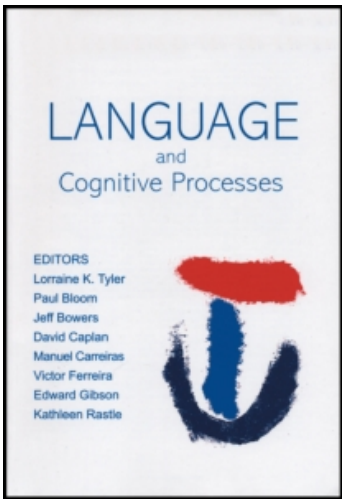

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Co-speech gestures in a naming task: Developmental data

Silvia Stefanini [a]; Arianna Bello [a]; Maria Cristina Caselli [b]; Jana M. Iverson [c]; Virginia Volterra [b]
[a] Department of Neurosciences, University of Parma, Italy [b] National Research Council, Institute of Cognitive Sciences and Technologies, Italy [c] Department of Psychology, University of Pittsburgh, USA

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Co-speech gestures in a naming task: Developmental data

Silvia Stefanini and Arianna Bello
Department of Neurosciences, University of Parma, Italy

Maria Cristina Caselli
Institute of Cognitive Sciences and Technologies, National Research Council, Italy

Jana M. Iverson
Department of Psychology, University of Pittsburgh, USA

Virginia Volterra
Institute of Cognitive Sciences and Technologies, National Research Council, Italy

Few studies have explored the development of the gesture-speech system after the two-word stage. Aim of the present study is to examine developmental changes in speech and gesture use, in the context of a simple naming task. Fifty-one children (age range: 2;3–7;6) were divided into five age groups and requested to name pictures representing objects, actions, or characteristics. In the context of a naming task that requires only the production of a single word, children produced pointing and representational gestures together with spoken responses. Pointing was the most frequent gesture produced by all groups of

Correspondence should be addressed to Silvia Stefanini, Dipartimento di Neuroscienze, Sezione Fisiologia – Università di Parma, Via Volturno, 39E – 43100 Parma, Italy. E-mail: silvia.stefanini@nemo.unipr.it

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children. Among representational gestures, action gestures were more frequent than size and shape gestures. In addition, gesture production declined as a function of increasing age and spoken lexical competence. Results are discussed in terms of the links between action, gesture, and language, and the ways in which these may change developmentally.

Keywords: Action; Gesture; Lexical abilities; Naming; Preschoolers.

INTRODUCTION

Gesture production is a robust developmental phenomenon whose importance has been firmly established by over 30 years of research. Although the role of gesture in relation to language has been well-documented for the early phases of communicative development (i.e., from just prior to first word onset to the transition to two-word utterances), relatively little is known about the ways in which this role may change as children's language becomes increasingly complex (i.e., progressed beyond the two-word stage). The overarching aim of the present study is to begin to address this gap in the literature by examining gesture and language production in children between the ages of 2 and 7 years. The data reported here were collected in the context of a simple picture naming task, which allowed us to examine developmental changes in speech and gesture use while holding communicative referents constant across children.

Gesture and language in the one-to two-word period

Before young children use words, they often use gestures to communicate (Bates, Benigni, Bretherton, Camaioni, & Volterra, 1979; Bates, Camaioni, & Volterra, 1975; Blake, 2000; Goldin-Meadow, 2002; Volterra & Erting, 1994). The first gestures to be produced are 'deictic': infants use their hands to give, to show, or to point to something in order to request a particular object or event or to share attention to it. The action origin of deictic gestures is quite evident in that there is a progressive detachment from direct contact with the object.

Among these gestures, *pointing* is the most frequently observed and the most closely linked with later language development (Bruner, 1975; Butterworth, 2003; Goldin-Meadow & Butcher, 2003; Lock, 1978; Tomasello, Carpenter, & Liszkowski, 2007). Pointing is also unique in that it provides the child with a means to refer to an object without directly grasping or touching it (see also Lock, 1997; Lock, Young, Service, & Chandler, 1994; Masur, 1983).

A second class of gestures, referred to as 'representational',[1] typically appear in children's production in the same age period. Unlike deictic

[1] Representational gestures have also been termed 'referential' (Caselli, 1994), 'recognitory' (Shore, Bates, Bretherton, Beeghly, & O'Connell, 1994), 'symbolic' (Acredolo & Goodwyn, 1988), or 'characterising' (Goldin-Meadow & Morford, 1994).

gestures, representational gestures have a basic semantic content that remains relatively stable across different situations. Some representational gestures are conventional and culturally defined (e.g., clapping hands for BRAVO; shaking the head for NO; Caselli, 1994) and can be specific to particular cultures (e.g., waving the hand for BYE BYE or, among Italians, bringing the index finger to the cheek and rotating it signifies GOOD). Others appear to be more directly action-related (e.g., bringing the head toward the shoulder for TO SLEEP) or object-related (e.g., bringing a fist hand to ear for TELEPHONE or for TO PHONE) and replicate the action schemes usually performed or observed by children as they are carried out by others (e.g., Werner & Kaplan, 1963).

Representational gestures and first words share a number of similarities: they emerge at around the same time and have a similar frequency of use; are used to communicate in contexts similar to those in which first words are produced (Caselli, 1994); express equivalent meanings (e.g., raising the arms, palms up for ALL GONE vs. 'all gone'; bringing the hand to the mouth for EAT vs. 'yum yum'); and are initially observed as part of routines from which they are progressively decontextualised (Abrahamsen, Cavallo, & McCluer, 1985; Acredolo & Goodwyn, 1988; Caselli, 1983, 1994).

Recent neurobiological data show that early on, processing of words and gestures activate a shared neural system, while later in development changes in semantic processing of gestures are shown (Sheehan, Namy, & Mills, 2007). Although children communicate more frequently with gestures than with words when gestures first appear, the gesture-word relationship undergoes significant changes over the course of the second year (Namy & Waxman, 2002; Volterra, Caselli, Capirci, & Pizzuto, 2005). As children's repertoires of spoken words expand, they begin to rely more heavily on words for communication (Caselli & Casadio, 1995; Fenson et al., 1994; Iverson, Capirci, & Caselli, 1994) and eventually two-word combinations and more complex sentences emerge. In the same period, children acquire fewer new gestures, and the frequency of gestures use also decreases (Bates & Dick, 2002; Butcher & Goldin-Meadow, 2000; Capirci, Iverson, Pizzuto, & Volterra, 1996).

Gesture and language beyond the two-word stage

Although the relation of gesture to speech changes during the second year, gestures do not by any means disappear from children's communicative repertoires (e.g., Kendon, 2004; McNeill, 2000, 2005). Indeed, there is now a large body of work investigating gesture production in school-aged children, particularly in problem-solving contexts (e.g., conservation, balance, mathematical equivalence). This research indicates that in this age range, children's speech, like that of adults, is frequently accompanied by gestures,

and those gestures frequently convey information about knowledge with respect to the task at hand (e.g., Alibali & Goldin-Meadow, 1993; Alibali, Kita, & Young, 2000; Church & Goldin-Meadow, 1986; Pine, Lufkin, Kirk, & Messer, 2007; Pine, Lufkin, & Messer, 2004). However, relatively few studies have explored the development of the gesture-speech system once children have begun to produce multiword utterances.

Research designed to focus on the speech-gesture relationship in the period between the second year and middle childhood, i.e., in older toddlers and preschoolers, is surprisingly rare; and the few studies that exist vary substantially in terms of communicative contexts employed and ways in which gestures were coded and categorised. Thus, for example, McNeill (1992) reported that when 4- to 5-year-old children were asked to narrate a story, they made productive use of idiosyncratic, content-loaded hand gestures as they spoke. He also noted that in some instances, the gestural modality appeared to provide a means for children to display ideas that could not be expressed using speech alone (see also Ozçaliskan & Goldin-Meadow, 2005, for a similar argument).

Mayberry and Nicoladis (2000; see also Nicoladis, Mayberry, & Genesee, 1999) conducted a longitudinal study of five French–English bilingual boys (from 2;0 to 3;6). Observations were conducted during free play in separate sessions for each language. Findings indicated that in terms of overall rate of gesture production and rate of gesture production with speech, the children used gestures much like adults from 2 years on. Because three of the five children exhibited uneven patterns of development in their two languages (i.e., development in one language outpaced that in the other), the authors were able to examine the question of whether gesture use is tied to advancements in language. Data were generally consistent with this notion: iconic and beat gestures began to appear when children started to produce sentences.

Although these studies provide an insight into the gesture-speech relationship beyond the two-word stage, variation in observational context, coding criteria, and age considered makes it difficult to draw conclusions regarding organisation and changes in the gesture-speech system during this period. The present study is an initial step in a program of research designed to address this issue by investigating the spontaneous production of gestures in a highly constrained, simple picture naming task. Although a task of this sort, which requires only a single-word response, may seem an unlikely context in which to examine gesture, it seemed to us to offer a number of advantages. First, picture naming provides a common set of referents for communication, referents that are known to the experimenter and the coder. Second, pilot work with the task indicated that many children produce gestures along with their verbal naming responses. And third, since previous work with the task indicates that the number of correct verbal responses

increases with age (Pettenati, Bello, Stefanini, & Caselli, 2005), we can examine ways in which gesture production changes as children's performance in the naming task improves.

The present study, therefore, was designed to address four interrelated questions: (1) Do children use gestures while performing a spoken naming task? (2) What kinds of gestures do they produce? (3) What meanings are expressed by these gestures? (4) How does the relationship between speech and gesture change as the spoken lexicon increases?

MATERIALS AND METHOD

Participants

Fifty-one Italian children (24 girls; 27 boys) with typical language development participated in this study. They were recruited from public nursery and primary schools. Children born preterm and children with recurrent otitis during the first year of life (according to parent report) were excluded.

The range of chronological age of participants was from 2;3 to 7;6 years. Children were divided into five age groups; mean ages, standard deviations, and ranges are reported in Table 1 for each group.

We were especially interested in examining developmental changes between the ages of 2 and 3 years, the age range for which the task was originally devised. However, we also wished to examine the performance of older children for whom the naming task would presumably be less demanding. For this reason, the first three groups of children were very close and relatively homogeneous in age (as is evident from the standard deviations), while there was more variability in the ages of the children in the two oldest groups.

TABLE 1
Mean ages, range and standard deviations (*SD*) for the five groups of children.

		Chronological age (years; months)		
Groups of children	*N*	*Mean*	*SD (months)*	*Range*
Age group 1	10	2;3	0.3	2;3–2;4
Age group 2	10	2;6	0.0	2;6
Age group 3	10	3;0	0.9	3–3;3
Age group 4	10	4;1	2.3	3;10–4;4
Age group 5	11	6;4	11.1	5;2–7;6

Lexical production task (LPT)

The LPT was designed for children between the ages of 2 and 3 years. Statistical procedures were used to select lexical items from the normative data of the 'Primo Vocabolario del Bambino- PVB' questionnaire (Caselli & Casadio, 1995), the Italian version of 'MacArthur-Bates Communicative Development Inventory-CDI'. The standardisation of the LPT task with an Italian population has been recently completed (Bello, Stefanini, Pettenati, & Caselli, 2008).

The version of the task employed here consists of 77 coloured pictures divided into two sets: a set of 44 pictures representing objects/tools (23 items, e.g., comb), body parts (5 items, e.g., eye), animals (5 items, e.g., penguin), food (6 items, e.g., cake) and clothing (5 items, e.g., gloves), and a set of 33 pictures representing actions (19 items, e.g., to eat), adjectives (11 items, e.g., small) and location adverbs (3 items, e.g., inside-outside).

Procedure

All of the children were tested individually at school. The two sets of pictures were presented separately in random order, but order of picture presentation within each set was fixed.

After a brief period of familiarisation, the experimenter placed the pictures in front of the child one at a time. For pictures of body parts, animals, objects/tools, food, and clothing, the child was asked 'What is this?' For pictures of actions, children were asked 'What is the child doing?' For pictures eliciting adjectives, the child was asked 'How is it?'; and for location adverbs, the child was asked 'Where is it?'. In the case of adjectives, two pictures were put in front of the child: one representing the expected characteristic (e.g., a small ball) and another representing the opposite characteristic (e.g., a big ball). If the child did not provide the expected label as a first answer, the experimenter said, 'This is big (pointing to the picture representing the big ball) and how is this?' (pointing to the picture representing the small ball). A similar procedure with two pictures was used for location adverbs.

When presenting the pictures, the experimenter sometimes pointed to the picture in order to help the child maintain focus but otherwise avoided producing any other kind of gesture. The test was administered in one or two sessions depending on the level of fatigue of the child, and breaks were given as needed.

Coding

All sessions were videotaped for later transcription. We coded the communicative exchange between the child and the experimenter beginning

from the time a picture was placed in front of the child and ending when the picture was removed. During these exchanges, children could, in principle, produce multiple spoken utterances and multiple gestures and we defined these productions as answers to the items proposed. We examined children's answers in terms of modality of expression, accuracy of the spoken response, types of gestures produced, and the relationship between correct spoken naming and gesture production.

Modality of expression. All answers to the items proposed were classified into one of three categories on the basis of modality. The first category included answers produced only in the spoken modality (*unimodal spoken productions*), the second category included all answers in which the child used both modalities (*bimodal productions*), and the last category included the answers produced only in the gestural modality (*unimodal gestural productions*).

Spoken responses. Spoken answers in the naming task were classified as correct responses, incorrect responses, or no-response. Responses were coded as *correct* when the child provided the expected label for the picture (expected word). Phonologically altered forms of expected words were also accepted (e.g.,'lelefono' for the picture of a telephone, intended to elicit the Italian word 'telefono'). For some pictures, more than one response was accepted as correct. For example, 'bag' can be called 'sacchetto', 'busta', or 'borsa' in Italian, while 'cake' can be called either 'torta' or 'dolce'.

Incorrect responses included words different from the target items expected to be elicited by the pictures.

No-responses were coded when children either stated that they did not know the word corresponding to a picture or did not provide an answer. When children gave an incorrect response or a no-response on their first attempt, they were given a second chance to provide the correct response.

A 'best response' criterion was adopted in these instances, such that if the child initially gave an incorrect spoken response and then the correct one, s/he was given credit for providing a correct response. If neither response was correct, the first one was counted.

Gesture production. All visible actions produced by the children as they interacted with the experimenter were coded as gestures (Kendon, 2004). These included gestures produced with and without speech, and those occurring both before and after the accepted spoken response.

Given the specific nature of the task (asking children to name pictures), the criteria for coding an action as a gesture were as follows: (1) The gesture had to be directed to the experimenter requesting to name the picture or toward the picture to be named. (2) The gesture could be performed with an

empty hand or holding the picture to be named. (3) The gesture must not be part of a ritual act or game. (4) The gesture must not be an imitation of the communication partner's preceding gesture.

This study is primarily limited to manual gestures and movements of the head, although occasional reference will be made to other kinds of non-manual gestures (e.g., posture, body movements, facial expressions, glance).

For the present study, we adopted a classification partially inspired by recent works conducted on young preschool children (Bello, Capirci, & Volterra, 2004; Butcher & Goldin-Meadow, 2000; Stefanini, Caselli, & Volterra, 2007). Each gesture was classified into one of the following three categories:

(1) *Deictic* gestures included showing, giving, and pointing. A distinctive feature of deictic elements is that their interpretation heavily or entirely depends upon contextual information. Their referent can be identified only by inspecting the physical context of interaction (McNeill, 1992; Pizzuto & Capobianco, 2005). Most of the deictic gestures produced were pointing. We also coded the direction of pointing to the target picture, the self, or an object in the environment. Pointing in the present study was defined as an extension of the index finger and classified as index pointing (e.g., asked to label a picture of a dog, the child points with the index finger extended towards the picture while saying 'dog'). Instances of pointing with multiple fingers extended were included in this category and classified as fingers pointing (e.g., asked to label a picture of a child being fed, the child points with the index, second, and ring fingers extended, saying 'child eats'). Showing was defined as an arm extension while holding an object (often the picture) in the hand. In the case of giving, the object (the picture) was transferred to another person.

(2) *Representational gestures* are pictographic representations of the meaning (or meanings) associated with the represented object or event. Regarding the 'techniques' of representation used, we distinguished between Action Gestures and Size-Shape Gestures. Action Gestures depict the action usually performed by a character, possibly with an object or movement of an object. In Action Gestures (defined by Kendon, 2004 as enactment; see also Gullberg, 1998), body parts engage in a pattern of action that has features in common with the pattern of action that serves as the referent. Size-Shape Gestures (defined by Kendon, 2004 as modelling and depiction) depict the dimension, form, or other perceptual characteristics of an object or an event. In this case, the form of the hands bears some relationship to the shape of the object to which the gesture refers and sometimes engages in a pattern of movement that is recognised as 'creating' an object in the air (some examples are reported in the Results section, Table 2).

(3) *Other gestures* included gestures that could not be classified as deictic or representational. Included in this category were conventional interactive

gestures (i.e., culturally defined gestures used for the purpose of regulating interaction, e.g., shaking the head for 'no'); beat gestures (also known as 'rhythmic' or 'emphatic' gestures, i.e., simple, repetitive movements lacking a discernable meaning, e.g., the hand moves in time with the rhythmical pulsation of speech or in the air while pronouncing a particular word); and Butterworth gestures (named after the British psycholinguist Brian Butterworth), which were produced exclusively during silent pauses (i.e., thinking and/or trying to remember something; e.g., supporting the head with the hand in the action of thinking; tapping fingers on the table).

Reliability. Reliability between two independent coders was assessed for all spoken and gestural productions as well as for bimodal productions. Agreement between coders was 98% for spoken answers and 92.3% for gestures, corresponding to kappa (a measure of agreement between two observers taking into account agreement that could occur by chance) of 0.92 and 0.86 respectively (both values are higher than 0.80 indicating 'almost perfect agreement' according to Landis and Koch classification).

TABLE 2
Examples of action and size-shape gestures produced on the lexical production task by the five groups of children

Picture	*Speech*	*Gesture*
Action gestures		
Comb	'pazzola' (brush)	The child moves the fingers near his head as if combing his hair
Radiator	'termosifone, scotta' (radiator, it's hot)	The child retracts his hand toward the body quickly
Lion	'i leone . . . .arrr' (the lion . . .aarr)	The child extends his arms forward with a fierce facial expression, pretending to make an attack
Turning merry-go-round	'gira' (it turns)	The child moves the hands in a circular motion
Writing	'scrive il suo nome' (he's writing his name)	The child makes circles on the table with the tip of the index finger
Size-shape gestures		
Table	'grande' (big)	The child opens his arms with the palms up
Roof	'tetto' (roof)	The child makes the finger tips of both hands in contact with each other, outlining the shape of a triangle in the air
Painting	'uno pecchio' (a mirror)	The child extends his arms to the sides and upward, indicating the size and location of the painting

RESULTS

Modality of expression

All answers (i.e., productions) provided by the children to the figures were classified according to modality of expression used: unimodal spoken, bimodal (i.e., spoken + gestural), and unimodal gestural productions.[2] The mean percentages and standard deviations of each type of answer for the five age groups are presented in Figure 1.

As is apparent in the figure, in age group 1 ($M = 2;3$ yrs) there was a very high percentage of bimodal productions (52%). The same children used the spoken modality of expression for 46% of their answers, but this type of expression was more frequent in the other age groups (accounting for 90% of answers in the oldest age group). Unimodal gestural productions were infrequent (about 3% or less) in all groups.

Two one way analyses of variance (ANOVA)[3] with Age Group (five levels) as the independent variable and the percentage of Unimodal Spoken Productions and the percentage of Bimodal Productions as the dependent variable were conducted. A significant difference across the groups emerged for both Unimodal Spoken Productions, $F(4, 46) = 20.47$, $p < .001$, and Bimodal Productions, $F(4, 46) = 20.63$, $p < .001$.

A follow-up Duncan test indicated that the percentage of Unimodal Spoken Productions was significantly different across all age groups (all ps $< .003$), except between age groups 2 and 3 ($p = .56$) and age groups 4 and 5 ($p = .73$). A similar finding was revealed by the follow-up Duncan test conducted on the percentage of Bimodal Productions: there were significant differences across all groups (all ps $< .001$), with the exception of age groups 2 and 3 ($p = .49$) and age groups 4 and 5 ($p = .69$).

It is interesting that in the context of a classic naming task, in which the expected response is a spoken label, the children in our sample produced a relatively large percentage of utterances containing gestures. This was

[2] We created a dataset that contained only first attempts and carried out a series of t-tests comparing the first attempt only data with those presented in the results (i.e., first + second attempts). Findings indicated that bimodal responses and gestures did not differ reliably across counting methods. Specifically, the percentage of bimodal responses was highly similar across counting methods (first attempts vs. first + second attempts): age group 1: 51.9% vs. 52.2%; age group 2: 28.2% vs. 29.7%; age group 3: 33.2% vs. 33.5%; age group 4: 10.5% vs. 11.5%; age group 5: 8.4% vs. 9.34%). The number of gestures was also relatively comparable: age group 1: $M = 44.9$ vs. $M = 51.6$; age group 2: $M = 25.7$ vs. $M = 31.1$; age group 3: $M = 32.4$ vs. $M = 36.5$; age group 4: $M = 8.5$ vs. $M = 10$; age group 5: $M = 7.1$ vs. $M = 8.9$. Because the basic pattern of results is similar, and in order to provide a more complete picture of children's communication in the task, we have elected to keep the analyses conducted with all attempts.

[3] We excluded from this analysis the category of 'unimodal gestural productions' to improve variance homogeneity

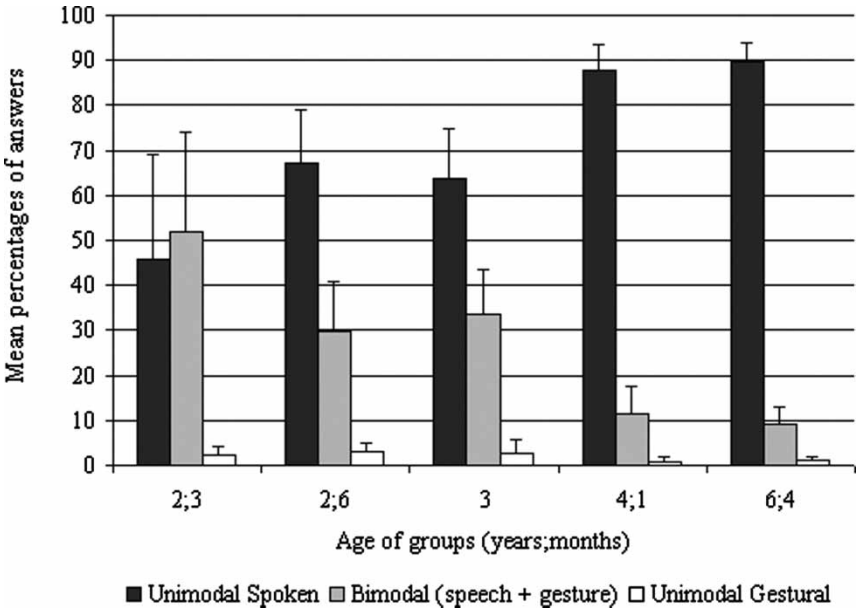

Figure 1. For each child, the percentages of unimodal vocal (i.e., number of unimodal vocal answers/total number of answers), bimodal (i.e., number of bimodal answers/total number of answers), and unimodal gestural productions (i.e., number of unimodal gestural answers/total number of answers) were computed. The error bars refer to standard deviations (*SD*).

especially true for younger children, for whom the task of finding and producing the expected label is presumably more difficult. Before considering this difference in further detail, we next present data on spoken production.

Spoken responses

We analysed the spoken responses provided by the children in unimodal spoken and bimodal answers to determine whether or not they corresponded to the expected word. Figure 2 displays the mean number and standard deviation of correct spoken responses given by each age group based on total number of LPT pictures presented (77 items).

Correct spoken naming increased gradually across age groups. However, the task was clearly difficult for the youngest children, who produced only slightly more than 50% of expected words. The next three age groups exhibited somewhat better performance and there was relatively little variation between them (all produced about 75% of expected words). Only age group 5 produced more than 90% of expected words. The number of no-responses was limited in each age group to a mean of 3.

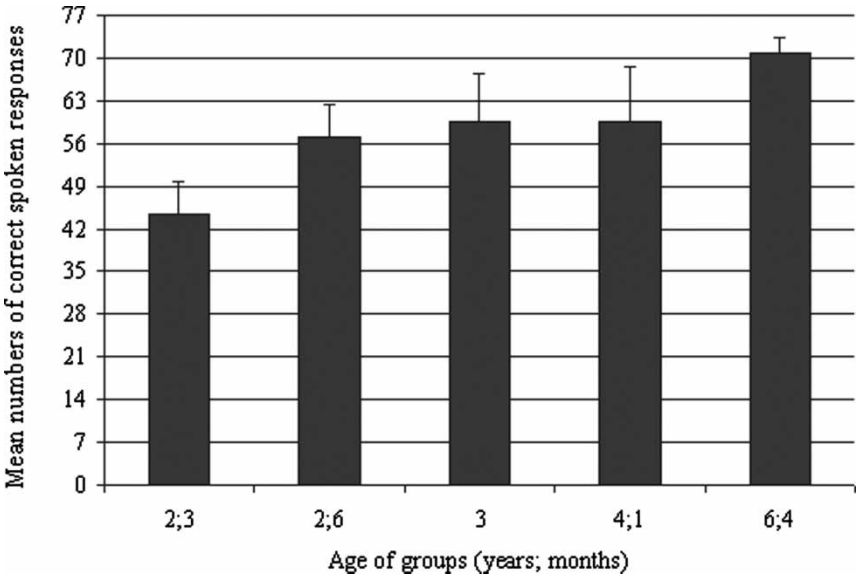

Figure 2. Mean numbers of the correct spoken answers produced on the Lexical Production Task by children in the five age groups. The maximum possible score on the task was 77. The error bars refer to standard deviations (*SD*).

We conducted a one way analysis of variance (ANOVA) with Age Group as the independent variable (five levels) and percentages of Correct Responses as the dependent variable. There was a significant difference across age groups, $F(4, 46) = 23.01$, $p < .001$. Post-hoc comparisons (Duncan test) indicated a significant increase in the number of expected words between age group 1($M = 2;3$ yrs) and other groups, all $ps < .001$, and between age group 4 ($M = 4;1$ yrs) and 5 ($M = 6;4$ yrs), $p < .001$.

Gesture production

Total gestures. In the previous section (see Figure 1) we presented the percentages of all unimodal gestural and bimodal productions. In this section we provide more detailed analyses of all gestures produced and contained in the answers given by children to the items proposed.

All children (except one 4-year-old) produced spontaneous gestures during the naming task. The total number of gestures produced was highest in the youngest age group ($M = 52$; $SD = 23$). Children in age group 2 ($M =$ 2;6 yrs) and age group 3 ($M = 3;0$ yrs) also produced a considerable (and similar) number of gestures during the task ($M = 32$, $SD = 12$ and $M = 37$, $SD = 12$, respectively). Children in the two oldest age groups ($M = 4;1$ yrs

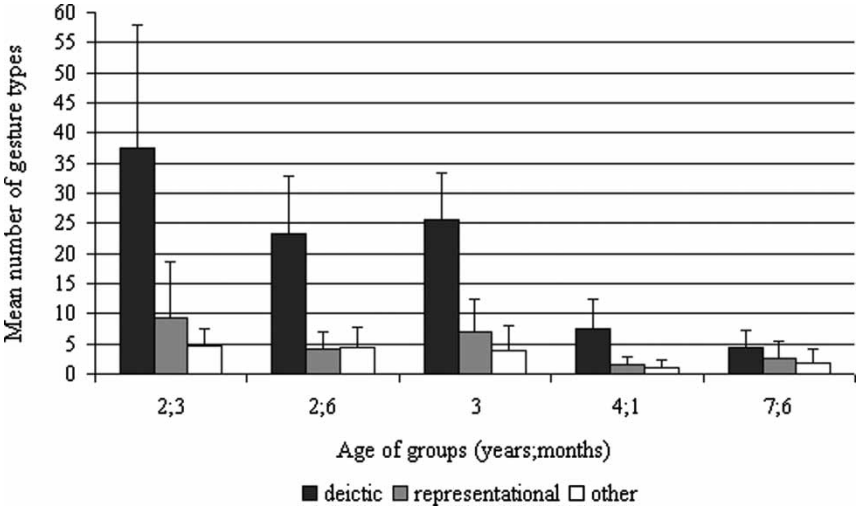

Figure 3. Mean numbers of the different gesture types (deictic, representational, or other) produced on the Lexical Production Task by the five groups of children. The error bars refer to standard deviations (*SD*).

and $M = 6;4$ yrs) produced smaller numbers of gestures and the means and ranges were similar ($M = 10$, $SD = 6$ and $M = 9$, $SD = 4$, respectively).

A one way analysis of variance (ANOVA), with Age Group as the independent variable (five levels) and number of Gestures produced during the task as the dependent variable revealed a significant difference across the groups, $F(4, 46) = 19.82$, $p < .001$. Post-hoc comparisons (Duncan test) indicated a significant difference in the number of gestures between age group 1 ($M = 2;3$ yrs) and age group 2 ($M = 2;6$ yrs), $p < .002$, and between age group 3 ($M = 3;0$ yrs) and age group 4 ($M = 4;1$ yrs), $p < .001$.

Gesture types. We next analysed the types of gestures produced. Figure 3 shows the mean numbers and standard deviations of the different gesture types (in both bimodal and the unimodal gestural responses) produced during the task by the five groups of children.

An analysis of variance (ANOVA) with Age Group as a between-subjects factor (five levels) and Gesture type (deictic, representational, other) as a within-subjects factor was conducted. We found an Age Group main effect, $F(4, 46) = 19.47$, $p < .001$, a Gesture type main effect, $F(2, 92) = 57.72$, $p < .001$ and a significant interaction between the two variables, $F(8, 92) = 8.50$, $p < .001$.

Post-hoc comparisons (Duncan Test) indicated a reliable change in deictic gestures among age groups. In particular, we observed a significant decrease between age group 1 ($M = 2;3$ yrs) and age group 2 ($M = 2;6$ yrs), $p < .001$,

and between age group 3 ($M = 3;0$ yrs) and the two oldest age groups ($M = 4;1$ yrs and $M = 6;4$ yrs), $ps = .001$.

There was a gradual decline across age groups in the number of representational gestures; but the difference was statistically significant only between age group 1 ($M = 2;3$ yrs) and age group 4 ($M = 4;1$ yrs), $p = .03$, and between age group 1 and age group 5 ($M = 6;4$ yrs), $p = .05$. With regard to other gestures, no significant difference between groups emerged. Finally, deictic gestures were more numerous than representational and other gestures at 2;3, 2;6, and 3;0 years ($ps = .001$); the two oldest age groups did not exhibit any differences between the types of gestures.

In summary, our data thus far indicate that children produced a substantial number of gestures in the context of a naming task, and that the majority of these gestures were deictic (though representational gestures were also relatively common). Production of deictic and representational gestures decreased as a function of age.

Furthermore, exploring deeper some characteristics of gestures produced during the LPT, interesting qualitative similarities and differences across the groups appeared in the age range considered.

Deictic gestures

A total of 989 deictic gestures were produced by the children. They were the most frequently produced gesture type by the first age groups, and the vast majority of these were pointing (97% pointing; 2% show; 1% give).

All children used pointing. However, great variability within and across groups was evident (age group 1, $M = 2;3$ yrs: $M = 38$, $SD = 20$; age group 2, $M = 2;6$ yrs: $M = 23$, $SD = 10$; age group 3, $M = 3;0$ yrs: $M = 26$, $SD = 8$; age group 4, $M = 4;1$ yrs: $M = 8$, $SD = 5$; age group 5, $M = 6;4$ yrs: $M = 5$, $SD = 3$).

Almost all pointing gestures (97%) were directed to the picture. Children directed the remaining pointing gestures to their bodies (e.g., when the picture represented body parts or clothing), or, in very few cases, to objects present in the environment (e.g., the table; the heater).

With regard to motoric execution patterns, pointing was performed in the majority of cases (83%) with the index finger extended (index pointing) or, in a few cases (17%), with multiple fingers extended (fingers pointing). Pointing with the index finger is evident in the communication of children before their first birthday; however, many investigators (e.g., Lock et al., 1994) report that these gestures are often executed in a more imprecise fashion, and this tendency continues to be apparent even in slightly older children, although much less frequently.

Representational gestures

Representational gestures were observed less often than deictic gestures, but they were evident in the production of almost all of the children: only eight children did not produce representational gestures and all were in the oldest two age groups. A higher variability within and across groups was observed (age group 1, $M = 2;3$ yrs: $M = 9$, $SD = 9$; age group 2, $M = 2;6$ yrs: $M = 4$, $SD = 3$; age group 3, $M = 3;0$ yrs: $M = 7$, $SD = 5$; age group 4, $M = 4;1$ yrs: $M = 2$, $SD = 1$; age group 5, $M = 6;4$ yrs: $M = 3$, $SD = 3$).

All representational gestures (247) produced were in accompaniment to speech, and their referents and meanings were easily identifiable because of the nature of the picture naming task (i.e., the picture was the common ground for both the child and the experimenter).

On the basis of 'techniques of representation' used gestures were classified in Action gestures and Size-Shape gestures (see Table 2).

The total number of Action gestures produced by children across age groups was 215 (87%), while Size-Shape gestures were 32 (13%). A high percentage of Action gestures was present in all age groups (age group 1, $M = 2;3$ yrs: $M = 87\%$; age group 2, $M = 2;6$ yrs: $M = 88\%$; age group 3, $M = 3;0$ yrs: $M = 86\%$; age group 4, $M = 4;1$ yrs: $M = 93\%$; age group 5, $M = 6;4$ yrs: $M = 84\%$). Table 2 shows different examples of Action and Size-Shape gestures.

Since only 25% of the lexical items presented explicitly contained pictorial images of actions and about a half of Action gestures produced (47%) was related to these pictures, their high number cannot be explained as a product of direct imitation of the represented actions. Thus, the production of Action gestures is not linked to the direct and explicit presence of an action in the images presented: for example, a great percentage of Action gestures were produced in response to pictures representing objects, animals, clothing, and body parts (42%). In a few cases, the picture itself became the manipulated object (e.g., the child combs his hair using the picture of the comb; the child rotates the picture of the turning merry-go-round).

Other gestures

Gestures grouped under this category were produced in a few cases (range: 0–8) across all age groups (see Figure 3). As reported in the method section, we collapsed in this category gestures previously defined as conventional, Butterworths, and beats, which were the most frequent in our data (conventionals, $M = 17\%$; Butterworths, $M = 19\%$; beats, $M = 65\%$). This is consistent with other work indicating that beat gestures begin to appear in this age range.

Relationship between correct spoken naming and gesture production

We next examined whether developmental changes in gesture production were attributable only to chronological age or also to increasing spoken naming accuracy. We conducted a multiple linear regression with total number of Gestures as the dependent variable and Chronological age and number of Correct spoken responses as the predictor variables. The stepwise procedure indicated that age was the strongest predictor, $R^2 = .41$, $F(1, 49) = 34.08$, $p < .001$, but the number of correct spoken responses accounted for a significant proportion of residual variance, R^2 change $= .06$; $F(1, 48) = 5.45$, $p = .024$. The goodness of fit of the final model was therefore, $R^2 = .47$. In terms of effect size, a one-year increase of age, controlling for naming accuracy, is estimated to reduce the number of gestures by 0.45 (ß $= -0.45$; 95% CI $= -0.13; -0.76$, $p = .007$), indicating that for every 10 months more in age, about five fewer gestures were produced. On the other hand, a 1% increase of naming accuracy, controlling for age, is estimated to reduce the number of gestures by 0.66 (ß $= -0.66$; 95% CI $= -.10; -1.23$, $p = .024$), indicating that for every 10% increase in accuracy, about seven gestures fewer were produced.

When separate analyses were done for the three gesture types, the negative association between naming accuracy and number of gestures was confirmed for each Gesture type (Deictic: $R = -.596$, $p < .001$; representational: $R = -.337$, $p = .016$; other: $R = -.404$, $p = .003$) and remained negative when age was partialled out, although with a lesser extent of statistical evidence (Deictic: $R = -.287$, $p < .043$; representational: $R = -.156$, $p = .279$; Other: $R = -.244$, $p = .087$).

GENERAL CONCLUSION AND DISCUSSION

In this study, we utilised a very simple experimental structured task in which children were asked to provide a noun or a predicate in order to name objects, actions, or characteristics. Around 2 years of age, the picture naming task appears to be difficult: children provided the correct expected spoken label for only about half of the pictures. Children produced many gestures together with words while performing the naming task. At the end of the period considered (between 6 and 7 years) children provided almost all of the expected spoken labels. With the increase in age and spoken naming competence, co-speech gestures decreased, but they did not disappear. The negative association between naming accuracy and number of gestures was confirmed and remained negative when age was partialled out.

It is striking that children who are already able to name in speech still used gestures in this task. They performed mainly deictic and representational

gestures, the same gestures already produced in the previous age period (see also Guidetti, 2005, for similar data on conventional gestures). Among deictic gestures, the most widely used was pointing, which appeared to be a device used to maintain attention by indicating the object or the action depicted in the picture.

With representational gestures, children performed or reproduced the action usually executed with that object in hand (e.g., the comb) or usually performed by the character depicted (e.g., the lion), or represented in the picture itself (e.g., to swim). Representational gestures thus appear to indicate the activation of motor programmes associated with objects or actions represented in the pictures. Indeed, Action gestures were much more frequent in our data than Size-Shape gestures. Performing the action observed or linked to the referent in the picture may be an important step in the process of labelling, particularly for 2- and 3-year-old children.

As discussed in the Introduction, deictic and representational gestures appear to originate from exploration and/or action execution. Representational gestures are stylised and often conventionalised versions of various manipulative actions such as bringing a comb to the head or grasping the door handle. Evidence of the link between the gesture and actions performed directly on objects is indicated by examples reported above in which children executed the gesture (e.g., combing or turning) with the picture in hand.

Pointing can also be interpreted in a similar fashion. According to Kendon, 'in pointing to an object (whether real or virtual), the actor acts directly in relation to the object; a specific object may be individuated, it may be referred to as an exemplar, it may be offered as an object for inspection. The different forms of pointing may be thought of as different kinds of actions that the actor may take in relation to the objects referred to' (Kendon, 2004, p. 224).

Our findings suggest that when 2-year–old children label pictures depicting objects or actions, they still need to perform an 'action' in the form of a 'gesture'. The function of these gestures may be to recreate a 'direct link' with the object or the action to be labelled. This suggests that words may not yet be fully decontextualised, and the production of a gesture may recreate the context in which the word was initially acquired (Capone, 2007).

Our data are also consistent with the notion that children may produce gestures not only to communicate with others but also for 'themselves'. In the early years the prevalence of pointing gestures suggests that it serves an anchoring purpose. It is produced by children not only to share an interesting referent with the adult (the picture to be named is already focused), but also to maintain their own attention during the task or to drive a physical contact with the referent. But as children get older we could

hypothesise that in the naming context its function changes, being produced more for the interlocutor than for 'themselves'.

Motor representations may be needed to support linguistic representations in speech. Pointing to the depicted referent (action or object) or performing a gestural motor representation may still be needed to create a more experiential dimension. In adults, the experiential dimension may be created mainly for public presentation (Kendon, 2004) to evoke an image for the interlocutor. But in the case of young children, gesture production may help create a more precise and concrete image linked to the word. Only later, after 3 or 4 years of age, do actions and gestures appear to become optional as a more direct link is established between the referent and the spoken word.

This interpretation is supported by two sets of findings. First, in other naming tasks with older typically developing children, these gestures are observed very infrequently, and when they do appear, they do with very low frequency words or during difficulties with word finding. For example, in one study exploring spontaneous gesture production in the Boston naming task, younger typically developing children (4–7 years) produced more representational gestures than older children (9–12 years; Bello et al., 2004). Second, Stefanini et al. (2007) recently investigated the relationship between gestures and words in a picture naming task (the same used in the present study) with a sample of children with Down syndrome (DS) (chronological age of about 6 years; mental age of about 4 years) and to two groups of typically developing children (TD): one matched for mental age and one for chronological age. Findings indicated that in comparison with both TD groups, children with DS gave fewer correct spoken answers but performed a higher number of gestures, and in particular, more representational gestures than the TD groups. Children with DS could therefore convey the correct information in their gestures even if they did not in their speech. Other studies have reported an increase in the use of gestures with age and increasing linguistic competence; however, they have examined gesture production in the context of spontaneous interaction (Mayberry & Nicoladis, 2000), narration (Colletta, 2004; McNeill, 2005), and explanation and problem-solving tasks (Goldin-Meadow, 2002; Pine et al., 2004), all of which sample longer spoken responses. The contradiction with our findings is only apparent, considering the different methods used in data collection. Thus, for example, Mayberry and Nicoladis (2000) examined the spontaneous production of speech and gesture in five bilingual boys (exposed to French and English) during play sessions with a parent, evaluating their gesture use in relation with their language development (calculating longitudinally their mean length of utterance in each language). In the present study, we investigated production of gestures in relation to naming accuracy in a simple picture naming task which

remained the same for all groups (from 2 to 7 years) of children examined and requested a single word as an answer. The picture naming task elicited mainly deictic and representational gestures, while the context of spontaneous interaction more easily induced the production of the beat gestures which accompany conversation and discourse. Given these important differences, the results of the two studies do appear consistent, confirming that gesture production, like spoken production, changes according to the communicative/interactional context of data collection.

Findings from this study indicate that in the context of a naming task that requires only the production of a single word, gesture production declines as a function of increasing age and spoken lexical competence. The negative association between naming accuracy and number of gestures was confirmed for both types of gestures, deictic and representational. Thus the present study does not allow us to draw definite conclusions about a possible different function of these two types of gestures in the developmental period considered. Even though the naming task is relatively simple, it appears to be quite useful as a tool for exploring the organisation of the gesture-speech system. We are currently examining the semantic coherence of speech and gesture in children's responses, along with the timing relationship between the two modalities, to explore the ways in which gestures are meaningfully and temporally integrated with speech to articulate meaning in different ways across the vocal and gestural modalities (Pizzuto & Capobianco, 2005).

In conclusion, it has been argued that around the end of the first year, pointing is the first way to refer to things and recognitory action gestures are an early form of naming (Bates & Dick, 2002; Butterworth, 2003). However, there was little empirical evidence that the same holds for older children. The present findings support this view, showing that children from 2–3 years of age, who use words for naming, still produce these gestures together with words when labelling pictures in a structured task, indicating functional similarities between forms of gestural and spoken naming. This is consistent with the notion of continuity between prelinguistic and linguistic forms (i.e., between actions, gestures, and spoken words), a perspective that emerged in the late 1970s (e.g., Lock, 1978) and is currently enjoying a resurgence of interest across disciplines and theoretical perspectives (Capirci & Volterra, 2008; Corballis, 2002; Gallese, 2000; Gentilucci & Corballis, 2006; Rizzolatti & Arbib, 1998; Rizzolatti & Luppino, 2001). Our findings are also consistent with the suggestion of a tight link between gestural motoric and spoken linguistic representations in young children, and more generally, the co-activation of hand-mouth motor programmes (e.g., Capirci, Contaldo, Caselli & Volterra, 2005; Iverson & Thelen, 1999), that provides the basis for a developmental model of language in human ontogeny that goes from action to gesture and word.

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