
Simon Child¹, Anna Theakston², Simone Pika³

¹Corresponding author: Simon Child, Assessment Research and Development Division, Cambridge Assessment, 1 Hills Road, Cambridge, CB1 2EU. Email: child.s@cambridgeassessment.org.uk

²University of Manchester, School of Psychological Sciences, Manchester, UK. Email: Anna.Theakston@manchester.ac.uk

³Max Planck Institute for Ornithology, Humboldt Research Group, Seewiesen, Germany. Email: spika@orn.mpg.de
Abstract

Around the age of nine months, children start to communicate by using first words and gestures, during interactions with caregivers. The question remains as to how older preschool children utilise the gestures they observe into their own gestural representations of previously unseen objects. Two accounts of gesture production (the ‘gesture learning’, and ‘simulated representation’ accounts) offer different predictions for how preschool children use the gestures they observe when describing objects. To test these two competing accounts underlying gesture production, we showed 42 children, (mean age: 45 months 14 days), four novel objects using speech only, or speech accompanied by either movement or physical feature gestures. Analyses revealed that (a) overall symbolic gesture production showed a high degree of individual variability, and (b) distinct observed gesture types influenced the children’s subsequent gesture use. Specifically, it was found that children preferred to match movement gestures in a subsequent communicative interaction including the same objects, but not physical feature gestures. We conclude that the observation of gestures (in particular gestures that depict movement) may act to change preschool children’s object representations, which in turn influences how they depict objects in space.
Keywords: Human children; gestures; acquisition; representation; action

Biography of authors: Simon Child is a Research Officer at Cambridge Assessment, a non-teaching department of the University of Cambridge, UK. Anna Theakston is a Senior Lecturer at the School of Psychological Sciences at the University of Manchester, UK. Simone Pika is head of the Humboldt Research group at the Max Planck Institute for Ornithology, Germany.
“The growth of children’s gestures [...] provide some of the best evidence that in 
performing gestures the hands are, in fact, symbols with meanings in their own rights”.
(McNeill, 1992, p. 295)

Early research on the communicative development of children has shown that 
gestures and speech emerge and develop together from around 9-12 months of age 
(Bates, Benigni, Bretherton, Camaioni, & Volterra, 1979; Riseborough, 1982).

Typically, children start to denote concrete objects and situations by either vocalising or 
estering (McNeill, 1992). These early performatives can be defined as gestures that 
communicate children’s expressions of thought (Doherty-Snieddon, 2003), and serve to 
gain attention and maintain a joint focus with an adult (Bruner, 1975; Capone & 
McGregor, 2004; Volterra & Erting, 1990). These gestures (also called protogestures by 
some authors, e.g., McNeill, 1992) can be classified into three distinct types: 

*ritualizations, deictics, and symbolic* gestures (Acredolo & Goodwyn, 1988; Bates et al., 
1979; Pika, 2008).

*Ritualizations* are behaviours in which the signaler uses an effective behaviour 
to request an action (Lock, 1978). For instance, children often use a stylised *arm-raise* 
to be picked up. *Deictics* are designed to direct the recipient’s attention to outside 
entities. Prototypes are *showing* (e.g., holding up an object to the recipient), and 
*pointing* (with an index finger or the whole hand). Pointing at first emerges in a non-
communicative fashion, to orient children’s own attention to objects and events (Bates, Camaioni, & Volterra, 1975; Carpenter, Nagell, & Tomasello, 1998; Moore & D’ Entremont, 2001; Werner & Kaplan, 1963). By around 12 months, children are able to use pointing gestures for communicative goals including declaring interesting objects and events to an interlocutor, or informing them about something (Liszkowski, 2005; Liszkowski, Carpenter, Striano, & Tomasello, 2006; Lock, Young, Service, & Chandler, 1990). Liszkowski and colleagues (Liszkowski, 2011; Liszkowski & Tomasello, 2011) suggested that declarative pointing in particular structures children’s social communicative activities with their caregivers. According to Cochet and Vauclair (2010), declarative pointing is utilised by children through deferred imitation processes, as they actively construct with their caregivers a variety of communicative experiences (see also Liszkowski & Tomasello, 2011, for a related account). This is perhaps best demonstrated during the early stages of spoken communication, where infants use gestures alongside speech to help create their first sentence-like utterances (e.g., Capone & McGregor, 2004; Ozcaliskan & Goldin-Meadow, 2005; Volterra, Caselli, Capirci, & Pizzuto, 2005).

The third gesture type, *symbolic* gestures (Acredolo & Goodwyn, 1988; Namy & Waxman, 1998) also referred to by others as ‘iconic’, ‘pictographic’ or
‘representational’ gestures (Iverson, Capirici, & Caselli, 1994; McNeill, 1992; Poggi, 2002) are produced by children from around nine months, and initially comprise whole-body enactments to depict actions and objects. They are either associated with a referent metonymically, in that the gesture refers to an element or attribute of something (e.g., putting a finger to the nose and raising it for ‘elephant’), or on the basis of their mutual iconic relation to each other (e.g., flapping one’s arms to represent a bird’s wings, Acredolo & Goodwyn, 1988; Pizzuto & Volterra, 2000).

In older preschool children, as speech becomes the preferred mode of communication (Namy & Waxman, 1998), gestures act to add semantic information to spoken utterances (Alibali, Evans, Hostetter, Ryan & Mainela-Arnold, 2009). These co-speech gestures differ from the gestures that earlier preschool children develop via interactive routines with caregivers, as they are tightly related to speech production, rather than an alternative mode of symbolic expression (Ozcaliskan & Goldin-Meadow, 2011). Virtually nothing is known about how older preschool children utilise the symbolic gestures they observe in their own descriptions of novel objects. One possibility is that children reproduce the symbolic gestures they observe being accompanied by objects, similarly to children aged around nine months. According to this ‘gesture learning’ account, Acredolo and Goodwyn (1988; Goodwyn & Acredolo,
1993; see also Caselli, 1990) proposed that infants acquire their first symbolic gestures within social interactions (gestural or motor routines) with their caregivers. However, while these gestures are clearly learned during interactive routines, it is uncertain as to whether these earliest examples of gestures are truly symbolic. Liszkowski (2008) suggested that children may not be reproducing these apparently symbolic gestures in the same way as the adult initially performed them (i.e., as an intentional means for highlighting something about an object) but may in fact just be mimicking the action to indicate that they recognise the object; the ‘symbolic’ status of these gestures is in the eyes of the observer, not in the mind of the child (Tomasello, Striano, & Rochat, 1999). Caselli (1990) suggested these gestures are better classified as conventional gestures; they are established by the conventions of specific communities or groups (McNeill, 1992). This implies standards of form that must be met if the gestures are to be recognised and thus involves low levels of individual differences within the community or group.

A second possibility is that children’s gesture production is grounded in their perceptive experiences. According to this ‘simulated representation’ account, Hostetter and colleagues (Hostetter & Alibali, 2008, 2010; Hostetter & Skirving, 2011) argue that gestures emerge from the perceptual and motor simulations that underlie embodied
language and mental imagery (e.g., Barsalou, 1999). This so-called gesture-as-
simulated-action (GSA) framework suggests that gestures are produced on the basis of
speakers ‘replaying’ the visualisation of the object through activation of relevant areas
of the visual and motor cortex. This in turn then leads to activation beyond a *gesture
threshold*, resulting in the production of a gesture (Hostetter & Alibali, 2008).

Furthermore, it has been argued that observing gestures can influence the
subsequent representations of objects and the physical environment (Cartmill, Beilock
found that after completing a Tower of Hanoi task, when participants explained the task
to an interlocutor, the gestures they produced were influenced by the method that they
had used to complete the task (computer versus real objects). Interestingly, when the
interlocutor was subsequently asked to do the task themselves on a computer, their
mouse trajectories bore a relation to how they had seen the task explained previously.
Goldin-Meadow and Beilock (2010) suggested that gestures may act to change how
individuals think about an object. Specifically, they argued that gestures can alter how
an object is represented by grounding it in action, as gestures themselves are produced
from simulations of action according to the GSA framework (Hostetter & Alibali, 2008,
2010; Hostetter & Skirving, 2011). Although gestures themselves do not change how an
object is perceived (i.e., its shape, colour etc), they may act to represent ideas which are not bound by the capabilities of the object in question. Hostetter (2011) and Feyereisen and Havard (1999) distinguish between gestures that depict movement and those that depict non-motor information, such as a physical feature of an object (see also Ozcaliskan & Goldin-Meadow, 2011). They suggest that observers may glean more information from motor gestures compared to non-motor gestures, as they are particularly effective at conveying detail about spatial relations.

The present study was designed to test the two competing accounts outlined above that explain how older preschool children may utilise the symbolic gestures they observe in their own representational strategies. To achieve this aim, children were asked to describe novel objects in one of three different scenarios. In each scenario, four different new objects were presented to preschool children. The researchers introduced these objects by either (1) using speech only, or by accompanying the verbal introductions with (2) movement gestures, or (3) physical feature gestures. The separation of gesture types into movement and physical feature conditions was included to assess for the possibility, found in previous research (Feyereisen & Havard, 1999; Ozcaliskan & Goldin-Meadow, 2011), that observers may utilise gestures that depict motor and non-motor aspects of objects and events differently.
We hypothesised that if children produce gestures on the basis of learning a conventionalised routine, as suggested by the ‘gesture learning’ account, then both movement and physical feature gestures should be produced more often by children who have observed these gestures, compared to children in the speech only condition, where no gestures are observed. Alternatively, if children’s thinking about an object is influenced by the representations they are exposed to through gesture, as suggested by the ‘simulated representation’ account, then children who observed gestures depicting movement should produce more of these gestures when asked to describe the objects, compared to children who had not observed any movement gestures.
Methods

Participants

Participants were 42 monolingual English-speaking children (18 girls, 24 boys) aged between 44 and 46 months of age (mean age: 45 months 14 days). They were recruited from a sample participating in a longitudinal study of symbolic development (Child, 2011). All the children had typical language development (as determined by their performance on the CELF-preschool test (Wiig, Secord, & Semel, 2000). An additional four children were not included in the sample because of fussiness before completion of testing.

Materials

To study how children utilised the symbolic gestures they observed, a game box, and a total of 20 objects varying in feature and shape were used. Four of the objects were designated target objects and the remaining 16 functioned as filler objects (see Table 1).
The tasks took place around a large cardboard box that was placed between the child and their caregiver (39 cm x 28 cm x 26 cm). The box was coloured red to make it attractive and engaging for the children. Extending from one side of the box was a large cardboard flap (32 cm x 26 cm), which was designed to impede the caregiver’s view of the target object and the gesture being produced by the experimenter. On the other side of the box was another cardboard flap (32 cm x 9 cm). This flap was designed to discourage the child from looking around the box to the caregiver’s side, while at the same time not impeding the view of the child towards the caregiver and vice versa, while the child attempted to describe the target objects. At each end of the box was a square hole (10 cm x 10 cm), to pass objects from one side of the box to the other. The main purpose of the box was to provide a restricted visual space between the experimenter and the caregiver, so that the caregiver was unable to see (a) the target object and (b) the experimenter’s gesture. An additional purpose of the box was to provide a motivating and engaging game environment for the children. Once the
children had described an object successfully, the caregivers pushed the object through
the hole in the box towards the child.

Objects

The four target objects were a spiky ball, a stretch toy, a string ball and a sway
triangle (these names were not revealed to the children at any stage). The target objects
were selected on the basis of them having both a distinctive appearance and a distinctive
movement, from which the demonstrated gestures were derived (see Table 1). These
objects had been tested in a pilot-study and had been chosen on the basis of their likely
novelty to children.

For each target object, there were four ‘filler’ objects (FO). Each filler object
matched a certain aspect of the target object (see Table 1). FO1 for instance was
matched on the basis of having a similar potential movement to the target object. For
example, the FO1 object for the string ball bobbed up and down in a similar fashion to
the target object. FO2 was matched on the basis of a distinct physical characteristic. For
example, for the sway triangle, FO2 had a hole through the middle. The remaining two
filler objects were chosen on the basis of matching the colour (FO3) and the basic shape
(FO4) of the target object.
The child had to describe each of the target objects in turn, so that the caregiver could distinguish that object from the filler objects that were presented alongside it. The filler objects were carefully selected so that the child had to provide full descriptions of each target object. For example, while children may have known the word “ball” for the spiky ball, the children had to provide extra information to their caregiver, so that the caregiver could disambiguate the target object from the other balls in the total array of objects. The filler objects were not visible to the child during the task, unless the caregiver selected a filler object post-description (see experimental procedure). This was to keep the child focused on describing the target objects, so that the descriptions (and the gestures) children produced could be linked to the target objects with certainty.

*Experimental procedure*

Testing took place either in a laboratory at the University of Manchester or at the children’s homes, depending on the caregiver’s preference. At the laboratory, the children were made to feel as comfortable as possible in their surroundings. At the children’s homes, testing took place in a quiet room, away from potential distractions. Before testing, the caregivers were informed about the aims of the study and what the task involved. The children were then asked if they wanted to play a describing game.
Once the children were comfortable, they were asked to sit on a chair opposite their caregiver, with a small table between them. The experimenter sat on the left side of the child placing himself in-between the child and a bag of objects, which were placed on the far side of the experimenter. The experimenter introduced the game box to the child and placed it on the table, with the front end of the box facing the caretaker. The child was then given the opportunity to explore the box and to get used to its appearance and position (see Figure 1).
Once the child appeared ready to begin, the experimenter introduced the game by saying, “Now we are going to play a describing game. I am going to show you some toys that your mum/dad can’t see. The aim of the game is to describe the toy to your mum/dad so that they can pick the right one from lots of other toys, and then send it back to you through the box.”

Experimental tasks

Each task consisted of a total of five trials - one warm-up trial and four test trials.

Warm-up trial: The aim of the warm-up trial was to familiarise children with the introduction of the objects and the procedures of the task. The child was introduced to an object (a small toy car) and given the opportunity to hold the object. The experimenter then said, “This is an interesting toy isn’t it?” Once the child had explored the toy, the experimenter took the object and placed it into a bag with some filler objects. The toy was placed in the bag so that the child could not see any of the filler objects. The bag was shaken and passed around to the caregiver. The experimenter then asked the child to describe the toy to his or her caregiver, so that the caregiver could select the correct one to send back to the child through the game box. If the child appeared reluctant, the experimenter encouraged the child by asking, “Is there anything you can tell your mum/dad about the toy you’ve just played with?”
Once the child had made an attempt to describe the toy to his or her caregiver, the experimenter asked the caregiver to choose which object they thought it was, pull it out of the bag of objects, and show their child. If the caregiver presented one of the incorrect filler objects to the child, the experimenter asked the caregiver to place the object back into the bag, and asked the child to continue describing the target object, so that the caregiver could make the correct selection. If the caregiver was unsure of which object to select, the experimenter asked the child, “Is there anything else you can tell your mum/dad about the object?” Once the caregiver was certain of the correct object, they were asked to show the object to the child for confirmation. If the correct toy was chosen, the experimenter asked the caregiver to place the object in the hole at his or her end of the box, which allowed the child to pick the toy up from his or her end of the box. Then the test trials started.

**Test trials:** Each test trial consisted of three subsequent steps:

**Step 1:** The experimenter introduced one of the four target objects to the child. The order of presentation of the target objects was randomised. On presentation of the first target object, the experimenter placed the object behind the flap of the game box, outside of the caregiver’s view but in full sight of the child. The experimenter then said, “Look at this toy!” to draw the child’s attention to the object. Depending on the test
condition (described below), the experimenter proceeded to communicate about the
target object by using distinct statements (see Table 2) with or without accompanying
gestures (see Table 3).

The gestures were performed directly above the target object to ensure that the child
could see each gesture. The child was then given an opportunity to play with the object,
to explore its properties. Once the child had finished playing with the toy, the
experimenter placed the target object into a bag with the four related filler objects,
shook the bag, and placed it on the caregiver’s side of the box. The experimenter then
prompted the child to describe the object to the caregiver by saying either, (i) “Can you
tell your mum/ dad what that toy looked like or what it moved like?” or (ii), “Can you
tell your mum/ dad what that toy moved like or what it looked like?” These phrases
were chosen in a pseudo-random manner, with two of the objects being accompanied by
phrase (i) and two by phrase (ii).

Step 2: The child was then asked to describe the target object to the caregiver.
Step 3: Once the child had made an attempt to describe the target object, the caregiver was asked to choose an object out of the selection of five objects (one target object and four filler objects) which best matched the child’s description, based on the information that the child had provided. If the caregiver selected the target object, the child was given positive verbal feedback by the experimenter, and the caregiver was asked to place the toy into the game box for the child to collect. The experimenter then asked the child for the object, took the bag of filler objects from the caregiver, put the object into the bag and placed it back into a second larger bag where all the toys were kept on the left side of the experimenter. If, after the child’s initial description, the caregiver was still unsure as to the correct object, the caregiver could ask further questions to try to clarify (see caregiver instructions below). If the child seemed unsure how to respond, the experimenter asked the child if there was anything else he or she could say about the object. If the child answered in the negative, the experimenter asked the caregiver to choose which object they thought might best fit the child’s description. The object was then held up so that the child could see it. If the caregiver was correct, the child was praised and asked to collect the toy from the caregiver, through the game box. If the caregiver selected one of the filler objects, this provided feedback to the child that some more description was required. The experimenter then asked the child to tell his or her
caregiver anything else he or she could about the object, until the caregiver chose the
target object.

Caregiver instructions

The caregivers had been instructed before the beginning of the test trials that they should not select which object they thought the child was describing until they were certain of their choice. They were also instructed that they could ask for more information from their child, but must not ask specific questions (e.g., “Is the toy blue?”) These guidelines were given to provide a context which encouraged the children to give full descriptions of the objects that had been presented to them.

Experimental conditions

Children were randomly placed into one of three experimental conditions: the Speech Only Condition (SO) – 12 children, the Movement Demonstration Condition (MD) – 13 children, and the Physical Feature Demonstration Condition (PF) – 17 children. The main manipulation of these three conditions was whether or not gestures were used to accompany speech (SO Condition) and the type of representative gesture utilised by the experimenter while introducing the four target objects (MD and PF Condition).

SO Condition
In the SO Condition, the experimenter only used spoken language (four statements, see Table 2) to introduce the four target objects. Two statements were intended to draw the child’s attention to the movement of the object (as per the MD Condition, see below) and two statements were intended to draw the child’s attention to the physical feature of the object (as per the PF Condition, see below). During each trial, the sentences were used in a randomised order.

**MD Condition and PF Condition**

In these two conditions, the experimenter introduced each target object, by drawing the attention of the child to the object (a) verbally (four different statements per trial, see Table 2) and (b) gesturally (four repetitions of the same gesture per trial, see Table 3). In the MD Condition, the child’s attention was drawn verbally to the movement of the object (e.g., “It moves in a funny way doesn’t it?”), while in the PF Condition, the accompanying speech referred to physical features of the target object (e.g., “See what it looks like!”).

Concerning gestures, in the MD Condition the experimenter depicted a characteristic movement of the object, when a small amount of force was applied to it. For example, for the *sway triangle* the experimenter’s hand swayed from side to side to represent the potential rocking motion of the triangle. In contrast, in the PF Condition,
the experimenter used gestures that highlighted a physical characteristic of the object.

For example the gesture accompanying the introduction of the *spiky ball* consisted of an up and down movement in an inverted ‘V’, performed with a pointing index finger to represent the spikes. Although these physical feature gestures occasionally had movement contained within them, the dominant semantic element of these gestures was always a physical feature.

**Data collection**

Each task was videotaped using a Sony HDD DCR-SR75E digital camera. The camera was placed on a tripod, which was one metre in height and was placed so that the child, caregiver, and experimenter were visible throughout testing.

**Coding**

Since the focus of the study concerns *symbolic* gestures, only these gestures were coded. For the SO Condition, gestures were classified under the same criteria as ‘same as demonstrated-movement’, ‘same as demonstrated-feature’ or ‘other-movement’ or ‘other physical feature’. All of the children’s symbolic gestures produced when describing the objects were coded using these criteria.
For the two gesture demonstration conditions (MD Condition and PF Condition), children’s symbolic gestures were coded for whether they were ‘same as demonstrated’ or ‘other- movement’ or ‘other physical feature’. For the MD Condition a gesture was classed as ‘same as demonstrated’ (i.e., reproduction of the previously modelled movement gesture) if the gesture had the same trajectory of movement as the demonstrated movement gesture. Hand shape did not have to be the same. For example, to be classed as ‘same as demonstrated’ for the sway triangle children had to rock their hand side to side pivoting on the wrist. For the PF Condition a gesture was classed as ‘same as demonstrated’ if the gesture produced had the same hand shape as the demonstrated physical feature gesture. The movement of the hands whilst in this shape did not have to be the same. For example, for the string ball children had to cup their hands to form a ball shape.

In order to test inter-coder reliability of these gesture classifications, 24% of the videos were coded by a second coder, who was blind to the aims and questions of the study. We found that overall agreement was good (87% agreement, Fleiss, 1981), with a Cohen’s kappa of .714.
Results

To investigate how preschool children utilise the gestures they observe during their own attempts at representing objects that they have no name for, we carried out several analyses.

First, we screened for whether the experimental condition influenced the children’s overall gesture production. To establish this, the total number of symbolic gestures produced by children were compared across the three experimental conditions. There was no significant difference between conditions (Kruskal-Wallis test; $\chi^2 (2, 42) = 3.61, p = .16$). Children performed a mean of 4.17 gestures ($SD = 2.92$) in the SO Condition, a mean of 5.62 gestures ($SD = 3.01$) in the MD Condition, and a mean of 3.82 gestures ($SD = 2.66$) in the PF Condition.

Second, to rule out differences in gesture performance due to gender, the total number of symbolic gestures produced by boys and girls were compared. There was no significant difference found (Mann Whitney U test; $U = 189.5, z = -.88, p = .50$; boys $M = 4.08, SD = 2.41$, girls $M = 5.00, SD = 3.48$), and so the data was collapsed across gender.
Spontaneous gesture production (SO Condition)

The gestures spontaneously produced by children in the SO Condition (see Table 4) were then analysed. This was to establish a baseline level of natural production of the target gestures that were demonstrated to the children in the MD and the PF conditions, and to establish whether specific objects elicited particular types of gesture more than others.

- insert Table 4 here -

Overall, gestures depicting physical features of objects were more frequently used than gestures depicting movements of objects, accounting for 75% \((M = 3.00, \text{SD} = 2.05)\) of the gestures produced by the children in the SO Condition. Of these physical feature gestures, 36% \((M = 1.00, \text{SD} = 1.13)\) matched the gestures demonstrated in the PF Condition. The physical feature gestures were spread evenly across the objects (spiky ball, \(M = .67, \text{SD} = .65\); sway triangle, \(M = .83, \text{SD} = .84\); stretch toy, \(M = .75, \text{SD} = .97\); string ball, \(M = .75, \text{SD} = .97\)). Movement gestures accounted for 25% \((M = 1.17, \text{SD} = 1.19)\) of the total gestures children produced in the SO Condition. Of these movement gestures, 63% \((M = .75, \text{SD} = .97)\) matched the gestures demonstrated in the
MD Condition. There were a similar number of movement gestures produced by children in the SO Condition across the objects (spiky ball, $M = .17$, $SD = .58$; stretch toy, $M = .33$, $SD = .49$; string ball, $M = .58$, $SD = .90$) apart from the sway triangle, which elicited few movement gestures ($M = .08$, $SD = .29$). Overall, while there were some gestures that were produced by more than one child (e.g., the drawing of a triangle with a finger for the sway triangle), there was individual variability in how children supplemented their speech with gestures.

The spontaneous production of the demonstrated movement and physical feature gestures indicated that these gesture types are able to be produced by children of this age, and are appropriate to describe the target objects. To determine whether children were more likely to spontaneously produce either the demonstrated movement or physical feature gestures, the total number of demonstrated movement gestures and the total number of demonstrated physical feature gestures were compared\(^1\), but a non-significant difference was found (Wilcoxon-test, $Z = -.749$, $p = .45$).

Across the four objects, children in the SO Condition used terms in speech that referred to the physical features of objects, e.g., “It’s a triangle shape” ($M = 8.25$ per

\(^1\) The children in the SO Condition were not shown any gestures by the experimenter. These analyses are based on the gestures that would have been coded as demonstrated movement or physical feature gestures if they were performed by children in the MD and PF conditions respectively.
child, $SD = 2.09$) more often than they used terms that referred to the action or movement of the object, e.g., “It bounces” ($M = 1.17$ per child, $SD = .72$). This statistically significant difference ($t(11) = 10.98, p < .001$) is likely due to children having instant access (on first viewing) to objects’ perceptual features, and could therefore potentially describe the colour, shape, or unusual features of the objects.

Meanwhile, the movement characteristics of the objects could only be fully explored by physically manipulating them.

**Influence of demonstration of gestures**

**Overall gesture production**

The children’s symbolic gesture production across all three conditions was highly coordinated with their speech. Overall, out of the 186 gestures produced by the children, 165 (89%) were produced as part of a spoken utterance, while only 21 were produced in the absence of any speech. The proportion of gestures that were produced with speech was similar across the three gesture demonstration conditions (Kruskal-Wallis test: $\chi^2 (2, 42) = 1.81, p = .40$), which suggested that children’s coordination between gesture and speech production was similar in all three conditions.

The next stage of the analysis was to establish to what extent the children were utilising the demonstrated gestures to facilitate their descriptions of the objects. The
analysis of the children’s gestures in the SO Condition showed that the demonstrated movement and physical feature gestures were produced spontaneously by the children. To address the question of whether children at this age learn the association between an object and a demonstrated gesture, we compared whether the observation of physical feature and movement gestures had an influence on children’s subsequent gestural performance. To do so, we calculated proportions of children’s symbolic gestures that matched the gestures that they observed in the experimental manipulation, by dividing this number of gestures by the total number of symbolic gestures produced. The subsequent analysis showed that children in the MD Condition used a significantly higher proportion of demonstrated movement gestures ($M = .41, SD = .27$) compared to the SO Condition ($M = .18, SD = .23$; Mann-Whitney U test, $U = 35, z = -2.37, p = .02$). There was no significant difference in gestural performance between children in the PF and the SO conditions (Mann-Whitney U test, $U = 81, z = - .99, p = .32$). However there was a tendency for children in the PF Condition ($M = .17, SD = .26$) to perform the demonstrated physical feature gesture less often than children in the SO Condition ($M = .28, SD = .32$). This suggests that experiencing a relation between a gesture and its referent in a social context does not consistently lead to greater use of that gesture in subsequent descriptions of that same object.
First gestures used

The previous analysis showed that children tended to match movement gestures they had previously observed, but not physical feature gestures. To investigate this finding in more detail, children’s production of their first gesture for each object description was analysed, since first gestures produced in a communicative act have been identified as children’s most ‘spontaneous’ communicative reaction (Huang & Charman, 2005). As there were four objects shown to each child during the test trials, children could score a maximum of four for their ‘total first gestures’. An initial analysis established that children in each of the three experimental conditions produced at least one gesture for the same number of objects ($\chi^2 (2, 42) = 2.52, p = .28$; MD Condition, $M = 3.00, SD = .81$; PF Condition, $M = 2.41, SD = 1.12$; SO Condition, $M = 2.58, SD = 1.00$). A subsequent analysis showed that for children in the MD Condition, a significantly higher proportion of their first gestures matched the demonstrated gestures in the MD Condition, compared to children in the SO Condition (MD Condition: $M = .43, SD = .33$; SO Condition: $M = .13, SD = .21$; Mann-Whitney U test, $U = 36, z = -2.39, p = .02$). There was no significant difference in the proportion of first gestures that matched the demonstrated gestures in the PF Condition between children in the PF and
SO Conditions (PF Condition: $M = .15$, $SD = .26$; SO Condition: $M = .32$, $SD = .37$;

Mann-Whitney U test, $U = 76$, $z = -1.29$, $p = .26$).

Object Manipulation and speech production

The results above suggest that children are inclined to produce more movement
gestures after observing gestures that depict movement compared to what they would
produce spontaneously, while the equivalent effect is not found when the experimental
manipulation comprised physical feature gesture demonstrations. To rule out the
possibility that the demonstrated movement gestures are merely making the children
aware of the movement ‘affordances’ of each object, which might lead children to
interact with the objects differently and hence recall different aspects of the objects, we
analysed whether the children across the three conditions manipulated the novel objects
differently when they had the opportunity to investigate them themselves (in between
the demonstration phase and when the children were asked to describe each object). As
the movement gestures for each object were linked to a particular manipulation of the
object, these specific manipulations were analysed for differences across conditions (see
Table 5). Overall, there was no difference between conditions for any of the four novel
objects in terms of these object manipulations, suggesting that in this study the
demonstrated movement gestures did not merely act to make children aware of the
movement affordances of the object.

- insert Table 5 here -

Furthermore, if the demonstrated gestures were acting to make children aware of
the affordances of objects (i.e., that they move), we may have expected that children in
the MD Condition would show an increased use of speech that referred to the actions or
movement, compared to the other conditions. We would also have expected to find
increased spoken references to physical features in the PF Condition, compared to the
other conditions. Overall, spoken references to the actions or movements of objects in
the MD Condition (\(M = 2.08\) references per child, \(SD = 1.18\)) was slightly higher than in
either the PF Condition (\(M = 1.47\) references per child, \(SD = 1.38\)) or the SO Condition
(\(M = 1.17\) references per child, \(SD = .72\)). However, this difference was non-significant
(\(F(2,41) = 2.02, p = .14\)). Spoken references to the physical features of objects in the PF
Condition (\(M = 9.06\) references per child, \(SD = 2.44\)) was higher than both the MD
Condition (\(M = 8.54\) references per child, \(SD = 2.18\)) and the SO Condition (\(M = 8.25\)
references per child, \(SD = 2.09\)), although again this was non-significant (\(F(2,41) = .47,\)
\(p = .62\)).
Taken together, these findings suggest that the demonstrated gestures were not
merely acting to orient children to certain aspects of objects, and that the effect of
demonstrated gestures in the MD Condition was above-and-beyond simply encouraging
children to speak about the object in ways relating to movement, which may have
subsequently increased movement gesture production.
Discussion

The present study aimed to shed light on how children’s gestural development progresses, and how they come to use symbolic gestures in their own representations of previously unseen objects. Specifically, the present study aimed to assess two competing accounts that explain how preschool children use symbolic gestures to represent novel objects after observing them performed by an adult.

We manipulated the gestural input of children to investigate if the use of distinct gesture types by an experimenter in combination with speech, when introducing distinct objects, had an influence on the subsequent gestural behaviour of children. We found that children showed a preference to match movement gestures in a subsequent communicative interaction including the same objects, but not physical feature gestures. We compared conditions involving a gestural input to a control condition designed to obtain a baseline measure of children’s spontaneous gesture production. The results showed that preschool children aged 44-46 months spontaneously combined verbal explanations of objects with symbolic gestures and, in the absence of any gestural input, had a preference to depict physical features of objects rather than movements of objects. These gestures were highly coordinated with the speech of the children during their
descriptions, instead of *in place* of speech which had previously been described for

Furthermore, we found that although some gestures types showed a higher
production frequency than others, children overall showed a high degree of individual
variability in their spontaneous gestural performance (including the use of idiosyncratic
gestures). These gestures often focused on one particular feature of an object that was of
interest to the child (e.g., a string of the *stretch toy*), or related to the object as a whole
(e.g., forming a triangle for the *sway triangle*). The children in the present study also did
not consistently use the gestures they observed, choosing to reproduce more of the
movement gestures post-demonstration compared to physical feature gestures.

Overall, our findings thus do not support the ‘gesture learning’ account that
children aged 44-46 months of age still mainly rely on socially learned gestural routines
learned in previous play interactions with their caretakers, as they appear to do up to
two years of age (Acredolo & Goodwyn, 1988; Goodwyn & Acredolo, 1993). On the
contrary, our results provide evidence that preschool children are able to use their
gestures flexibly, and make their own inferences about the best way to represent objects
on the basis of their salient properties.
It was also found that some gesture types observed in a communicative interaction, and with a distinct object, influence the subsequent gestural behaviour of children differently than others. As mentioned above, we do not expect that this is due to preschool children learning conventional gestural routines in a similar manner to younger children, as according to this perspective, children should have displayed no preference for any kind of gesture type (movement or physical feature) in the post-demonstration phase.

In the present study, there was a clear preference in favour of demonstrated gestures that depicted movement compared to those that depicted physical features. There are two possible explanations that we consider here. First, it may not be the gesture *per se* that changed children’s imagistic representation of the object. The gesture may instead have made children more aware of the potential affordances of the object, specifically the way it can move (Bird, Brindley, Leighton & Heyes, 2007). This in turn may have led children individually to create their own symbolic gestures to represent that object. However, the children across all three conditions did not display any significant differences in how they manipulated each object when they were given the opportunity. If the movement gestures were merely acting as an ‘affordance guide’ then we would have expected children in the MD Condition to handle the objects differently.
in response to the gesture demonstrations. We would have also expected the children to
have referred to movement in their speech significantly more in the MD Condition, as
they would have been made more aware of the movement potential of the objects,
compared to children in the SO or PF Conditions. In the present study, there were no
significant differences found among the three conditions, either in children’s object
manipulations, or their references to the movement or physical features of objects in
speech. This suggests that the gestural input was influencing children’s subsequent
gestural production over-and-above simply directing children to discover more about
the properties of the target objects.

A second explanation, and the one that we favour, is that preschool children’s
production of particular kinds of symbolic gestures may have been influenced by the
imagistic properties of the gesture itself, in line with the ‘simulated representation’
account. In the present study the act of the adult depicting motor actions through
symbolic gestures may change children’s own representation of the object, leading them
to simulate this aspect of the object when asked to describe it. Previous research has
shown that children glean information from adult’s gestures in distinct learning contexts
(e.g., Goldin-Meadow, 2003; Singer & Goldin-Meadow, 2005). In addition, research on
adult speakers has suggested that more gestures are produced if the object or event
being spoken about evokes high levels of *motor* imagery, compared to *visual* imagery (Cook & Tanenhaus, 2009; Feyereisen & Havard, 1999; Pine, Gurney, & Fletcher, 2010). According to the GSA perspective (Hostetter & Alibali, 2008, 2010; Hostetter & Skirving, 2011), gestures are produced when speakers “simulate actions in the interest of speaking” (Hostetter & Alibali, 2010, p. 245). Alibali, Kita and Young (2000) suggested that gestures facilitate the process of ‘breaking down’ perceptual and motor knowledge into a verbal form. The expressive possibilities of gesture to represent spatial information are numerous (Alibali et al., 2009; Emmorey & Casey, 2001; Kendon, 2004) and, for children in particular, rate and type of symbolic gestures has been linked to their attempts to represent complex spatial events (Alibali et al., 2009; Kidd & Holler, 2009).

The GSA framework contends that speakers are more likely to produce gestures that simulate actions compared to gestures that simulate visual properties. This is because the motor imagery created when simulating these actions is more likely to reach the gesture threshold, as this imagery is closely tied to the actions of the body (Hostetter & Alibali, 2008). Indeed, motor imagery is more closely tied to neural motor activation in the brain (e.g., Wexler, Kosslyn, & Berthoz, 1998). On the other hand *visual* properties of objects are less directly linked to bodily action. Imagery involving visual
features of objects (e.g., size or shape) need to be ‘converted’ on the basis of how these
features affect the affordances of the object (i.e., how it can be held).

However, in the present study, children who had not observed any gestures
during the study produced more gestures that depicted a physical feature of an object
compared to the movement of the object. On the face of it, this contrasts with the GSA
framework which suggests that gesture formation is more likely occur when the speaker
is referencing actions rather than spatial features (see also Feyereisen & Havard, 1999).
However, it is possible that in the present study children did not encode the movement
of the objects naturally, instead opting to focus on the multitude of physical properties
of each object.

In the object description task used in the present study, the demonstrated
movement gestures may have acted to change children’s thinking about the object by
changing the imagistic properties of their object representation. As the demonstrated
physical feature gestures were more likely to be matched with children’s initial
representation of the object (as shown in the SO Condition), this type of demonstrated
gesture may have been redundant in the context of this task. Therefore, the conflicting
imagistic information provided by the movement gestures may have acted to alter
children’s representation, which subsequently changed how they used gestures to communicate about the object.

Future research could address these potential explanations further by manipulating children’s access to the object after the experimenter has presented the object (and gestures) to them. If the same pattern of results is found in children who were given access to the object, compared to those that were not given access to the object, it would suggest the ‘rich’ interpretation that the gesture itself is altering children’s representation of the object (Cook & Tanenhaus, 2009; Goldin-Meadow, 2003; Singer & Goldin-Meadow, 2005). However, if there is a higher number of reproduced gestures in the ‘object accessed’ condition, it would suggest a ‘lean’ interpretation, that the symbolic gestures are making children aware of the affordances of the object, but that the children are using their own representation of the object as a basis for their symbolic gestures.

Overall, the present study extends and challenges previous work that has implied a role of adult input in children’s use of symbolic gestures from around nine months of age (Acredolo & Goodwyn, 1988; Goldin-Meadow, Goodrich, Sauer, & Iverson, 2007; Iverson, Capirci, Longobardi, & Caselli, 1999) by expanding the scope of research to three-year-old children who are just beginning to use symbolic co-speech gestures in
everyday interactions (Nicoladis, Mayberry, & Genesee, 1999). Furthermore, our findings provide the first evidence that children at the age of three years glean information from gestures and utilise them as a representational resource.
Acknowledgements

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References


Lock, Andrew., Andrew Young, Valerie Service, & Paul Chandler (1990). Some observations on the origins of the pointing gesture. In Virginia Volterra & Carol J.
Eting (Eds.), From gesture to language in hearing and deaf children (pp. 42-55). New York: Springer-Verlag.


Table 1: Target object and filler objects

<table>
<thead>
<tr>
<th>Target Objects</th>
<th>Filler Objects</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Movement (FO1)</strong></td>
</tr>
<tr>
<td>Spiky Ball</td>
<td><img src="image1" alt="Image" /></td>
</tr>
<tr>
<td>Sway Triangle</td>
<td><img src="image5" alt="Image" /></td>
</tr>
<tr>
<td>Stretch Toy</td>
<td><img src="image9" alt="Image" /></td>
</tr>
<tr>
<td>String Ball</td>
<td><img src="image13" alt="Image" /></td>
</tr>
</tbody>
</table>

Table 1 shows the four target objects, children had been asked to describe and four filler objects (FO) for each target object. Each filler object matches a distinct characteristic of the target object such as similar action (FO1), physical property (FO2), colour (FO3), and same approximate shape (FO4).
Figure 1: Video still of object description task

Figure 1 shows the location of participants during the object description task.
**Table 2**: Sentences used by condition

<table>
<thead>
<tr>
<th>MD Condition</th>
<th>PF Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td>“Look at this toy, look at how it <strong>moves</strong>”</td>
<td>“Look at this toy. See what it <strong>looks</strong> like”</td>
</tr>
<tr>
<td>“It <strong>moves</strong> in a funny way doesn’t it?”</td>
<td>“It <strong>looks</strong> quite funny doesn’t it?”</td>
</tr>
<tr>
<td>“Look at what you <strong>can do</strong> to this toy”</td>
<td>“Look at what this toy <strong>looks</strong> like”</td>
</tr>
<tr>
<td>“It can <strong>move</strong> about in a fun way”</td>
<td>“It is quite a fun <strong>looking</strong> toy”</td>
</tr>
<tr>
<td>“Look at what it <strong>can do</strong>”</td>
<td>“This toy <strong>looks</strong> like a lot of fun”</td>
</tr>
</tbody>
</table>

Table 2 shows the different sentences used in a randomised order in the MD and PF conditions. Words in bold emphasise the movement or physical features of the presented objects.
Table 3: Gestures demonstrated to children in demonstration conditions

<table>
<thead>
<tr>
<th>Object</th>
<th>Description</th>
<th>Movement Gestures (MD Condition)</th>
<th>Physical Feature Gestures (PF Condition)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spiky Ball</td>
<td>Hand in 'C' shape, bringing the thumb to the fingers to represent squeezing action.</td>
<td>Pointed finger moving up and down to represent spikes.</td>
<td></td>
</tr>
<tr>
<td>Sway Triangle</td>
<td>Flat hand facing upwards rocking side to side, pivoting on the wrist to represent rocking action.</td>
<td></td>
<td>Pointed finger creating a circle to represent the hole.</td>
</tr>
<tr>
<td>Stretch Toy</td>
<td>Two closed fists moving away then back towards each other, to represent stretch movement.</td>
<td></td>
<td>Fingers interlock to represent multiple 'legs' of the toy.</td>
</tr>
<tr>
<td>String Ball</td>
<td>One closed fist remains still, while other hand moves up and down to represent 'bouncing' action</td>
<td></td>
<td>Fingers and wrist on one hand touches the respective part on the other hand, creating a ball shape</td>
</tr>
</tbody>
</table>

Table 3 shows the gestures that were demonstrated to children in the MD Condition and the PF Condition for each object.
Table 4: Examples of original gestures for each target object

<table>
<thead>
<tr>
<th>Target Object</th>
<th>Demonstrated Movement</th>
<th>Demonstrated Physical Feature</th>
<th>Other Movement</th>
<th>Other Physical Feature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spiky Ball</td>
<td>0</td>
<td>5</td>
<td>Enacting action of bouncing a ball (1)</td>
<td>Covering self in 'spikes' (1)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Both hands circling (1)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Putting fists together for 'spikes' (1)</td>
</tr>
<tr>
<td>Sway Triangle</td>
<td>1</td>
<td>4</td>
<td>Drawing triangle in air with finger (3)</td>
<td>Forming triangle with hands together (2)</td>
</tr>
<tr>
<td>Stretch Toy</td>
<td>1</td>
<td>1</td>
<td>Drinking action (1)</td>
<td>Moving hand away from body once (4)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Twist wrist (1)</td>
<td>Both/one hand circling (2)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Hand up and down (1)</td>
<td>Closing fist (1)</td>
</tr>
<tr>
<td>String Ball</td>
<td>5</td>
<td>1</td>
<td>Moving hand across to represent 'string' (4)</td>
<td>Circling hand for 'round' (1)</td>
</tr>
</tbody>
</table>

Table 4 provides an overview of spontaneous gestures produced by children in the SO Condition ($N = 12$), which either matched the demonstrated movement gestures, the demonstrated physical feature gestures or non-demonstrated movements or features of the target objects. The number of children who produced these gestures at least once is given in brackets.
Table 5: Chi-square analyses for movement based object manipulations

<table>
<thead>
<tr>
<th>Object manipulation- squeeze</th>
<th>Yes</th>
<th>No</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>MD Condition</td>
<td>10</td>
<td>3</td>
<td>13</td>
</tr>
<tr>
<td>PF Condition</td>
<td>12</td>
<td>5</td>
<td>17</td>
</tr>
<tr>
<td>SO Condition</td>
<td>8</td>
<td>4</td>
<td>12</td>
</tr>
</tbody>
</table>

χ²(2,42) = .33, p = .57

<table>
<thead>
<tr>
<th>Object manipulation- rock</th>
<th>Yes</th>
<th>No</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>MD Condition</td>
<td>9</td>
<td>4</td>
<td>13</td>
</tr>
<tr>
<td>PF Condition</td>
<td>11</td>
<td>6</td>
<td>17</td>
</tr>
<tr>
<td>SO Condition</td>
<td>6</td>
<td>6</td>
<td>12</td>
</tr>
</tbody>
</table>

χ²(2,42) = 1.07, p = .59

<table>
<thead>
<tr>
<th>Object manipulation- stretch</th>
<th>Yes</th>
<th>No</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>MD Condition</td>
<td>6</td>
<td>7</td>
<td>13</td>
</tr>
<tr>
<td>PF Condition</td>
<td>10</td>
<td>7</td>
<td>17</td>
</tr>
<tr>
<td>SO Condition</td>
<td>8</td>
<td>4</td>
<td>12</td>
</tr>
</tbody>
</table>

χ²(2,42) = 1.11, p = .58

<table>
<thead>
<tr>
<th>Object manipulation- bounce</th>
<th>Yes</th>
<th>No</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>MD Condition</td>
<td>9</td>
<td>4</td>
<td>13</td>
</tr>
<tr>
<td>PF Condition</td>
<td>13</td>
<td>4</td>
<td>17</td>
</tr>
<tr>
<td>SO Condition</td>
<td>7</td>
<td>5</td>
<td>12</td>
</tr>
</tbody>
</table>

χ²(2,42) = 1.08, p = .58