Their examples included panting to represent dog or stretching the arms out to represent airplane. Whereas the former example seems to correspond to the fully embodied gestures as described by Stefanini et al. (2009), the latter seems to match body-part-as-object gestures, as described by Overton and Jackson (1973). Perhaps the main difference between embodiment and body-part-as-object gestures is that embodied gestures refer more towards other animate beings, whereas body-part-as-object gestures are more reserved for inanimate objects or tools. While imaginary object gestures represent the use of a tool and body-part-as-object gestures represent the form of the tool, embodied gestures may not even involve a tool. This classification may have implications on people’s mapping ability as it may be easier to map one’s body to other animate bodies than inanimate bodies. Children may find gestures that are the most analogically similar to one’s body shape easier to learn than gestures that are not as analogically straightforward. Though Acredolo
and Goodwyn (1988) further dissected their category of object gestures into gestures in which the action is inherent in the referent (e.g., panting for dog) and gestures in which the action can be demonstrated on the referent (e.g., sniffing for flower), they never distinguished between embodied gestures and body-part-as-object gestures in their analysis. The inconsistent classification of iconic gestures in the literature makes it challenging to compare findings on the role of iconicity in language learning.

**Role of Iconicity in Adult Language Learning**

Adults vary in their use of iconicity to aid them in sign language learning, depending on their level of knowledge of a sign language. Sign-naïve adults acquire iconic signs more easily than noniconic signs (Beykirch, Holcomb, & Harrington, 1990; Baus, Carreiras, & Emmorey, 2013). Additionally, while hearing non-signers recalled both iconic and non-iconic signs after a short period of time after the initial teaching, they also remembered iconic signs better in the long-term (Lieberth & Gamble, 1991). In contrast, hearing ASL-English bilingual adults displayed slower recognition and translation of iconic signs compared to arbitrary signs, suggesting that iconicity can actually impede language processing once that language has already been acquired (Baus et al., 2013). Thus, iconicity appears to help people acquire signs if they are in the process of learning a new language but not if they have already learned the language. Iconicity may function similarly for child language learners, helping children first access meaning through sign.

**Production of Iconic Gestures in Childhood**

Children’s ability to produce iconic gestures may be a testament to their understanding of the relationship between a gesture and its referent. By the age of two, children spontaneously produce iconic gestures during interactions with their parents (Özçalıskan & Goldin-Meadow,
2011). However, it is unclear whether their naturalistic productions of iconic gestures are merely imitations of their parents’ gestures, and thus two-year-olds may not actually understand the relationship between iconic gestures and their referents (Özçalişkan, Gentner, & Goldin-Meadow, 2013). Yet, when 2-year-olds are shown novel objects and are asked to convey the use of those objects, they quickly produce appropriate novel iconic gestures (Behne, Carpenter, & Tomasello, 2014), suggesting that in an elicited task, children can independently detect and build connections between a gesture and features of its referent. Without experience with novel objects or a parental source from which they can imitate gestures, children may independently possess the ability to map meaning onto gestures in order to convey a message. Strikingly, in both spontaneous and elicited gesture, two-year-olds produced predominantly action-based gestures, suggesting an early attunement to gestures that encode movement (e.g., Behne et al., 2014; Özçalişkan & Goldin-Meadow, 2011; Stefanini et al., 2009).

Children also produce different types of iconic gestures to varying degrees throughout development. Out of their total iconic gesture production, both spontaneous and elicited, children primarily produce enactments, of which imaginary object gestures are a subset (Acredolo & Goodwyn, 1988; Stefanini et al., 2009). In an elicited gesture task in which children were asked to pretend using instruments, 3-year-old children produced more body-part-as-object gestures, whereas older children favored more imaginary object gestures (Overton & Jackson, 1973; Boyatzis & Watson, 1993), a pattern reflected in adult gesture production (Goodglass & Kaplan, 1963). Overton and Jackson (1973) offer a possible explanation for the greater production of imaginary object gestures by older children: imaginary object gestures may be cognitively harder for children to produce because children have to imagine an invisible object around which they wrap their hands, versus using their body part (e.g., hand) to anchor the intended representation.
(e.g., house). In support of this claim, 3-year-olds poorly imitated modeled imaginary object gestures, but successfully imitated body-part-as-object gestures (Boyatzis & Watson, 1993). Three-year-old children, but not older children, tend to produce body-part-as-object gestures in response to modeled imaginary object gestures, suggesting that young children’s understanding of iconicity may be limited to shape iconicity.

Comprehension of Iconic Gestures in Development

Iconicity does not seem to be readily accessible to children before the age of 2, but as children get older, they develop better comprehension of iconic gestures. For example, children of signing parents acquire both iconic and arbitrary signs throughout development, yet their early productive lexicons, by 18 months of age, does not display a preference for iconic signs over arbitrary signs, suggesting that young children may not tap iconicity when first learning language (Orlansky & Bonvillian, 1984). Similarly, 18-month-old hearing children exhibit no sensitivity to iconicity in mapping novel gestures (Namy, Campbell, & Tomasello, 2004). Yet, during the preschool years, children begin to show an advantage in learning iconic symbols (e.g., Namy et al., 2004; Namy, 2008; Tolar et al., 2008). Research on children’s gesture comprehension has revealed mixed findings about the age when young children acquire the ability to use iconicity to learn new signs. Some research has shown that 2-year-olds reliably recognize iconic gestures more than 14- to 22-month-olds do (Namy, 2008). Namy et al. (2004) tested children’s ability to learn gestures by asking them to match gestures to target objects, after having labeled some target objects with iconic signs and some with arbitrary signs. Whereas 26-month-olds mapped only iconic, but not arbitrary, symbols, showing a distinct preference for iconicity, 18-month olds showed no iconic advantage (Namy et al., 2004). Novack, Goldin-Meadow, and Woodward (2015) also found that while 2-year-olds may not recognize iconicity as well as older children,
they still attend to iconic gestures on more than they attend to pointing gestures. Taken together, these results indicate that 26 months of age seems to be the earliest age at which children begin to appreciate iconicity.

Conversely, other researchers have argued that children begin recognizing iconicity at around 3 years of age but not reliably until they reach 4.5 to 5 years of age (Tolar, Lederberg, Gokhale, & Tomasello, 2008). Contrary to the research suggesting that 2-year-old children can recognize iconicity, Tolar et al. (2008) showed that 2.5-year-old children do not use iconicity when identifying novel iconic signs. One crucial difference was that Namy et al. (2004) taught children gestures, while Tolar et al. (2008) asked children to match a gesture with its referent, with no prior scaffolding. Examining both children’s recognition and learning of iconic signs, Magid and Pyers (2015) also found that 3-year-olds do not recognize shape, or perceptual, iconic gestures above chance, but 4- to 5-year-olds can recognize shape iconic gestures above chance. Other research suggests that 3- to 4-year-olds find function-based gestures are more accessible and aid in word learning (e.g., Goodrich & Hudson Kam, 2009).

One reason for these conflicting findings about the age at which children recognize iconicity may be due to the different types of iconicity examined in these studies. Namy et al. (2004) examined imaginary object gestures and body-part-as-object gestures under one umbrella term of action-based iconic gestures. Goodrich and Hudson Kam (2009) focused predominantly on imaginary object gestures. In contrast, Magid and Pyers (2015) examined only shape iconic gestures that contained no instrumental action, such as the tracing of the perceptual features of the target. Moreover, Tolar et al. (2008) divided iconic gestures into action-based pantomimic, static perceptual, or both pantomimic and perceptual gestures, where pantomimic gestures resembled imaginary object gestures and perceptual gestures resembled stationary body-part-as-
object gestures, similar to Magid and Pyers’ (2015) object gestures. Thus, without a consistent classification of iconic gestures, we cannot readily interpret the differences across studies. Children may perceive and respond to various types of iconic gestures differently. For instance, older children comprehend pantomimic signs more easily than static perceptual signs (Tolar et al., 2008), which suggests that some level of body movement within gestures may be helpful for children to recognize iconicity.

**Embodiment and the Current Study**

Children are highly attuned to the actions associated with the referents of iconic gestures. For instance, children who learn about the actions associated with novel objects first tend to name the objects according to their functional properties whereas children who participate in naming tasks, before learning about the functional properties of objects, first tend to name the objects according to their global, perceptual properties (Kemler Nelson, 1999). At a neurological level, processing language related to actions activates higher level sensorimotor areas (Zwaan, 2004 as cited in Perniss & Vigliocco, 2014). Embodiment theory suggests that physical actions are connected to semantic representations and that gesturing certain actions may activate the semantic representations of those actions (e.g., Perniss & Vigliocco, 2014). Thompson et al. (2012) propose that signing children acquire iconic signs more easily than arbitrary signs because the iconicity of signs often makes the actions of the referents more salient, activating the motor representations of those actions. If iconic gestures help children access the motor representations of actions more readily, then highly embodied signs should be easier for children to learn. Thus, teasing apart the levels of embodiment within different types of gestures is important in determining the effect of iconicity on children’s gesture learning.
Using a novel word-learning paradigm, the current study investigated whether the degree to which a gesture shows embodiment affects children’s gesture comprehension. We examined children’s ability to learn four types of gestures that varied in their degree of embodiment: (1) handling gestures, which depict how one uses an object and have a high degree of embodiment, (2) object with action gestures, which have a reduced level of embodiment because they represent both the shape of the object and the movement associated with the object, (3) object without action gestures, which depict only the perceptual features of the object and thus contain no embodiment, and (4) arbitrary gestures, which bear no resemblance to the object.

Because the frequent use of an object establishes a strong motor representation of that action (Perniss & Vigliocco, 2014), handling gestures may be able to tap into that representation more than any other gesture type. Handling gestures represent the use of the object and engage the body in actions familiar to those enacted regularly in life. Object with action gestures may not trigger as strong of a motor representation because they no longer directly map onto the actions that one might enact regularly. In the gesture, the hand represents the object itself, so while the movement may still be familiar and reminiscent of the action associated with the referent, the handshape no longer maps onto the embodied action, thus resulting in a reduced level of embodiment. Object without action gestures contain no movement or handling element associated with the action, so they do not have any level of embodiment.

We used a fast-mapping learning task, in which children learned gestures through a single exposure to each gesture. Fast-mapping refers to the mental process in which children immediately map meaning onto a concept and retain that information, in this case, between a gesture and its referent (Carey, 1978 as cited in Capone & McGregor, 2005). We tested how well
children would be able to quickly associate a gesture with its referent and recall that association a short time later.

We were interested in how people recognized and learned different types of iconic gestures, so we tested adults to determine adult-like sensitivity to iconicity. We predicted that adults would recognize all types of iconic gestures and learn iconic and arbitrary gestures, equally well.

Crucially, we examined sensitivity to iconicity during the preschool years, when previous studies have observed the greatest transition (e.g., Magid & Pyers, 2015; Tolar et al., 2008). We first wanted to investigate whether children would be able to recognize iconic gestures more frequently than non-iconic gestures. We predicted that all children would be able to detect the iconic relationship between gestures that encoded the actions and their referents (i.e., handling gestures and object with action gestures), since previous research showed that children preferred action-based gestures in both production (e.g., Özçalışkan & Goldin-Meadow, 2011) and comprehension (e.g., Tolar et al., 2008). Additionally, we hypothesized that older children would recognize iconic gestures that did not encode the actions associated with the referents (i.e., object without action gestures), but younger children would lack this ability, replicating the findings from Magid and Pyers (2015).

Second, we wanted to understand whether children could leverage iconicity in order to learn new gestures. We hypothesized that older children would be able to learn more gestures than younger children, regardless of gesture type. We also predicted that older children would learn more handling and object with action gestures than younger children, but only older children would learn object without action gestures. Finally, we predicted that if children did display an iconic advantage in gesture learning, then their advantage would be due to encoding
the iconic relationship during the learning phase of the fast-mapping task and not to recognizing iconicity during the test phase. That is, if children scored significantly higher in the learning task than in the recognition task, we could conclude that children were actually learning gestures in the learning task, instead of merely recognizing the iconicity of the gestures and mapping the gestures to the referents.

Method

Participants

Participants included adults (N = 20, \( M_{age} = 20.85, SD = 1.03 \)), recruited from an undergraduate institution in the Northeastern United States, and children (N = 81, 41 M), recruited from preschools, daycare centers, and children’s museums in the Northeastern United States. The thirty-three 3-year-olds and forty-seven 4- to 5-year-olds ranged in age from 2;11 to 5;6 (\( M_{age} = 4;4 \) years, \( SD = 0.75 \)). Because the study consisted of two tasks, a baseline gesture recognition task and a gesture learning task, administrated in two sessions, separated by at least one day apart, children’s ages were recorded according to the time they participated in the second session when the key gesture learning task was administered.

A total of 77 children completed both tasks. Three children could only participate in one session, so they completed only the learning task. Both tasks were administered to 1 child who refused to participate in either of the tasks. Additionally, 3 children refused to complete the gesture learning task, although they all finished at least half of the task before stopping. Another child observed a different child’s test trials in the gesture recognition task, but the child’s responses did not differ substantially from those of the other children in the same condition and across conditions. The child’s responses only matched on 3 of the observed child’s responses, all 3 of which were the correct choices. Finally, two children turned four between the administration
of the recognition and learning tasks, so their responses were considered part of the four-year-old group.

Data on children’s experience with baby sign were collected from 37 of the participants. Twenty-seven of the thirty-seven children reported experience with baby sign, with three of those children reporting producing at least ten signs.

Overview

Adults were tested individually in a single fifteen-minute session in a quiet room. Following the procedure from Magid and Pyers (2015), adults first completed a gesture recognition task in which they were shown gestures and had to select referents that matched the gestures with no prior scaffolding. Immediately following the gesture recognition task, the experimenter administrated a gesture learning task, in which participants were taught gestures for a series of objects and then tested on how well they remembered those gestures. Children were tested individually in two five- to ten-minute sessions in a quiet room in their school or at the Children’s museum. The procedure was identical to that of adults, except each child received the recognition task in the first session and the learning task in the second session. The tasks were administered at least one day and no more than two weeks apart for each child.

Materials

In the experiment, children each saw four fixed groups of four familiar objects (see Appendix). The familiar objects included items such as backpack, spoon, and hat, which were present in the productive vocabulary of at least 2 children by the age of three (CHILDES, MacWhinney, 2000).

Gesture stimuli development. Many of the iconic gestures included in the study were borrowed from different sign languages around the world that described either the target objects’
shapes or functions. The three types of iconic gestures were assigned to each of 18 total familiar items. In order to verify the iconicity of the gesture stimuli, hearing non-signers ($N = 30, M_{age} = 21.18$ years, $SD = 3.20$) watched short video clips of an experimenter gesturing, with each clip immediately followed by pictures of two familiar items. Through a forced-choice format, participants were asked to select the item that best matched the displayed gesture. The top 16 most accurately identified objects and their gestures were selected to be in the experiment. All were identified accurately at least 90% of the time. Arbitrary gestures, derived from signs in ASL, were also assigned to each of the 16 stimuli. The arbitrary gestures consisted of handshapes that 3-year-old signing children produce, according to the Communicative Development Inventory for American Sign Language (ASL-CDI) (Anderson & Reilly, 2002).

We carefully matched arbitrary gestures to the other three iconic gestures in terms of whether the gestures were one- or two-handed, whether the dominant hand touched the torso or head, and whether the handshapes were symmetrical for two-handed gestures. Therefore, each object had four types of gestures that differed only in embodiment so as to reduce the effect of any confounding variables, such as contact within the gestures. For example, hearing adults acquire signs that involve contact between the hands or between a hand and the body more easily than noncontact signs (Doherty, 1983 as cited in Beykirch et al., 1990). Children tend to prefer unmarked hand shapes too (Anderson & Reilly, 2002), possibly because of the lower complexity in these types of signs (Battison, 1978 as cited in Edmondson & Wilbur, 1996). Similar to the procedure for the iconic gesture norming, we confirmed that the selected arbitrary signs were indeed arbitrary by asking hearing non-signers ($N = 20, M_{age} = 23.80$ years, $SD = 9.42$) to watch the experimenter produce arbitrary gestures, with each gesture immediately followed by pictures of two familiar objects, one of which was designated as the target object. The adults were at
chance ($M = 4.51, SD = 2.16$) in matching the arbitrary gestures to the target referent, $t(15) = .91, p = .38$.

**Iconicity rating.** To confirm the iconicity and arbitrariness of the four types of gestures (three iconic: handling, object with action, and object without action; one non-iconic: arbitrary), hearing adult participants on Amazon Mechanical Turk ($N = 28, M_{age} = 40.49$ years, $SD = 11.14$) completed an online survey in which they watched short video clips of an experimenter gesturing and then rated how similar the gestures were to their respective familiar objects, on a scale from 1 (not at all iconic) to 5 (highly iconic). We excluded 7 participants either because they reported knowing more than just the alphabet in any sign language ($n = 6$) or because they failed the check questions placed there to verify that the participants were attentive to the survey’s instructions ($n = 1$). The participants rated the iconic gestures ($M = 3.25, SD = 0.89$) significantly higher than arbitrary gestures ($M = 1.10, SD = 0.13$), Wilks’ Lambda = .006, $F(3,18) = 1008, p < .001$.

Furthermore, each type of iconic gesture was rated significantly higher than the arbitrary gesture type, $t_{handling}(20) = 48.97, p < .001$, $t_{object \ with \ action}(20) = 43.43, p < .001$, $t_{object \ without \ action}(20) = 12.83, p < .001$. Within the iconic gesture types, participants rated handling gestures ($M = 3.89, SD = 0.24$) and object with action gestures ($M = 3.77, SD = 0.30$) significantly higher than object without action gestures ($M = 2.08, SD = 0.42$), $t_{handling}(20) = 20.50, p < .001$, $t_{object \ with \ action}(20) = 25.87, p < .001$. Handling gestures were not rated significantly higher than object with action gestures ($M = 3.77, SD = 0.30$), $t(20) = 1.66, p = .112$.

**Procedure**

**Design.** The gesture recognition task and the gesture learning task each consisted of a 2x4 mixed factorial design with a between-group factor of age (3-year-olds vs. 4- to 5-year-olds)
and a within-group factor of gesture type (handling vs. object with action vs. object without action vs. arbitrary). We treated the adult data separately from the children’s data so that we could better detect the developmental trends during the preschool years. In the case of the adults, the experiment involved a within-subjects design with four gesture type conditions.

**Gesture recognition task.** In this task, both adult and child participants were asked to choose an object from a set of four objects that matched a gesture produced by the experimenter. Condition order (gesture type) was counterbalanced across participants. The gesture recognition task verified that participants were learning the gestures in the subsequent learning task and not merely relying on the iconicity of the gestures presented during the recall phase to help them map the correct gesture to the referent. As such, the recognition task provided a baseline ability to recognize iconicity for each participant.

For the child participants, the task began with a practice trial in order to familiarize the children with the process of selecting an object after a label is provided for an object. The experimenter started the task by saying, “We’re going to play a guessing game. I’m going to show you some toys, and you’re going to pick the toy that goes with what I say.” One at a time, the experimenter placed a doll and toy chair on the table in front of the child. After introducing the objects to the child, the experimenter said, “It’s your turn to choose the toy that goes with what I say. Which one is the doll?” If the child seemed hesitant, the experimenter further prompted the child by asking the question again. If the child selected the chair, the experimenter provided corrective feedback and re-administered the practice child until the child selected the target object (doll). The order in which the child was presented with either the doll or chair first was counterbalanced across participants. The practice trial was eliminated for the adult participants.
After the practice trial, the experimenter moved onto the test trials by saying, “Some people use sign language and their hands to talk. I’m going to show you a sign, and you’re going to pick the toy that goes with that sign.” The experimenter placed a set of four objects on the table, which consisted of one target object (e.g., object A) and three distractor objects (e.g., objects B, E, and F; see Table 1). The experimenter then called the participant’s attention by saying, “Look at me. Which one is this one (gesture for A)?” The gesture was produced simultaneously with the English word “one.” If the participant did not select an object immediately after seeing the gesture, the experimenter prompted the participant up to three more times by pointing to and naming all of the objects before asking, “Which one is this one (gesture for A)?” If the participant appeared hesitant or admitted uncertainty (“I don’t know”), the experimenter replied, “It’s okay to take a guess.” The experimenter maintained eye contact with the participant so as not to inadvertently guide the participant to select one object over another. The participant received no corrective feedback.

Participants saw a total of eight trials, with two trials in each condition. Specific to the child participants, at the end of the test trials, the experimenter displayed each of the object sets again in front of the child and asked the child to choose his or her favorite toy. Collecting preferences ensured that comparisons could be made between the objects the children selected in the test trials and the objects the children selected as their favorites, so that we could verify that the children were following the instructions of the task instead of choosing their preferred objects in each trial.
**Table 1. Gesture Recognition Task Format.**

<table>
<thead>
<tr>
<th>Objects and gestures</th>
<th>Target (A)</th>
<th>Distractor (B)</th>
<th>Distractor (E)</th>
<th>Distractor (F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Objects</td>
<td><img src="image1" alt="Target" /></td>
<td><img src="image2" alt="Distractor" /></td>
<td><img src="image3" alt="Distractor" /></td>
<td><img src="image4" alt="Distractor" /></td>
</tr>
<tr>
<td>Handling gesture</td>
<td><img src="image5" alt="Handling" /></td>
<td><img src="image6" alt="Object Action" /></td>
<td><img src="image7" alt="Object No Action" /></td>
<td><img src="image8" alt="Arbitrary" /></td>
</tr>
</tbody>
</table>

**Note.** Participants were shown eight gestures total, two of which corresponded to one gesture type. Each participant could score one point for the correct identification of the target object, resulting in a maximum score of 2 per condition.
We excluded examining arbitrary gestures in the recognition task, since we expected participants to be selecting target objects based on chance in that condition. Arbitrary gestures became more important to look at in the learning task to determine if participants were learning non-iconic gestures better than chance, and if participants were learning iconic gestures better than non-iconic gestures.

**Gesture learning task.** In this task, participants were taught one type of gesture for each of the four objects in a set. The set of objects were slight variations of those used in the gesture recognition task. The objects were just different enough (e.g., different color) so that any featural information the participants recognized about the object from the gesture recognition task would not carry over or influence their decisions in the gesture learning task.

In this task, children were first presented with all 32 familiar objects (targets and distractors) so that no item appeared novel in the testing phase. After presenting each toy one by one in the familiarization phase to the child, the experimenter began the practice trial, identical to the one from the gesture recognition task with the doll and the chair. Unlike the gesture recognition task’s presentation as a “guessing” game, the experimenter introduced this task as a “remembering game.” Again, the adult participants skipped this step.

After the practice trial, the experimenter moved to the test trials by saying, “Some people use sign language and their hands to talk. I’m going to teach you some signs for these toys.” The experimenter placed one object at a time on the table in front of the participant and brought the participant’s attention to each object by saying, “Look at this one (gesture for the object). See this one (gesture)? There’s this one (gesture).” The learning process was repeated for each of the four objects in one condition (e.g. objects A, B, C, and D for the handling condition; see Table 2). For each condition, participants were taught four gesture referent mappings, in which the target
object gestures were in the second and third positions, in order to combat possible primacy and recency effects.

Table 2. Gesture Learning Task Format.

<table>
<thead>
<tr>
<th>Objects</th>
<th>Distractor (C)</th>
<th>Target (D)</th>
<th>Target (A)</th>
<th>Distractor (B)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Handling gesture</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Object with action gesture

Object without action gesture

Arbitrary gesture

Note. Participants were taught gestures for four sets of objects and tested on eight of the gestures, two from each condition. Dotted lines surround the target objects that the children were tested on in the test trials.
At the end of each condition’s learning phase, the experimenter administered two test trials for the one set of objects. The experimenter placed four objects on the table, two of which were introduced in the gesture learning phase (e.g. objects A and B) and two of which were introduced in the initial familiarization stage at the very beginning of the study (e.g. objects E and F; see Table 3). The four target-distractor object groups remained consistent from the gesture recognition task.

The experimenter then asked, “Which one is this one (gesture for B)?” If the child was hesitant to respond, the experimenter would prompt up to three more times by pointing to and naming all of the objects before asking, “Which one is this one (gesture for B)? Show me this one (gesture for B). Where is this one (gesture for B)?” The child received no corrective feedback. This process was repeated for another set of four objects (e.g. objects C, D, G, and H where G and H are distractor objects from the familiarization phase).

The learning and test phases in this task were repeated for each of the remaining conditions (e.g., object with action, object without action, and arbitrary). Participants saw all four gesture types; the order in which the conditions were administered was counterbalanced. The gesture types they saw for the target objects in this task were different from the types they saw in the gesture recognition task. For example, a child who saw objects A-D in the handling condition in the gesture recognition task might see objects A-D with arbitrary gestures in the gesture learning task. The layout of the objects in both tasks was randomized so that the target object was in every position over the eight test trials.
Table 3. Example of a test trial layout.

<table>
<thead>
<tr>
<th>Objects and gestures</th>
<th>Distactor (H)</th>
<th>Distactor (G)</th>
<th>Distactor (D)</th>
<th>Target (C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test Trial</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gesture</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Test Trial</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Gesture</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

Note. In each test trial, children were shown one target object, one distractor object for which they were taught a gesture, and two distractor objects from the familiarization phase.

Coding & Scoring
Participants’ choices were coded as correct if the participants correctly selected the target item. Participants could receive a minimum score of 0 and maximum score of 2 in each condition, with a maximum composite score of 8 for each task. All responses were coded during each session, either by the experimenter or a live coder. Nearly fifty percent of the responses were coded online by a second coder through video recordings of the sessions. A second coder online coded the data for 35 children in the recognition task, $\kappa = .996$, $p < .001$, and the learning task, $\kappa = .974$, $p < .001$. A second coder also online coded the data for all 20 participating adults in recognition, $\kappa = .986$, $p < .001$, and learning, $\kappa = .977$, $p < .001$.

**Results**

We used nonparametric statistics to examine the data because the data did not meet the assumption of homogeneity of variance needed to run parametric statistics for some conditions, Levene’s Test, $F(1,74) = 8.81$, $p = .004$. Additionally, because our dependent variable, namely the number of target objects identified, was not truly continuous, nonparametric statistics were the most conservative approach to analyzing the data.

**Adults**

**Recognition.** As hypothesized, adults recognized all three of the iconic gesture types equally well, Friedman Test, $\chi^2 = 4.5$, $p = .105$, although they were not as accurate with the object without action iconic gestures (see Fig. 2). We determined chance performance to be 25% since children were asked to choose from a set of four different objects; as expected, adults matched arbitrary gestures to their target at chance level, Wilcoxon Signed-Rank Test, $Z = 1.134$, $p = .240$.

**Learning.** Contrary to our hypothesis, adults learned all types of iconic gestures better than arbitrary gestures, Friedman Test, $\chi^2 = 9.0$, $p = .029$ (see Fig. 3). Although this significant effect is driven by a small number of errors ($n=3$) in the arbitrary condition, each made by a
different adult participant. The Friedman statistical test may be sensitive to a small number of errors when performance in other conditions is at ceiling.

**Figure 2.** Average number of correct target items selected by adults within each gesture type in the recognition task. Error bars report standard error.

**Figure 3.** Average number of correct target items selected by adults within each gesture type in the learning task. Error bars report standard error.

**Children**

Our samples of 4- and 5-year-olds performed similarly on both the recognition and learning tasks. Give this similar performance and the small sample of 5-year-olds, we combined 4-year-olds and 5-year-olds into one age group under the name of “4-year-olds.” Furthermore,
children who had experience with baby sign were not significantly different from those of children who did not have experience with baby sign in both the recognition and learning tasks, Mann-Whitney Test, $U_{\text{recognition}} = 636.0, p = .876, U_{\text{learning}} = 602.5, p = .710$. Therefore, we did not exclude participants based on their experience with baby sign.

**Recognition.** In agreement with our hypothesis, 3-year-olds reliably matched handling gestures (Wilcoxon Signed-Rank $Z = 1.929, p = .049$) and object with action gestures ($Z = 2.559, p = .009$) to their referents better than chance, but they failed to recognized object without action gestures ($Z = 0.971, p = .307$; see Fig. 4). On the other hand, 4-year-olds reliably matched all of the iconic gesture types above chance, Wilcoxon Signed-Rank Tests, $Z_{\text{handling}} = 3.758, p < .001, Z_{\text{object with action}} = 3.679, p < .001, Z_{\text{object without action}} = 2.100, p = .034$.

Across all age groups, we found that children’s recognition differed significantly across all iconic and non-iconic gesture types, Friedman Test, $\chi^2 = 24.148, p < .001$. Three-year-olds and four-year-olds performed similarly in recognition when performance was collapsed across conditions, Mann-Whitney, $U = 635.50, p = .411$. Children selected their favorite object 36% of the time, and their favorite object matched the target object 18% of the time. Across the iconic gesture types, we found that children did use their preferences in selecting objects, $\chi^2 (7) = 27.71, p < .001$. Within each iconic condition, children used their preferences in choosing objects in response to object with action gestures ($\chi^2 (7) = 21.36, p = .003$) and object without action gestures ($\chi^2 (7) = 21.36, p = .046$). However, children did not use their preferences in choosing objects in response to handling gestures, $\chi^2 (7) = 8.11, p = .323$. Therefore, the results in recognition should be taken with caution.
Learning. As hypothesized, gesture learning increased with age. Additionally, 4-year-olds learned significantly more gestures than 3-year-olds, Mann-Whitney, $U = 390.50$, $p < .001$. This difference was carried by their performance the iconic gesture conditions, Mann-Whitney, $U_{\text{handling}} = 552.00$, $p = .031$, $U_{\text{object with action}} = 383.50$, $p < .001$, $U_{\text{object without action}} = 497.00$, $p = .013$, not the arbitrary gesture condition, $U = 603.00$, $p = .089$.

In order to determine how reliably children learned gestures, we compared their performance in each condition to chance. Because 32 three-year-olds and 31 four-year-olds selected at least one of distractor objects introduced in the familiarization phase during the fast-mapping test trials, chance was determined to be 25%. Three-year-olds displayed similar trends as they did in the recognition task, learning handling gestures (Wilcoxon Signed-Rank Tests, $Z = 2.677$, $p = .005$) and object with action gestures ($Z = 2.6882$, $p = .006$) significantly better than chance (see Fig. 5). They did not learn object without action gestures ($Z = 1.414$, $p = .178$) or arbitrary gestures ($Z = 0.582$, $p = .646$) significantly above chance. Similar to their trends in
recognition, four-year-olds learned all three types iconic gestures, Wilcoxon Signed-Rank Tests, $Z_{\text{handling}} = 5.503, \ p < .001$, $Z_{\text{object with action}} = 6.131, \ p < .001$, $Z_{\text{object without action}} = 4.619, \ p < .001$, and arbitrary gestures, $Z = 1.984, \ p = .0496$, significantly above chance.

With the p value set at .008 to correct for multiple comparisons, we found that children’s learning differed significantly across all gesture types, Friedman Test, $\chi^2 = 46.633, \ p < .001$.

Three-year-olds learned object with action gestures (Wilcoxon Signed-Rank Tests, $Z = 3.258, \ p = .001$) significantly better than arbitrary gestures. Additionally, they learned handling gestures marginally better than arbitrary gestures ($Z = 2.610, \ p = .009$), but they did not learn object without action gestures ($Z = 1.725, \ p = .084$) better than arbitrary gestures. Four-year-olds learned handling gestures ($Z = 3.607, \ p < .001$) object with action gestures ($Z = 3.607, \ p < .001$), and object without action gestures ($Z = 3.607, \ p = .003$), significantly better than arbitrary gestures. Furthermore, children learned object with action gestures significantly better than object without action gestures, Wilcoxon Signed-Rank Test, $Z = 2.880, \ p = .004$. 
In comparing children’s scores in the fast-mapping task to their scores in the recognition task, we hoped to determine whether children were actually encoding iconicity during the learning phase instead of recognizing iconicity during the test phase. In line with our hypothesis, 4-year-olds scored significantly higher in the learning task than in the recognition task, indicating that they were actually learning and encoding iconic gestures, Wilcoxon Signed-Rank Tests, \( Z_{\text{handling}} = 2.976, p = .003, Z_{\text{object with action}} = 3.892, p < .001, Z_{\text{object without action}} = 2.953, p = .003 \).

Contrary to our hypothesis, 3-year-olds did not score significantly higher in the learning task than in the recognition task, Wilcoxon Signed-Rank Tests, \( Z_{\text{handling}} = 1.173, p = .241, Z_{\text{object with action}} = -0.465, p = .642, Z_{\text{object without action}} = -0.871, p = .384 \). Only when comparing composite recognition scores to composite learning scores, which each take all four gesture types into account, did we see 3-year-olds score significantly higher in learning than in recognition, \( Z = 2.412, p = .016 \). However, performance in the arbitrary condition likely drove this effect.
Discussion

The current study investigated children’s ability to recognize and learn different types of iconic gestures by examining which iconic features were most salient for children. Researchers have disagreed on the age at which children begin to appreciate iconicity. We speculated that this disagreement may result from the inconsistent operationalization of iconic gestures. We hypothesized that highly embodied gestures may help children more strongly tap into their motor representation for the action associated with that referent, in turn making the iconic relationship more accessible.

The results from the current study indicated that adults reliably recognized all types of iconic gestures and performed at ceiling for learning iconic gestures. Hearing non-signing adults participated in this study, and they performed similarly to second language learners of sign languages in that they readily used iconicity in word learning (e.g., Baus et al., 2013). Iconicity helps adults strengthen the connection between a symbol and its referent. The significant difference between adults’ performances across the iconic and arbitrary conditions is likely due to the sensitivity of the statistical test, yet we cannot ignore that adults performed so strongly in all of the iconic conditions and relatively weakly in the arbitrary condition. The results suggest that iconicity provides adults with some benefit in language learning. Thus, while type of iconicity may not matter for adults, iconicity nevertheless proves beneficial to adult sign learning.

Across all three age groups (3-year-olds, 4- to 5-year-olds, and adults), participants generally correctly remembered the target objects more often in the iconic conditions, suggesting that regardless of age, iconicity is useful in learning gestures. At age 4 or 5, the ability to learn gestures becomes more adult-like, as the older children in our study learned iconic and arbitrary
gestures above chance. Thus, while the extent to which iconicity affects learning improves throughout development, all ages still find iconic gestures easier to recall than arbitrary gestures.

Preschoolers displayed more variable recognition of different types of iconic gestures compared to adults, and children’s ability to recognize certain types of iconic gestures increased with age. While 3- to 5-year-olds reliably recognized iconic gestures that represented the action associated with the referent, only 4- to 5-year-olds could also recognize iconic gestures without embodiment. Thus, an embodied element of iconicity may be the easiest for children to detect, but they broaden their ability to tap different forms of iconicity as they get older.

A key feature of an embodied gesture is the presence of movement, associated with the action of the referent. Marentette and Nicoladis (2011) highlight children’s bias in detecting action as a defining feature of a gesture. When preschool-aged children were presented with a set of multiple novel objects, they more frequently identified the target object when they saw an iconic action-based gesture than when they saw an arbitrary gesture or were provided with the target object’s novel name. In other words, when they saw an iconic gesture involving movement, they chose the object that had the potential to function according to the action encoded in the gesture. Therefore, children construed iconic gestures as action associates, indicating that children are extremely sensitive to movement and expect gestures to reveal information about a referent’s function or use (Marentette & Nicoladis, 2011). Children also may find the element of action encoded within an iconic gesture helpful in acquiring action-based words. Iconic handling gestures that depicted the path of motion helped preschoolers identify the meaning of novel spoken verbs (Goodrich & Hudson Kam, 2009). In other words, children were able to fill in gaps in their semantic knowledge (i.e., the novel verb) from gestural cues, suggesting that iconic gestures with action elements may help children access motor information about a referent.
In the current study, 4- to 5-year-olds even learned object with action gestures better than object without action gestures. The two types of gesture types were identical except for the movement. On the other hand, we observed no statistical difference between recognizing and learning handling gestures over object without action gestures. Taken together, these results indicate that a combination of perceptual and action features of object with action gestures are the most readily accessible for children. Handling gestures, in contrast to object with action gestures, shared a very common handshape, with the hand(s) in fist-like forms. The only way to distinguish one handling gesture from another was in the movement and placement of the gestures. In contrast, object with action gestures clearly defined the perceptual features of the referent and contained an element of semantically relevant movement. Children may more easily map and learn object with action gestures, and not handling gestures, compared to object without action gestures because object with action gestures have the added benefit of perceptual distinguishability. Research has provided evidence that children attend to both shape (e.g., Gershkoff-Stowe & Smith, 2004) and function (e.g., Marentette & Nicoladis, 2011) when learning new words or generating novel mental representations of objects. Yet, previous studies have treated shape and function iconic gestures as separate entities, separating iconic gestures into general action-based or static shape-based gestures (e.g., Özçalışkan & Goldin-Meadow, 2011). The results of the current study suggest that perhaps shape and function are not as binary, and gestures that combine the two provide children with the most benefit in recognizing and learning iconicity.

Familiarity may also influence children’s ability to recognize and learn iconic gestures. Embodiment theory suggests that frequent use of objects strengthens the mental links between the objects and their associated actions. In other words, perhaps familiarity with objects in the
current study allowed children to use their motor representation for those objects to better map meaning onto the iconic gestures. In support of a familiarity effect, children match iconic gestures to pictures more readily when experimenters label the referent than when they do not (Tolar et al., 2008), suggesting that some prior knowledge of the referents may help children better map the iconic gestures onto the referents. Namy (2008) also performed actions on the objects before testing children’s ability to recall iconic signs. This scaffolding may provide children with additional experience with the referents, perhaps leading to why children as young as 2-years-olds were able to recognize iconicity. Additional experience with the referents right before the test trials may be crucial to children as young as 2 years old to recognize iconicity.

In our study, children did not seem to recognize or learn static shape iconic gestures to extent that Magid and Pyers (2015) reported in their study. While Magid and Pyers (2015) found no effect of movement in their gesture stimuli, our results appear to hinge on movement. Due to analogous study designs, we can compare the two studies fairly easily. Though Magid and Pyers (2015) showed that children recognized iconic gestures for familiar and novel objects similarly, their findings may be a result of the stimuli that they chose to use in the study. In the current study, we used instruments as our stimuli, and our gestures reflected actions that could be acted upon the objects. In contrast, Magid and Pyers (2015) used non-instrumental gestures, such as the tracing of the shape of an object. Gestures involving actions that have an action-directed goal may have stronger motor representations than gestures that do not reflect commonly performed actions. Novack et al. (2015) found that children as young as 2 years of age can infer novel actions from iconic action-based gestures that involve instruments. Gestures about objects that can be acted upon may be more accessible to children because children’s interactions with objects may help them build a motor representation that becomes part of the meaning of their
word. In addition, these instrumental gestures may be more similar to the gestures that they produce spontaneously (e.g., Özçalişkan & Goldin-Meadow, 2011). Again, movement seems to be critical in children’s ability to recall iconic gestures.

Yet, despite working with familiar objects, the children in the current study did not score as highly in recognizing and learning iconic gestures, compared to previous studies (e.g., Magid & Pyers, 2015). A possible explanation for children’s low scores in recognition may be that in recognition, the 3- to 5-year-olds generally made their selections after the first presentation of the gesture, instead of waiting for the three presentations of the gesture. In the fast-mapping task, children were exposed to the gestures at least three times in the learning phase before they had to identify the referent object in the test phase. It may be the case that children may recognize iconicity better with more repeated exposures to the iconic gestures. One point of evidence against this reasoning is the statistically equivalent performance of the 3-year-olds in both the recognition and learning tasks. Thus, it seems that 3-year-olds’ performance in the fast-mapping task could be driven by a general ability to recognize iconic signs during the test phase rather than encoding iconic signs in the learning phase.

Future research should focus on determining what type of movement is essential to children’s understanding of iconicity. In the current study, we cannot concretely determine whether embodiment truly influences children’s iconic gesture learning, or whether non-meaningful movement in signs enhances learnability. We speculate that the latter is not likely the case because all of the arbitrary signs in our study contained non-meaningful movement, and Magid and Pyers (2015) report no effect of non-meaningful movement in their iconic shape gesture condition. Instead, theories of embodiment suggest that using hands to perform and process certain actions activates sensorimotor areas in the brain (Hostetter & Alibali, 2008),
suggesting that gesturing actions may help stimulate the motor representation of that action in the brain. For example, when people retrieve words from categories that have a strong motor association (e.g., tools), the left premotor area in the brain is activated, indicating that semantic features of words can activate the motor representations of those words (Iverson & Thelen, 1999). We speculate that children in our study, upon seeing a familiar target like a broom, activated an embodied motor representation of that object. Therefore, when they were presented with an iconic sign that represented the action of sweeping, they mapped the gesture to their motor representation. If children lacked the familiarity with an object and its associated action, then their embodied motor representation was not as strong and thus children may be less likely to map the iconic sign to their motor representation.

Does the action of the gesture have to be restricted to the part of the object that gives the object its function, or is the type of action unimportant and movement alone enough to activate the sensorimotor areas in the brain? In the current study, the action-based gestures varied in what part of the item was moving. For example, the object with action gesture for “broom” involved the moving the hands, which were outstretched and inverted so that the palms were facing the chest and the fingers were pointed downwards, in a back-and-forth brushing motion. As such, this gesture conveyed motion in the part of the object (i.e., the bristles) that gave the object its defining function (i.e., to sweep the floor). In contrast, the object with action gesture for “paintbrush” involved moving one hand, with the pointer finger extended, in a wave-like pattern across the open palm of the other hand. Unlike the gesture for broom, the gesture for paintbrush makes no distinction between whether the movement is restricted to the bristles only or to the entire paintbrush, including the handle. Enactment gestures, specifically with a semantic rather than phonological iconicity, help adults recall signs better than meaningless hand motion or
referent visualization alone, suggesting that embodied movement and mental imagery combined facilitate understanding between signs and their referents (Morett, 2015). If children learn better when the movement is restricted to the part of the object that gives it its function, then children may use specific function-related movements to form connections between gestures and their referents, supporting the theory of embodied cognition. However, if children learn equally, regardless of where the movement is contained, then children may not be activating their motor representation associated with that action in learning gestures.

Iconicity remains crucial in children’s symbolic development, though the ability to use iconicity varies with age. Specifically, 3-year-old children show an advantage in reliably recognizing movement-based gestures more than they recognize static iconic gestures. Furthermore, gestures that combine both action-based and perceptual features seem most accessible to preschool-aged children, though children lose that preference as they transition into adulthood. The findings from this study emphasize the importance of categorizing iconicity to understand which aspects of iconicity are the most accessible early in development. In a world where children are constantly exploring and acquiring new information at a rapid pace, their growth in understanding iconicity may be linked to their experiences with many actions, giving more support to the theory of embodied cognition in language processing.
References


Graphic depicting the target-distractor object sets, organized by position on the table facing the participants, in the recognition task. The learning task consisted of the same stimuli, just of different colors, patterns, and sizes. The black border denotes the target object in each set.