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Journal

Proceedings of the Annual Meeting of the Cognitive Science Society, 46(0)

Authors

Nicoladis, Elena

Marentette, Paula

St. Jean, Jennifer

Publication Date

2024

Peer reviewed

Toddlers Associate Iconic Gestures with Actions not Objects

Elena Nicoladis (elena.nicoladis@ubc.ca)
Department of Psychology, 1147 Research Road
Kelowna BC V1V 1V7 Canada

Paula Marentette (paula@ualberta.ca)
Psychology Augustana Campus, 3-04 Founders' Hall, 4901 46 Avenue
Canmore AB T4V 2R3 Canada

Jennifer St. Jean (jgstjean@ualberta.ca)
Department of Psychology, P217 Biological Sciences Building
Edmonton AB T6G 2E9 Canada

Abstract

Previous studies have shown that infants and toddlers can learn novel symbols, equally well as gestures or words. In Study 1, we test whether toddlers can learn iconic/arbitrary gestures equally well as arbitrary words for familiar objects. The results showed that the toddlers learned only an iconic gesture for top (i.e., spinning) above chance. In Study 2, we tested whether toddlers could learn iconic/arbitrary gestures as labels of actions equally well as novel words. Indeed, they did learn iconic gestures equally well. These results suggest that toddlers associate iconic gestures with actions performed by objects more readily than objects themselves.

Keywords: iconicity; arbitrariness; language learning; words

Introduction

Children communicate before they produce recognizable words (Tomasello, 1999). For instance, children hearing only spoken languages start communicating through gestures before they begin to speak. These early gestures include pointing, conventional gestures (such as hi/bye), and symbolic gestures (e.g., Acredolo et al., 2002; Iverson et al., 2008). Symbolic gestures are hand movements that refer to actions or objects symbolically, i.e., with a consistent gestural form linked to a meaning. Some studies have shown that children who use symbolic gestures early on stop using them when they acquire a word for the same referent (Acredolo & Goodwyn, 1988; Goodwyn et al., 2000; Iverson & Goldin-Meadow, 2005).

These results have led some researchers to argue that infants can learn symbols equally well in either a gestural or verbal modality, with a possible early advantage for the gestural modality (Acredolo et al., 2002; Graham & Kilbreath, 2007; Namy et al., 2000; Namy & Waxman, 2000). Children's initial equal treatment of words and gestures as symbols could be part of a larger phenomenon of an early broad acceptance of what can constitute a symbol (Woodward & Hoyne, 1999). As children get older (around 22-26 months), they become more conservative in what constitutes a symbol, accepting only spoken words (Namy & Waxman, 1998; Woodward & Hoyne, 1999). Older children use gestures for indicating or emphasizing and no longer accept gestures as object labels (Namy,

2009). Older children tend to interpret gestures as referring to actions or properties of objects rather than objects (Marentette & Nicoladis, 2011).

Gestures can be either iconically or arbitrarily related to their referents. For this paper, iconicity refers to a resemblance between the form/movement of the gesture and the form/movement of the referent. For example, gesturing by holding a flat hand to the ear could be iconic for a phone. Many gestures that accompany speech are iconic (McNeill, 1992). In contrast, words are often arbitrarily related to their referent (Hockett, 1960). Some gestures are arbitrarily related to their referent: the hi/bye gesture does not resemble the act of coming or going. Young children can learn arbitrary gestures with multiple exposures sometimes even before the related words (Iverson et al., 2008).

Do children find iconic gestures easier than arbitrary ones? Some studies have found that 18-month-olds learn arbitrary and iconic gestures equally well as object labels (Namy et al., 2004; Namy & Waxman, 1998; see review in Namy, 2009). This finding is consistent with the argument that young children accept gestures as symbols (Namy, 2009). In contrast, between the age of 26 months (Namy et al., 2004; Namy & Waxman, 1998) and three years of age (Magid & Pyers, 2017; Tolar et al., 2008), children show advantages in learning iconic over arbitrary gestures. These results suggest that children become increasingly sensitive to iconicity between one and three years.

Some studies have suggested that children tend to assume that iconic gestures are related to action (Hall et al., 2013; Marentette & Nicoladis, 2011; Stanfield et al., 2014). For example, Marentette and Nicoladis (2011) showed that two- to four-year old children tended to interpret iconic gestures as "action associates", that is, providing information about the action associated with an object. Even when taught gestures as labels of objects, the children in the Marentette and Nicoladis (2011) study interpreted the gestures as referring to actions associated with those objects. The association between gestures and actions has also been observed in children's production: Andren and Blomberg (2018) found that children between 18 and 30 months produced iconic gestures with dynamic (rather than static) verbs. The results of these studies do not challenge Namy's

(2009) argument that children younger than 26 months of age can learn gestures as labels for objects: these studies have included only a small number of children below that age. It is important to verify the claim that toddlers can interpret gestures as object labels. If young children initially assume that gestures are object labels (Namy, 2009), then they have to unlearn or override that assumption in order to start associating gestures with actions/properties, as older children do.

In sum, the research to date suggests that children younger than 26 months of age can learn gestures (either iconic or arbitrary) as well as if not better than words to symbolize objects. Between 18 months and three years of age, they become more conservative by accepting the spoken modality alone as appropriate for object labels and also become more sensitive to the iconicity of gestures. If so, then children somehow have to revise their earlier understanding of gestures as symbols to use gestures as action associates. In the present work, we first test toddlers' learning of arbitrary and iconic gestures as labels of objects (Study 1) and then as labels of actions (Study 2).

Before turning to these studies, it is important to keep in mind that they concern children's learning of gestures as symbols, i.e., without accompanying words. Some previous studies have explored children's word learning when the words are accompanied by hand movements with objects. The effectiveness of pairing arbitrary hand movements with an object as support for word learning has varied by age, consistency, and timing (Bothe et al., 2024a; Bothe et al., 2024b; Eiteljoerge et al., 2019a; Eiteljoerge et al., 2019b). The present paper explores the symbolic quality of gestures by comparing the likelihood of children to form word-object pairs to their ability to form either iconic or arbitrary gesture-object pairs. In other words, our studies examine children's response to referential gestures *in place of* words, not combined with words.

Study 1

The purpose of Study 1 was to test whether toddlers learn novel iconic and arbitrary gestures equally well as novel words as labels of objects, a conceptual replication of Namy and Waxman (1998).

Method

56 toddlers between the ages of 18 and 26 months participated. Half the toddlers (N = 28) were randomly assigned to the gesture and half to the word condition.

Test Objects Test objects consisted of four objects: a hat, a spinning top, a baby and (eye)glasses. Following Namy et al. (2004), these were objects with which children were likely to have been familiar. For the gesture group, we used the same four gesture-toy pairings for all children. Two of the toys (baby and glasses) had arbitrary gestures associated with them. Arbitrary gestures were developed by creating a gesture that was iconic for one object and associating it with the other object (i.e., arms rocking

motion for glasses, fingers circling eyes for baby). The other two toys (hat and top) had iconic gestures associated with them (i.e., patting the head for hat, twisting the wrist for top). For the novel word group, each of these items was paired with an English-sounding word (i.e., baby = dax, glasses = tipit, hat = pilog, top = nep).

Procedure The experimenter sat facing the child with the toys in a bag beside her. The child was first exposed to a training phase immediately followed by a testing phase for each object. The order of the items was counterbalanced across children.

To present the novel gestures/words as similarly as possible, they were presented in isolation. That is, the novel gestures were presented without co-occurring speech and the novel words were presented without determiners. During the training phase, the experimenter presented one object to the child and allowed them to interact with the object. The experimenter then drew the child's attention to the object approximately five times and labeled it using phrases such as "Look at this. [novel word/gesture]". Before producing the gesture, the experimenter tried to make eye contact with the child and then produced the gesture just below her face to ensure that the children saw it. To familiarize the children with the process of giving an object, the experimenter also asked the child to give the object to the experimenter using a phrase such as, "Can you give it to me? [novel word/gesture]". When the child provided the object, the child received reinforcement in the form of clapping and cheering. During this phase, the only toy visible to the children was the target toy.

In the testing phase two toys were placed in front of the child, one that had been just used in the training phase and a new toy that had not been trained with a novel label. The new toy was one of the other toys that would be or had been used in training previously and was randomly chosen out of the three toys for each trial. The child was then asked to give one of the objects to the experimenter using a phrase such as "Can you give it to me? [novel gesture/word]." The experimenter waited for the child to make a choice and asked once more if the child did not indicate a choice. If the child chose both objects, or did not choose an object, the response was considered incorrect. This testing phase was followed by another training phase with another one of the target objects.

Analytic Approach The data were analyzed with mixed-effects logistic regression models to predict the log-odds of accuracy for an item. To check for possible effects of iconicity/arbitrariness, we compared the children's responses to each item to chance on chi-square tests. Chance was 50% since children were asked to choose from two toys. The number of children who gave a correct or incorrect response was compared against expected value of half the total number of children who gave either a correct or incorrect response.

Results

The mixed-effects logistic regression model including subject, item, and symbol type (word vs. gesture) revealed a main effect of symbol type: the children were more accurate with words than with gestures ($b = 0.79$, $z = 2.45$, $p = .014$). No other main effects or interactions were significant. The children averaged 50.0% (SD = 40.0%) correct in the gesture condition and 77.8% (SD = 28.9%) correct in the word condition. Age was not related to accuracy.

We next tested the children's accuracy by item (see Figure 1). The children in the gesture condition scored no differently from chance for three of the four items: the hat, χ^2 (df = 1, N = 28) = 0, ns, Cramer's V = 0, the baby χ^2 (df = 1, N = 28) = 0.04, ns, Cramer's V = 0.04, and the glasses, χ^2 (df = 1, N = 28) = 0.04, ns, Cramer's V = 0.04. They only scored significantly above chance for the top, χ^2 (df = 1, N = 28) = 3.85, $p = .0498$, Cramer's V = 0.37. In contrast, the children in the word condition scored above chance for every item: the top, χ^2 (df = 1, N = 28) = 3.85, $p = .0498$, Cramer's V = 0.37, the hat, χ^2 (df = 1, N = 28) = 4.55, $p = .03$, Cramer's V = 0.40, the baby, χ^2 (df = 1, N = 28) = 8.33, $p = .004$, Cramer's V = 0.55, and the glasses, χ^2 (df = 1, N = 28) = 5.54, $p = .02$, Cramer's V = 0.45.

Discussion of Study 1

This study was designed to test whether toddlers between 18 and 26 months of age learn iconic and arbitrary gestures equally well as words as labels for objects (Namy & Waxman, 1998). Surprisingly, the children scored above chance in learning all four novel words we taught them and above chance for only one of the four novel gestures.

The one gesture that the children learned above chance was an iconic one (the spinning gesture for the top). This gesture is iconic through miming what one does with a top. It is possible that toddlers can learn iconic gestures when the gestures iconically represent an action (Hall et al., 2013; Hodges et al., 2018; Marentette & Nicoladis, 2011). If our interpretation is correct, it would suggest that children have already established a connection between iconic gestures and action by the age of 18 months. If so, then they might learn iconic gestures meaning action at least as well as words meaning action. In contrast, arbitrary gestures associated with actions should be difficult for children to learn.

Study 2

The purpose of Study 2 was to test whether toddlers could associate novel iconic gestures with actions as well as or better than novel words. The novel words in this study were verbs. For the gesture group, again, half our gestures were iconic (i.e., miming the action) and half were arbitrary. If toddlers interpret gestures as the associated actions, they should learn iconic gestures at least as well if not better than novel words for actions. They should also show difficulties learning arbitrary gestures.

In this study, we asked the toddlers to indicate their learning of the novel word/gesture by performing the relevant action. As children could potentially have produced an infinite number of different responses, it was not possible to test children's performance against chance. In a somewhat similar design, Novack et al. (2015) found that two-year olds performed, on average, between 25% and 50% of the actions communicated through iconic gestures.

Method

Thirty-nine hearing English-speaking children between the ages of 18 and 25 months participated in Study 2; none of these children had participated in Study 1. About half the children (N = 20) were randomly assigned to the gesture condition and the other half to the word condition (N = 19).

Test Objects Test objects consisted of the same four toys we used in Study 1, the only difference being that the toys now served as objects with which the children could demonstrate the target action. Two iconic gestures were deveoped that had visual similarities to the target action they were paired with (i.e. patting the head to indicate placing toys on the head, and a twisting motion with the wrist and hand to indicate spinning the toys). Two arbitrary gestures were also created by re-using gestures from Study 1 (i.e. rocking motion with arms, fingers circling eyes) to indicate the target actions (i.e. make toys jump, make toys dance). In the novel word condition each action was paired with an English-sounding verb (i.e. daxing = place toys on head, tippiting = spin toys around, pilogging = make toys jump, nepping = make toys dance).

Procedure We replicated the procedure from Study 1 as closely as possible, changing the target response from an object to an action. For this reason, the results of this study are not directly comparable to those of Study 1.

The children again participated in a training phase and then testing phase for each target action before moving to the next action. In the training session, all four toys were placed in front of children. The experimenter encouraged the children to play with the toys, and used the target word/gesture at least five times in phrases such as "Look at this, what can the baby do? [Novel word/gesture]" (following up with a demonstration of the action with the toy). The experimenter demonstrated the action associated with each word/gesture on at least three toys. During the testing phase, the toddlers still had all four toys in front of them and were asked, "Can you make a toy do this? [Novel word/gesture]". After the testing phase of one word/gesture, the experimenter proceeded immediately to the next item.

Results

The logistic regression model revealed a significant main effect for symbol type ($b = 11.88$, $z = 2.46$, $p = .013$). The children's ratio of accurate responses with words averaged .408 (SD = .288) of the trials and with gestures .275 (SD = .197). It is important to note, too, that age interacted with symbol type ($b = 0.62$, $z = 2.64$, $p = .008$). This interaction

was due to the fact that children's accuracy with words increased with age and children's accuracy with gestures decreased slightly with age. To understand that relationship with age better, we ran correlations between the children's age and their ratio accurate for iconic and arbitrary gestures. While neither correlation reached significance, the correlation between age and arbitrary gestures was higher, r (18) = -.316, p = .18, than for iconic gestures, r (18) = -.139, p = .56.

There were differences by item. Figure 2 summarizes the number of children who performed the action corresponding to the symbol for each item. For the two iconic gestures, there was no difference between the word and gesture conditions, both putting on head, χ^2 (df = 1, N = 39) = 1.24, *ns*, Cramer's V = 0.18, and spinning, χ^2 (df = 1, N = 39) = 1.25, *ns*, Cramer's V = 0.18. In contrast, for the two arbitrary gestures, the children were significantly less likely to perform the corresponding action in the gesture than in the word condition, for jumping, χ^2 (df = 1, N = 39) = 4.51, p = .03, Cramer's V = 0.34, and for dancing, χ^2 (df = 1, N = 39) = 4.69, p = .03, Cramer's V = 0.35.

Discussion of Study 2

The results of Study 2 show that toddlers can associate iconic gestures with actions as well as they can with words, but showed little success in associating arbitrary gestures with actions. These results suggest that when interpreting gestures, toddlers, like older children (Marentette & Nicoladis, 2011), associate gestures with actions.

Unlike in Study 1, age was an important variable in this study. Age interacted with symbol type, with older children learning more novel words than younger children and the reverse for novel gestures. Children learn more verbs as they get older (Bates et al., 1994), so it is perhaps unsurprising that they become better at acquiring novel verbs with age. The slight decrease in age with gesture learning, particularly arbitrary gesture learning replicates Namy et al. (2004). They found that 18-month-olds learned arbitrary gestures better than 26-month-olds. We discuss these age effects in the General Discussion.

One intriguing result was the low accuracy in learning the arbitrary gesture for dancing (see Figure 2; none of the children learned it). This gesture was the only gesture that was itself static (i.e., holding fingers as circles around the eyes). Future studies can systematically test whether the very dynamicity of gestures implies action to toddlers.

General Discussion

In Study 1, we showed that the children who learned novel words associated with objects were significantly more accurate than those who learned gestures associated with objects. All of the words were arbitrarily related to the objects and yet the children showed an advantage for learning words over both arbitrary and iconic gestures. In fact, the children in this study looked remarkably like the 26-month olds in previous studies (e.g., Namy, 2001; Namy & Waxman, 2002, 1998; Namy et al., 2004; Namy, 2008), even though we included children up to eight months younger. That is, these children were more accurate with words as object labels than gestures. These results contradict the claim that young children can equally well learn words and gestures as labels for objects (e.g., Namy, 2009). Our results support the claim that young children have difficulty learning gestures as object labels (see also Puccini & Liszkowski, 2012).

The toddlers may have failed to learn gestures as object labels because, like older children, iconic gestures are strongly associated with actions (Bohn et al., 2016; Magid & Pyers, 2017; Stanfield et al., 2014). Actions can be associated with objects, according to the actions typically performed with those objects (Bub et al., 2003). So, it is possible that even very young children generally associate gestures with action and that association could increase in strength with age (Stanfield et al., 2014). In most previous studies teaching gestures as object labels, researchers have taught iconic gestures that children could have been conceptualized as what one might do with an object (Graham & Kilbreath, 2007; Namy & Waxman, 1998). In the present Study 1, the only item for which a gesture advantage was found was for the top. Recall that the paired gesture for this item was an iconic one, the action one does with a top, although we presented the gesture in the context of an object label. In Study 2, we tested if children learn gestures as action-associates by attempting to teach children either words or iconic and arbitrary gestures associated with actions. We found that the children learned the association between iconic action gestures and words equally well, but were worse at learning arbitrary action gestures.

Taken together, our results suggest that the children in the studies by Namy and her colleagues successfully learned to pair a gesture with an object to the extent that they could interpret the gesture as an action-associate of that object (i.e., either what the object itself did or what one does with the object). For example, the iconic gesture for "spoon" in Namy et al. (2004) was a fist raised repeatedly toward the face as if eating with a spoon. If so, children's ability to learn arbitrary gestures with short-term exposure could be related to their ability to imagine that the object does the depicted action or one does the depicted action with the object. For example, children in Namy et al. (2004) who successfully learned the arbitrary gesture for "spoon" (i.e., a fist rocking side to side with the thumb and pinky extended) could have imagined a spoon posed on top of the hand, rocking side to side. 18-month-olds have less world knowledge than 26-month-olds so they may have learned more arbitrary gestures because they could imagine that the action was plausible. Further research will elucidate the possible role of affordances in children's gesture learning.

To test our claim that even toddlers tend to assume that gestures are associated with actions, future research could test children's extensions of gestures to novel instances of similar kinds (Graham & Kilbreath, 2007; Namy &

Waxman, 1998). A case study involving longitudinal data from one girl showed that although she was taught gestures as object labels between the ages of 9 months and 2 years 6 months, she tended to extend the meaning of the gestures to objects that performed a similar action (Nicoladis et al., 2011). For example, for the iconic gesture "butterfly", formed with both hands fluttering like wings, the child extended to a hinge (an object that performs the same action) rather than a novel butterfly. Future research could test the generalizability of this finding.

Testing children's willingness to extend gestures to novel instances would clarify what associations between gestures and objects/actions mean to children. In other words, while we have shown that children associate gestures and actions, we do not know whether that association means that children interpret gestures as referring to the actions. One alternative possibility is that, like adults, children do not interpret gestures as referring so much as specifying or highlighting the important aspects of an action for a particular context and/or pragmatic purpose. If so, then there is a clear developmental continuity between toddlers' interpretation of iconic gestures and adults' use of co-speech gestures, which often accompany verbs and signify something literal or metaphorical about actions (Williams et al., 2007).

In sum, this study has shown that children between 18 and 26 months were significantly more successful at learning novel words than gestures as object labels and equally successful at learning novel words as iconic gestures as action associates. These results suggest that at least from toddlerhood on, gestures tend to be interpreted as signifying action.

Figures
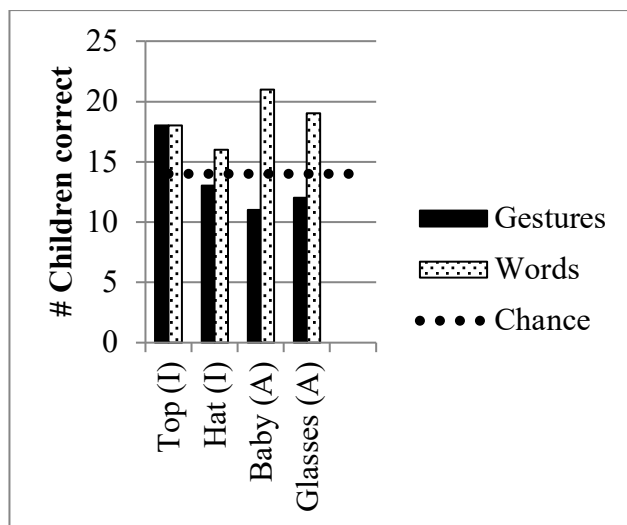
Note: (A) = Arbitrary gesture in the gesture condition; (I) = Iconic gesture in the gesture condition

Figure 1: The number of children accurate in the gesture and word conditions (Study 1)
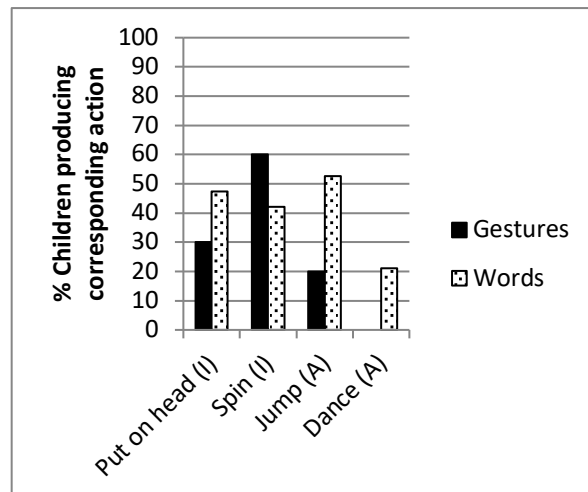
Note: (A) = Arbitrary gesture in the gesture condition; (I) = Iconic gesture in the gesture condition. There was no chance performance

Figure 2: The percentage of children accurate in the gesture and word conditions (Study 2)

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