

1 **How do modelled gestures influence preschool children’s spontaneous gesture**
2 **production? Social versus semantic influence.**

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1 **Abstract**

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

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1 Keywords: Human children; gestures; acquisition; representation; action

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1 “The growth of children’s gestures [...] provide some of the best evidence that in
2 performing gestures the hands are, in fact, symbols with meanings in their own rights”.
3 (McNeill, 1992, p. 295)

4

5 Early research on the communicative development of children has shown that

6 gestures and speech emerge and develop together from around 9-12 months of age

7 (Bates, Benigni, Bretherton, Camaioni, & Volterra, 1979; Riseborough, 1982).

8 Typically, children start to denote concrete objects and situations by either vocalising *or*

9 gesturing (McNeill, 1992). These early performatives can be defined as gestures that

10 communicate children’s expressions of thought (Doherty-Sneddon, 2003), and serve to

11 gain attention and maintain a joint focus with an adult (Bruner, 1975; Capone &

12 McGregor, 2004; Volterra & Erting, 1990). These gestures (also called protogestures by

13 some authors, e.g., McNeill, 1992) can be classified into three distinct types:

14 *ritualizations*, *deictics*, and *symbolic* gestures (Acredolo & Goodwyn, 1988; Bates et al.,

15 1979; Pika, 2008).

16 *Ritualizations* are behaviours in which the signaller uses an effective behaviour

17 to request an action (Lock, 1978). For instance, children often use a stylised *arm-raise*

18 to be picked up. *Deictics* are designed to direct the recipient’s attention to outside

19 entities. Prototypes are *showing* (e.g., holding up an object to the recipient), and

20 *pointing* (with an index finger or the whole hand). Pointing at first emerges in a non-

1 communicative fashion, to orient children's own attention to objects and events (Bates,
2 Camaioni, & Volterra, 1975; Carpenter, Nagell, & Tomasello, 1998; Moore &
3 D'Entremont, 2001; Werner & Kaplan, 1963). By around 12 months, children are able
4 to use pointing gestures for communicative goals including declaring interesting objects
5 and events to an interlocutor, or informing them about something (Liszkowski, 2005;
6 Liszkowski, Carpenter, Striano, & Tomasello, 2006; Lock, Young, Service, &
7 Chandler, 1990). Liszkowski and colleagues (Liszkowski, 2011; Liszkowski &
8 Tomasello, 2011) suggested that declarative pointing in particular structures children's
9 social communicative activities with their caregivers. According to Cochet and Vauclair
10 (2010), declarative pointing is utilised by children through deferred imitation processes,
11 as they actively construct with their caregivers a variety of communicative experiences
12 (see also Liszkowski & Tomasello, 2011, for a related account). This is perhaps best
13 demonstrated during the early stages of spoken communication, where infants use
14 gestures alongside speech to help create their first sentence-like utterances (e.g., Capone
15 & McGregor, 2004; Ozcaliskan & Goldin-Meadow, 2005; Volterra, Caselli, Capirci, &
16 Pizzuto, 2005).

17 The third gesture type, *symbolic* gestures (Acredolo & Goodwyn, 1988; Namy &
18 Waxman, 1998) also referred to by others as 'iconic', 'pictographic' or

1 'representational' gestures (Iverson, Capirci, & Caselli, 1994; McNeill, 1992; Poggi,
2 2002) are produced by children from around nine months, and initially comprise whole-
3 body enactments to depict actions and objects. They are either associated with a referent
4 metonymically, in that the gesture refers to an element or attribute of something (e.g.,
5 putting a finger to the nose and raising it for 'elephant'), or on the basis of their mutual
6 iconic relation to each other (e.g., flapping one's arms to represent a bird's wings,
7 Acredolo & Goodwyn, 1988; Pizzuto & Volterra, 2000).

8 In older preschool children, as speech becomes the preferred mode of
9 communication (Namy & Waxman, 1998), gestures act to add semantic information to
10 spoken utterances (Alibali, Evans, Hostetter, Ryan & Mainela-Arnold, 2009). These *co-*
11 *speech* gestures differ from the gestures that earlier preschool children develop via
12 interactive routines with caregivers, as they are tightly related to speech production,
13 rather than an alternative mode of symbolic expression (Ozcaliskan & Goldin-Meadow,
14 2011). Virtually nothing is known about how older preschool children utilise the
15 symbolic gestures they observe in their own descriptions of novel objects. One
16 possibility is that children reproduce the symbolic gestures they observe being
17 accompanied by objects, similarly to children aged around nine months. According to
18 this 'gesture learning' account, Acredolo and Goodwyn (1988; Goodwyn & Acredolo,

1 1993; see also Caselli, 1990) proposed that infants acquire their first symbolic gestures
2 within social interactions (gestural or motor routines) with their caregivers. However,
3 while these gestures are clearly learned during interactive routines, it is uncertain as to
4 whether these earliest examples of gestures are truly symbolic. Liszkowski (2008)
5 suggested that children may not be reproducing these apparently symbolic gestures in
6 the same way as the adult initially performed them (i.e., as an intentional means for
7 highlighting something about an object) but may in fact just be mimicking the action to
8 indicate that they recognise the object; the ‘symbolic’ status of these gestures is in the
9 eyes of the observer, not in the mind of the child (Tomasello, Striano, & Rochat, 1999).
10 Caselli (1990) suggested these gestures are better classified as *conventional* gestures;
11 they are established by the conventions of specific communities or groups (McNeill,
12 1992). This implies standards of form that must be met if the gestures are to be
13 recognised and thus involves low levels of individual differences within the community
14 or group.

15 A second possibility is that children’s gesture production is grounded in their
16 perceptive experiences. According to this ‘simulated representation’ account, Hostetter
17 and colleagues (Hostetter & Alibali, 2008, 2010; Hostetter & Skirving, 2011) argue that
18 gestures emerge from the perceptual and motor simulations that underlie embodied

1 language and mental imagery (e.g., Barsalou, 1999). This so-called gesture-as-
2 simulated-action (GSA) framework suggests that gestures are produced on the basis of
3 speakers ‘replaying’ the visualisation of the object through activation of relevant areas
4 of the visual and motor cortex. This in turn then leads to activation beyond a *gesture*
5 *threshold*, resulting in the production of a gesture (Hostetter & Alibali, 2008).

6 Furthermore, it has been argued that observing gestures can influence the
7 subsequent representations of objects and the physical environment (Cartmill, Beilock
8 & Goldin-Meadow, 2012; Cook, Duffy & Fenn, 2013). Cook and Tanenhaus (2009)
9 found that after completing a Tower of Hanoi task, when participants explained the task
10 to an interlocutor, the gestures they produced were influenced by the method that they
11 had used to complete the task (computer versus real objects). Interestingly, when the
12 interlocutor was subsequently asked to do the task themselves on a computer, their
13 mouse trajectories bore a relation to how they had seen the task explained previously.
14 Goldin-Meadow and Beilock (2010) suggested that gestures may act to change how
15 individuals think about an object. Specifically, they argued that gestures can alter how
16 an object is represented by grounding it in action, as gestures themselves are produced
17 from simulations of action according to the GSA framework (Hostetter & Alibali, 2008,
18 2010; Hostetter & Skirving, 2011). Although gestures themselves do not change how an

1 object is perceived (i.e., its shape, colour etc), they may act to represent ideas which are
2 not bound by the capabilities of the object in question. Hostetter (2011) and Feyereisen
3 and Havard (1999) distinguish between gestures that depict movement and those that
4 depict non-motor information, such as a physical feature of an object (see also
5 Ozcaliskan & Goldin-Meadow, 2011). They suggest that observers may glean more
6 information from motor gestures compared to non-motor gestures, as they are
7 particularly effective at conveying detail about spatial relations.

8 The present study was designed to test the two competing accounts outlined
9 above that explain how older preschool children may utilise the symbolic gestures they
10 observe in their own representational strategies. To achieve this aim, children were
11 asked to describe novel objects in one of three different scenarios. In each scenario, four
12 different new objects were presented to preschool children. The researchers introduced
13 these objects by either (1) using speech only, or by accompanying the verbal
14 introductions with (2) *movement* gestures, or (3) *physical feature* gestures. The
15 separation of gesture types into movement and physical feature conditions was included
16 to assess for the possibility, found in previous research (Feyereisen & Havard, 1999;
17 Ozcaliskan & Goldin-Meadow, 2011), that observers may utilise gestures that depict
18 motor and non-motor aspects of objects and events differently.

1 We hypothesised that if children produce gestures on the basis of learning a
2 conventionalised routine, as suggested by the ‘gesture learning’ account, then both
3 movement and physical feature gestures should be produced more often by children
4 who have observed these gestures, compared to children in the speech only condition,
5 where no gestures are observed. Alternatively, if children’s thinking about an object is
6 influenced by the representations they are exposed to through gesture, as suggested by
7 the ‘simulated representation’ account, then children who observed gestures depicting
8 movement should produce more of these gestures when asked to describe the objects,
9 compared to children who had not observed any movement gestures.

10

1 **Methods**

2 ***Participants***

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

10 ***Materials***

11 To study how children utilised the symbolic gestures they observed, a game box,
12 and a total of 20 objects varying in feature and shape were used. Four of the objects
13 were designated *target* objects and the remaining 16 functioned as *filler* objects (see
14 Table 1).

1

2

-insert Table 1 here-

3

4 *The game box*

5

The tasks took place around a large cardboard box that was placed between the

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child and their caregiver (39 cm x 28 cm x 26 cm). The box was coloured red to make it

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attractive and engaging for the children. Extending from one side of the box was a large

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cardboard flap (32 cm x 26 cm), which was designed to impede the caregiver's view of

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the target object and the gesture being produced by the experimenter. On the other side

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of the box was another cardboard flap (32 cm x 9 cm). This flap was designed to

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discourage the child from looking around the box to the caregiver's side, while at the

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same time not impeding the view of the child towards the caregiver and vice versa,

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while the child attempted to describe the target objects. At each end of the box was a

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square hole (10 cm x 10 cm), to pass objects from one side of the box to the other. The

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main purpose of the box was to provide a restricted visual space between the

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experimenter and the caregiver, so that the caregiver was unable to see (a) the target

17

object and (b) the experimenter's gesture. An additional purpose of the box was to

18

provide a motivating and engaging game environment for the children. Once the

1 children had described an object successfully, the caregivers pushed the object through
2 the hole in the box towards the child.

3 *Objects*

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

10 For each target object, there were four ‘filler’ objects (FO). Each filler object
11 matched a certain aspect of the target object (see Table 1). FO1 for instance was
12 matched on the basis of having a similar potential movement to the target object. For
13 example, the FO1 object for the *string ball* bobbed up and down in a similar fashion to
14 the target object. FO2 was matched on the basis of a distinct physical characteristic. For
15 example, for the *sway triangle*, FO2 had a hole through the middle. The remaining two
16 filler objects were chosen on the basis of matching the colour (FO3) and the basic shape
17 (FO4) of the target object.

1 The child had to describe each of the target objects in turn, so that the caregiver
2 could distinguish that object from the filler objects that were presented alongside it. The
3 filler objects were carefully selected so that the child had to provide full descriptions of
4 each target object. For example, while children may have known the word “ball” for the
5 *spiky ball*, the children had to provide extra information to their caregiver, so that the
6 caregiver could disambiguate the target object from the other balls in the total array of
7 objects. The filler objects were not visible to the child during the task, unless the
8 caregiver selected a filler object post-description (see experimental procedure). This
9 was to keep the child focused on describing the target objects, so that the descriptions
10 (and the gestures) children produced could be linked to the target objects with certainty.

11 ***Experimental procedure***

12 Testing took place either in a laboratory at the University of Manchester or at the
13 children’s homes, depending on the caregiver’s preference. At the laboratory, the
14 children were made to feel as comfortable as possible in their surroundings. At the
15 children’s homes, testing took place in a quiet room, away from potential distractions.
16 Before testing, the caregivers were informed about the aims of the study and what the
17 task involved. The children were then asked if they wanted to play a describing game.

1 Once the children were comfortable, they were asked to sit on a chair opposite
2 their caregiver, with a small table between them. The experimenter sat on the left side of
3 the child placing himself in-between the child and a bag of objects, which were placed
4 on the far side of the experimenter. The experimenter introduced the game box to the
5 child and placed it on the table, with the front end of the box facing the caretaker. The
6 child was then given the opportunity to explore the box and to get used to its appearance
7 and position (see Figure 1).

8

9

- insert Figure 1 here -

10

1 Once the child appeared ready to begin, the experimenter introduced the game
2 by saying, “Now we are going to play a describing game. I am going to show you some
3 toys that your mum/dad can’t see. The aim of the game is to describe the toy to your
4 mum/dad so that they can pick the right one from lots of other toys, and then send it
5 back to you through the box.”

6 *Experimental tasks*

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

8 Warm-up trial: The aim of the warm-up trial was to familiarise children with the
9 introduction of the objects and the procedures of the task. The child was introduced to
10 an object (a small toy car) and given the opportunity to hold the object. The
11 experimenter then said, “This is an interesting toy isn’t it?” Once the child had explored
12 the toy, the experimenter took the object and placed it into a bag with some filler
13 objects. The toy was placed in the bag so that the child could not see any of the filler
14 objects. The bag was shaken and passed around to the caregiver. The experimenter then
15 asked the child to describe the toy to his or her caregiver, so that the caregiver could
16 select the correct one to send back to the child through the game box. If the child
17 appeared reluctant, the experimenter encouraged the child by asking, “Is there anything
18 you can tell your mum/dad about the toy you’ve just played with?”

1 Once the child had made an attempt to describe the toy to his or her caregiver,
2 the experimenter asked the caregiver to choose which object they thought it was, pull it
3 out of the bag of objects, and show their child. If the caregiver presented one of the
4 incorrect filler objects to the child, the experimenter asked the caregiver to place the
5 object back into the bag, and asked the child to continue describing the target object, so
6 that the caregiver could make the correct selection. If the caregiver was unsure of which
7 object to select, the experimenter asked the child, “Is there anything else you can tell
8 your mum/dad about the object?” Once the caregiver was certain of the correct object,
9 they were asked to show the object to the child for confirmation. If the correct toy was
10 chosen, the experimenter asked the caregiver to place the object in the hole at his or her
11 end of the box, which allowed the child to pick the toy up from his or her end of the
12 box. Then the test trials started.

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

14 Step 1: The experimenter introduced one of the four target objects to the child. The
15 order of presentation of the target objects was randomised. On presentation of the first
16 target object, the experimenter placed the object behind the flap of the game box,
17 outside of the caregiver’s view but in full sight of the child. The experimenter then said,
18 “Look at this toy!” to draw the child’s attention to the object. Depending on the test

1 condition (described below), the experimenter proceeded to communicate about the
2 target object by using distinct statements (see Table 2) with or without accompanying
3 gestures (see Table 3).

4

5 - insert Table 2 and 3 here -

6

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

17 Step 2: The child was then asked to describe the target object to the caregiver.

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

1 caregiver anything else he or she could about the object, until the caregiver chose the
2 target object.

3 *Caregiver instructions*

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

10 *Experimental conditions*

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

17 *SO Condition*

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

7 *MD Condition and PF Condition*

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

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

1 the experimenter used gestures that highlighted a physical characteristic of the object.
2 For example the gesture accompanying the introduction of the *spiky ball* consisted of an
3 up and down movement in an inverted 'V', performed with a pointing index finger to
4 represent the spikes. Although these physical feature gestures occasionally had
5 movement contained within them, the dominant semantic element of these gestures was
6 always a physical feature.

7 ***Data collection***

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

11

12 ***Coding***

13 Since the focus of the study concerns *symbolic* gestures, only these gestures
14 were coded. For the SO Condition, gestures were classified under the same criteria as
15 'same as demonstrated-movement', 'same as demonstrated-feature' or 'other-
16 movement' or 'other physical feature'. All of the children's symbolic gestures produced
17 when describing the objects were coded using these criteria.

1 For the two gesture demonstration conditions (MD Condition and PF
2 Condition), children's symbolic gestures were coded for whether they were 'same as
3 demonstrated' or 'other- movement' or 'other physical feature'. For the MD Condition a
4 gesture was classed as 'same as demonstrated' (i.e., reproduction of the previously
5 modelled *movement* gesture) if the gesture had the same trajectory of movement as the
6 demonstrated *movement* gesture. Hand shape did not have to be the same. For example,
7 to be classed as 'same as demonstrated' for the *sway triangle* children had to rock their
8 hand side to side pivoting on the wrist. For the PF Condition a gesture was classed as
9 'same as demonstrated' if the gesture produced had the same hand shape as the
10 demonstrated *physical feature* gesture. The movement of the hands whilst in this shape
11 did not have to be the same. For example, for the *string ball* children had to cup their
12 hands to form a ball shape.

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

17

1 **Results**

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

5 First, we screened for whether the experimental condition influenced the
6 children's overall gesture production. To establish this, the total number of symbolic
7 gestures produced by children were compared across the three experimental conditions.
8 There was no significant difference between conditions (Kruskal-Wallis test; $\chi^2(2, 42)$
9 = 3.61, $p = .16$). Children performed a mean of 4.17 gestures ($SD = 2.92$) in the SO
10 Condition, a mean of 5.62 gestures ($SD = 3.01$) in the MD Condition, and a mean of
11 3.82 gestures ($SD = 2.66$) in the PF Condition.

12 Second, to rule out differences in gesture performance due to gender, the total
13 number of symbolic gestures produced by boys and girls were compared. There was no
14 significant difference found (Mann Whitney U test; $U = 189.5$, $z = -.88$, $p = .50$; boys
15 $M = 4.08$, $SD = 2.41$, girls $M = 5.00$, $SD = 3.48$), and so the data was collapsed across
16 gender.

17

18

1 *Spontaneous gesture production (SO Condition)*

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

7

8 - insert Table 4 here -

9

10 Overall, gestures depicting physical features of objects were more frequently
11 used than gestures depicting movements of objects, accounting for 75% ($M = 3.00$, SD
12 $= 2.05$) of the gestures produced by the children in the SO Condition. Of these physical
13 feature gestures, 36% ($M = 1.00$, $SD = 1.13$) matched the gestures demonstrated in the
14 PF Condition. The physical feature gestures were spread evenly across the objects
15 (*spiky ball*, $M = .67$, $SD = .65$; *sway triangle*, $M = .83$, $SD = .84$; *stretch toy*, $M = .75$,
16 $SD = .97$; *string ball*, $M = .75$, $SD = .97$). Movement gestures accounted for 25% ($M =$
17 1.17 , $SD = 1.19$) of the total gestures children produced in the SO Condition. Of these
18 movement gestures, 63% ($M = .75$, $SD = .97$) matched the gestures demonstrated in the

1 MD Condition. There were a similar number of movement gestures produced by
2 children in the SO Condition across the objects (*spiky ball*, $M = .17$, $SD = .58$; *stretch*
3 *toy*, $M = .33$, $SD = .49$; *string ball*, $M = .58$, $SD = .90$) apart from the *sway triangle*,
4 which elicited few movement gestures ($M = .08$, $SD = .29$). Overall, while there were
5 some gestures that were produced by more than one child (e.g., the drawing of a triangle
6 with a finger for the *sway triangle*), there was individual variability in how children
7 supplemented their speech with gestures.

8 The spontaneous production of the demonstrated *movement* and *physical feature*
9 gestures indicated that these gesture types are able to be produced by children of this
10 age, and are appropriate to describe the target objects. To determine whether children
11 were more likely to spontaneously produce either the demonstrated movement or
12 physical feature gestures, the total number of demonstrated movement gestures and the
13 total number of demonstrated physical feature gestures were compared¹, but a non-
14 significant difference was found (Wilcoxon-test, $Z = -.749$, $p = .45$).

15 Across the four objects, children in the SO Condition used terms in speech that
16 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.

1 child, $SD = 2.09$) more often than they used terms that referred to the action or
2 movement of the object, e.g., “It bounces” ($M = 1.17$ per child, $SD = .72$). This
3 statistically significant difference ($t(11) = 10.98$, $p < .001$) is likely due to children
4 having instant access (on first viewing) to objects’ perceptual features, and could
5 therefore potentially describe the colour, shape, or unusual features of the objects.
6 Meanwhile, the movement characteristics of the objects could only be fully explored by
7 physically manipulating them.

8 ***Influence of demonstration of gestures***

9 *Overall gesture production*

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

17 The next stage of the analysis was to establish to what extent the children were
18 utilising the demonstrated gestures to facilitate their descriptions of the objects. The

1 analysis of the children's gestures in the SO Condition showed that the demonstrated
2 movement and physical feature gestures were produced spontaneously by the children.
3 To address the question of whether children at this age learn the association between an
4 object and a demonstrated gesture, we compared whether the observation of physical
5 feature and movement gestures had an influence on children's subsequent gestural
6 performance. To do so, we calculated proportions of children's symbolic gestures that
7 matched the gestures that they observed in the experimental manipulation, by dividing
8 this number of gestures by the total number of symbolic gestures produced. The
9 subsequent analysis showed that children in the MD Condition used a significantly
10 higher proportion of demonstrated movement gestures ($M = .41, SD = .27$) compared to
11 the SO Condition ($M = .18, SD = .23$; Mann-Whitney U test, $U = 35, z = -2.37, p =$
12 $.02$). There was no significant difference in gestural performance between children in
13 the PF and the SO conditions (Mann-Whitney U test, $U = 81, z = -.99, p = .32$).
14 However there was a tendency for children in the PF Condition ($M = .17, SD = .26$) to
15 perform the demonstrated *physical feature* gesture less often than children in the SO
16 Condition ($M = .28, SD = .32$). This suggests that experiencing a relation between a
17 gesture and its referent in a social context does not consistently lead to greater use of
18 that gesture in subsequent descriptions of that same object.

1 *First gestures used*

2 The previous analysis showed that children tended to match movement gestures
3 they had previously observed, but not physical feature gestures. To investigate this
4 finding in more detail, children's production of their *first* gesture for each object
5 description was analysed, since first gestures produced in a communicative act have
6 been identified as children's most 'spontaneous' communicative reaction (Huang &
7 Charman, 2005). As there were four objects shown to each child during the test trials,
8 children could score a maximum of four for their 'total first gestures'. An initial
9 analysis established that children in each of the three experimental conditions produced
10 at least one gesture for the same number of objects ($\chi^2(2, 42) = 2.52, p = .28$; MD
11 Condition, $M = 3.00, SD = .81$; PF Condition, $M = 2.41, SD = 1.12$; SO Condition, $M =$
12 $2.58, SD = 1.00$).

13 A subsequent analysis showed that for children in the MD Condition, a
14 significantly higher proportion of their first gestures matched the demonstrated gestures
15 in the MD Condition, compared to children in the SO Condition (MD Condition: $M =$
16 $.43, SD = .33$; SO Condition: $M = .13, SD = .21$; Mann-Whitney U test, $U = 36, z = -$
17 $2.39, p = .02$). There was no significant difference in the proportion of first gestures that
18 matched the demonstrated gestures in the PF Condition between children in the PF and

1 SO Conditions (PF Condition: $M = .15$, $SD = .26$; SO Condition: $M = .32$, $SD = .37$;
2 Mann-Whitney U test, $U = 76$, $z = -1.29$, $p = .26$).

3 *Object Manipulation and speech production*

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

1 demonstrated movement gestures did not merely act to make children aware of the
2 movement affordances of the object.

3 - insert Table 5 here -

4 Furthermore, if the demonstrated gestures were acting to make children aware of
5 the affordances of objects (i.e., that they move), we may have expected that children in
6 the MD Condition would show an increased use of speech that referred to the actions or
7 movement, compared to the other conditions. We would also have expected to find
8 increased spoken references to physical features in the PF Condition, compared to the
9 other conditions. Overall, spoken references to the actions or movements of objects in
10 the MD Condition ($M = 2.08$ references per child, $SD = 1.18$) was slightly higher than in
11 either the PF Condition ($M = 1.47$ references per child, $SD = 1.38$) or the SO Condition
12 ($M = 1.17$ references per child, $SD = .72$). However, this difference was non-significant
13 ($F(2,41) = 2.02, p = .14$). Spoken references to the physical features of objects in the PF
14 Condition ($M = 9.06$ references per child, $SD = 2.44$) was higher than both the MD
15 Condition ($M = 8.54$ references per child, $SD = 2.18$) and the SO Condition ($M = 8.25$
16 references per child, $SD = 2.09$), although again this was non-significant ($F(2,41) = .47,$
17 $p = .62$).

1 Taken together, these findings suggest that the demonstrated gestures were not
2 merely acting to orient children to certain aspects of objects, and that the effect of
3 demonstrated gestures in the MD Condition was above-and-beyond simply encouraging
4 children to speak about the object in ways relating to movement, which may have
5 subsequently increased movement gesture production.

6

1 **Discussion**

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

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

1 descriptions, instead of *in place* of speech which had previously been described for
2 younger children (Acredolo & Goodwyn, 1985, 1988).

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

11 Overall, our findings thus do not support the ‘gesture learning’ account that
12 children aged 44-46 months of age still mainly rely on socially learned gestural routines
13 learned in previous play interactions with their caretakers, as they appear to do up to
14 two years of age (Acredolo & Goodwyn, 1988; Goodwyn & Acredolo, 1993). On the
15 contrary, our results provide evidence that preschool children are able to use their
16 gestures flexibly, and make their own inferences about the best way to represent objects
17 on the basis of their salient properties.

1 It was also found that some gesture types observed in a communicative
2 interaction, and with a distinct object, influence the subsequent gestural behaviour of
3 children differently than others. As mentioned above, we do not expect that this is due
4 to preschool children learning conventional gestural routines in a similar manner to
5 younger children, as according to this perspective, children should have displayed no
6 preference for any kind of gesture type (movement or physical feature) in the post-
7 demonstration phase.

8 In the present study, there was a clear preference in favour of demonstrated
9 gestures that depicted movement compared to those that depicted physical features.
10 There are two possible explanations that we consider here. First, it may not be the
11 gesture *per se* that changed children's imagistic representation of the object. The gesture
12 may instead have made children more aware of the potential affordances of the object,
13 specifically the way it can move (Bird, Brindley, Leighton & Heyes, 2007). This in turn
14 may have led children individually to create their own symbolic gestures to represent
15 that object. However, the children across all three conditions did not display any
16 significant differences in how they manipulated each object when they were given the
17 opportunity. If the movement gestures were merely acting as an 'affordance guide' then
18 we would have expected children in the MD Condition to handle the objects differently

1 in response to the gesture demonstrations. We would have also expected the children to
2 have referred to movement in their speech significantly more in the MD Condition, as
3 they would have been made more aware of the movement potential of the objects,
4 compared to children in the SO or PF Conditions. In the present study, there were no
5 significant differences found among the three conditions, either in children's object
6 manipulations, or their references to the movement or physical features of objects in
7 speech. This suggests that the gestural input was influencing children's subsequent
8 gestural production over-and-above simply directing children to discover more about
9 the properties of the target objects.

10 A second explanation, and the one that we favour, is that preschool children's
11 production of particular kinds of symbolic gestures may have been influenced by the
12 imagistic properties of the gesture itself, in line with the 'simulated representation'
13 account. In the present study the act of the adult depicting motor actions through
14 symbolic gestures may change children's own representation of the object, leading them
15 to simulate this aspect of the object when asked to describe it. Previous research has
16 shown that children glean information from adult's gestures in distinct learning contexts
17 (e.g., Goldin-Meadow, 2003; Singer & Goldin-Meadow, 2005). In addition, research on
18 adult speakers has suggested that more gestures are produced if the object or event

1 being spoken about evokes high levels of *motor* imagery, compared to *visual* imagery
2 (Cook & Tanenhaus, 2009; Feyereisen & Havard, 1999; Pine, Gurney, & Fletcher,
3 2010). According to the GSA perspective (Hostetter & Alibali, 2008, 2010; Hostetter &
4 Skirving, 2011), gestures are produced when speakers “simulate actions in the interest
5 of speaking” (Hostetter & Alibali, 2010, p. 245). Alibali, Kita and Young (2000)
6 suggested that gestures facilitate the process of ‘breaking down’ perceptual and motor
7 knowledge into a verbal form. The expressive possibilities of gesture to represent spatial
8 information are numerous (Alibali et al., 2009; Emmorey & Casey, 2001; Kendon,
9 2004) and, for children in particular, rate and type of symbolic gestures has been linked
10 to their attempts to represent complex spatial events (Alibali et al., 2009; Kidd &
11 Holler, 2009).

12 The GSA framework contends that speakers are more likely to produce gestures
13 that simulate actions compared to gestures that simulate visual properties. This is
14 because the motor imagery created when simulating these actions is more likely to reach
15 the gesture threshold, as this imagery is closely tied to the actions of the body (Hostetter
16 & Alibali, 2008). Indeed, motor imagery is more closely tied to neural motor activation
17 in the brain (e.g., Wexler, Kosslyn, & Berthoz, 1998). On the other hand *visual*
18 properties of objects are less directly linked to bodily action. Imagery involving visual

1 features of objects (e.g., size or shape) need to be ‘converted’ on the basis of how these
2 features affect the affordances of the object (i.e., how it can be held).

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

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

1 children's representation, which subsequently changed how they used gestures to
2 communicate about the object.

3 Future research could address these potential explanations further by
4 manipulating children's access to the object after the experimenter has presented the
5 object (and gestures) to them. If the same pattern of results is found in children who
6 were given access to the object, compared to those that were *not* given access to the
7 object, it would suggest the 'rich' interpretation that the gesture itself is altering
8 children's representation of the object (Cook & Tanenhaus, 2009; Goldin-Meadow,
9 2003; Singer & Goldin-Meadow, 2005). However, if there is a higher number of
10 reproduced gestures in the 'object accessed' condition, it would suggest a 'lean'
11 interpretation, that the symbolic gestures are making children aware of the affordances
12 of the object, but that the children are using their own representation of the object as a
13 basis for their symbolic gestures.

14 Overall, the present study extends and challenges previous work that has implied
15 a role of adult input in children's use of symbolic gestures from around nine months of
16 age (Acredolo & Goodwyn, 1988; Goldin-Meadow, Goodrich, Sauer, & Iverson, 2007;
17 Iverson, Capirci, Longobardi, & Caselli, 1999) by expanding the scope of research to
18 three-year-old children who are just beginning to use symbolic co-speech gestures in

1 everyday interactions (Nicoladis, Mayberry, & Genesee, 1999). Furthermore, our
2 findings provide the first evidence that children at the age of three years glean
3 information from gestures and utilise them as a representational resource.
4

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8

1 **References**

- 2
- 3 Acredolo, Linda P. & Susan W. Goodwyn (1985). Symbolic gesturing in language
4 development: A case study. *Human Development*, 28, 40-49.
- 5
- 6 Acredolo, Linda P. & Susan W. Goodwyn (1988). Symbolic gesturing in young infants.
7 *Child Development*, 59(2), 450-466.
- 8
- 9 Alibali, Martha W., Julia L. Evans, Autumn B. Hostetter, Kristin Ryan, & Elina
10 Mainela-Arnold (2009). Gesture-speech integration in narrative: Are children less
11 redundant than adults? *Gesture*, 9(3), 290-311.
- 12
- 13 Alibali, Martha W., Sotaro Kita, & Amanda Young (2000). Gesture and the process of
14 speech production: We think, therefore we gesture. *Language and Cognitive*
15 *Processes*, 15(6), 593-613.
- 16
- 17 Barsalou, Lawrence W. (1999). Perceptual symbol systems. *Behavioral and Brain*
18 *Sciences*, 22, 577-660.
- 19
- 20 Bates, Elizabeth., Laura Benigni, Inge Bretherton, Luiga Camaioni, & Virginia Volterra
21 (1979). *The emergence of symbols: Cognition and communication in infancy*.
22 New York: Academic Press.
- 23
- 24 Bates, Elizabeth., Luiga Camaioni, & Virginia Volterra (1975). The acquisition of
25 performatives prior to speech. *Merrill-Palmer Quarterly*, 21, 205-226.
- 26
- 27 Bird, Geoffrey., Rachel Brindley, Jane Leighton, & Cecilia Heyes (2007). General
28 processes rather than "goals" explain imitation errors. *Journal of Experimental*
29 *Psychology: Human Perception and Performance*, 33(5), 1158-1169.
- 30
- 31 Bruner, Jerome S. (1975). From communication to language: A psychological
32 perspective. *Cognition*, 3(3), 255-287.
- 33
- 34 Capone, Nina C. & Karla K. McGregor (2004). Gesture development: A review for
35 clinical and research practices. *Journal of Speech Language and Hearing*
36 *Research*, 47(1), 173-186.
- 37

- 1 Cartmill, Erica A., Sian L. Beilock, & Susan Goldin-Meadow (2012). A word in the
2 hand: Action, gesture and mental representation in humans and non-human
3 primates. *Philosophical Transactions of the Royal Society B: Biological Sciences*,
4 367, 129-143.
5
- 6 Caselli, Maria C. (1990). Communicative gestures and first words. In Virginia Volterra
7 & Carol J. Erting (Eds.), *From gesture to language in hearing and deaf children*
8 (pp. 56-67). New York: Springer-Verlag.
9
- 10 Carpenter, Malinda., Katherine Nagell, Michael Tomasello, George Butterworth, &
11 Chris Moore (1998). Social cognition, joint attention, and communicative
12 competence from 9 to 15 months of age. *Monographs of the Society for Research*
13 *in Child Development*, 63(4), i-174.
14
- 15 Child, Simon F. J. (2011). *Investigating the development of cognitive symbolic*
16 *representation and gestural communication*. Unpublished doctoral thesis.
17 University of Manchester.
18
- 19 Cochet, Helena & Jacques Vauclair (2010). Pointing gestures produced by toddlers
20 from 15 to 30 months: Different functions, hand shapes and laterality patterns.
21 *Infant Behavior & Development*, 33(4), 431-441.
22
- 23 Cook, Susan W., Ryan G. Duffy, & Kimberly M. Fenn (2013). Consolidation and
24 transfer of learning after observing hand gesture. *Child Development*, 84(6), 1863-
25 1871.
26
- 27 Cook, Susan W. & Michael K. Tanenhaus (2009). Embodied communication: Speakers'
28 gestures affect listeners' actions. *Cognition*, 113, 98-104.
29
- 30 Doherty-Sneddon, Gwyneth (2003). *Children's unspoken language*. London: Jessica
31 Kingsley.
32
- 33 Emmorey, Karen & Shannon Casey (2001). Gesture, thought, and spatial language.
34 *Gesture*, 1, 35-50.
35

- 1 Feyereisen, Pierre & Isabelle Havard (1999). Mental imagery and production of hand
2 gestures while speaking in younger and older adults. *Journal of Nonverbal*
3 *Behavior*, 23(2), 153-171.
4
- 5 Fleiss, Joseph (1981). *Statistical methods for rates and proportions*. New York: John
6 Wiley & Sons.
7
- 8 Goldin-Meadow, Susan (2003). *Hearing gesture: How our hands help us think*.
9 Cambridge: Harvard University Press.
10
- 11 Goldin-Meadow, Susan & Sian L. Beilock (2010). Action's influence on thought: The
12 case of gesture. *Perspectives on Psychological Science*, 5(6), 664-674.
13
- 14 Goldin-Meadow, Susan., Whitney Goodrich, Eve Sauer, & Jana M. Iverson (2007).
15 Young children use their hands to tell their mothers what to say. *Developmental*
16 *Science*, 10, 778-785.
17
- 18 Goodwyn, Susan W. & Acredolo, Linda P. (1993). Symbolic gesture versus word: Is
19 there a modality advantage for onset of symbol use? *Child Development*, 64, 688-
20 701.
21
- 22 Hostetter, Autumn B (2011). When do gestures communicate? A meta-analysis.
23 *Psychological Bulletin*, 137(2), 297-315.
24
- 25 Hostetter, Autumn B. & Martha W. Alibali (2008). Visible embodiment: Gestures as
26 simulated action. *Psychonomic Bulletin and Review*, 15(3), 495- 514.
27
- 28 Hostetter, Autumn B. & Martha W. Alibali (2010). Language, gesture, action! A test of
29 gesture as simulated action framework. *Journal of Memory and Language*, 63,
30 245-257.
31
- 32 Hostetter, Autumn B. & Catherine J. Skirving (2011). The effect of visual vs verbal
33 stimuli on gesture production. *Journal of Nonverbal Behavior*, 35, 205-223.
34
- 35 Huang, Chi-Tai & Tony Charman (2005). Gradations of emulation learning in infants'
36 imitation of actions on objects. *Journal of Experimental Child Psychology*, 92,
37 276-302.




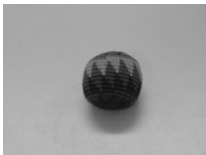

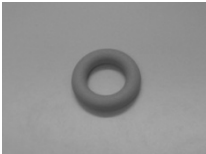

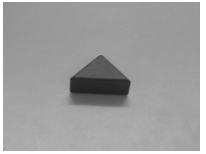


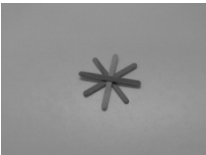



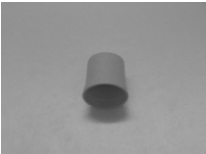

- 1
2 Iverson, Jana M., Olga Capirci, & Maria C. Caselli (1994). From communication to
3 language in two modalities. *Cognitive Development*, 9, 23-43.
4
- 5 Iverson, Jana M., Olga Capirci, Emiddia Longobardi, & Maria C. Caselli (1999).
6 Gesturing in mother-child interactions. *Cognitive Development*, 14, 57-75.
7
- 8 Kendon, Adam (2004). *Gesture. Visible action as utterance*. Cambridge: Cambridge
9 University Press.
10
- 11 Kidd, Evan & Judith Holler (2009). Children's use of gesture to resolve lexical
12 ambiguity. *Developmental Science*, 12(6), 903-913.
13
- 14 Liszkowski, Ulf (2005). Human twelve-month-olds point cooperatively to share interest
15 with and helpfully provide information for a communicative partner. *Gesture*, 5,
16 135-154.
17
- 18 Liszkowski, Ulf (2008). Before L1: A differentiated perspective on infant gestures.
19 *Gesture*, 8(2), 180-196.
20
- 21 Liszkowski, Ulf (2011). Three lines in the emergence of prelinguistic communication
22 and social cognition. *Journal of Cognitive Education and Psychology*, 10(1), 32-
23 43.
24
- 25 Liszkowski, Ulf., Malinda Carpenter, Tricia Striano, & Michael Tomasello (2006). 12-
26 and 18-month-olds point to provide information for others. *Journal of Cognition
27 and Development*, 7(2), 173-187.
28
- 29 Liszkowski, Ulf & Michael Tomasello (2011). Individual differences in social,
30 cognitive, and morphological aspects of pointing at 12 months of age. *Cognitive
31 Development*, 26, 16-29.
32
- 33 Lock, Andrew (1978). *Action, gesture and symbol: The emergence of language*.
34 London: Academic Press.
35
- 36 Lock, Andrew., Andrew Young, Valerie Service, & Paul Chandler (1990). Some
37 observations on the origins of the pointing gesture. In Virginia Volterra & Carol J.

- 1 Erting (Eds.), *From gesture to language in hearing and deaf children* (pp. 42-55).
2 New York: Springer-Verlag.
3
- 4 McNeill, David (1992). *Hand and mind: What gestures reveal about thought*. Chicago:
5 Chicago University Press.
6
- 7 Moore, Chris & Barbara D'Entremont (2001). Developmental changes in pointing as a
8 function of attentional focus. *Journal of Cognition and Development*, 2(2), 109-
9 129.
10
- 11 Namy, Laura L. & Sandra R. Waxman (1998). Words and gestures: Infants'
12 interpretations of different forms of symbolic reference. *Child Development*,
13 69(2), 295-308.
14
- 15 Nicoladis, Elena., Rachel I. Mayberry & Fred Genesee (1999). Gesture and early
16 bilingual development. *Developmental Psychology*, 35(2), 514-526.
17
- 18 Ozcaliskan, Seyda & Susan Goldin-Meadow (2005). Gesture is at the cutting edge of
19 early language development. *Cognition*, 96(3), B101-B113.
20
- 21 Ozcaliskan, Seyda & Susan Goldin-Meadow (2011). Is there an iconic gesture spurt at
22 26 months? In Gale Stam & Mika Ishino (Eds.), *Integrating gestures: The*
23 *interdisciplinary nature of gesture*. Amsterdam: John Benjamins.
24
- 25 Pika, Simone (2008). Gestures of apes and prelinguistic human children: Similar or
26 different? *First Language*, 28(2), 116-140.
27
- 28 Pine, Karen J., Daniel J. Gurney, & Ben Fletcher (2010). The semantic specificity
29 hypothesis: When gestures do not depend upon the presence of a listener. *Journal*
30 *of Nonverbal Behavior*, 34, 169-178.
31
- 32 Pizzuto, Elena & Virginia Volterra (2000). Iconicity and transparency in sign
33 languages: A cross-linguistic cross-cultural view. In Karen Emmorey & Harlan L.
34 Lane (Eds.), *The Signs of Language Revisited: An anthology to honor Ursula*
35 *Bellugi* (pp. 261-286). New York: Erlbaum.
36

- 1 Poggi, Isabella (2002). Symbolic gestures: The case of the Italian gestionario. *Gesture*,
2 2(1), 71-98.
3
- 4 Riseborough, M. G. (1982). Meaning in movement: An investigation into the
5 interrelationship of physiographic gestures and speech in seven-year-olds. *British*
6 *Journal of Psychology*, 73, 497-503.
7
- 8 Singer, Melissa A. & Susan Goldin-Meadow (2005). Children learn when their teacher's
9 gestures and speech differ. *Psychological Science*, 16(2), 85-89.
10
- 11 Tomasello, Michael., Tricia Striano, & Phillippe Rochat (1999). Do young children use
12 objects as symbols? *British Journal of Developmental Psychology*, 17, 563-584.
13
- 14 Volterra, Virginia., Maria C. Caselli, Olga Capirci & Elena Pizzuto (2005). Gesture and
15 the emergence and development of language. In Dan I. Slobin & Michael
16 Tomasello (Eds.), *Beyond nature-nurture: Essays in honor of Elizabeth Bates* (pp.
17 3-40). Mahwah, NJ: Erlbaum.
18
- 19 Volterra, Virginia & Carol J. Erting (Eds.). (1990). *From gesture to language in*
20 *hearing and deaf children*. New York: Springer-Verlag.
21
- 22 Werner, Heinz & Bernard Kaplan (1963). *Symbol formation: An organismic*
23 *developmental approach to language and the expression of thought*. New York:
24 Wiley.
25
- 26 Wexler, Mark., Stephen M. Kosslyn, & Alain Berthoz (1998). Motor processes in
27 mental rotation. *Cognition*, 68, 77-94.
28
- 29 Wiig, Elizabeth H., Wayne Secord, & Eleanor Semel (2000). *Clinical evaluation of*
30 *language fundamentals- preschool UK*. London: Psychological Corporation.
31
32
33

1 **Table 1:** Target object and filler objects

2

Target Objects	Filler Objects			
	Movement (FO1)	Physical Feature (FO2)	Colour (FO3)	Shape (FO4)
Spiky Ball				
Sway Triangle				
Stretch Toy				
String Ball				

3

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

7

1 **Figure 1:** Video still of object description task



2

3 Figure 1 shows the location of participants during the object description task.

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1 **Table 2:** Sentences used by condition

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

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3 Table 2 shows the different sentences used in a randomised order in the MD and PF conditions. Words in
4 bold emphasise the movement or physical features of the presented objects.

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1 **Table 3:** Gestures demonstrated to children in demonstration conditions

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

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4 Table 3 shows the gestures that were demonstrated to children in the MD Condition and the PF Condition
 5 for each object.

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1 **Table 4:** Examples of original gestures for each target object

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

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

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Table 5: Chi-square analyses for movement based object manipulations

Spiky Ball	Object manipulation- squeeze		
	Yes	No	Total
MD Condition	10	3	13
PF Condition	12	5	17
SO Condition	8	4	12

$$\chi^2(2,42) = .33, p = .57$$

Sway Triangle	Object manipulation- rock		
	Yes	No	Total
MD Condition	9	4	13
PF Condition	11	6	17
SO Condition	6	6	12

$$\chi^2(2,42) = .107, p = .59$$

Stretch Toy	Object manipulation- stretch		
	Yes	No	Total
MD Condition	6	7	13
PF Condition	10	7	17
SO Condition	8	4	12

$$\chi^2(2,42) = .111, p = .58$$

String Ball	Object manipulation- bounce		
	Yes	No	Total
MD Condition	9	4	13
PF Condition	13	4	17
SO Condition	7	5	12

$$\chi^2(2,42) = .108, p = .58$$