Available online at www.sciencedirect.com
SCIENCE DIRECT®
COGNITION
ELSEVIER
Cognition 96 (2005) B101–B113
www.elsevier.com/locate/COGNIT

Brief article

Gesture is at the cutting edge of early language development

Şeyda Özçalışkan*, Susan Goldin-Meadow

Department of Psychology, University of Chicago, 5848 S. University Avenue, Green 317, Chicago, IL 60637, USA

Received 26 November 2004; accepted 14 January 2005

Abstract

Children who produce one word at a time often use gesture to supplement their speech, turning a single word into an utterance that conveys a sentence-like meaning ('eat' + point at cookie). Interestingly, the age at which children first produce supplementary gesture–speech combinations of this sort reliably predicts the age at which they first produce two-word utterances. Gesture thus serves as a signal that a child will soon be ready to begin producing multi-word sentences. The question is what happens next. Gesture could continue to expand a child's communicative repertoire over development, combining with words to convey increasingly complex ideas. Alternatively, after serving as an opening wedge into language, gesture could cease its role as a forerunner of linguistic change. We addressed this question in a sample of 40 typically developing children, each observed at 14, 18, and 22 months. The number of supplementary gesture–speech combinations the children produced increased significantly from 14 to 22 months. More importantly, the types of supplementary combinations the children produced changed over time and presaged changes in their speech. Children produced three distinct constructions across the two modalities several months before these same constructions appeared entirely within speech. Gesture thus continues to be at the cutting edge of early language development, providing stepping-stones to increasingly complex linguistic constructions.

Keywords: Gesture; Two-word speech; Argument structure; Gesture–speech relation

* Corresponding author. Tel.: +1 773 834 1447; fax: +1 773 834 5261.
E-mail address: seyda@uchicago.edu (Ş. Özçalışkan).

0022-2860/$ - see front matter © 2005 Elsevier B.V. All rights reserved.
doi:10.1016/j.cognition.2005.01.001

1. Gesture's role in early language-learning

At a certain stage in the process of learning language, children produce one word at a time. They have words that refer to objects and people and words that refer to actions and properties in their productive vocabularies (Nelson, 1973). However, they do not combine these words into sentence-like strings.

Interestingly, at the earliest stages of language learning, children also fail to combine their words with gesture. They use deictic gestures to point out objects, people, and places in the world, and iconic gestures to convey relational information as early as 10 months (Acredolo & Goodwyn, 1985, 1989; Bates, 1976; Bates, Benigni, Bretherton, Camaioni & Volterra, 1979; Greenfield & Smith, 1976; Iverson, Capirci, & Caselli, 1994). However, they do not combine these gestures with words—despite the fact that, during this same period, they are able to combine gestures with meaningless vocalizations (e.g. grunts, exclamations; Butcher & Goldin-Meadow, 2000). Producing meaningful words and gestures in a single combination thus appears to be a significant developmental step.

Children take the developmental step that allows them to combine words with gestures several months before they take the step that enables them to combine words with other words (Capirci, Iverson, Pizzuto, & Volterra, 1996; Goldin-Meadow & Butcher, 2003; Greenfield & Smith, 1976). For example, before a child produces two-word utterances, the child is able to point at a cup while saying the word "cup" or, more interestingly, point at a cup while saying the word "mommy". Note that this second type of gesture–speech combination provides children with a technique for conveying sentence-like information before they are able to convey that same information in words alone ("mommy cup"). Gesture–speech combinations of both types precede the onset of two-word utterances. The question we address in this paper is what role these gesture–speech combinations play in the development of children's first sentences.

There is, in fact, evidence that children's gesture–speech combinations are related to their first two-word utterances. The age at which children first produce gesture–speech combinations conveying sentence-like information (e.g. "mommy" + point at cup) is highly correlated with the age at which they begin to produce their first two-word utterances (Goldin-Meadow & Butcher, 2003; Iverson & Goldin-Meadow, in press). Importantly, the onset of combinations in which gesture is redundant with speech (e.g. "mommy" + point at mommy) does *not* predict the onset of two-word utterances. It is the relation between gesture and speech, and not the presence of gesture *per se*, that predicts when children will first produce multi-word combinations.

A child's ability to convey sentence-like meanings *across* gesture and speech is thus a signal that the child will soon be able to convey these meanings entirely *within* speech. But if there is truly a tight link between early gesture–speech combinations and later language development, we ought to be able to see precursors of *particular* sentence constructions in children's early gesture–speech combinations.

Children use deictic gestures to convey object information (e.g. point at mommy to refer to *mommy*) and iconic gestures to convey predicate information (e.g. fist pounding in

the air to refer to the act of *hitting*).[1] These gestures could be added to words to build more complex meanings. For example, a child could produce a point at a peg along with the word "mommy" to request mommy to act on the peg, thus conveying two arguments of a simple proposition (the agent *mommy* in speech, and the patient *peg* in gesture). Or, the child could produce an iconic *hit* gesture along with the word "mommy" to make the same request, this time conveying the predicate and argument of the proposition (the action *hit* in gesture, and the agent *mommy* in speech). If gesture–speech combinations are precursors to linguistic constructions, we might expect children to produce argument + argument and predicate + argument combinations *across* gesture and speech before they produce these combinations *within* speech ("mommy peg," "mommy hit").

More convincing still, children ought to be able to take the next step toward sentence construction—complex constructions containing two predicates—in gesture–speech combinations before taking this step in speech on its own. For example, a child who produces an iconic *hit* gesture along with the sentence "help me" has, in effect, produced a two-predicate construction, the *help* predicate in speech and the *hit* predicate in gesture. Do children produce predicate + predicate constructions in gesture–speech combinations before they produce them entirely in speech ("help me hit")? Does gesture continue to predict the child's next linguistic steps?

To examine the role that gesture–speech combinations play in early language learning, we observed 40 children as they progressed from one-word to multi-word speech. Our question was whether the types of gesture–speech combinations that the children produced presage oncoming changes in their speech and thus serve as a forerunner of linguistic advances.

2. Method

2.1. Sample and data collection

Forty children (21 girls, 19 boys) were videotaped in their homes at 14, 18, and 22 months while interacting with their primary caregivers. The children's families were representative of the population in the greater Chicago area in terms of ethnic composition and income distribution (see Table 1), and children were being raised as monolingual English speakers. Each session lasted 90 minutes, and caregivers were asked to interact with their children as they normally would and ignore the experimenter. Sessions typically

[1] We followed Goldin-Meadow and Mylander (1984) in relying on gesture form (which, in our data, was primarily action-based and, only occasionally, attribute-based) in assigning meaning to iconic gestures. In most instances, the decision was bolstered by context. Take, for example, the hit gesture mentioned in the text. The child and the mother were playing with a toy containing pegs of different colors and a plastic hammer. Initially, the child was hammering the pegs while mother told him which pegs to hammer (e.g. "hammer the blue one," "hammer the purple one"). Later, the child handed the plastic hammer to mother and said "you" while producing an iconic *hit* gesture. The child seemed to be using his iconic gesture to tell his mother to hit the peg and was thus conveying an action meaning with his gesture.

Table 1
The sample of children classified according to ethnicity and family income

Family income	Parents' ethnicity					
	African-American	Asian	Caucasian	Hispanic	Mixed	Total
Less than $15,000	1	0	1	0	0	2
$15,000–$34,999	2	1	2	2	1	8
$35,000–$49,999	2	0	3	0	1	6
$50,000–$74,999	2	1	6	0	0	9
$75,000–$99,999	1	0	5	1	0	7
$100,000 or more	0	0	7	0	1	8
Total	8	2	24	3	3	40

Mixed, two or more ethnic groups.

involved free play with toys, book reading with the caregiver, and a meal or snack time, but also varied depending on the preferences of the caregiver.

2.2. Procedure for data analysis

All meaningful sounds and communicative gestures were transcribed. Hand movements were considered communicative gestures if they were used to convey information to a listener and did not involve direct manipulation of objects (e.g. banging a peg) or a ritualized game (e.g. itsy-bitsy spider). Sounds were considered meaningful words if they were used reliably to refer to specific referents or events; onomatopoeic sounds (e.g. "meow", "choo-choo") and conventionalized evaluative sounds (e.g. "oopsie", "uh-oh") were also included as words. A communicative act was defined as a word or gesture, alone or in combination that was preceded and followed by a pause, a change in conversational turn, or a change in intonational pattern. Communicative acts were divided into three categories: (1) Gesture only acts were gestures produced without speech, either singly (e.g. point at dog) or in combination (e.g. point at dog + nod; point at puzzle piece + point at puzzle board). (2) Speech only acts were words produced without gesture, either singly (e.g. "dog") or in combination ("baby fall down"). (3) Gesture–speech combinations were acts containing both gesture and speech (e.g. "see dog" + point at dog; "cookie" + *eat* gesture). We did not code the order in which gesture and speech were produced in gesture–speech combinations; as a result, all of these combinations are marked with a '+', with the word arbitrarily listed first and the gesture second.

Gesture–speech combinations were categorized into three types according to the relation between the information conveyed in gesture and speech. (1) A *reinforcing* relation was coded when gesture conveyed information that was redundant with speech (e.g. "dog" + point at dog, "cup" + hold-up milk cup). (2) A *disambiguating* relation was coded when gesture clarified the referent of a pronominal (e.g. "her" + point at sister), demonstrative (e.g. "that one" + point at doll), or deictic (e.g. "there" + point at table) word in speech. (3) A *supplementary* relation was coded when gesture added semantic

information to the message conveyed in speech (e.g. "push" + point to couch, "all gone" + hold-up empty milk bottle).

Supplementary gesture–speech combinations and multi-word combinations were categorized into three types according to the type of semantic elements conveyed (see examples in Table 2):[2] (1) multiple arguments without a predicate, (2) a predicate with at least one argument, and (3) multiple predicates with or without arguments.[3] Gesture–gesture combinations were rare in our data and thus were not included in the analysis.[4]

Reliability was assessed on a subset of the videotaped sessions by an independent coder. Agreement between coders was 88% ($k=0.76$; $N=763$) for identifying gestures, 91% ($k=0.86$; $N=375$) for assigning meaning to gestures, and 99% ($k=0.98$; $N=482$) and 96% ($k=0.93$; $N=179$) for coding semantic relations in multi-word speech and supplementary gesture–speech combinations, respectively.

Data were analyzed using ANOVAs, with either one (*age*) or two (*age*×*type of gesture–speech combination*) within-subject factors, *t*-tests, or χ^2, as appropriate.

3. Results

3.1. Children's early speech and gesture production

Not surprisingly, children's speech improved with age (see Table 3). Children produced more communicative acts containing speech ($F(2,78)=51.58$, $P<0.001$), more different word types ($F(2,78)=70.90$, $P<0.001$), and more words overall (i.e. tokens, $F(2,78)=40.04$, $P<0.001$) with increasing age. There was a significant increase in all three measures from 14 to 18 months (Scheffé, $P<0.05$) and from 18 to 22 months (Scheffé, $P<0.001$). The majority of the children in the sample were already producing single words by 14 months, and more than half began producing two-word speech by 18 months.

Children's gestures also changed with age. Children produced more communicative acts containing gesture ($F(2,78)=17.52$, $P<0.001$), more gesture tokens ($F(2,78)=17.80$,

[2] The children produced a small number of adjective + argument combinations ("big gum", "all-sticky" + point to marker) which were excluded from the analyses; if these combinations are included as predicate + argument constructions, the patterns described below do not change. In addition, combinations containing fillers (e.g. filler + argument: "sorry zoe", "please" + point at cookie, or filler + predicate: "please help", "please" + give gesture) were excluded from the analyses because they do not constitute sentential constructions (although they too appeared in gesture + speech before speech alone).

[3] There were a few children who produced "want" combined with another verb ($N=7$, e.g. "I want to go", "I want see baby") or with a predicate gesture ($N=4$, "I want vitamin" + give gesture, "I want more" + allgone gesture) at 22 months. We were not certain that "want" was functioning as a second predicate in these combinations; it may instead have been serving as a quasi-modal. Indeed, for a number of children, "want" was the only verb used as a second predicate, suggesting that the predicate + predicate construction was not productive for them. To be conservative, we did not count "want" as a second predicate in either speech alone or gesture + speech combinations; however, if "want" is treated as a second predicate, the patterns described below do not change.

[4] Fourteen of the 40 children never produced gesture + gesture combinations, and the children who did produce them produced, on average, no more than one per session.

Table 2
Examples of the types of semantic relations children conveyed in multi-word speech combinations and in supplementary gesture–speech combinations

Combination type	Multi-word speech combinations	Supplementary gesture–speech combinations[a]
Argument + argument (s)		
Two arguments	"Mama chair" [22]	"Mommy" + *couch* (point) [18]
	"Earring upstairs" [22]	"Bike" + *helmet* (point) [18]
	"Mommy in kitchen" [22]	"Daddy" + *dirt on floor* (point) [18]
	"Baby on car" [22]	"Booboo" + *place-in-house* (point) [22]
Three arguments	"Here mommy doggie" [22]	"Here mommy" + *bag* (hold-up) [18]
	"I Karyn in house" [22]	"Mama plate" + *trashcan* (point) [22]
		"Mama Anthony" + *camera* (point) [22]
Predicate + argument (s)		
Predicate + argument	"I paint" [22]	"You" + *hit* (iconic) [18]
	"Baby sleeping" [22]	"Hair" + *wash* (iconic) [18]
	"Ride horsie" [22]	"Drive" + *car* (point) [18]
	"Allgone hat" [22]	"Eat" + *muffin* (hold-up) [18]
Predicate + two arguments	"I cooking eggs" [22]	"Me touch" + *laundry* (point) [14]
	"Give me haircomb" [22]	"I do" + *spoon* (hold-up) [14]
	"Baby scratched me" [22]	"Daddy gone" + *outside* (point) [18]
	"Put it on the baby" [22]	"Mommy jump" + *mickey* (point) [22]
Predicate + predicate		
Two predicates (with or without arguments)	"Help me find" [22]	"I like it" + *eat* (iconic) [22]
	"Done cooking [22]	"I paint" + *give* (iconic) [22][b]
		"Alldone" + *pick-up* (iconic) [22]

The age, in months, at which each example was produced is given in brackets after the example.

[a] The meaning gloss for the gestures is in italics and the type of gesture (point, iconic) is indicated in parentheses following the gesture gloss. We did not code the order in which gesture and speech were produced in gesture–speech combinations; the word is arbitrarily listed first and the gesture second in each example.

[b] The child is asking for a crayon so that he could paint.

$P < 0.001$), and more gesture–speech combinations ($F(2,78) = 44.09$, $P < 0.001$) over time. There was a significant increase in all three measures from 14 to 18 months (Scheffé, $P < 0.01$) and from 18 to 22 months (Scheffé, $P < 0.05$). By 14 months, 21 of the 40 children were producing gesture–speech combinations, and by 18 months, all but one child were combining gesture with speech.

3.2. Types of gesture–speech combinations

Fig. 1 presents the mean number of gesture–speech combinations children produced at each time period, classified according to whether gesture *reinforced* ("car" + point to car), *disambiguated* ("look it" + point to car), or *supplemented* ("drive" + point to car) the information conveyed in speech. Children produced more gesture–speech combinations over time ($F(2,78) = 44.09$, $P < 0.001$), significantly increasing production from 14 to 18 months (Scheffé, $P < 0.01$) and from 18 to 22 months (Scheffé, $P < 0.001$). They also produced the three different types of combinations at different rates ($F(2,78) = 30.32$, $P < 0.001$), producing significantly more *reinforcing* than *supplementary*

Table 3
Summary of the children's speech and gesture production

	14-months	18-months	22-months
Speech[a]			
Mean number of communicative acts containing speech (SD)	38 (44)	150 (120)	350 (249)
Mean number of word tokens (SD)	43 (53)	180 (143)	479 (402)
Mean number of word types (SD)	11 (12)	37 (26)	95 (63)
Number of children producing at least one one-word utterance	36	40	40
Number of children producing at least one two-word combination	10	25	37
Gesture			
Mean number of communicative acts containing gesture (SD)	53 (36)	89 (62)	116 (72)
Mean number of gesture tokens (SD)	53 (36)	90 (64)	119 (75)
Mean number of gesture–speech combinations (SD)	6 (9)	27 (31)	64 (47)
Number of children producing at least one gesture–speech combination	21	39	39

SD, standard deviation.
[a] All speech utterances are included in the top part of this table, even those produced with gesture.

combinations (Scheffé, $P<0.05$) and more *supplementary* than *disambiguating* combinations (Scheffé, $P<0.001$).

Of the three types of gesture–speech combinations, supplementary combinations are potentially the most revealing because, in these combinations, gesture and speech work together to convey sentence-like meanings. Supplementary gesture–speech combinations thus have the potential to be a sensitive probe for burgeoning new constructions that a child cannot yet express entirely in speech. And indeed children did produce more supplementary gesture–speech combinations over time, significantly increasing production from 14 to 18 months (Scheffé, $P<0.01$) and from 18 to 22 months (Scheffé, $P<0.001$). The crucial question, however, was whether the children produced

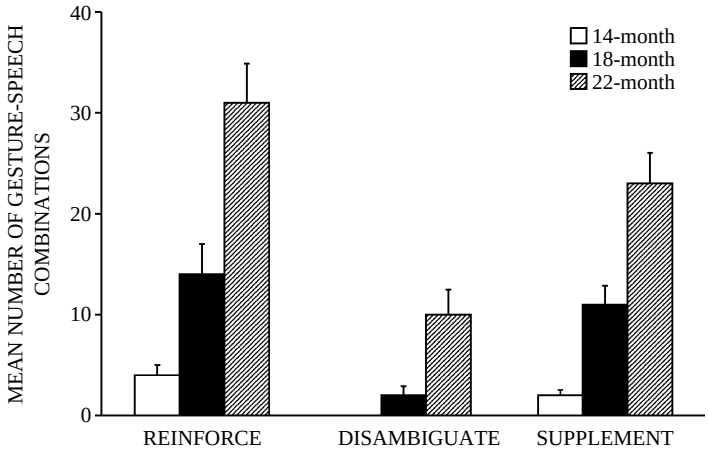

Fig. 1. Types of gesture–speech combinations produced by children at 14, 18, and 22 months of age.

increasingly complex supplementary combinations over time and whether those combinations presaged changes in their speech. We address this question in Section 3.3.

3.3. Types of semantic information conveyed in children's supplementary gesture–speech combinations and multi-word speech

Fig. 2 presents the number of children who produced at least one instance of each of the three sentence construction types (*argument + argument(s)*, *predicate + argument(s)*, and *predicate + predicate*) either in a supplementary gesture–speech combination (gesture + speech) or in a multi-word combination (speech) at each age. At 14 months, very few children produced *argument + argument(s)* or *predicate + argument(s)* combinations either in gesture + speech or entirely in speech. However, by 18 months, more than half of the children produced instances of these constructions, but they produced them in gesture + speech and not yet in speech on its own. Significantly more 18-month-olds produced *argument + argument(s)* ($\chi^2(1)=12.0$, $P<0.001$) and *predicate + argument(s)* ($\chi^2(1)=8.80$, $P<0.01$) combinations in gesture + speech than in speech-only. Furthermore, children produced more instances of each of these constructions in gesture + speech than in speech-only at 18 months (*argument + argument(s)*: 63 [SD = 2.4] *vs.* 17 [SD = 1.3], $t(39)=2.74$, $P<0.01$); *predicate + argument(s)*: 113 [SD = 4.0] *vs.* 50 [SD = 3.35], $t(39)=2.14$, $P<0.05$).

Turning next to *predicate + predicate* constructions, we found that no child produced this type of combination at 14 months and only 3 produced it at 18 months. However, by 22 months, many children were producing *predicate + predicate* combinations, but they produced them in gesture + speech and not in speech on its own. Significantly more 22-month-olds produced *predicate + predicate* combinations in gesture + speech than in speech ($\chi^2(1)=7.01$, $P<0.01$). In addition, children produced more instances of the construction in gesture + speech than in speech-only at 22 months (17 [SD = 0.78] *vs.* 2 [SD = 0.2], $t(39)=3.06$, $P<0.01$).

The analysis showed that, as a group, children produced particular sentence constructions in gesture + speech before they produced the same constructions entirely within speech. But the crucial question is whether each individual child followed this path. Table 4 presents the number of children who produced each of the three constructions classified according to whether the child produced the construction in only one format (either gesture + speech or speech-only) or in both formats over the observation sessions. Children who used both formats were further classified according to whether they produced the construction first in gesture + speech, first in speech, or in both formats at the same age. Note first that there were very few outright violations of the predicted path; very few of the children who produced only one format, produced the construction entirely in speech, and very few of the children who produced both formats, produced the construction in speech first (11%[4/35] *argument + argument*, 14%[5/36] *predicate + argument*, 8%[1/13] *predicate + predicate* for the two types of violations combined).

A substantial number of children who produced both formats produced the two formats during the same observation session. These children could have produced one format prior to the other sometime during the four months between our observation sessions; their data consequently neither confirmed nor disconfirmed our hypothesis. Eliminating these

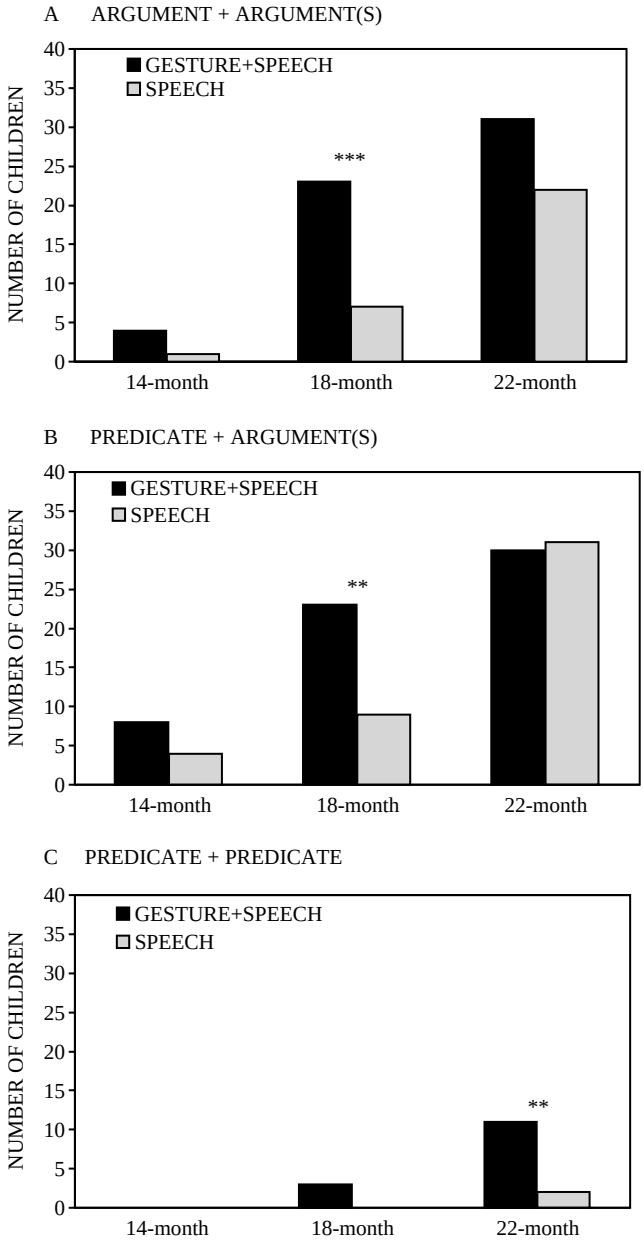

Fig. 2. Number of children who produced utterances with two or more arguments (panel A), utterances with a predicate and at least one argument (panel B), or utterances with two predicates (panel C) in speech alone (gray bars) or in a gesture+speech combination (black bars). $^{**}P<0.01$, comparing gesture+speech to speech. $^{***}P<0.001$, comparing gesture+speech to speech.

Table 4
Number of children who produced the three types of constructions in only one format (gesture + speech or speech-only) or in both formats classified according to the format used first

Type of construction	Produced in one format		Produced in both formats		
	Only in G + S	Only in S	G + S first then S	G + S and S at same age	S first then G + S
Argument + argument(s)	12	1	14	5	3
Predicate + argument(s)	5	2	13	13	3
Predicate + predicate	11	1	0	1	0

G + S, gesture + speech; S, speech only.

children from the analyses along with those who produced each construction in only one format, we found that significantly more children produced *argument + argument* and *predicate + argument* combinations in gesture + speech first than in speech first (*argument + argument*: 14 *vs.* 3, $\chi^2(1) = 7.47$, $P < 0.01$; *predicate + argument*: 13 *vs.* 3, $\chi^2(1) = 6.33$, $P < 0.02$). Very few of the children in our sample had begun to produce *predicate + predicate* constructions entirely within speech; however, significantly more of the children who produced *predicate + predicate* combinations in only one format produced them in gesture + speech rather than in speech (11 *vs.* 1; $\chi^2(1) = 7.94$, $P < 0.01$). Thus, for an individual child, the typical path seems to be to produce a construction in gesture + speech first and only later produce that same construction entirely within speech.

4. Discussion

We have examined very young children's gesture–speech combinations as they progressed from one-word speech to multi-word combinations. Over this period, children produced more and more gesture–speech combinations in which gesture supplemented the information conveyed in speech (e.g. "eat" + point at muffin). More importantly, the *types* of supplementary gesture–speech combinations that children produced changed over time and presaged changes in their speech. Children did not routinely produce utterances with two arguments ("mommy the bell") or with an argument and a predicate ("me touch") in speech until 22 months. However, many children produced constructions of this sort in gesture + speech at 18 months ("mommy" + point at couch; "you" + *hit* gesture). Moreover, few children produced utterances with two predicates in speech ("help me find") even at 22 months, but many produced this construction in gesture + speech ("I like it" + *eat* gesture; "I have one" + *give* gesture) at this age. Gesture provides children with a tool to expand their communicative repertoire, and children use this tool to convey increasingly complex ideas. Shortly thereafter, they are able to convey these same ideas entirely within speech.

Our findings underscore the fact that speech is frequently an imperfect guide to a child's (and perhaps to any speaker's, cf. Goldin-Meadow, 2003) knowledge. Gesture often conveys information that is not captured in a speaker's words, not only in children but in speakers of all ages (Alibali, Bassok, Olseth, Syc, & Goldin-Meadow, 1999; Beattie &

Shovelton, 1999; Garber & Goldin-Meadow, 2002; Perry & Elder, 1997; Schwartz & Black, 1996; Stone, Webb, & Mahootian, 1991). Interestingly, speakers who produce gestures that convey different information from their speech (supplementary gestures, in our terms) on a particular task are more likely to profit from instruction on that task than speakers whose gestures serve only to reinforce or disambiguate their speech (Goldin-Meadow, Alibali, & Church, 1993). Indeed, 5- to 8-year-old children often take their first step toward solving conservation problems in gesture (Church & Goldin-Meadow, 1986), as do 9–to 10-year-old children solving mathematical equivalence problems (Alibali & Goldin-Meadow, 1993; Perry, Church, & Goldin-Meadow, 1988) and 5–to 9-year-old children solving balance problems (Pine, Lufkin, & Messer, 2004). Gesture is the first sign of progress on a variety of tasks, including early language-learning.

The fact that children can produce a construction, say *predicate + argument*, in a gesture–speech combination makes it clear that their inability to produce the construction entirely in speech does not stem from an inability to understand predicate frames—the children not only know that arguments need to be related to predicates, but they can even communicate about this relation, albeit across modalities. What then prevents children from producing the construction entirely in speech?

One possibility is that conveying information in the manual modality is less demanding than conveying the same information in the verbal modality. Indeed, children use gesture in word-like ways several months before they use sounds for the same functions (Iverson & Goldin-Meadow, in press). Even deaf children who are learning language in the manual modality (e.g. American Sign Language) produce their first signs several months earlier than children learning a spoken language produce their first words (Anderson & Reilly, 2002; Bonvillian, Orlansky, & Novack, 1983; Meier & Newport, 1990), although there is disagreement over whether these first productions are true signs or gestures (Volterra & Iverson, 1995). Using the hand to produce recognizable manual gestures may require less fine motor control than using the mouth and tongue to produce recognizable sounds.

In addition, gesture may put less strain on memory than words (or signs) whose conventionalized forms must be memorized and recalled at the moment of production. A pointing gesture whose form does not vary with its referent is not only physically easy to produce but also easy to remember. Iconic gestures too can be generated on the spot with whatever resources the child has available at the moment. As a result, children might find it cognitively less demanding to flesh out their predicate frames with a spontaneous gesture than with a conventional word form. Indeed, a hearing child learning both spoken Italian and Italian Sign Language began producing gesture + word combinations several months before producing sign + word combinations (Capirci, Montanari, & Volterra, 1998), presumably because a conventional sign puts more strain on memory than a gesture whose form is not conventionalized but constructed on the spot on an *ad hoc* basis.[5]

More generally, gesturing while talking has been associated with a reduction in a speaker's cognitive load. Speakers, both children and adults, when asked to remember a list of words (or letters) while explaining their solutions to a math problem, remember

[5] The child also produced sign + word combinations several months before producing word + word combinations (Capirci et al., 1998), perhaps because manual signs are easier to produce than spoken words.

more of those words (or letters) if they gesture during their explanations than if they do not gesture (Goldin-Meadow, Nusbaum, Kelly, & Wagner, 2001; Wagner, Nusbaum, & Goldin-Meadow, 2004). Gesturing thus eases the process of speech production, providing speakers (including young speakers at the early stages of language-learning) with extra cognitive resources that could enable them to produce more complex constructions.

In summary, our findings place gesture firmly at the cutting edge of early language development. Gesture both precedes and signals oncoming changes in speech. At a point when children do not yet have the necessary skills to convey semantically complex information (multiple argument/predicate combinations), gesture provides them with a relatively easy way to convey that information. And by doing so, it acts as a harbinger of change in the child's developing language system.

Acknowledgements

We thank Kristi Schoendube and Jason Voigt for their administrative and technical support and the project research assistants, Karyn Brasky, Kristin Duboc, Molly Nikolas, Jana Oberholtzer, Lilia Rissman, Becky Seibel, and Julie Wallman, for their help in collecting and transcribing the data. The research presented in this paper was supported by grant #PO1 HD406-05 to Goldin-Meadow.

References

Acredolo, L. P., & Goodwyn, S. (1985). Symbolic gesturing in language development. *Human Development*, *28*, 40–49.

Acredolo, L. P., & Goodwyn, S. (1989). Symbolic gesturing in normal infants. *Child Development*, *59*, 450–466.

Alibali, M. W., Bassok, M., Olseth, K. L., Syc, S. E., & Goldin-Meadow, S. (1999). Illuminating mental representations through speech and gesture. *Psychological Science*, *10*, 327–333.

Alibali, M. W., & Goldin-Meadow, S. (1993). Gesture–speech mismatch and mechanisms of learning: what the hand reveal about a child's state of mind. *Cognitive Psychology*, *25*, 468–523.

Anderson, D., & Reilly, J. (2002). The MacArthur communicative development inventory: normative data for American Sign Language. *Journal of Deaf Studies and Deaf Education*, *7*(2), 83–106.

Bates, E. (1976). *Language and context*. New York: Academic Press.

Bates, E., Benigni, L., Bretherton, I., Camanioni, L., & Volterra, V. (1979). *The emergence of symbols: Cognition and communication in infancy*. New York: Academic Press.

Beattie, G., & Shovelton, H. (1999). Do iconic hand gestures really contribute anything to the semantic information conveyed by speech? An experimental investigation. *Semiotica*, *123*, 1–30.

Bonvillian, J. D., Orlansky, M. O., & Novack, L. L. (1983). Developmental milestones: Sign language acquisition and motor development. *Child Development*, *54*, 1435–1445.

Butcher, C., & Goldin-Meadow, S. (2000). Gesture and the transition from one- to two-word speech: When hand and mouth come together. In D. McNeill, *Language and gesture* (pp. 235–258). Cambridge, MA: Cambridge University Press, 235–258.

Capirci, O., Iverson, J. M., Pizzuto, E., & Volterra, V. (1996). Gestures and words during the transition to two-word speech. *Journal of Child Language*, *23*, 645–673.

Capirci, O., Montanari, S., & Volterra, V. (1998). Gestures, signs, and words in early language development. In J. M. Iverson, & S. Goldin-Meadow, *The nature and functions of gesture in children's communications* (pp. 45–60). San Francisco: Jossey-Bass, 45–60 (New Directions for Child Development, no. 79).

Church, R. B., & Goldin-Meadow, S. (1986). The mismatch between gesture and speech as an index of transitional knowledge. *Cognition*, *23*, 43–71.

Garber, P., & Goldin-Meadow, S. (2002). Gesture offers insight into problem-solving in adults and children. *Cognitive Science*, *26*, 817–831.

Goldin-Meadow, S. (2003). *Hearing gesture: How our hands help us think*. Cambridge, MA: Harvard University Press.

Goldin-Meadow, S., Alibali, M. W., & Church, R. B. (1993). Transitions in concept acquisition: using the hand to read the mind. *Psychological Review*, *100*(2), 279–297.

Goldin-Meadow, S., & Butcher, C. (2003). Pointing: Where language, culture, and cognition meet. In S. Kita, *Pointing toward two word speech in young children* (pp. 85–107). Hillsdale, NJ: Lawrence Erlbaum Associates, 85–107.

Goldin-Meadow, S., & Mylander, C. (1984). Gestural communication in deaf children: the effects and non-effects of parental input on early language development. *Monographs of the Society for Research in Child Development*, *49*(3), 207.

Goldin-Meadow, S., Nusbaum, H., Kelly, S. D., & Wagner, S. (2001). Explaining math: gesturing lightens the load. *Psychological Science*, *12*(6), 516–522.

Greenfield, P., & Smith, J. (1976). *The structure of communication in early language development*. New York: Academic Press.

Iverson, J. M., Capirci, O., & Caselli, M. C. (1994). From communication to language in two modalities. *Cognitive Development*, *9*, 23–43.

Iverson, J. M., & Goldin-Meadow, S. (in press). Gesture paves the way for language development. *Psychological Science*.

Meier, R. P., & Newport, E. L. (1990). Out of the hands of babes: On a possible sign advantage in language acquisition. *Language*, *1*, 1–23.

Nelson, K. (1973). Structure and strategy in learning to talk. *Monographs of the Society for Research in Child Development*, *38*(149).

Perry, M., Church, R. B., & Goldin-Meadow, S. (1988). Transitional knowledge in the acquisition of concepts. *Cognitive Development*, *3*(4), 359–400.

Perry, M., & Elder, A. D. (1997). Knowledge in transition: adults' developing understanding of a principle of physical causality. *Cognitive Development*, *12*, 131–157.

Pine, K. J., Lufkin, N., & Messer, D. (2004). More gestures than answers: Children learning about balance. *Developmental Psychology*, *40*, 1059–1067.

Schwartz, D. L., & Black, J. B. (1996). Shuttling between depictive models and abstract rules: Induction and fallback. *Cognitive Science*, *20*, 457–497.

Stone, A., Webb, R., & Mahootian, S. (1991). The generality of gesture–speech mismatch as an index of transitional knowledge: Evidence from a control-of-variables task. *Cognitive Development*, *6*, 301–313.

Volterra, V., & Iverson, J. M. (1995). Language, gesture, and space. In K. Emmorey, & J. S. Reilly, *When do modality factors affect the course of language acquisition?* (pp. 371–390). Hillsdale, NJ: Erlbaum, 371–390.

Wagner, S. M., Nusbaum, H., & Goldin-Meadow, S. (2004). Probing the mental representation of gesture: is handwaving spatial. *Journal of Memory and Language*, *50*, 395–407.