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Does Iconicity Matter? Deaf and Hearing Preschoolers' Sensitivity to Symbols' Form-Meaning Similarities

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Deaf and Hearing Preschoolers’ Sensitivity to Symbols’ Form-Meaning Similarities

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Abstract

Iconicity, the relationship between a symbol’s form and its meaning, is an inherent part of sign languages, as both signs’ referents and signs themselves exist in physical space. Adult learners of sign languages are able to take advantage of iconicity. This paper explores whether preschoolers are sensitive to the iconicity of signs and use form-meaning mappings in language learning like adults. Experiment 1 tested the ability of 87 hearing children, ages 3 to 5 years, to recognize the iconicity of signs that describe the shape of objects. Experiment 2 assessed 82 hearing 3- to 5-year-olds’ memory for iconic and arbitrary signs to see whether children take advantage of the similarities between iconic signs and their referents to learn new signs. Experiment 3 considered the same abilities in 27 deaf children learning American Sign Language (ASL) to explore whether the modality of the language one is acquiring affects iconicity recognition and use.

Children recognized iconic signs with familiar referents as well as those with unfamiliar referents, implying that previous experience with a referent does not mediate recognition of iconicity. Hearing and deaf 4- and 5-year-olds reliably recognized iconicity ($p = .001$), while 3-year-olds recognized iconic signs only at chance ($ps > .05$). Accordingly, hearing 4- and 5-year-olds benefitted from iconicity in a fast-mapping task, and learned iconic signs better than arbitrary ones ($p = .015$), and older deaf children showed a similar pattern in their sign learning ($p = .07$). Children seemed to recognize perceptually iconic signs that describe shape later in development than function iconic signs that mimic how to use an object, and perform equivalently when signs’ referents are familiar or novel objects. Despite iconicity’s prevalence in sign languages but not spoken languages, preschoolers’ use of iconicity does not depend on the modality of the language they are acquiring.
Does Iconicity Matter?

Deaf and Hearing Preschoolers’ Sensitivity to Symbols’ Form-Meaning Similarities

During the preschool years, children must tackle the task of learning countless new words. For most children, this process happens automatically, by actively attending to the language used in their environment and by making inferences about words’ meanings based on context (Carey, 1977) and syntax (e.g. Arunachalam & Waxman, 2010). Children use context and syntax to determine a word’s meaning from the form of the word when the form is completely arbitrary as is the case with most spoken word, but what process do children use during learning when the form of a symbol is related to its meaning? The current study investigates 3- to 5-year-olds’ ability to recognize and remember a symbol’s meaning when there is a transparent relationship between the symbol’s form and meaning.

Iconic symbols, such as the onomatopoeic English word *boom*, share features with the concepts they describe. In other words, the phonology of *boom* recreates the sounds it represents. Four-year-olds learning Japanese, a language with substantial onomatopoeia, can generalize the principles of onomatopoeia to understand the meanings of both known and novel onomatopoetic words (Haryu, 2010). In general, spoken languages afford limited opportunities for iconicity, because vocal symbols are emitted using sound waves and therefore can only iconically describe sound-related representations. The visual-manual modality of sign languages and gesture lends itself well to iconicity, as objects, signs, and gestures all exist in the same perceptual, in this case physical, space (Bosworth & Emmorey, 2010). For example, the sign TREE in American Sign Language (ASL) is iconic in its depiction of the object’s shape, with the forearm held upright to represent the tree’s trunk and the hand spread open to represent the tree's branches (see Figure 1).
Similarly, gestures are iconic when the form, and movement, of the hands relates to the semantic content of a speaker’s message. If there are two baskets displayed in a shop window, a customer might make an iconic gesture to clarify which basket he is interested in purchasing (see Figure 2). In this way, iconic gestures supplement information in speech and can clarify meaning (McNeill, 1985).
The speaker uses an iconic gesture to describe the shape of the basket (a).

Iconicity can take many forms (for a review see Bellugi & Klima, 1976, and Taub, 2001). The current study investigates children’s understanding of perceptually iconic gestures and signs for objects, where the hands and arms describe the referent’s shape, as seen in the ASL sign TREE and the gesture for the basket described above (see Figures 1 and 2), as opposed to iconic signs or gestures that employ pantomime, where the signer mimics a behavior associated with an object or action.

**Symbolic Gesture**

Children’s spontaneous production of iconic gestures provides compelling evidence for children’s ability to understand symbol-referent connections, because if children can produce an iconic symbol, they may have an implicit understanding of how symbols and referents relate.
Infants develop both gestural and verbal symbols at roughly the same time in development, yet a statistically insignificant time lag exists between the first production of symbolic gesture and the first production of symbolic word. This lag might exist because gestures are initially easier for children to articulate, but the development of memory and certain requisite cognitive skills need to be attained before children can produce any kind of symbol (Goodwyn & Acredolo, 1993). Together with the maturation of articulators, reaching these cognitive milestones determines when children will start to use symbolic gesture.

Children begin to produce iconic gestures during their second year, but these gestures are most commonly enactments rather than descriptions of objects’ shapes or features like those often produced by adults (Acredolo & Goodwyn, 1988). At 18 months, toddlers interpret gestures as symbols, but at 26 months, they prefer to accept spoken words as symbols. However, after a training period where the 26-month-olds were taught and encouraged to use gestures, they accepted gestures as symbols, implying that children begin life without a bias toward spoken-language symbols, but later form a bias as they begin to combine multiple spoken words (Namy & Waxman, 1998). While children, including preschoolers, produce iconic gestures (Boyatzis & Watson, 1993), their understanding of the iconic relationship between a gesture and its referent may be weak. In their gesture production, children may be modeling their caregivers and not exhibiting a deep understanding of iconicity. This paper explores children’s ability to recognize the connections between iconic signs and their referents to determine whether preschool-age children are explicitly aware of inherent symbol-referent relationships.

Analogical Reasoning: Overcoming the Dual Representation Problem

An iconic symbol is analogical in that information about the referent is embedded in the symbol’s form. Studying children’s appreciation of models as stand-ins for real-world objects
provides us with a basis for how children interpret symbols, and addresses whether children are sensitive to the analogical relationship between a symbol and its meaning. The model-object connection (i.e., understanding that a toy car is a model for a larger functional car) is not always easy for children to grasp and develops with age. By 18 months, children have a fragile comprehension of the toy-real exemplar relationship, but show a solid understanding of this connection by 26 months (Younger & Johnson, 2004). Increasing the similarities between the model and the real-world object improves children’s understanding of their relationship. For example, preschoolers are better able to find a hidden toy in a matching room when the setups of the rooms are similar in terms of furniture as well as similar in terms of size, and older children understand the significance of models better than younger children (DeLoache, Peralta de Mendoza, & Anderson, 1999).

Children depend on similarity, or iconicity, to make the mapping between two similar setups. The scale models in these experiments were both real-world objects themselves as well as symbols. The reason younger children struggle with this task could be that they have difficulty constructing dual representations for the model—the room as a scale-model and the room as its own object (DeLoache, Kolstad, & Anderson, 1991). Iconic signs might be challenging for children to interpret, as they are not only symbols but also are distinct entities themselves, just like models are both objects themselves as well as symbols. Perhaps once a child has sufficient experience with symbolic materials—either models or gestures—the child can master the dual representation problem and appreciate symbol-referent relations (DeLoache, Peralta de Mendoza, & Anderson, 1999).
Children’s Developing Ability to Interpret Iconicity

The ability to recognize iconicity develops during early childhood, and the type of iconicity, method of labeling, as well as children’s experience with referents likely affect this ability. Eighteen-month-olds and 4-year-olds can map both arbitrary gestures, such as touching one’s index fingers together to mean *bunny*, as well as iconic gestures, onto familiar objects, while 26-month-olds only map iconic function gestures (Namy, Campbell, & Tomasello, 2004). The changing nature of children’s sensitivity to iconic gestures suggests that an intriguing pattern unfolds during development. While 18-month-olds can map iconic and arbitrary symbols onto their familiar referents, 26-month-olds seem attuned to gestures only when those gestures describe a relevant function. Their expectation for iconicity may prevent them from mapping arbitrary gestures. Because this pattern of increased sensitivity to only iconic gestures reverts at 4 years, children likely lose their bias for iconicity rather than lose their ability to recognize iconicity. Testing children who are between the ages of 26 months and 4 years on their ability to map iconic signs to their referents with a single sign presentation using novel objects would help to determine whether 26-month-olds’ selective mapping of only iconic gestures is due to a recently acquired and reliable ability to recognize iconicity under a variety of circumstances or rather a nascent understanding of function iconicity, which is only engaged after extensive experience with referents.

Children’s willingness to accept iconic gestures as demonstrated in Namy et al. (2004) does not directly answer questions about children’s ability to understand the relationship between an iconic gesture’s form and its meaning. Twenty-six-month-olds who were introduced to novel and familiar objects’ functions and interacted with those objects by demonstrating the functions themselves reliably selected the related referent when shown an iconic function gesture (Namy,
Therefore, when the experimenter draws attention to an object’s function and the child has the opportunity to manipulate the object, 26-month-olds can recognize iconic function gestures. Similarly, 2-3- and 4-year-olds who saw novel actions performed with novel toys selected the correct referent for the function gesture at an above-chance level (Goodrich & Kam, 2009). However, children may not necessarily interpret these function gestures as symbols, but instead may treat the function gestures as an explanation about how to use a given object. Therefore, their facility with object-function matching tasks may be the result of their ability to connect a function with an object as opposed to a symbol with an object.

Children’s ability to take advantage of the iconicity in perceptually iconic signs, which describe the shape of their referents, has been considered in terms of semantic representation. Children 2.5 years old retrieved novel words they had heard accompanied by gestures describing shape more often than words they had heard accompanied by function gestures during subsequent picture naming (Capone & McGregor, 2005). Toddlers’ word retrieval might be enhanced by perceptually iconic gestures in this case because they retrieved words by looking at pictures of the words’ referents, which inevitably portrayed the perceptual features of the objects. However, the method of this study did not address questions related to whether children can successfully map perceptual iconic signs onto their referents.

The type of iconic sign, as well as children’s familiarity with the referent, may differentially affect children’s abilities to discern iconic relationships depending on the age of the child. In a study using a multiple-choice format, hearing preschoolers matched highly iconic signs in ASL with their familiar referents at an above-chance level (Tolar, Lederberg, Gokhale, & Tomasello, 2008). Four- and 5-year-olds recognized significantly more of the iconic signs than did 2.5- or 3-year-olds, a developmental trend not observed in Goodrich and Kam (2009).
Children younger than 4 years did not select the correct referent at an above-chance level when they could not label the referent in English. In other words, younger children only seemed to recognize iconicity when they were familiar enough with the referent to provide a label. Four-year-olds performed well on the sign-referent matching task, regardless of whether they could label the referent, implying that the amount of experience a child has with a given object might mediate their ability to recognize iconicity, where younger children have less experience with objects that they could not label, and therefore had weaker sign-referent matching abilities.

In addition, children performed better with pantomimic, or function, signs than with perceptual ones. In other words, when children were shown signs that described an object’s function as opposed to an object’s characteristics including shape, they were more likely to select the correct referent. The experimenter in Tolar et al. (2008) provided children with corrective feedback when they chose the wrong referent for a given sign during six practice trials. The experimenter also drew attention to a sign’s iconicity by forming the sign with the hand directly in front of the picture of the referent. This type of corrective feedback and instruction may have called attention to iconicity and led children to identify more referents than they would have otherwise.

Together, the findings that young children can map iconic function gestures onto familiar and novel referents (Namy, 2008), guess the meaning of a verb from its accompanying function gesture (Goodrich & Kam, 2009), benefit from perceptually iconic signs during encoding (Capone & McGregor, 2005), and select the referent for highly iconic ASL signs at an above-chance level (Tolar et al., 2008), suggest that iconicity is salient for children during tasks when the similarities between objects and their gestures are highlighted. Still, the ability to spontaneously recognize the iconicity of symbols seems to develop with age. Moreover,
perceptual signs (i.e., signs that describe the characteristics of an object including its shape) seem to be less transparent for children than iconic signs depicting function that involve embodiment, or acting out how one handles an object. Perhaps children can reliably recognize function iconicity but not shape iconicity during the early preschool years because signs that depict objects’ functions are likely highly relevant to children’s own experiences, since children interact with objects in ways that are outlined by iconic function signs. In other words, the form of the hands in the gesture mimics the form of the hands when one acts on the object. Additionally, the tasks that tapped children’s mapping abilities with iconic function signs offered demonstrations of the objects’ functions and encouraged children to interact with the object in a functionally-relevant manner by producing the object’s desired function. This type of interaction, as well as providing corrective feedback for children’s incorrect choices, draws attention to iconic signs’ relevance, and may support a nascent understanding of iconicity. For example, children as young as 3 years can pretend to brush their teeth with an imaginary toothbrush, employing a gesture remarkably similar to the action of brushing (Boyatzis & Watson, 1993). In order for children to recognize signs that iconically describe shape without manipulating the object or being shown characteristics of the object’s shape, children would have to identify prominent features of the shape of the objects and signs on their own, a potentially more cognitively difficult task. Therefore, the question of whether children can perceive the similarities between iconic signs and their unfamiliar referents whose properties they have yet to discover remains unanswered.

Accordingly, iconic signs and gestures are not always transparent enough to convey meaning for children or to confer an advantage in all task types. Hearing children ages 4 – 5 years who saw only the ASL sign for an object guessed the object’s function correctly only 6% of the time (Markham & Justice, 2004) and succeeded more often on counting tasks when they
used arbitrary counting words, such as *seven* and *eight*, as opposed to iconic gestures—in this case their fingers—to represent numbers (Nicoladis, Pika, & Marentette, 2010).

Testing 3- to 5-year-olds’ ability to recognize perceptual iconicity with a single sign presentation will inform our understanding of the robustness of preschoolers’ ability to map iconic gestures onto their corresponding objects. Whether iconicity contributes to word learning for children who recognize iconic relationships remains unclear. The first study to empirically investigate iconicity’s role in word learning with 12 children found that 4- to 5-year-olds retained iconic signs for familiar objects over a short period of time better than arbitrarily-linked signs for the same objects (Brown, 1978).

**Signers’ Understanding and Use of Iconicity**

Just as hearing children must learn to relate spoken words and their meanings, deaf children learning a sign language must develop an understanding of the relationship between signs’ forms and their meanings. While all hearing (sighted) children have access to gestures in the visual-manual modality, their primary spoken language affords limited opportunities for iconicity. On the other hand, children learning a sign language are exposed to symbols that have both iconic and arbitrary relationships to their meanings, because signs can have either iconic or arbitrary forms.

While the relationships between iconic signs and their referents are apparent, not all iconic signs are transparent, in that naïve observers may not be able to easily guess the meaning of signs that are considered to be iconic (Bellugi & Klima, 1976). For example, to make the ASL sign *BOY*, one grabs an imaginary baseball cap near the forehead. While this sign is iconic in that it is related to its referent, a non-signer would probably not be able to guess its meaning. Similarly, various sign languages around the world have different, yet often iconic, signs for the
same concept. In Turkish Sign Language (TID), one element of the sign BOY is the tracing of a mustache on one’s upper lip (See Figure 3). Both the ASL and TID signs for the same noun are iconic, but each sign represents a distinct characteristic of the noun. Although they share some properties, pantomime and iconic language are distinct because in iconic language, one symbol is chosen to represent one referent and becomes part of the lexicon, despite the fact that one could represent that idea or object iconically in many other ways (Taub, 2001). Additionally, the ability to interpret the iconicity of signs depends on several factors unique to each person, including mental models for a given concept, cultural associations, and personal experiences.

Figure 3. The ASL sign BOY (a) and the TID sign BOY (b) are both iconic, yet different.

Sign languages, because of their visual-manual modality, afford more opportunities for iconic symbols than do spoken languages. How do deaf children interpret iconic symbols, which are built into the language they are acquiring? We were interested specifically in deaf children’s ability to recognize the similarities between signs and their referents, and whether they use these similarities to support sign learning during the preschool years.
For hearing individuals with a fully developed native language and the requisite cognitive skills to identify similarities between iconic signs and their referents, iconicity confers an advantage. For adults learning a sign language as a second language, iconic signs are remembered better than non-iconic signs (Beykirch, Holcomb, & Harrington, 1990; Lieberth & Gamble, 1991). Additionally, iconic gestures can enhance foreign language learning even with spoken languages. Pantomimic iconic gestures presented in conjunction with foreign words led to better word learning in hearing adults (Macedonia, Müller, & Friederici, 2011). Hearing adults also rated iconic signs higher than metaphorical or arbitrary signs on scales that assessed the degree to which the signs had obvious relations to their referents, made sense, and seemed natural (O’Brien, 1999).

However, evidence from research with hearing adults suggests that iconicity is not always transparent. Non-signing adults were able to guess the exact meanings of isolated signs approximately 9-10% of the time (Bellugi & Klima, 1976) and 21% of the time when the iconic signs were selected based on their use enhancing communication with intellectually-disabled people (Griffith, Robinson, & Panagos, 1981). Without information about context for iconic signs, even such signs are unlikely to convey meaning on their own.

Iconic signs seem to facilitate word retrieval for signers in some circumstances but not in others. Semantically related signs and iconic signs were no easier for signing adults to recall than were unrelated or non-iconic signs (Poizner, Bellugi, & Tweney, 1981). Semantically related primes facilitated recognition but iconic primes had no effect on speed or accuracy of recognition for signing adults in a lexical access task (Bosworth & Emmorey, 2010). When native signers perceive motor-iconic verbs, or verbs that depict an object’s function, such as HAMMER in ASL, identical patterns of neural activation occur as when they see non-iconic, or arbitrary,
verbs. Moreover, similar neural regions within the left premotor and left inferior parietal cortex are activated when English speakers and ASL signers name tools or name actions performed using tools (Emmorey et al., 2004). Signs with pantomimic properties activate language and not motor areas of the brain, implying that native signers do not process iconic signs differently than arbitrary signs. However, in a sign-picture matching task, native ASL signers responded faster when an iconic property of a sign was visually apparent in a target picture (Thompson, Vinson, & Vigliocco, 2009). Deaf 3rd, 4th and 5th graders exposed to sign language had faster sign recognition times with iconic signs (Ormel, Knoors, Hermans, & Verhoeven, 2009).

Perhaps when the saliency of a sign’s iconic features are highlighted sufficiently in the target picture, signers will show enhanced performance. However, when considering iconic signs in isolation, iconicity does not seem sufficient to enhance sign or word retrieval for signing individuals.

Observationally, children who are native signers do not show a bias early on for learning iconic signs because hearing and deaf children born to deaf parents appear to acquire iconic and arbitrary signs with equal facility. In a case study with a native British Sign Language (BSL) user, no more than 20% of the signs he produced between the ages of 1;10 and 2;5 were iconic (Morgan, Barriere, & Woll, 2003). Less than one-third of 13 native signing children’s first 10 signs were iconic. Thirty-six percent of children’s vocabularies at 13 months were iconic and 33.7% of their vocabularies at 18 months were iconic (Folven & Bonvillian, 1991; Orlanksy & Bonvillian, 1984).

The relevance of the findings from Folven and Bonvillian (1991) and Orlanksy and Bonvillian (1984) depends heavily on the proportion of iconic signs relative to all signs in ASL. If only 10% of signs in ASL are iconic, then the fact that one-third of children’s signs at 18 months are iconic would imply that children learn relatively more iconic signs than arbitrary
ones. Wescott (1971, as cited in Orlanksy & Bonvillian, 1984) surveyed an ASL dictionary and found that approximately two-thirds of the signs therein were iconic in some manner. The proportion of signs with iconicity accessible to children with limited exposure to the signs’ referents is unknown. However, from this preliminary assessment, deaf children do not seem to have a bias during their first two years for learning iconic signs and, in fact, they seem to learn proportionally more arbitrary signs.

Research on native signing children’s errors also supports the conclusion that signing toddlers are not biased towards producing iconic signs. In a corpus of four native signers’ signs between the ages of roughly 1 and 2 years of age, children’s versions of signs were either equally as iconic as the standard adult forms of the signs or less iconic than adult forms (Meier, Mauk, Cheek, & Moreland, 2008). These findings imply that children do not impose iconicity on the language they are learning in order to make it more straightforward or understandable.

Why do iconic signs exist in sign languages if they do not seem to confer a processing advantage for, and are not acquired earlier by, native signers? Bosworth and Emmorey (2010) suggest that iconicity is the result of the gestural origins of relatively young sign languages. Despite iconicity’s prevalence in sign languages, the only research investigating iconicity and language learning with deaf children has been solely observational. Therefore, we do not yet know if children acquiring a manual language with inherent iconicity as their first language recognize iconicity or actively learn and retain iconic signs better than non-iconic ones, or how deaf children use and interpret iconicity during the preschool years. The current study addresses the role iconicity might play in deaf children’s language acquisition after the age when they have developed other cognitive skills, such as analogical reasoning abilities.
In addition to increasing our knowledge about how signing children process iconic symbols, the current study elucidates whether iconicity is a significant factor for children learning a sign language. Deaf children learning ASL might be more sensitive than their hearing peers to the iconic features of signs. Because of this potential increased sensitivity due to exposure, deaf children might match more iconic signs with their referents than their hearing peers because deaf children are accustomed to pairing signs and novel referents. Next, we consider whether deaf children exploit the iconic properties of signs to enable sign learning, as do hearing adults, or whether they show no differential processing of iconic and arbitrary signs, as do deaf adults.

**Experiment 1**

In order to understand the iconic relationship between a sign and its referent, children must be able to interpret gestures as symbols and identify the features of an iconic sign that are similar to the features of the referent. This understanding requires that children identify salient features of the referent object that are depicted in the form of the sign. This skill may not develop until the middle of the preschool years because of the need for requisite analogical reasoning skills and symbolic awareness. Therefore, children younger than 4 years may not identify the shared characteristics of iconic signs and their referents. If prior experience with a sign’s referent allows for a better understanding of the relationship between symbol and its referent, children should recognize iconic signs for shape better when the referent objects are familiar rather than unfamiliar. On the other hand, shape iconicity might be equally accessible regardless of children’s familiarity with the object, because shape can be perceived without extensive
experience with the object. If this is the case, then children will recognize iconic signs for familiar and unfamiliar objects at similar levels.

This experiment assessed whether hearing preschoolers can recognize iconic signs. By presenting children with two objects and a sign, which either described the shape of one object, or in a control condition, described the shape of neither object, we tapped children’s potential capacity for recognizing perceptual iconicity with familiar and unfamiliar referents.

Method

Participants

A total of 87 hearing children ($M_{age} = 4.16$ years, $SD = .67$, $range_{age} = 3.05-5.61$ years) participated in the study. Children were recruited from preschools, daycare centers, and museums for children in the Northeast. All children who participated were included in the analyses.

Materials

In the experiment, children saw four pairs of familiar objects and four pairs of unfamiliar objects. Familiar objects were toys, pieces of furniture or clothing, or animals familiar to most children ages 3 years and older, which are either found in or similar to words in the MacArthur Communicative Development Inventory (CDI) (Fenson, Dale, Reznick, Bates, Thal, & Pethick, 1994). Additionally, all the familiar objects selected appear in the lexicons of two children in the age range of the participants (Brown, 1973; MacWhinney, 2000). The unfamiliar objects were household objects, obscure toys, or pieces of hardware, which would be novel for most adults, and therefore unfamiliar to children in the study as well. These objects do not have concise names in English and can best be labeled using descriptions such as “a long yellow dog toy,” “the head of a faucet,” and “a square piece of copper with a hole in the center.”
In order to create sign stimuli for the study, hearing non-signers ($N = 12$, $M_{age} = 20.33$ years, $SD = 1.15$) generated gestures describing the shape of 30 unfamiliar objects. From their gestures, the researchers selected iconic signs for 15 of these unfamiliar objects. These invented gestures’ iconic relationships to their referents were verified by a second set of adult participants ($N = 14$, $M_{age} = 20.62$ years, $SD = 1.19$), who after viewing each of the iconic signs selected the correct referent from a set of four unfamiliar objects. A selection criterion of 85% was predetermined for items’ inclusion in the study. When presented with the invented iconic signs, the four target unfamiliar objects used in this study were selected 100% of the time by the adult participants.

The iconic signs for familiar objects in the study are signs from foreign sign languages that describe the target objects’ shapes. For instance, the iconic sign for the target item *star* was taken from German Sign Language and traces the shape of a five-pointed star with the index fingers. Iconic signs from ASL were not used in the study so that the signs would be novel to children who use ASL as well as to hearing children. The arbitrary signs for both the familiar and unfamiliar objects were signs that *could* be found in ASL (phonologically allowable), many of which are signs for other nouns in foreign sign languages. These signs did not resemble either the target or distractor objects, and served as a control in the experiment. On a scale of 1 (not at all iconic) to 5 (highly iconic), ten hearing non-signing adults ($M_{age} = 42.60$ years, $SD = 21.71$) rated iconic signs significantly higher ($M = 3.95$, $SD = .48$) than arbitrary signs ($M = 1.53$, $SD = .39$) paired with same set of objects ($t (7) = 10.82$, $p < .001$).
Design

Experiment 1 consisted of a 2x2x2 mixed factorial design with a within-group factor of object familiarity (familiar vs. unfamiliar) and between-group factors of sign iconicity (iconic vs. arbitrary) and age (3-year-olds vs. 4-year-olds).

Procedure

The experiment was conducted individually in a quiet room. Children were asked to choose one object from an object pair that matched a given sign presented by the experimenter. Each child was randomly assigned to either the iconic ($N = 46, M_{age} = 4.15$ years, $SD = .71$) or the arbitrary ($N = 41, M_{age} = 4.18$ years, $SD = .62$) sign condition and saw one sign for each of four familiar and four unfamiliar objects. Order of items, as well as whether children saw the set of familiar or unfamiliar objects first, was counterbalanced across participants.

For each participant, the task began with a practice trial with either familiar or unfamiliar objects, depending on which object set the participant was to see first. The experimenter began by saying, “We are going to play a matching game. Here are some toys.” The experimenter then placed on the table in front of the child either a car and an apple (for those who saw familiar first) or a sparkly curtain rod holder and part of a bird feeder (for those who saw unfamiliar first) and said, “You chose the one that goes with what I say. Let’s do one now. Show me the car. Which one is the car? Where is the car?” (for familiar first) and “Show me the zav. Which one is the zav? Where is the zav?” (for unfamiliar first). After the child selected an object in the practice trial, the experimenter explained the rest of the task to the child saying, “Some people use sign language and their hands to communicate.”

For all children, the experimenter began the test trials by saying, “Let’s play more of the matching game. Here are some toys. I’m going to show you a sign, and your job is to pick the
toy that goes with the sign.” Then the experimenter placed two objects on the table, one designated as the target object and one as the distractor object and said, “Look at me. Show me this one (iconic sign for one of the objects or arbitrary sign).” The sign was produced simultaneously with the English word “one” and was produced approximately one foot above the table in the center of the two objects. If the child did not select an object immediately after seeing the sign, the experimenter prompted the child up to three times by adding, “Which one is this one (sign)? Where is this one (sign)?” If the child was hesitant to make a decision, the experimenter prompted the child by saying, “It’s okay to take a guess.”

Children saw a total of eight trials, four with pairs of familiar objects (see Table 1) and four with pairs of unfamiliar objects (see Table 2), and saw signs of one type only—either iconic or arbitrary. At the end of the test trials, the experimenter presented each of the eight object pairs one at a time again and asked the child to pick his/her favorite toy from each pair. These preferences allowed for comparisons between children’s choices during the test trials and their choices based on preference alone.
### Table 1. Examples of familiar object stimuli and their iconic and arbitrary signs.

<table>
<thead>
<tr>
<th>Object and signs</th>
<th>Target object</th>
<th>Distractor object</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iconic sign</td>
<td><img src="image1" alt="Iconic Sign" /></td>
<td><img src="image2" alt="Distractor Object" /></td>
</tr>
<tr>
<td>Arbitrary sign</td>
<td><img src="image3" alt="Arbitrary Sign" /></td>
<td><img src="image4" alt="Arbitrary Object" /></td>
</tr>
</tbody>
</table>

*Note. Children either saw all iconic or all arbitrary signs in Experiment 1, and were asked to select the matching object.*

### Table 2. Examples of unfamiliar object stimuli and their iconic and arbitrary signs.

<table>
<thead>
<tr>
<th>Object and signs</th>
<th>Target object</th>
<th>Distractor object</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iconic sign</td>
<td><img src="image5" alt="Iconic Sign" /></td>
<td><img src="image6" alt="Distractor Object" /></td>
</tr>
<tr>
<td>Arbitrary sign</td>
<td><img src="image7" alt="Arbitrary Sign" /></td>
<td><img src="image8" alt="Arbitrary Object" /></td>
</tr>
</tbody>
</table>

*Note. Children either saw all iconic or all arbitrary signs in Experiment 1, and were asked to select the matching object.*
Results

Participants’ choices in Experiment 1 were coded as correct in the iconic sign condition when they picked the corresponding object, the target. Since children in the arbitrary sign control condition were unable to pick a “correct” object because the sign was not iconically related to either object, their choices were coded in terms of whether they selected the object designated as the target in the iconic condition or the distractor object. Inter-rater reliability for 30% of the recognition choice data was 98% and 99% for preference choice. Before comparing object selection in the two sign conditions, the data were first submitted to chi-squared tests of association to ensure that no single item elicited significantly more choices in the arbitrary condition. Arbitrary signs were designed to have no relationship to either referent and this condition would not serve as an appropriate control if children systematically chose one referent more often than another in the arbitrary condition. Item analyses revealed that children’s selection frequencies for the target and distractor items in each pair in the arbitrary condition were statistically equivalent ($\chi^2 (7) = 8.11, p = .32$). Next, we confirmed that children were not selecting specific items based on their preferences for those items. Children selected their favorite item (as elicited during preference trials) during the recognition phase of the experiment 56% of the time, and there was no significant association between choice during the recognition phase of the experiment and children’s favorite objects ($\chi^2 (7) = 6.35, p = .50$).

Experiment 1 addressed children’s recognition of the iconicity of signs. Because all of the test items in the arbitrary condition yielded similar frequencies of choices, we compared children’s object choices (target vs. distractor) to chance performance (50%) in the two iconicity conditions. In order to identify developmental differences, children were divided into two age groups: 3-year-olds ($N = 49$, $mean_{age} = 3.55$ years, $SD = .43$) and 4-year-olds ($N = 38$, $mean_{age} = $...
4.66 years, \( SD = .29 \)). Four-year-olds in the iconic sign condition performed significantly above chance \( (\chi^2 (26) = 48.50, p < .01) \), selecting the target object 75.92\% of the time, but 3-year-old children in the iconic condition performed at chance \( (\chi^2 (19) = 11.50, p = .91) \), and as expected, both age groups in the arbitrary condition selected the target only at chance \( (\chi^2 (21) = 15.5, p < .60; \chi^2 (18) = 9.25, p < .95) \). The ability to recognize the relationship between an iconic sign describing shape and its referent does not develop until the middle of the preschool years, and correlates with chronological age \( (r = .29, p < .01) \).

Next, we conducted a 2x2x2 mixed factorial analysis of variance (ANOVA) with a within-group factor of familiarity (familiar vs. unfamiliar) and between group factors of iconicity (iconic vs. arbitrary) and age (3-year-olds vs. 4-year-olds). For the ANOVA, we calculated two scores for each participant from 0-4 indicating the number of target objects they chose in the familiar and unfamiliar conditions. This ANOVA yielded a significant main effect of age, where 4-year-olds performed better at the iconicity recognition task than 3-year-olds \( (F (1,83) = 18.59, p = .004, \eta_p^2 = .09) \). No main effects for iconicity condition \( (F (1,83) = 1.92, p = .17, \eta_p^2 = .02) \) or familiarity \( (F (1,83) = 1.26 p = .27, \eta_p^2 = .02) \) were found, indicating that iconicity condition alone did not affect performance, and that children were not better at identifying signs’ referents when they had previous experience with the objects themselves than when the objects were novel.
Of interest are the interaction effects—whether children’s ability to recognize perceptual iconicity differs depending on age or familiarity. Iconicity and age interacted, such that 4-year-olds, but not 3-year-olds, performed better in the iconic than the arbitrary condition ($F(1,83) = 12.27, p = .001, \eta_p^2 = .13$). We hypothesized that due to their increased experience with familiar objects, children in both age groups in the iconic condition would select the correct referents more often with familiar objects than with unfamiliar objects. However, the anticipated two-way interaction between iconicity and familiarity was not observed ($F(1,83) = .57, p = .45, \eta_p^2 = .01$). This finding suggests that having a greater conceptual understanding of an object and its properties does not support children’s ability to recognize perceptual iconicity. The three-way interaction between age, familiarity, and iconicity was not significant ($F(1,83) = .16, p = .69, \eta_p^2 = .00$).
Experiment 2

Given that children older than 4 years recognize the relationship between iconic signs and their referents, will children of different ages capitalize on this understanding to remember iconic signs better than arbitrary ones? Experiment 2 considers iconic and arbitrary sign fast-mapping abilities in preschoolers.

Method

Participants

Eighty-two hearing children participated in Experiment 2 (\(M_{\text{age}} = 4.27 \text{ years}, SD = .69, \) range\(_{\text{age}} = 3.05-5.63 \text{ years}\)), and 64 of these children also participated in Experiment 1. The scores for children who participated in Experiment 1 first versus those who only participated in Experiment 2 were statistically equivalent (\(t(80) = .25, p = .80, d = .22\)). Children who participated in both Experiment 1 and Experiment 2 were tested in two sessions separated by an average of 1 month and 11 days (\(SD = 20.74 \text{ days}\)).

Materials & Procedures

The experimenter taught children one sign for each of eight unfamiliar objects, different from those used in Experiment 1. Because the iconicity of signs describing familiar objects were no easier for children to recognize than those describing unfamiliar objects, all objects in Experiment 2 were novel to young children. In this within-group design, half of the signs presented were iconic and half were arbitrary. The arbitrary and iconic signs were generated and verified for their resemblance to their referents by adult participants using the same method as in Experiment 1. On a scale of 1 (not at all iconic) to 5 (highly iconic), ten hearing non-signing adults (\(M_{\text{age}} = 42.60, SD = 21.71\)) rated iconic signs significantly higher (\(M = 3.83, SD = .48\)) than arbitrary signs (\(M = 1.34, SD = .36\)) for the same set of objects (\(t(7) = 10.15, p < .001\)).
The task began with a practice trial using familiar objects (a chair and a baby doll) to accustom children to the nature of the task. The experimenter began by placing either the chair or the doll in front of the child and saying, “Here’s the baby (chair). See the baby (chair)? That’s the baby (chair).” Next, the experimenter removed the object recently introduced and placed the other object (chair or baby) on the table and introduced it to the child in the same manner. Finally, the experimenter tested the child’s comprehension by placing both the chair and baby on the table and saying, “Now it’s your turn to show me the toy. Where’s the chair (baby)? Show me the chair (baby).”

For the learning phase of the actual task, the experimenter placed objects one at a time on the table in front of the child (order counterbalanced across participants) and said to the child, “Some people use sign language and their hands to communicate. I’m going to teach you signs for some toys today and we are going to play a remembering game.” Then the experimenter pointed to the object on the table and said, “Look at this one (sign for one of the objects). See this one (sign)? There’s this one (sign).” This process was repeated with four different objects (A-D), each with different signs, which were either all iconic or all arbitrary (see Table 3).
At the end of the sign-learning phase, children participated in two test trials for the first object set. For each of the two trials, the experimenter placed three objects on the table, two of which were introduced during the sign learning phase (e.g., objects A and C) and one object that was not previously introduced (e.g., object E). Then the experimenter said, “Where’s this one (sign for object A). Show me this one (sign for object A)?” The child received no corrective feedback. The child saw objects B, D and F on the second test trial along with the sign for object B and was asked to select the matching referent. The presentation of signs (A, B, C and D) as well as sign iconicity was counterbalanced across participants. Sign learning and test trials were repeated with a second set of four objects so that children saw a total of eight signs, four iconic and four arbitrary (see Table 4).
Finally, 38 children who also participated in Experiments 1 and 2 were given two cognitive tasks, the Object Assembly task from the Wechsler Preschool and Primary Scale of Intelligence-Revised, which measures visual-perceptual organization, integration and synthesis of part-whole relationships, non-verbal reasoning, and trial-and-error learning, and the Corsi Block-Tapping Task adapted for preschool children from the Working Memory Test Battery for Children (Gathercole & Pickering), which measures spatial working memory.

Results

Participants’ choices in Experiment 2 were marked as correct in both iconicity conditions (iconic vs. arbitrary) if they selected the correct referent for the sign they saw. Using the same age groupings as in Experiment 1, 3-year-olds ($N = 36, M_{age} = 3.60$ years, $SD = .33$) remembered
an average of 1.08 (SD = .87) iconic signs and .86 (SD = .76) arbitrary signs, and 4-year-olds (N = 46, M_{age} = 4.80 years, SD = .36) remembered an average of 1.69 (SD = .51) iconic signs and 1.37 (SD = .71) arbitrary signs. Three and four year old children’s scores in both iconicity conditions were compared to chance. Four-year-olds remembered both iconic (\chi^2 (45) = 90.57, p < .001) and arbitrary signs (\chi^2 (45) = 68.10, p = .01) significantly above chance. On the other hand, 3-year-olds performed at chance on the fast-mapping task with both iconic (\chi^2 (35) = 35.47, p = .45) and arbitrary signs (\chi^2 (35) = 32.33, p = .60). These results suggest that older children have developed mechanisms for learning which enable them to reliably remember new signs over a short period of time.

The data were then submitted to a 2x2 mixed factorial analysis of variance (ANOVA) with a within-group factor of iconicity (iconic vs. arbitrary) and a between-group factor of age (3-year-olds vs. 4-year-olds). For the ANOVA, each participant received two scores from 0 to 2 indicating the number of target objects they identified correctly in each of the two iconicity conditions. This ANOVA yielded main effects for age and iconicity. As expected, 4-year-old children remembered signs better than 3-year-old children (F (1,80) = 22.88, p < .001, \eta_p^2 = .22). Overall children retained iconic signs better than arbitrary ones, suggesting that iconicity has a facilitative effect on fast-mapping abilities (F (1,80) = 6.53, p = .012, \eta_p^2 = .08). No significant interaction between age and iconicity was found. In other words, children’s ability to benefit from objects’ iconicity in their word learning did not seem to differ based on their age group. However, the variances for the iconic condition were marginally significantly different (Levene’s Test: F(1) = 3.44, p = .07) due to the relatively large variation in younger children’s ability to remember iconic signs. Because 3-year-olds did not perform significantly above chance at remembering signs in either the iconic or arbitrary sign condition, we ran a paired-samples t-test
to determine whether younger children learn iconic signs better than arbitrary ones. Children younger than 4 years remembered a statistically equivalent number of signs in the iconic condition as in the arbitrary condition \((t(35) = 1.24, p = .22, d = .22)\), implying that only some 3-year-old children have developed the capacity to use iconicity. A paired-samples t-test examining the mean differences between iconicity conditions in older children revealed that 4-year-olds remembered iconic signs better than arbitrary ones during the fast-mapping task, even though they remembered both types of signs at an above-chance level \((t(45) = 2.54, p = .015, d = .38)\).

*Figure 5.* Mean number of 3- and 4-year olds’ correct target object selections by iconicity condition. The dotted line represents chance performance. Error bars show standard error.

Children’s chronological age correlated with their overall ability to remember signs \((r = .38, p < .001)\). Thirty-eight children’s scores on the Object Assembly task correlated with
chronological age as expected \( (r = .43, p = .01) \), but did not correlate with children’s performance in either iconicity condition (iconic vs. arbitrary) of the sign-learning task, implying that this domain of cognitive ability likely does not affect children’s use of iconicity. Spatial working memory scores from 37 children correlated with chronological age \( (r = .62, p < .001) \), as well as with children’s ability to remember both iconic \( (r = .35, p = .032) \) and arbitrary signs \( (r = .49, p = .002) \).

Discussion

The current study considered children’s understanding of perceptually iconic signs describing the shapes of objects, and whether children’s ability to remember signs is enhanced for signs that have an iconic relation to their referents. Experiment 1 assessed hearing children’s ability to recognize the meanings of iconic signs, and Experiment 2 tested children’s fast-mapping abilities with iconic and arbitrary signs. In Experiment 1, we investigated the age at which children can understand the similarities between a symbol’s form and meaning, and aimed to determine whether this understanding varies depending on how familiar children are with the sign’s referent.

The results of Experiment 1 suggest that the ability to recognize the shared properties of an iconic sign and the object it describes develops during the preschool years. Children younger than 4 years are not able to reliably match iconic signs with the objects they describe, whereas 4- to 5-year-olds perform above chance at recognizing iconic signs’ referents. Successfully mapping the form of an iconic sign to its referent requires the integration of two distinct visual representations. In order to connect the form of the sign to that of the object, children need to identify the salient features of the sign, namely those that depict its shape, and then evaluate each
object to see whether the sign they recently saw captures the features of the object. Additionally, children need to interpret the sign as a symbol, and not as a hand engaged in an action, as is the case with function gestures.

Adults are able to seemingly effortlessly carry out these necessary steps, as they were able to recognize 100% of the referents’ for signs in the pilot study. They can attend to the key features of signs and objects, as well as engage analogical reasoning to connect signs to objects. Nonetheless this process still demands attention. Older children’s superior performance on Experiment 1 is confirmed by findings about preschoolers’ ability to use analogical reasoning, or to apply information from a model to another situation. Four-year-olds require fewer instructions and less similar models to succeed at analogical reasoning tasks than do 3-year-olds (DeLoache, Peralda de Mendoza, & Anderson, 1999). In other words, children younger than 4 years need more explicit instructions about the similarities between a symbol and its referent to understand their relationship.

The successful mapping of an iconic sign to its referent object also involves an understanding of symbolism, specifically that the sign represents one of two objects, and might share properties with the object it represents. Because iconic symbols are not abundant in spoken languages, 4-year-olds’ superior performance on our recognition task could be attributed to their more explicit awareness of symbolic relations in general (Karmiloff-Smith, 1992 as cited in Namy et al., 2004). In addition, improving development of interpretative Theory-of-Mind (iTOM), the knowledge that others can have alternative beliefs about the same object or event, may support children’s ability to recognize iconicity, because children with better iTOM were also better at communicating the meaning of iconic symbols during a legend-designing task (Myers & Liben, 2012). The understanding that another person might be using iconicity to
communicate meaning may develop with iTOM, along with requisite analogical reasoning abilities.

Experiment 1, both its design and its findings, diverges from past work on young children’s understanding of iconic symbols. Previous research has documented that children as young as 26 months can map iconic function gestures onto their familiar and novel referents (Namy, 2008). Why then do 3-year-olds in the current study fail to reliably recognize iconicity? We propose two explanations to account for the failure of 3-year-olds to recognize iconicity in Experiment 1: 1) differences in the type of iconic signs and 2) differences in children’s interactions with the objects and the amount of scaffolding provided.

Both the shape (Gershkoff-Stowe & Smith, 2004) and function (Booth & Waxman, 2002) characteristics of objects appear relevant to young children when they learn new words or extend categories to novel exemplars. A gesture that describes an object’s function can serve both as a symbol and as an instruction about how to use an object. The way in which one acts upon an object is closely related to a child’s own experiences manipulating objects. For a child, bouncing a ball is inextricably tied to the concept of a ball (Booth & Waxman, 2002). Therefore, an object’s function might be extremely salient for children. Shape is also ubiquitously present during children’s experiences with objects. Children exhibit a shape bias when they use objects’ shapes to form categories (Landau, Smith, & Jones, 1988). However, this bias for shape as a clue to category disappears when the objects’ shapes are complex, as are the shapes of the objects in Experiment 1 (Cimpian & Markman, 2005). Thus, identifying and interpreting the relationship between a perceptually iconic sign for an object’s shape may be more difficult than the same process with a function iconic sign. Additionally, function gestures are most often formed by imitating how one holds or manipulates an object. Children can understand function gestures by
mapping their hands onto those of a person engaged in an activity with the object. Therefore, function gestures are analogically closer to the real-world referent than are shape gestures.

Additionally, demonstrating the features of an object that will be highlighted in its iconic sign might boost children’s awareness of iconicity. In Namy (2008), the experimenter demonstrated the function of each referent object and explicitly encouraged the child to act upon the object and imitate its desired function. In this way, children were actively attending to function, associating the object’s action with the object itself. This emphasis may have primed children to attend to how the iconic signs for the objects mimicked or resembled the functions performed by the objects. In fact, children who had the opportunity to discover the function of an object in an activity session attended exclusively to the object’s function when they later participated in naming and categorization tasks, while children who participated in the naming task first attended to global characteristics of the object (Nelson, 1999). Children’s tendency to focus on function when information about an object’s function is available suggests that if the similarities between the nature of an object and its iconic sign are highlighted, children may be better able to map a sign’s form to its meaning. In contrast, children in the current study were not given an opportunity to discover the targeted property of the object’s shape, perhaps removing critical scaffolding that would have otherwise enabled younger children to make the mapping between an iconic sign and its referent. Without introducing the object and any relevant characteristics before the recognition task, younger children in Experiment 1 may have failed to identify shape as the common feature shared by the sign and the object.

Together, the differences in shape versus function iconic signs and the effect of object demonstration as a cue to salient features in this study compared to previous studies likely account for the older age at which children reliably recognize the iconicity of signs. This study
and its findings contribute to the literature on children’s early symbolic understanding, demonstrating that without explanation and support, children younger than 4 years are not able to take advantage of semantic information contained in iconic signs or gestures describing shape.

Experiment 1 also addressed questions about familiarity and children’s recognition of iconicity. We hypothesized that children, especially those younger than 4 years, would better recognize iconicity with familiar compared to unfamiliar objects because knowing a label for an object is associated with better sign-referent matching for 3-year-olds (Tolar et al., 2008). In contrast to this previous finding, children recognized the referent objects of iconic signs equally well when the objects were familiar, such as a bed or a jar, as when the objects were novel. In the familiar condition, children saw signs intended to describe an object for which they already knew a label. In this case, already knowing the English word for the target object might have hindered children from mapping a novel gestural label (Markman & Waachtel, 1988). Mutual exclusivity might have counteracted the benefit provided by previous experience with the object for 3-year-olds. Four-year-olds might have been equally able to recognize unfamiliar and familiar objects. Additionally, familiarity may not be essential to identify the relationship between an iconic sign and its referent if the sign describes shape as opposed to function properties, given that children can perceive an object’s shape with only limited visual experience.

Experiment 2 investigated whether iconicity enhanced hearing children’s ability to learn new symbols. Children’s ability to map iconic symbols onto their referents, demonstrated by 4- and 5-year-olds in Experiment 1, could have two possible implications for the use of iconicity during a fast-mapping task involving both iconic and arbitrary signs. Given that not all symbols in the manual modality are iconic, and not all of the signs in Experiment 2 were iconic, children might choose not to invoke a strategy that involves seeking out a form-meaning relationship
between each symbol and its referent because the process of identifying common features of a sign and the object it describes is cognitively demanding. Conversely, hearing children who can recognize iconicity reliably might be able to assess a given symbol’s potential iconic relationship relatively easily, and thus benefit from iconicity during a sign-learning task by rapidly evaluating the common features of the sign and the referent.

Four-year-olds learned both iconic and arbitrary signs at an above chance level, whereas three-year-olds learned neither type of sign significantly above chance. Clearly, older children have more developed mechanisms, such as better working memory, for learning new signs presented in a semantic-poor context with little repetition than do younger children. Spatial working memory correlated with both children’s ability to remember iconic and arbitrary signs, suggesting that enhanced working memory abilities are not associated specifically with a better application of iconicity.

An analysis of variance revealed that children learn iconic signs better than arbitrary ones over a short period of time, but no interaction was found between iconicity and age, implying that 3-year-olds and 4-year-olds benefit similarly from iconicity. However, paired sample t-tests indicated that older children remembered iconic signs better than arbitrary ones, while younger children’s performance on the sign learning task was not enhanced by iconicity. Three-year-olds’ performance in the iconic condition, with a score of 1.08 (SD = .87), was numerically higher than their mean score for arbitrary signs, .86 (SD = .76). However, the variability in three year old children’s performance in the iconic condition was greater than variability in the other conditions, suggesting that some younger children may have been able to take advantage of iconicity in this type of task, while others were not able to use iconicity. This variation, trending towards significant inequality, may have resulted in a non-significant interaction between age
and iconicity, when in fact 3- and 4-year-olds appear to process and use iconicity differently. Collecting more data from younger children may allow us to see this pattern emerge more clearly.

Older children seem to use iconicity to support their word learning, thereby showing an adult-like pattern of sign learning, where memory is better for iconic signs (Beykirch, Holcomb, & Harrington, 1990; Lieberth & Gamble, 1991). Perhaps the strong similarities between the sign’s form and its meaning enhance encoding of the symbol. Because of their more sophisticated analogical reasoning abilities, children older than 4 years are able to easily evaluate signs and detect any potential iconicity. For children who are able to recognize iconic signs, the benefit of making a form-meaning mapping outweighs the potential cognitive tax. Scores on the Object Assembly task, which measures visual-spatial cognitive ability, correlated neither with the amount of signs learned in the iconic condition, nor with the amount of signs learned in the arbitrary condition. Sign learning, as well as children’s ability to take advantage of iconicity while learning signs, appears to be independent of this measure of cognitive skill.

Hearing children learning a spoken language have experience with gesture in their daily lives. However, the language that these children are acquiring has primarily arbitrary symbols. Children who are learning a language with abundant iconicity, such as deaf children acquiring ASL, might recognize iconicity with more accuracy because of its role in their language. Alternatively, the ability to recognize iconicity might be associated not with experience using iconicity in language, but with cognitive maturation, including more sophisticated analogical reasoning skills. If this is the case, deaf children should show similar patterns of recognition as hearing children. Additionally, deaf children may show no bias for iconicity during a fast-mapping sign-learning task because they likely began acquiring ASL before they had the
cognitive mechanisms to decode iconicity. However, deaf children may show a similar pattern of sign learning as hearing children if the advantage conveyed from transparent form-meaning mappings in iconic signs is substantial.

Experiment 3

The results of Experiments 1 and 2 indicated that hearing preschools over the age of 4 years recognize the relationship between a perceptually iconic sign and its referent, and use this understanding to learn new signs. Experiment 3 considered how deaf children exposed to ASL interpret iconic signs like those found in their language, and whether they use iconicity to benefit their sign learning.

Method

Participants

Twenty-seven deaf children participated in Experiment 3 ($M_{age} = 4.52$ years, $SD = .79$, $range_{age} = 3.02-5.56$ years). Three of the children had additional physical disabilities, but performed within the normal range on the Object Assembly task and the Corsi Block Task (Corsi, 1972), so their data were included in the analyses. The data from four additional children were not included due to failure to complete the task.

Materials and Procedure

Stimuli and procedure for the first task, the sign recognition task, were similar to those used in Experiment 1. However, all children saw only unfamiliar objects and iconic signs. Stimuli and procedure for the second task, the fast-mapping task, were identical to those used in Experiment 2. The instructions for both the recognition and fast-mapping task were given in ASL.
Results

As in Experiment 1, choices in the recognition task were coded as correct when children selected the sign’s corresponding object. We confirmed that children were not selecting specific items based on their preferences for those items. Children selected their favorite item (as elicited during preference trials) during the recognition phase of the experiment 44% of the time, and there was no significant association between choice during the recognition phase of the experiment and children’s favorite objects. ($\chi^2(27) = 22.00, p > .50$).

We first compared children’s object choices (target vs. distractor) to chance performance (50%) in order to see whether deaf children reliably recognize iconic signs. In order to identify developmental differences, children were divided into two age groups: 3-year-olds ($N = 9$, $mean_{age} = 3.60$ years, $SD = .36$) and 4- and 5-year-olds ($N = 18$, $mean_{age} = 4.98$ years, $SD = .49$). Younger children selected the correct referent 67% of the time and older children selected the correct referent 71% of the time, but neither group performed significantly above chance using a chi-squared test ($\chi^2(8) = 6.00, p = .65$; $\chi^2(17) = 14.50, p = .63$) because of the variability in children’s scores ($SD_{3\text{ years}} = 1.00$, $SD_{4\text{ years}} = .98$). Because of the small sample size and stringency of the chi-squared test, we decided to compare both groups’ performance on the recognition task to expected chance performance of identifying two items correctly using a one-sample t-test. Four year old children identified significantly more than two items in the iconic condition ($t(17) = 3.59, p < .01, d = 1.74$), while 3-year-olds’ recognition was marginally significantly above chance ($t(8) = 2.00, p = .08, d = 1.41$).

Next, we conducted an independent samples t-test comparing 3- and 4-year-olds’ performance on the recognition task. For the t-test, we calculated a score for each participant from 0-4 indicating the number of target objects they chose. Both age groups of children
performed equivalently ($t(25) = .41$, $p = .68$, $d = .35$). We collapsed age groups to compare unfamiliar object recognition scores in the iconic condition from Experiment 1 of hearing children age-matched to the deaf children ($N = 27$, $M\text{age} = 4.43$ years, $SD = .73$) with deaf children’s recognition scores from Experiment 3 ($N = 27$, $M\text{age} = 4.52$ years, $SD = .79$). Deaf and hearing children performed statistically equivalently on the recognition task, although deaf children’s mean score was higher than that of hearing children (see Table 5).

<table>
<thead>
<tr>
<th>Table 5. Mean scores and standard deviations for deaf and hearing children’s iconic sign recognition with unfamiliar objects.</th>
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<tr>
<td>Deaf</td>
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</tr>
<tr>
<td>Mean</td>
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<td>2.78</td>
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We then considered whether deaf children acquiring a sign language use iconicity to advantage their sign learning. Participants’ choices in the learning task were marked as correct in both iconicity conditions (iconic vs. arbitrary) if they selected the correct referent for the sign they saw. Using the same age groupings as those used to analyze performance on the first task, 3-year-olds remembered an average of $0.89$ ($SD = .78$) iconic signs and $0.67$ ($SD = .70$) arbitrary signs, and 4-year-olds remembered an average of $1.61$ ($SD = .61$) iconic signs and $1.22$ ($SD = .87$) arbitrary signs. Three year old and 4-year-old children’s scores in both iconicity conditions were compared to chance. Four-year-olds remembered both iconic ($\chi^2(17) = 33.46, p < .01$) and arbitrary signs ($\chi^2(17) = 27.97, p < .05$) significantly above chance. On the other hand, 3-year-olds performed at chance on the fast-mapping task with both iconic ($\chi^2(8) = 7.99, p = .43$) and arbitrary signs ($\chi^2(8) = 5.99, p = .65$). These results suggest that older deaf children have
developed mechanisms for learning which enable them to reliably remember new signs over a short period of time, similar to hearing children.

The data were then submitted to a 2x2 mixed factorial analysis of variance (ANOVA) with a within-group factor of iconicity (iconic vs. arbitrary) and a between-group factor of age (3-year-olds vs. 4-year-olds). For the ANOVA, each participant received two scores from 0 to 2 indicating the number of target objects they identified correctly in each of the two iconicity conditions. This ANOVA yielded a main effect for age. As expected, 4-year-olds remembered signs better than 3-year-olds \(F(1,25) = 6.67, p < .05, \eta_p^2 = .21\). Overall, children retained iconic and arbitrary signs equally well, suggesting that iconicity does not affect fast-mapping abilities for children learning a sign language \(F(1,25) = 2.82, p = .11, \eta_p^2 = .10\). No significant interaction between age and iconicity was found. In other words, children’s ability to benefit from signs’ iconicity in their word learning does not seem to depend on age. Paired-samples t tests comparing memory for iconic signs versus arbitrary ones indicates that 4-year-old deaf children show marginally significant enhanced learning with iconic signs over arbitrary signs \(t(17) = 1.941, p = .07, d = .48\), while iconicity does not advantage 3-year-olds’ learning \(t(8) = .69, p = .51, d = .23\).
A qualitative approach to considering data indicates that deaf children show a similar pattern of benefiting from iconicity as hearing children. A group of hearing children from Experiment 2 ($N = 27$, $mean_{age} = 4.46$ years, $SD = .76$) was age-matched to the deaf children in Experiment 3 ($N = 27$, $mean_{age} = 4.52$ years, $SD = .80$). Of the age-matched hearing children, 10 learned more iconic than arbitrary signs, 11 learned equal numbers of iconic and arbitrary signs, and 6 learned more arbitrary than iconic signs. This pattern seems to be replicated in Experiment 3 with deaf children, where 12 children learned more iconic than arbitrary signs, 12 learned equal numbers of iconic and arbitrary signs, and 3 learned more arbitrary than iconic signs (see Fig. 7).
Children’s chronological age correlated with their overall ability to remember signs ($r = .41, p < .05$). Children’s scores on the Object Assembly task were significantly correlated with chronological age as expected ($r = .45, p < .05$), and their overall ability to remember signs was also related to scores on the Object Assembly task ($r = .64, p < .001$). Scores on the Corsi Block-Tapping task also correlated with age ($r = .46, p < .05$) and the ability to remember signs ($r = .63, p < .001$). Object Assembly scores from 27 deaf children in Experiment 3 and 38 hearing children who participated in Experiments 1 and 2 were equivalent ($p > .05$). Block recall scores for the two groups were significantly different ($t(62) = 2.052, p = .04, d = .52$), where the group of hearing children had a higher mean score than the group of deaf children.
Discussion

Experiment 3 investigated how deaf preschoolers learning ASL interpret and process the iconicity of manual signs describing shape. The ability to recognize iconicity may be unaffected by the language a child is acquiring, and develops as a result of improved analogical reasoning skills and an increase in children’s ability to process multiple pieces of information simultaneously. If this is the case, then we would expect deaf children to recognize iconicity equally as well, and at the same point in development, as hearing children. On the other hand, if exposure to a language with abundant iconicity enhances the ability to recognize iconic signs, then deaf children would identify more target signs than hearing children, and perhaps even recognize iconicity at a younger age.

Chi-squared tests considering deaf children’s ability to recognize iconicity showed that deaf children do not recognize iconic signs at an above-chance level. However, one-sample t-tests showed that older deaf children reliably recognize iconicity, while younger children do not. The number of younger children in the study limits our ability to determine whether deaf children younger than 4 years recognize iconicity. A comparison of recognition of unfamiliar iconic signs between deaf children from Experiment 3 and a set of age-matched hearing children from Experiment 1 suggests that deaf and hearing children have similar abilities to recognize perceptually iconic signs presented in isolation. These findings indicate that exposure to a language, which frequently employs iconicity, does not lead to a better understanding of the relationship between iconic signs and their referents.

Interestingly, younger and older deaf children recognize the referents of iconic signs statistically equivalently, implying that deaf children might develop the ability to recognize
iconic signs earlier than hearing children. Deaf children may have more experience extracting meaning from visual information and therefore might receive more feedback about the iconicity of signs in their daily lives, resulting in an earlier understanding of iconic relationships. Testing the iconic sign recognition of deaf children younger than 3 years who are learning a sign language would allow us to address this question.

The fast-mapping task in Experiment 3 assessed whether deaf children learn iconic signs that resemble the objects they describe better than signs with arbitrary relationships to their referents. Because the ASL lexicon includes both iconic and arbitrary signs, deaf children might use the ability to recognize signs to advantage their word learning, as do hearing children over the age of 4. Alternatively, deaf children might default to treating all signs as arbitrary in order to avoid engaging in the potentially cognitively demanding task of assessing individual signs’ iconic relationships to their referents given that not all signs have iconic relationships to their referents. This second account would predict that deaf children remember iconic and arbitrary signs equally well.

The results from Experiment 3 indicate that deaf children over the age of 4 reliably remember novel iconic and arbitrary signs because they have developed strategies for word learning. Additionally, older deaf children seem to learn iconic signs somewhat better than arbitrary ones. This pattern of sign learning suggests that deaf children use iconicity as a strategy to learn new signs. Even though deaf children are exposed to iconic and arbitrary signs in daily life, they seem to favor a word learning strategy that incorporates an evaluation of similarities between the form of a sign and the form of its referent, as do hearing children not exposed to sign language. Even though deaf children begin learning sign language before they can recognize
iconic relationships, in the preschool years they have developed tools to learn signs that include iconicity.

Signing preschoolers’ use of iconicity diverges from that of 13- and 18-month-olds, whose vocabularies are composed of relatively fewer iconic signs (Folven & Bonvillian, 1991; Orlanksy & Bonvillian, 1984). Deaf native-signers do not show a processing advantage for iconic signs (Bosworth & Emmorey, 2010; Poizner, Bellugi, & Tweney, 1981). Perhaps children who are born into families that sign use iconicity differently in their sign learning than do children exposed to ASL when they start early intervention programs or enter school. Information about children’s age of exposure to ASL would allow for a consideration of how language acquisition and fluency might play a role in the use of iconicity during the preschool years. The results from Experiment 3 suggest that iconicity plays a role in deaf children’s sign learning.

General Discussion

Exposure to symbolic gesture boosts young children’s vocabulary development (Goodwyn, Acredolo, & Brown, 2000), and parents incorporate iconic gestures into their child-directed explanations about new objects (Clark & Estigarribia, 2011; Namy, Acredolo, & Goodwyn, 2000). Children as young as 2 years produce iconic gestures (Acredolo & Goodwyn, 1988), and previous research has detailed the capacity of toddlers and preschoolers to understand function iconicity under certain circumstances (Goodrich & Kam, 2009; Namy, 2008). The results from studies considering young children, symbolic gesture, and iconicity would indicate that toddlers recognize and use iconicity.

The current study informs our understanding of the circumstances under which children of different ages can map a symbol’s form onto its meaning. With a single presentation and no
explicit instructions to attend to the shape of an object, children under the age of 4 are unable to recognize the iconicity of a symbol. Perhaps children who produce iconic gestures are imitating the gestures of their caregivers without understanding their iconic properties, rendering these gestures arbitrary for the child. The positive effects on vocabulary development associated with increased exposure to symbolic gesture may be the result of multi-modal exposure (Capone & McGregor, 2004), as opposed to an advantage conferred when children bootstrap a word’s meaning based on a simultaneously produced iconic gesture. The results of the current study suggest that the ability to detect iconicity does not emerge at the same time for all types of form-meaning relationships involved in iconic signs and gestures. In fact, children who are as much as one year older than the 26-month-year-olds in Namy’s (2008) study, where children mapped iconic function gestures onto novel objects, did not reliably identify the referents of perceptually iconic signs in the current study.

Evaluating the circumstances under which children younger than 4 years can recognize and perhaps even use iconicity is necessary in order to determine how children learning language might benefit from iconic symbols in the manual modality. This study explored children’s ability to successfully interpret perceptual iconicity as opposed to previous studies, which have considered function iconicity. This study also minimized the amount of scaffolding provided during the task by not directing the child’s attention to relevant features of the iconic sign and referents.

The findings from this study have implications for the age at which teachers and parents can begin to use iconic gesture to enhance learning. As children enter the later preschool years, they have the analogical reasoning abilities to identify the similarities between iconic signs and their referents. Introducing a new and complex object in conjunction with an iconic gesture will
likely facilitate children’s memory for the object itself. For children old enough to understand iconic symbols, like children in elementary school, gestures can convey meaning not spoken in words, and enhance communication during teaching (Ping & Goldin-Meadow, 2008; Singer & Goldin-Meadow, 2005). Children younger than 4 years may also recognize and use iconic symbols to enhance their learning when given more explicit instructions about where to direct their attention. For children younger than 4 years, presenting new concepts with iconic symbols or emphasizing the iconic nature of a manual symbol likely has minimal effect on their learning, because iconic signs are not remembered better than arbitrary ones at this stage in development.

Future research should explore whether the amount of scaffolding provided during sign-object pairing affects young children’s ability to recognize iconicity. For instance, if children are told, “This sign looks like one of the objects on the table. The sign has the same shape as one of the objects,” they might be able to answer a more targeted question about form-meaning relationships such as, “Which object matches the sign’s shape?” However, even with this kind of supporting language, younger children may still struggle to identify commonalities between signs and their referents if having dual representations for the sign as a symbol and as a model proves challenging.

Recognizing iconicity is an important part of symbolic development and seems to develop in both children acquiring a language with built-in iconicity such as ASL and in children acquiring a language with limited iconicity, such as English. However, hearing children, and possibly deaf children as well, do not recognize iconic signs until the middle of their preschool years. Therefore, the iconicity inherent in sign languages likely does not support language acquisition. Contrary to the account put forth in Brown (1978), our results suggest that learning a sign language is just as difficult as learning a spoken language for young children.
The modality of the language a child is acquiring does not seem to affect whether he or she will engage the tool of iconicity to learn new symbols during the preschool years. Deaf and hearing children learn iconic signs better than arbitrary ones, possibly because they expect the form of signs in the manual modality to align with their meanings. Using iconicity might reduce the cognitive burden associated with learning new signs, and confer an advantage for these children. Even though not all signs in ASL are iconic, deaf children likely still consider iconicity when presented with a new sign, because this strategy helps to unlock an iconic sign’s meaning for children who can recognize iconicity.
References


