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Divergence of verbal expression and embodied knowledge: Evidence from speech and gesture in children with specific language impairment

Julia L. Evans, Martha W. Alibali and Nicole M. McNeil
University of Wisconsin, Madison, USA

It has been suggested that phonological working memory serves to link speech comprehension to production. We suggest further that impairments in phonological working memory may influence the way in which children represent and express their knowledge about the world around them. In particular, children with severe phonological working memory deficits may have difficulty retaining stable representations of phonological forms, which results in weak links with meaning representations; however, nonverbal meaning representations might develop appropriately due to input from other modalities (e.g., vision, action). Typically developing children often express emerging knowledge in gesture before they are able to express this knowledge explicitly in their speech. In this study we explore the extent to which children with specific language impairment (SLI) with severe phonological working memory deficits express knowledge uniquely in gesture as compared to speech. Using a paradigm in which gesture-speech relationships have been studied extensively, children with SLI and conservation judgement-matched, typically developing controls were asked to solve and explain a set of Piagetian conservation tasks. When gestures accompanied their explanations, the children with SLI expressed information uniquely in gesture more often than did the typically developing children.

Requests for reprints should be addressed to Julia L. Evans, Waisman Center, University of Wisconsin-Madison, 1500 Highland Avenue, Madison, WI 53705-2280, USA.

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Further, the children with SLI often expressed *more sophisticated* knowledge about conservation in gesture (and in some cases, distributed across speech and gesture) than in speech. The data suggest that for the children with SLI, their embodied, perceptually-based knowledge about conservation was rich, but they were not always able to express this knowledge verbally. We argue that this pattern of gesture-speech mismatch may be due to poor links between phonological representations and embodied meanings for children with phonological working memory deficits.

Children with specific language impairment (SLI) fail to acquire age-appropriate language skills in the absence of clearly identifiable emotional, neurological, visual, hearing, or intellectual impairments. While it has been suggested that SLI is due to underlying linguistic deficits (e.g., Clahsen, 1989; Gopnik & Crago, 1991; Rice, Wexler, & Cleave, 1995), there is strong evidence to suggest that the language impairments seen in children with SLI are secondary to deficits in processing capacity (e.g., Bishop, 1992, 1997; Ellis Weismer, Evans, & Hesketh, 1999; Gathercole & Baddeley, 1990a; Leonard, 1998). In particular, there is strong evidence to suggest that children with SLI have particular deficits in phonological working memory capacity. Recent studies have shown that children with SLI are significantly worse than age-matched peers on nonword repetition tasks, a paradigm used by Baddeley and colleagues as a direct measure of phonological working memory (Dollaghan & Campbell, 1998; Edwards & Lahey, 1998; Gathercole & Baddeley, 1990b; Montgomery, 1995). Further, research suggests that poor phonological working memory, as measured by these nonword repetition tasks, may be a phenotypic marker of language impairments in these children (Bishop, North, & Donlan, 1996).

Phonological working memory has been argued to be key in the processing and retention of language, in particular, retaining a stable representation of the phonological forms of new words (e.g., Baddeley, 1986; Gathercole & Baddeley, 1993). Plaut and Kello (1999), in a recent connectionist model of language acquisition, have suggested that phonological representations are the key link between language comprehension and production during language acquisition. In the early stages of language learning, before infants can learn to produce the articulatory movements required for comprehensible speech, they must first extract and maintain stable and accurate internal acoustic representations of words from the ongoing stream of speech. These stable acoustic representations must then be mapped onto their meaning representations (e.g., semantics). In addition to linking the acoustic pattern of a word to its meaning, infants also must map the meaning of the word to the articulatory patterns required to produce the word. Plaut and Kello have suggested that phonological representations are what enable the infant to accomplish this link, during comprehension, between acoustic input and meaning representations, and during production, between meaning and articulatory representations.

In Plaut and Kello's model, phonological representations are not predefined, but are distributed representations that evolve over time as a result of the child's active processing of language. It is the distributed nature of the acoustic representations that allows a stable phonological representation to emerge from the highly variable acoustic input. While phonological representations are derived from the acoustic input, Plaut and Kello suggest that semantic representations are derived from input from other modalities (e.g., vision).

The idea that meaning representations are based on input from other modalities (e.g., vision, motor activity, proprioception) is central to embodied accounts of language and cognition. According to these accounts, meaning is grounded in bodily and perceptual experiences, and language comprehension and production are the activation and extraction of these embodied meanings (Gibson, 1966; Glenberg, 1997; Glenberg & Robertson, 1999; Iverson & Thelen, in press; MacWhinney, 1999). If one extends Plaut and Kello's notion of semantic representations to incorporate embodied meaning representations, then language comprehension is the mapping of acoustic input onto stable, embodied meaning representations via phonological representations. Production is the expression of embodied meanings via articulatory movements derived from phonological representations.

But what happens if a part of the developmental process is disrupted? In particular, what happens to the child with SLI who has poor phonological working memory abilities? It has been suggested that, when confronted with novel words, the listener must rely upon phonological working memory to encode and maintain the novel phonological sequence in an undegraded form long enough to generate a stable long-term memory representation of the sound structures of the words (Gathercole, 1995). Plaut and Kello have suggested further that it is the phonological representations themselves that "instantiate" the memory necessary to map the acoustic patterns of words to meaning representations (p. 385). Presumably then, the child with SLI who has difficulty with nonword repetition tasks might have been a child who, throughout the language learning process, had difficulty maintaining the phonological sequence of novels words long enough to establish the links between meaning representations, acoustic input, and articulatory patterns. However, because other input modalities would not be impaired, the child's meaning representations would continue to develop appropriately.

In spontaneous language, meanings can be conveyed not only through speech, but also through other avenues of communication, such as through gesture. Very young typically developing children often rely on gestures when they are still limited in their verbal abilities (Acredolo & Goodwyn, 1988; Bates, 1979; Butcher & Goldin-Meadow, in press). In older, school-age children, newly emerging knowledge is often expressed in gesture before it is expressed in speech (Church & Goldin-Meadow, 1986; Perry, Church, & Goldin-Meadow, 1988). Further, gestures and speech are often integrated to express a speaker's overall meaning (McNeill, 1992). Iverson and Thelen (in press) have suggested that the tight integration of gestures and speech is a manifestation of the embodiment of thought. In particular, they propose that hand and mouth are tightly coupled in the mutual cognitive activity of language. What does this idea suggest about children with SLI? If these children have meaning representations that are intact but poorly linked to phonological representations, might they express such representations more readily in gestures than in speech?

To date, investigations of gesture use in children with SLI and toddlers at risk for SLI have focused on these children's ability to spontaneously produce or imitate symbolic gestures (Hill, 1998; Thal & Bates, 1988; Thal, O'Hanlon, Clemmons, & Fralin, 1999; Thal & Tobias, 1992; Thal, Tobias, & Morrison, 1991). These studies suggest that both children with SLI and toddlers at risk for SLI may have difficulties generating and imitating symbolic gestures as compared to typically developing peers. However, no studies to date have focused on the nature of the *relationship* between their verbal expression and spontaneous gestures, or more importantly, on the extent to which children with SLI might rely adaptively on the use of spontaneous gestures to express meanings they are unable to express verbally.

One domain in which the relationship between gesture and verbal expression has been extensively studied in typically developing children is Piagetian conservation (Alibali, Kita, & Young, 2000; Church & Goldin-Meadow, 1986). In a conservation task, a child is presented with two objects that have equal quantities (e.g., two identical glasses with the same amount of water). One of the objects is then transformed (e.g., water from one glass is poured into a short, wide dish) and the child is asked to *judge* whether the quantities are still the same or different. After the judgement, the child is then asked to *explain* the judgement (i.e., to provide a rationale for why the quantities are the same or different). When providing such an explanation, children may express their knowledge in speech and in gestures. In some cases, the meaning conveyed in gestures is the same as that conveyed in speech. For example, a child may say, "The dish is *shorter*", and simultaneously indicate the *height* of the dish in gesture by holding a flat palm at the rim of the dish. In this example, both speech and gesture convey information about the height of the dish.

In other cases, the meaning conveyed in children's gestures differs from that conveyed in speech. For example, a child may say, "The dish is *shorter*", but may indicate the *width* of the dish in gesture, by using a cupped hand to demarcate the width of the dish. In this case, the child's gesture conveys a dimension, *width*, that is not expressed at all in the child's verbal explanation. Thus, information about width is conveyed uniquely in the child's gesture. In this latter example, if one considers only the child's speech, one might infer that the child focused only on the object's height, and did not understand that width is also relevant to the quantity judgement. However, if one considers both speech and gesture, one might infer that the child understands the principle of compensating dimensions (i.e., that even though the dish is shorter, it's also wider, so the quantities are the same). In typically developing children, such "mismatches" between gesture and speech indicate their emerging understanding of conservation (Church & Goldin-Meadow, 1986).

The purpose of this study was to investigate the nature of the relationship between speech and gesture in children with SLI. Specifically, the goal of this study was to determine the extent to which children with SLI, who have severe phonological working memory deficits, express knowledge uniquely in gesture as compared to speech in their explanations of Piagetian conservation tasks.

METHOD

Participants

Eight children with SLI (ages 7;0 to 9;4; 4 girls and 4 boys) participated in the study. One girl had difficulty remaining focused on the tasks, so she was excluded from the sample. The children all met the exclusion criteria for SLI: (1) no hearing loss as measured by pure tone audiometry, (2) no behavioural or emotional problems, (3) no demonstrable neurological involvement, (4) no oral motor deficits, and (5) nonverbal IQ at or above chronological age, as measured by the Columbia Mental Maturity Scale (CMMS; Burgemeister, Blum, & Lorge, 1972). The children also had severe expressive language deficits as measured by the Clinical Evaluation of Language Functions–Revised (CELF-R; Semel, Wiig, & Secord, 1989). All children with SLI were in a speech and language resource classroom, were receiving speech and language services, and had not been exposed to natural or artificial sign languages.

In addition, the children with SLI were selected to have severe auditory working memory deficits as measured by the Goldman–Fristoe–Woodcock Test of Auditory Discrimination, a multisyllabic nonsense word repetition task (Goldman, Fristoe, & Woodcock, 1980). A number of cognitive processes are required for a child to successfully complete nonword repetition tasks (e.g., Dollaghan, Biber, & Campbell, 1993; Gathercole, 1995). These include discriminating the acoustic signal, encoding the acoustic information into a phonological representation, and maintaining that acoustic representation in working memory long enough to plan and execute a verbal response. These nonword repetition tasks, regarded as an index of phonological short-term memory, are strong predictors of a child's ability to learn nonword lexical items such as names for toys (Gathercole & Baddeley, 1990b). It has also been argued that, for children with SLI, they may be a reliable measure of children's ability to form and/or store phonological representations in working memory (e.g., Bishop et al., 1996; Dollaghan & Campbell, 1998; Edwards & Lahey, 1998).

While the children's nonword repetition scores were all below the 10th percentile, their scores on a range of other standardised language measures varied. The additional standardised language measures for each child included: (1) the Peabody Picture Vocabulary Test (PPVT–R; Dunn & Dunn, 1981), (2) the composite receptive language score of the Clinical Evaluation of Language Fundamentals–Revised (CELF–R; Semel et al., 1989), (3) verbal working memory as measured by the Competing Language Processing Task (CLPT; Gaulin & Campbell, 1994), (4) composite expressive language score of the CELF–R, and (5) mean length of utterance (MLU) derived from a separate free play spontaneous language sample. The scores for all of the standardised language test measures for the children with SLI are shown in Table 1.

TABLE 1

Chronological age (CA), Mean Length of Utterance[a] (MLU), percentile scores for Non-Word Repetition task (NWRP)[b] and PPVT–R[c], percent words recalled for CLPT[d], and standard scores for the composite expressive (ELS) and receptive language scores (RLS) on CELF–R[e] for the children with SLI[f]

Child	*CA*	*MLU*	*NWRP (Percentile)*	*PPVT–R (Percentile)*	*CLPT* (%)	*ELS (ss)*	*RLS (ss)*
1	7;0	4.99	< 1	37 (7;7)	48	70	76
2	7;7	3.99	< 1	25 (7;6)	40	59	85
3	9;4	3.50	< 1	2 (8;4)	50	67	74
4	7;10	1.73	< 1	3 (7;11)	52	73	80
5	7;3	2.88	2	1 (7;2)	40	50	74
6	8;10	3.58	6	5 (7;10)	60	62	80
7	8;11	3.65	< 1	2 (8;6)	36	64	70

[a] Calculated from a 15-minute freeplay language sample.

[b] Goldman–Fristoe–Woodcock (1980).

[c] Peabody Picture Vocabulary Test–Revised (Dunn & Dunn, 1981).

[d] Competing Language Processing Test (Gaulin & Campbell, 1994).

[e] Clinical Evaluation of Language Fundamentals–Revised (Semel et al., 1989).

[f] With the exception of the PPVT–R, all tests were administered within 6 months of the administration of the experimental tasks used in this study. Age at administration of the PPVT–R is noted in parentheses in the table.

Seven additional children (ages 6;5 to 7;7—5 girls and 2 boys) were also selected to participate. The typically developing children were drawn from a larger sample of children who had taken part in a previous, unpublished study of children learning Piagetian conservation. No additional IQ or standardised language tests were administered to these children; however, they were in age-appropriate classrooms and had no known history of atypical development. Each child with SLI was matched to a typically developing child on the basis of the pattern of same and different judgements they provided for six conservation tasks (see below). Selection of the typically developing children was otherwise random among the typically developing children whose judgement pattern corresponded to each child with SLI. This matching strategy resulted in a typically developing judgement-matched group that was somewhat younger than the language-impaired group (mean chronological ages 7;0 vs. 8;1).

Procedure

Each child completed six Piagetian conservation tasks, including two liquid quantity tasks, two length tasks, and two number tasks. The typically developing children completed these tasks as part of a larger set of 18 conservation tasks, whereas the children with SLI completed the six conservation tasks only. All six tasks used the same procedure, which was based on that used by Church and Goldin-Meadow (1986), and which has previously been used to study gesture production in children with unilateral brain damage (Alexander, 1999). First, the child was presented with two identical quantities (i.e., two identical glasses each containing the same amount of water, two sticks of the same length, or two rows of six checkers spaced approximately 1" apart). The experimenter then asked, “Are these two (glasses of water, sticks, sets of checkers) the same or different (amounts, lengths, numbers)?” After the child verified that the quantities were the same, the experimenter then transformed one of the quantities. The six transformations used in the study are listed in Table 2. After the transformation, the experimenter asked, “Now, are these two (glasses of water, sticks, sets of checkers) the same or different (amounts, lengths, numbers)?” The child’s response to this question is termed the child’s *judgement*. The experimenter then asked the child to explain his or her judgement (“How can you tell?” or “Why are they the same (different)?”). The experimenter probed the child for additional explanations (“How else can you tell?” or “Any other reason?”) until the child stopped providing explanations. The child’s responses to these questions are termed the child’s *explanations*.

To assess the relationship between speech and gesture in children’s explanations, we used the procedure developed by Church and Goldin-

TABLE 2
Tasks used in study

Quantity	*Transformation*
Liquid quantity (water)	Pour contents of one glass into a taller, thinner container Pour contents of one glass into a shorter, wider container
Length (sticks)	Move one stick so that its endpoint extends approximately two inches beyond that of the other stick Move one stick so that it is perpendicular to the other stick
Number (checkers)	Spread or compress the checkers in one row, so that the two rows differ in both length and density Form one row of checkers into a circle shape

Meadow (1986), which involves independently evaluating the content of the verbal and gestured explanations.

Coding verbal explanations

Children's verbal explanations of the conservation tasks were transcribed, and the content of the verbal explanations was coded using Church and Goldin-Meadow's (1986) system. Eight different types of strategies were identified in children's spoken explanations. Definitions and examples are presented in Table 3. Conserving strategies (e.g., Identity, Compensation) argue that the two quantities are the same after the transformation. Non-conserving strategies (e.g., Comparison, Transformation) argue that the two quantities are different after the transformation.

Coding gestured explanations

Children's gestured explanations were transcribed and coded using the system developed by Church and Goldin-Meadow (1986). The stream of manual movement was segmented into individual gestures based on changes in the shape, orientation, placement, or motion of the hand(s). A meaning was assigned to each individual gesture. Strings of gestures were then assigned to strategy categories. Six different types of strategies were identified in children's gestured explanations. Examples are presented in Table 3.

Coding the relation of gesture to speech

For each explanation, the relation of gesture to speech was classified into one of four categories: (1) *speech alone*, in which no gesture accompanies the verbal explanation, (2) *gesture used to indicate only*, in which gesture simply indicates the objects described in the accompanying speech, but does not convey substantive information about the objects, (3) *all gestured*

TABLE 3
Strategies expressed in verbal and gestured explanations

Strategy	*Definition*	*Speech example*	*Gesture example*
Nonconserving strategies			
Description	Focus on one attribute of one task object	*Number task, SLI* 'Cause that's small (Description: size)	*Number task, Typical* 1. RH & LH palms at endpoints of U row (Description: length)
Comparison	Focus on one attribute on both task objects	*Length task, SLI* Because this one's down and this one's up (Comparison: placement)	*Water task, SLI* 1. LH palm at level of T glass 2. RH palm at level of U glass (Comparison: level)
Missed compensation	Focus on two different, non-compensating attributes on one or both task objects	*Water task, Typical* 'Cause this is more round, this is more skinny (Missed compensation: shape, width)	*Length task, SLI* 1. RH & LH palms at endpoints of U stick 2. LH point at left endpoint of T stick (Missed compensation: length, placement)
Transformation	Focus on the transformation	*Length task, Typical* 'Cause you pushed that one up	*Number task, Typical* 1. RH & LH in neutral space mime putting checkers into a circle
Conserving strategies			
Identity	Focus on the current or initial identity of quantity	*Number task, Typical* They're still the same number (Identity: number)	*Length task, SLI* 1. RH & LH palms at endpoints of U stick 2. RH & LH palms at endpoints of T stick (Identity: length)
Reversibility	Focus on the reversibility of the transformation	*Water task, SLI* If you dump that back in there, then it will be the same	Not observed in gesture in this study
Compensation	Focus on two, compensating dimensions on one or both task objects	*Water task, SLI* It's taller than this one. This one is skinny and this one is fat (Compensation: height, width)	*Water task, SLI* 1. RH curved handshape around T glass, moves up 2. RH curved handshape around U glass, moves up (Compensation: width, height)
Add–Subtract	Focus on the fact that nothing was added or taken away	*Number task, Typical* 'Cause you didn't add any, and you didn't take any away	Not observed in gesture in this study

T = transformed object, U = untransformed object; LH = left hand, RH = right hand.

information also in speech, in which gesture conveys substantive information that is also conveyed in speech, or (4) *some information unique to gesture*, in which gesture conveys some substantive information that is not conveyed at all in speech.

Next, explanations in which some information was expressed uniquely in gesture were further classified into one of three categories: (a) *specific*, in which gesture provides more specific information than speech, (b) *overlap*, in which gesture expresses some of the information expressed in speech as well as some additional, unique information, or (c) *disjoint*, in which gesture expresses information that is completely distinct from that expressed in speech. Examples of explanations in each of these categories are presented in Table 4.

Reliability of coding procedures

Reliability was established by having a second coder evaluate a subset of the data. Agreement between coders was 94% ($N = 70$ explanations) for coding strategies expressed in speech and 91% ($N = 43$ explanations) for coding strategies expressed in gesture. Agreement was 88% ($N = 50$ explanations) for coding the relationship between gesture and speech.

RESULTS

The pattern of same and different judgements provided by each child across the liquid, length and number conservation tasks is presented in Table 5. As described above, the children with SLI and the typically developing controls in this study were matched on their pattern of same and different judgements across the tasks, so the pattern of judgements in the control children was identical to that of the children with SLI. From the set of 18 tasks administered to the children in the control group, the six that we used in our analysis (those that corresponded to the tasks administered to the children with SLI) were tasks, 1, 3, 4, 5, 6, and 9. No differences were observed between children's performance on the ninth task and their performance on the other tasks. Children provided a comparable number of explanations on the ninth task as on the other five tasks ($M = 1.28$ on the ninth task vs. $M = 1.26$ on the others). Thus, there was no evidence that the number of explanations dropped off as children progressed through the set of tasks. Further, the rate at which children produced gestures was comparable on the ninth task, which was a liquid quantity task, and the first task, which was the other liquid quantity task ($M = 0.27$ gestures per word vs. $M = 0.20$ gestures per word), $F(1, 17) = 1.04$, $p = .32$. Thus, there was no evidence that the pattern of gesture use changed as children progressed through the set of tasks.

TABLE 4
Examples of different types of gesture–speech relationship

Relationship	*Speech*	*Gesture*
Speech alone	Because it's the tallest bottle (Description: height)	No gesture
Speech plus indicating gesture	Because this is bigger than this one (Comparison: size)	1. RH point to side of transformed glass (T glass) 2. LH point to side of untransformed glass (U glass) (Indicate glasses)
All gestured information also in speech	Because this one is only up to here, and this one is only up to here (Comparison: level)	1. RH palm at water level of transformed glass (level T) 2. LH palm at water level of untransformed glass (level U) (Comparison: level)
Different information in gesture and speech–specific	Because this smaller and this bigger (Comparison: size)	1. RH palm at top edge of transformed glass (height T) 2. LH palm at top edge of untransformed glass (height U) (Comparison: height)
Different information in gesture and speech–overlap	This is thinner and this is fatter (Comparison: width)	1. RH cupped around transformed glass, moves up (width + height T) 2. RH cupped around untransformed glass, moves up (width + height U) (Compensation: width + height)
Different information in gesture and speech–disjoint	You put that into here (Transform)	1. RH & LH palms facing near experimenter (width of original glass) 2. RH & LH palms facing at top edge of transformed glass (width + height T) (Compensation: width + height)

Note: All examples are drawn from children with SLI explaining one of the two water tasks.

TABLE 5

Number of same judgements (out of two) on the three types of conservation tasks for children with specific language impairment (SLI) and typically developing judgement-matched children (JM)

Child	*Liquid*	*Length*	*Number*
SLI/JM			
1	0	0	2
2	0	0	1
3	2	0	2
4	0	0	2
5	0	0	0
6	0	0	0
7	0	0	2

The results are organised around three main questions. First, do children with SLI produce gestures at a rate comparable to typically developing judgement-matched children? Second, do children with SLI express information uniquely in gesture more often than do typically developing judgement-matched children? Third, do children with SLI express more advanced understanding of conservation in their gestures than in their speech? Note that all of the data analyses focus on children's *explanations* (i.e., their responses to the "How can you tell?" question), which followed their conservation judgements. All of the children spontaneously produced gestures with at least some of their verbal explanations.

Before exploring the nature of the speech-gesture relationship in the two groups, we first examined the number of explanations children provided for each task. The children with SLI were much more likely than the judgement-matched typically developing children to provide additional explanations when they were probed after their initial explanation. Children with SLI provided an average of 2.55 explanations per task, whereas judgement-matched children provided only 1.29, $t(12) = 5.39$, $p < .001$. These data suggest that, with prompting, children with SLI had more to say about the conservation tasks than they expressed in their initial explanations.

Do children with SLI produce gestures at a rate comparable to judgement-matched typically developing children?

Each *explanation* was coded as including gestures or not including gestures. Children with SLI produced a greater proportion of explanations without gesture than typically developing judgement-matched (JM) children (SLI, 19%; JM, 8% of all explanations); however this difference was not significant, $t(12) = 1.84$, *ns*, two-tailed. Across both groups, explanations that did not include gestures tended to be very brief, "minimal" explanations of five words or fewer, such as, "because I counted them" or "it got big one". Such brief explanations were more common in children with SLI than in judgement-matched typically developing children (SLI, $M = 23\%$; JM, $M = 8\%$ of all explanations).

For explanations that included gestures, we then examined the rate at which children in the two groups produced gestures. The rate of gestures per 10 words was comparable in both groups (SLI, $M = 2.40$, $SE = .13$; JM, $M = 2.14$, $SE = .09$), $F(1, 13) = 2.76$, $p = .12$.

Do children with SLI express information uniquely in gesture more often than judgement-matched typically developing children?

When children produced gestures, they could use gestures to indicate the objects, to convey information that they also expressed in speech, or to convey information that they did not express at all in speech. Figure 1

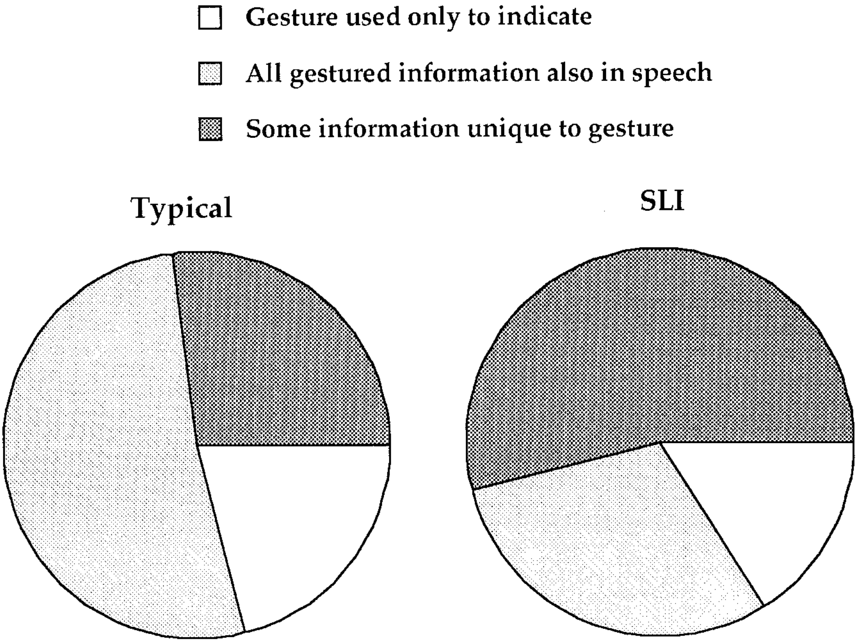

Figure 1. Distribution of explanations that include gesture for children with SLI and younger judgement-matched typically developing children, classified according to whether gesture serves only to indicate the task objects (□), gesture conveys information that is also expressed in speech (░), or gesture conveys unique information not expressed in speech (▓).

presents the mean proportion of explanations of each of these three types across all explanations that included gesture. As seen in the figure, when they produced gestures, children with SLI more often expressed some information unique to gesture than did judgement-matched typically developing children (SLI, $M = 54\%$; JM, $M = 29\%$), $t(12) = 2.58, p < .02$, one-tailed. These data are complicated by the fact that the proportions are based on different numbers of responses for different children, with low *N*s in some cases. Therefore, to confirm this finding, we also compared the two groups using a non-parametric test, the median test, which compares the number of children in each group who are above versus at or below the grand median. More of the children with SLI were above the median in the proportion of explanations they produced that included some information unique to gesture (SLI, $N = 6$; JM, $N = 2$), $p < .05$, Fisher's Exact (see Siegel & Castellan, 1988).

For explanations in which gesture conveyed information not expressed in speech, we next examined the gesture-speech relationship at a finer grain. As noted above, the gesture-speech relationship was classified as *specific* for explanations in which the information expressed in gesture was more specific than that expressed in speech. For example, on a water task, one child said, "because this is bigger and this is smaller" while pointing to the water level in the tall, thin glass, and then to the water level in the untransformed glass. In this example, gesture conveys a more specific dimension (level) than speech (size). The gesture–speech relationship was classified as *overlap* for explanations in which gesture expressed some of the information expressed in speech, as well as some additional information. For example, on a water task, one child said, "because you put that in here" while making a pouring motion into the tall glass, and then placed his flat palm at the top of the tall glass. In this example, gesture conveys some of the information expressed in speech (the water was poured into the tall glass), as well as some additional information (the height of the tall glass). Finally, the gesture–speech relationship was classified as *disjoint* for explanations in which gesture conveyed completely different information from speech. For example, on a number task, one child said, "because these still have six and these still have six" while tracing the round shape of the transformed row of checkers and the straight shape of the untransformed row of checkers. In this example, speech conveys information about the number of checkers in each of the rows, and gesture conveys completely different information about the shapes of the rows.

Table 6 displays the proportion of explanations that included gesture that were classified into each of these three categories. As seen in the table, children with SLI produced overlapping information in gesture three times as often as judgement-matched typically developing children (median test,

TABLE 6
Proportion of explanations (mean and standard errors) that included gestures characterised by each type of gesture–speech relationship for specifically language impaired (SLI) and typically developing judgement-matched (JM) groups

Type of explanation	*SLI* *M* (*SE*)	*JM* *M* (*SE*)
Specific	0.14 (.05)	0.13 (.06)
Overlap	0.18 (.04)	0.06 (.06)
Disjoint	0.23 (.05)	0.11 (.05)

$p < .02$, Fisher's Exact), and disjoint information in speech and gesture twice as often as judgement-matched children (median test, $p = .13$, Fisher's Exact).

Thus, children with SLI expressed information uniquely in gesture more often than judgement-matched typically developing children. We have suggested that this pattern of gesture-speech mismatch seen in the children with SLI can be attributed to their poor phonological working memory, on which basis the participants were selected. This pattern of gesture use might alternatively relate more strongly to severity of impairment in some other language domain, such as receptive vocabulary. Pearson pairwise correlation coefficients revealed that none of the correlations between the standardised language indices (see Table 1) and the proportion of explanations in which children with SLI expressed information uniquely in gesture were significant (PPVT, $r = .63$, *ns*; MLU, $r = .38$, *ns*; CLPT, $r = -.48$, *ns*; ELS, $r = -.09$, *ns*; RLS, $r = -.16$, *ns*).

Do children express more advanced reasoning in speech and gesture together than in speech alone?

The preceding analyses indicate that children with SLI have knowledge about conservation that is expressed in gestures but not speech. We next examined the nature of this "hidden knowledge" about conservation. Would children's gestures reveal more advanced knowledge about conservation than their speech? To address this question, we examined when and how often children expressed *conserving* knowledge in their explanations. As noted above, conserving strategies are strategies that justify why the quantities have the same amount. They include strategies that focus on the *identity* or *initial equality* of the quantities, the *compensation* of two dimensions, or the *reversibility* of the transformation. Examples of conserving strategies are presented in Table 3.

We first counted the number of times that children expressed conserving strategies in their verbal explanations of the tasks. As seen in Figure 2 (left

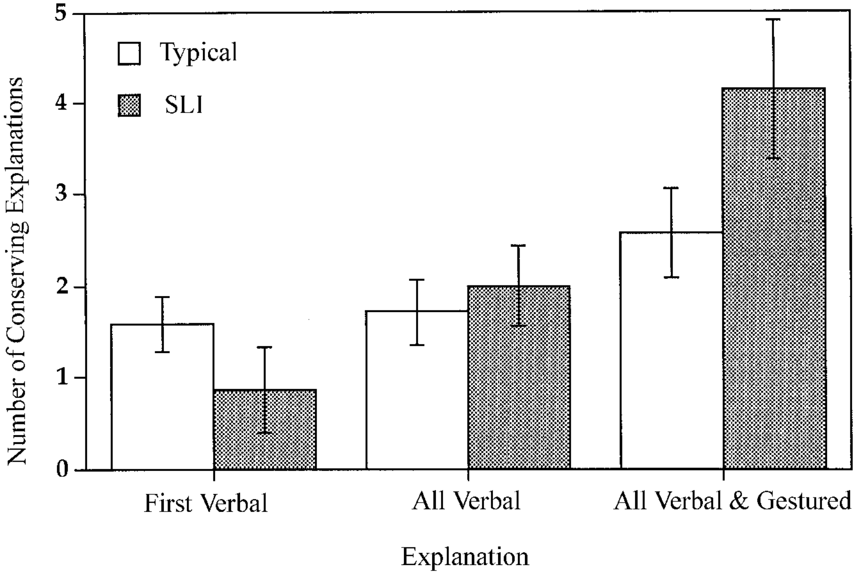

Figure 2. Number of conserving strategies (means and standard errors) expressed by children with SLI and younger judgement-matched typically developing children across the set of six tasks, in the first verbal explanation for each task (left), in all verbal explanations (middle), and in all verbal and gestured explanations (right).

set of bars), on the first explanation for each task, children with SLI produced slightly (though not significantly) *fewer* conserving strategies than the younger judgement-matched children, $t(12) = 1.31$, $p = 0.22$. When all verbal explanations were considered (middle set of bars), children with SLI produced slightly (though not significantly) *more* conserving strategies than the younger judgement-matched children, $t(12) = 0.51$, $p = .62$.

The crucial comparison considers whether children's gestures revealed conserving strategies that they did not express in speech. We assessed the number of conserving strategies that each child produced when both modalities (speech and gesture) and all explanations were considered. In this analysis, we included both conserving strategies that children expressed *uniquely in gesture* (e.g., on a water task, gesturing about *both the height and width* of a particular container while talking about *only the height* of the container) and conserving strategies that were *distributed across speech and gesture* in a single explanation (e.g., on a water task, gesturing about *only the width* of a particular container while talking about *only the height* of the container). As seen in Figure 2, in their explanations, when both speech and gesture were considered, children with SLI produced more conserving strategies than when only verbal explanations were considered, paired $t(6) = 3.38$, $p < .02$. Further, when both modalities were considered, children with SLI produced significantly more conserving strategies in their explanations as compared to the younger judgement-matched children, $t(12) = 1.73$, $p = .05$, one-tailed.

DISCUSSION

This study investigated the relationship between gesture and speech in Piagetian conservation tasks for children with SLI who had phonological working memory deficits and for judgement-matched typically developing children. While the children with SLI produced slightly more brief explanations that did not include gestures, when they produced gestures, the children with SLI expressed unique information in gesture significantly more often than did judgement-matched children. Thus, the nature of the relationship between speech and gesture appears to differ in children with SLI who have deficits in phonological working memory as compared to typically developing children. Further, in this study, the children with SLI often expressed *more sophisticated* knowledge about conservation in gesture (and in some cases, distributed across speech and gesture) than in speech. Thus, our data suggest that for these children with SLI, their embodied, perceptually-based knowledge about conservation was rich, but they were not always able to express this knowledge verbally. We have argued that this pattern of gesture-speech mismatch may be a result of poor links between phonological representations and embodied meanings for children with phonological working memory deficits like the participants in this study.

Church and Goldin-Meadow (1986) have observed a similar pattern of mismatch between speech and gesture in typically developing children who are on the brink of learning to conserve. They found that children who frequently conveyed additional information in gesture were particularly receptive to instruction about conservation. In their view, frequent mismatches of speech and gesture are an index of transitional knowledge states (see also Perry et al., 1988). One interpretation of Church and Goldin-Meadow's findings is that children whose knowledge is "transitional" have knowledge about the tasks that is represented in a nonverbal, perceptual format. According to this view, children initially acquire knowledge in a nonverbal format, and over developmental time, this knowledge then becomes re-represented in an explicit, verbalisable form. Indeed, the redescription of knowledge from one format to another may be a hallmark of transitional knowledge states (Alibali & Goldin-Meadow, 1993; Karmiloff-Smith, 1986, 1992). Thus, Church and Goldin-Meadow argued that the relation between gesture and speech might serve as an index not only of children's "readiness" to learn about conservation, but more broadly as an index of transitional knowledge.

It is possible that the children with SLI in this study, who also frequently conveyed additional information in gesture, were in a similar transitional knowledge state with regard to their conservation knowledge as well. Previous studies have documented delays in the acquisition of conservation among children with language impairments, even when conservation is assessed using nonverbal tasks. For example, Siegel and colleagues used an operant conditioning paradigm to test concrete operational reasoning in children with SLI and age-matched peers (Siegel, Lees, Allan, & Bolton, 1981). They found that children with SLI were less likely to demonstrate concrete operational reasoning on conservation and seriation tasks than peers. Similarly, Kamhi (1981) found that 5-year-old children with SLI showed poorer understanding of number conservation than age-matched peers. However, Johnston and Ramstad (1983) found that some children with SLI do eventually acquire explicit, verbal knowledge about conservation, but at a much slower rate than typically developing children.

One possibility is that, for both children with SLI and typically developing children, the mismatch between knowledge conveyed in gestures and in speech may signal somewhat weak links between embodied knowledge and verbally explicit representations. We suggest that, for children with SLI, embodied meaning representations may evolve in advance of and possibly independently of phonological representations, due to input from other modalities. According to Plaut and Kello (1999), the typically developing child's phonological representations evolve over time through repeated exposure to speech input. It might be that for children with SLI who have poor phonological working memory deficits, their exposure to speech input has been insufficient to develop stable phonological representations. Thus children with SLI might require more exposure to speech input as compared to their typically developing peers before they are able to develop stable phonological representations that can then be linked to embodied meanings, resulting in a prolonged state of transitional knowledge for these children. There is support for this idea in studies of lexical learning in children with SLI. While there is some inconsistency in the findings (Dollaghan, 1987), it has been reported that these children are less likely to incidentally learn new words quickly as compared to their age-matched peers (Rice, Buhr, & Nemeth, 1990). In particular, research suggests that these children require increased exposures to a new word before they show evidence of learning it (Rice, Buhr, & Oetting, 1992). Thus, children with SLI may express different information in speech and gesture for an extended period of time because they need increased exposure to language input in order to translate embodied knowledge into a more explicit verbal format. We plan to explore this hypothesis in future work.

Alternative accounts of SLI have been put forth that suggest that the deficits observed in linguistic and non-linguistic tasks in children with SLI are not due to phonological working memory deficits, but are due to limitations in general processing capacity (e.g., Johnston, 1994; Leonard, 1998). For example, Leonard (1998) has suggested that the deficits seen in children with SLI are secondary to impairments in their ability to simultaneously process the acoustic patterns of bound morphemes and derive their grammatical function before the acoustic pattern disappears from memory. In addition, Johnston and colleagues (e.g., Johnston & Smith, 1989) have proposed limited processing capacity as an account of *cognitive* deficits seen in children with SLI, arguing that overall information processing factors may be more critical than language specific factors. These limited processing accounts of SLI are not incompatible with the findings from this study. It has been argued that gestures may help speakers manage resource demands (Goldin-Meadow, in press). In particular, it has been suggested that gestures externalise some information, which helps speakers to manage cognitive load (Alibali & DiRusso, 1999). Further, some evidence suggests that speakers produce gestures that mismatch speech whey they are working at the limits of their processing capacity (Goldin-Meadow, Nusbaum, Garber, & Church, 1993). It may be that the children with SLI in this study often produced gestures that conveyed different information from speech because they were at the limits of their processing capacity, due to the cognitive and conversational demands of the task.

In particular, it is noteworthy that the children with SLI were more likely than the typically developing children to provide additional explanations when they were probed after their initial explanation (“How else can you tell?”). It might be that the children with SLI were unable to simultaneously process the verbal request of the examiner and verbally formulate their entire conceptual understanding of the task in a single response, and they needed the additional probes on the part of the examiner to express their full conceptual knowledge. This is consistent with studies of the conversation abilities of children with SLI. In particular, in conversations with adults, children with SLI are more likely to respond to an adult with a minimal, elliptic response (Johnston, Miller, Curtiss, & Tallal, 1993). However when given additional opportunities to respond, or when conversational demands are reduced, children with SLI are more likely to add information in their subsequent responses (e.g., Evans, 1996; Leonard, 1986; Van Kleeck & Frankel, 1981). Alternatively, however, it is possible that in this study the children in the two groups interpreted the communicative intent of the additional probe questions differently (see

Siegal, 1997; Siegal & Waters, 1988, for discussion). The children with SLI may have interpreted the experimenter's repeated questioning as an indication that their initial explanation was inadequate, so they may have attempted to provide another (hopefully more adequate) explanation. The typically developing children appeared to interpret the experimenter's probe question as a simple request for additional information, and they seemed quite comfortable indicating that they had no other reasons for their judgement. This issue needs to be explored further in future work.

In this paper, we have suggested that phonological working memory deficits critically affect the developmental organisation of phonological representations and their links to embodied knowledge for children with SLI. Further, we have suggested that impairments in phonological working memory may play a role in the extent to which children with SLI express knowledge uniquely in gesture. These suggestions should be taken tentatively. First, the protocol was not completely identical for both groups of children (as noted above, the judgement-matched group completed the tasks as part of a larger study). Second, although the correlations between the degree of gesture-speech mismatch and language indices were not significant for the children with SLI, one cannot rule out the possibility that language indices other than phonological working memory might be related to the unique gesture-speech profile seen in these children. For example, receptive language abilities have been shown to be highly correlated with nonword repetition abilities in prior work (e.g., Gathercole & Baddeley, 1990a). In the current study, for two of the children with SLI, receptive vocabulary abilities were assessed approximately a year prior to the completion of the conservation tasks. One would anticipate that for these two children, even very low PPVT–R scores would improve over the course of the school year. Thus, it is possible that receptive language abilities might also relate to the unique gesture-speech profile seen in these children. Future research is needed to replicate the findings in this study with a larger group of children with SLI who have a wider range of phonological working memory abilities, and with an identical protocol for both groups of children.

In sum, this study showed that, when they produced gestures, children with SLI expressed knowledge uniquely in gesture more often than judgement-matched typically developing children. Thus, patterns of gesture-speech integration differ in children with SLI and children who are developing typically. Further, children with SLI often conveyed more advanced reasoning in gesture than in speech. Our results suggest that phonological working memory deficits may have consequences for children's ability to translate embodied knowledge into a verbally explicit format. Based on these findings, we suggest that children with SLI may represent their knowledge in a format that is more readily accessible to gesture, and less readily accessible to verbal expression. As a result, children with language impairments may express their knowledge in ways that are qualitatively different from typically developing children.

REFERENCES

Acredolo, L.P., & Goodwyn, S.W. (1988). Symbolic gesturing in normal infants. *Child Development*, *59*, 450–456.

Alexander, E.P. (1999). *Language and gesture production in normal and congenitally, left-hemisphere-damaged individuals: A developmental study.* Unpublished doctoral dissertation, University of Chicago.

Alibali, M.W., & DiRusso, A.A. (1999). The function of gesture in learning to count: More than keeping track. *Cognitive Development*, *14*, 37–56.

Alibali, M.W., & Goldin-Meadow, S. (1993). Transitions in learning: What the hands reveal about a child's state of mind. *Cognitive Psychology*, *25*, 468–523.

Alibali, M.W., Kita, S., & Young, A. (2000). Gesture and the process of speech production: We think, therefore we gesture. *Language and Cognitive Processes*, *15*, 593–613.

Baddeley, A. (1986). *Working memory.* Oxford, UK: Oxford University Press.

Bates, E. (1979). *The emergence of symbols: Cognition and communication in infancy.* New York: Academic Press.

Bishop, D.V.M. (1992). The underlying nature of specific language impairment. *Journal of Child Psychology and Psychiatry*, *33*, 1–64.

Bishop, D.V.M. (1997). *Uncommon understanding: Development and disorders of language comprehension in children.* Hove, UK: Psychology Press.

Bishop, D.V.M., North, T., & Donlan, C. (1996). Nonword repetition as a behavioural marker for inherited language impairment: Evidence from a twin study. *Journal of Child Psychology and Psychiatry*, *37*, 391–403.

Burgemeister, B., Blum, L.H., & Lorge, I. (1972). *Columbia Mental Maturity Scale.* Harcourt, Brace, Jovanovich, Inc.

Butcher, C., & Goldin-Meadow, S. (in press). Gesture and the transition from one- to two-word speech: When hand and mouth come together. In D. McNeill (Ed.), *Language and gesture: Window into thought and action.* Cambridge, UK: Cambridge University Press.

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

Clahsen, H. (1989). The grammatical characterization of developmental dysphasia. *Linguistics*, *27*, 897–920.

Dollaghan, C. (1987). Fast mapping of normal and language-impaired children. *Journal of Speech and Hearing Disorders*, *52*, 218-222.

Dollaghan, C., Biber, M., & Campbell, T. (1993). Constituent syllable effects in a nonsense-word repetition task. *Journal of Speech and Hearing Research*, *36*, 1051–1054.

Dollaghan, C., & Campbell, T.F. (1998). Nonword repetition and child language impairment. *Journal of Speech, Language, and Hearing Research*, *41*, 1136–1146.

Dunn, L., & Dunn, D. (1981). *Peabody Picture Vocabulary Test-Revised.* Minneapolis: American Guidance Service.

Edwards, J., & Lahey, M. (1998). Nonword repetitions of children with specific language impairment: Exploration of some explanations for their inaccuracies. *Applied Psycholinguistics*, *19*, 279–309.

Ellis Weismer, S., Evans, J.L., & Hesketh, L.J. (1999). An examination of verbal working memory capacity in children with Specific Language Impairment. *Journal of Speech, Language, and Hearing Research*, *42*, 1249–1260.

Evans, J. (1996). SLI subgroups: Interaction between discourse constraints and morphosyntactic deficits. *Journal of Speech and Hearing Research*, *39*, 655–660.

Gathercole, S.E. (1995). Is nonword repetition a test of phonological memory or long-term knowledge? It all depends on the nonwords. *Memory and Cognition*, *23*, 83–94.

Gathercole, S.E., & Baddeley, A.D. (1990a). Phonological memory deficits in language-disordered children: Is there a causal connection? *Journal of Memory and Language*, *29*, 336–360.

Gathercole, S.E. & Baddeley, A.D. (1990b). The role of phonological memory in vocabulary acquisition: A study of young children learning arbitrary names of toys. *British Journal of Psychology*, *81*, 439–454.

Gathercole, S.E., & Baddeley, A.D. (1993). *Working memory in language processing.* Hove, UK: Lawrence Erlbaum Associates Ltd.

Gaulin, C., & Campbell, T. (1994). Procedure for assessing verbal working memory in normal school-age children: Some preliminary data. *Perceptual and Motor Skills*, *79*, 55–64.

Gibson, J.J. (1966). *The senses considered as perceptual systems.* Boston, MA: Houghton Mifflin.

Glenberg, A.M. (1997). What memory is for. *Behavioral and Brain Sciences*, *20*, 1–55.

Glenberg, A.M., & Robertson, D.A. (1999). Indexical understanding of instructions. *Discourse Processes*, *28*, 1–26.

Goldin-Meadow, S. (in press). Giving the mind a hand: The role of gesture in cognitive change. In J.L. McClelland & R.S. Siegler (Eds.), *Mechanisms of change in cognitive development: Behavioral and neural perspectives.* Mahwah, NJ: Lawrence Erlbaum Associates Inc.

Goldin-Meadow, S., Nusbaum, H., Garber, P., & Church, R.B. (1993). Transitions in learning: Evidence for simultaneously activated strategies. *Journal of Experimental Psychology: Human Perception and Performance*, *19*, 1–16.

Goldman, R.W., Fristoe, M., & Woodcock, R.W. (1980). *Goldman–Fristoe-Woodcock test of auditory discrimination.* Circle Pines, MN: American Guidance Service.

Gopnik, M., & Crago, M. (1991). Familial aggregation of a developmental language disorder. *Cognition*, *39*, 1–50.

Hill, E.L. (1998). A dyspraxic deficit in specific language impairment and developmental coordination disorder: Evidence from hand and arm movements. *Developmental Medicine and Child Neurology*, *40*, 388–395.

Iverson, J.M., & Thelen, E. (in press). Hand, mouth, and brain: The dynamic emergence of speech and gesture. In R. Nunez & W.J. Freeman (Eds.), *Reclaiming cognition: The primacy of action, intention, and emotion.* Thorverton, UK: Imprint Academic.

Johnston, J.R., Miller, J., Curtiss, S., & Tallal, P. (1993). Conversations with children who are language impaired: Asking questions. *Journal of Speech and Hearing Research*, *36*, 973–978.

Johnston, J.R., & Smith, L.B. (1989). Dimensional thinking in language impaired children. *Journal of Speech and Hearing Research*, *32*, 33–38.

Johnston, J.R. (1994). Cognitive abilities of children with language impairment. In R.V. Watkins & M.L. Rice (Eds.), *Specific language impairments in children.* Baltimore, MD: Brookes.

Johnston, J.R., & Ramstad, V. (1983). Cognitive development in preadolescent language-impaired children. *British Journal of Disorders of Communication*, *18*, 49–55.

Kamhi, A. (1981). Nonlinguistic symbolic and conceptual abilities of language-impaired and normally developing children. *Journal of Speech and Hearing Research*, *24*, 446–453.

Karmiloff-Smith, A. (1986). From meta-processes to conscious access: Evidence from children's metalinguistic and repair data. *Cognition*, *23*, 95–147.

Karmiloff-Smith, A. (1992). *Beyond modularity: A developmental perspective on cognitive science.* Cambridge, MA: MIT Press.

Leonard, L. (1986). Conversational replies of children with specific language impairment. *Journal of Speech and Hearing Research*, 29, 114–119.

Leonard, L. (1998). *Children with specific language impairment.* Cambridge, MA: MIT Press.

MacWhinney, B. (1999). The emergence of language from embodiment. In B. MacWhinney (Ed.), *The emergence of language* (pp. 213–256). Mahwah, NJ: Lawrence Erlbaum Associates Inc.

McNeill, D. (1992). *Hand and mind: What gestures reveal about thought.* Chicago: University of Chicago Press.

Montgomery, J. (1995). Sentence comprehension in children with specific language impairment: The role of phonological working memory. *Journal of Speech and Hearing Research*, *38*, 177–189.

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

Plaut, D.C., & Kello, C.T. (1999). The emergence of phonology from the interplay of speech comprehension and production: A distributed connectionist approach. In B. MacWhinney (Ed.), *The emergence of language* (pp. 381–415). Mahwah, NJ: Lawrence Erlbaum Associates Inc.

Rice, M., Buhr, J., & Nemeth, M. (1990). Fast mapping word learning abilities of language delayed preschoolers. *Journal of Speech and Hearing Disorders*, *55*, 33–42.

Rice, M., Buhr, J., & Oetting, J. (1992). Specific-language-impaired children's quick incidental learning of words: The effects of a pause. *Journal of Speech and Hearing Research*, *35*, 1040–1048.

Rice, M., Wexler, K., & Cleave, P.L. (1995). Specific language impairment as a period of extended optional infinitive. *Journal of Speech and Hearing Research*, *38*, 850–863.

Semel, E., Wiig, E., & Secord, W. (1989). *The Clinical Evaluation of Language Fundamentals–Revised*. Texas: The Psychological Co., Harcourt, Brace, Jovanovich, Inc.

Siegal, M. (1997). *Knowing children: Experiments in conversation and cognition.* Hove, UK: Psychology Press.

Siegal, M., & Waters, L.J. (1988). Misleading children: Causal attributions for inconsistency under repeated questioning. *Journal of Experimental Child Psychology*, *45*, 438–456.

Siegel, L.S., Lees, A., Allan, L., & Bolton, B. (1981). Nonverbal assessment of Piagetian concepts in preschool children with impaired language development. *Educational Psychology*, *2*, 153–158.

Siegel, S., & Castellan, N.J., Jr. (1988). *Nonparametric statistics for the behavioral sciences.* New York: McGraw-Hill, Inc.

Thal, D.J., & Bates, E. (1988). Language and gesture in late talkers. *Journal of Speech and Hearing Research*, *31*, 115–123.

Thal, D.J., O'Hanlon, L., Clemmons, M., & Fralin, L. (1999). Validity of a parent report measure of vocabulary and syntax for preschool children with language impairment. *Journal of Speech, Hearing, and Language Research*, *42*, 482–496.

Thal, D.J., & Tobias, S. (1992). Communicative gestures in children with delayed onset of oral expressive vocabulary. *Journal of Speech and Hearing Research*, *35*, 1281–1289.

Thal, D.J., Tobias, S., & Morrison, D. (1991). Language and gesture in late talkers: A 1-year follow-up. *Journal of Speech and Hearing Research*, *34*, 604–612.

Van Kleeck, A., & Frankel, T. (1981). Discourse devices used by language disordered children: A preliminary investigation. *Journal of Speech and Hearing Disorders*, *46*, 250–257.