Gesture Development: A Review for Clinical and Research Practices

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The aim of this article is to provide clinicians and researchers a comprehensive overview of the development and functions of gesture in childhood and in select populations with developmental language impairments. Of significance is the growing body of evidence that gesture enhances, not hinders, language development. In both normal and impaired populations, gesture and language development parallel each other and share underlying symbolic abilities. Gesture serves several functions, including those of communication, compensation, and transition to spoken language. In clinical practice, gesture may play a valuable role in diagnosis, prognosis, goal selection, and intervention for children with language impairments. Where available, supporting evidence is presented. Needs for additional research on gesture are also highlighted.

KEY WORDS: gesture, language, development, language impairment, disorder/delay

In clinical practice, gestured input has been used to help children attain goals such as establishing functional communication or enhancing direction following, or to help facilitate children's word retrieval or development of an idea (German, 1992; Linder, 1993; Manolson, 1992). In addition, commercially available tests such as the Rossetti Infant–Toddler Language Scale (RITLS; Rossetti, 1990), the Communication and Symbolic Behavior Scale (CSBS; Wetherby & Prizant, 2002), and the MacArthur Communicative Development Inventories (MCDI; Fenson et al., 1993) assess a variety of gesture categories. Few attempts have been made to bridge the gap between what is accepted as best clinical practice and the empirical data. The current literature review is a preliminary step toward that goal.

Gesture, speech, and language are "tightly coupled" neurologically and developmentally (Iverson & Thelen, 1999, p. 20; see also Bates & Dick, 2002). There is overlap in the neural control for speech and gesture such that spreading neural activation from one brain region to the other may underlie their co-occurrence. Gesture–speech synchrony originates in early activities of hand and mouth. For example, at birth, infants open their mouths when pressure is applied to a palm (Babkin reflex). Also, hand-to-mouth behavior is a frequent phenomenon of infancy. Later, rhythmic movements of hands (e.g., banging objects) and mouth (e.g., babbling) emerge at approximately the same time, and more refined movements for first words and gestures co-occur as motor control for both systems advances. Oral and manual activities have equal access to cognitive processes that underlie them (Iverson & Thelen, 1999). For example, when school-age children explain concepts of equivalence,

they express information in both gesture and speech (e.g., Church & Goldin-Meadow, 1986). The gesture–language link is so robust that deaf children raised in hearing households with no exposure to formal sign languages will create a gestural system to communicate (Goldin-Meadow, Butcher, Mylander, & Dodge, 1994; Goldin-Meadow & Morford, 1985). Their gestures express single lexical items and semantic relations similar to those of hearing children's spoken forms. Further, their system spontaneously takes on language-like characteristics, such as morphological marking of nouns and verbs (Goldin-Meadow et al., 1994). As Goldin-Meadow and Morford (1985) observed "…communication in humans is a resilient phenomenon; when prevented from coming out the mouth, it emanates almost irrepressibly from the fingers" (p. 146).

This review describes the development of three types of manual gestures (deictic, symbolic play schemes, and representational) and their relationship to the development of early language.[1] Across-development gesture serves several functions in relation to language, including that of communication and scaffolding to subsequent milestones. Like language, gesture provides an index of a child's cognitive status. Throughout this review, the functions of gesture and the relationships between gesture and spoken language are revisited at each stage of development. It is anticipated that better understanding of gesture development will improve clinical practices of assessment and intervention of young children and will encourage treatment efficacy research in this potentially fruitful area.

Infancy to Toddlerhood

In this section we review the developmental course of gesture and explicate the relations between gesture and early language development. Early gestures serve to obtain and maintain attention and communication with adults, which are essential for establishing language learning opportunities. Early symbols, manual and spoken, appear to share underlying cognitive abilities, and so manual symbols can aid the transition to advancing language milestones and predict them in some instances.

Gesture Types Emerge

SHOWING-OFF[2] is one of the first signs the infant gives of intentional communication (Bates, Benigni, Bretherton, Camaioni, & Volterra, 1979; Bates, Camaioni, & Volterra, 1975). Young infants repeat behaviors that previously have been successful in gaining adult attention. These showing-off behaviors precede the use of objects as a means to obtain adult attention. The use of objects to gain adult attention marks the entry into use of deictic gestures (showing, giving, pointing). These behaviors are also referred to as prelinguistic gestures (and performatives) because their emergence is observed prior to spoken language; however, deictic gestures, especially pointing, continue to be used throughout development. Showing, giving, and pointing emerge in this predictable sequence starting at approximately 10 months of age (Bates et al., 1975, 1979; Folven & Bonvillian, 1991). These behaviors show a marked increase in occurrence after 11 months as more primitive gestures such as reaching and emotive gestures (e.g., moving the body up and down) decline (Blake & Dolgoy, 1993).

Another gesture, ritualized request, is observed during the period between 9 and 13 months. Ritualized requests include a variety of behaviors such as reaching with an open–close grasping motion, placing an adult's hand on an object to request setting it in motion, or pulling at an empty hand to obtain something (Bates et al., 1979, pp. 137–138). These differ from less mature requesting behaviors (e.g., whining, fussing) in that the former are more conventional signals. In fact, Bates et al. (1979) found showing, giving, pointing, and ritualized requests to be strongly related to each other but not to other communicative behaviors, such as refusals.

At around 12 months, new gesture types begin to develop. One type of gesture, recognitory gesture, is best described as a play scheme. These are actions carried out on an object and depict the object in terms of its function. There is some debate as to whether this earliest form of play is appropriately categorized as gesture proper, because its use does not necessarily meet communicative and symbolic status criteria (Acredolo & Goodwyn, 1988; Iverson, Capirci, & Caselli, 1994). However, play schemes are argued to be enactive names for objects (Escalona, 1973), and they illustrate an infant's capacity for symbolic representation in similar ways to spoken words (McCune-Nicolich, 1981).

Another type of gesture, representational gesture, emerges before the onset of the 25-word milestone and has been labeled in many ways, including representational, symbolic, iconic, empty-handed, or referential gesture and baby signs (Acredolo & Goodwyn, 1988, 1996; Capirci, Iverson, Pizzuto, & Volterra, 1996; Caselli, 1990; Nicoladis, Mayberry, & Genesee, 1999). These gestures are not instrumental (i.e., the referent is not being manipulated) as is the case with play schemes. Representational gestures carry meaning in their form to symbolize a referent, and that form does not change with

[1] There is a rich literature base on another manual form, American Sign Language, that is not reviewed here. The reader is directed to Emmorey and Lane (2000) for an anthology of literature.

[2] Please note, when words in the manuscript contain only capitalized letters, they refer to gesture forms.

context (e.g., flapping arms to represent a bird's flight or blowing to create bubbles). They are arguably examples of language symbols in their own right. In fact, Goodwyn and Acredolo (1993) operationally defined gesture symbols by criteria commonly used to define spoken symbols. For example, a gesture or word is considered symbolic if it refers to multiple exemplars, including pictures, in the absence of the referent; is produced spontaneously, without models; and is not part of well-rehearsed routines (Goodwyn & Acredolo, 1993, p. 695; for a similar argument see Volterra & Erting, 1990). Acredolo and Goodwyn (1988) found a range of 0–17 representational gestures, with means of 3–5 gestures per child, in the infant–toddler repertoires they studied.

Gesture Predicts Subsequent Language Milestones

Observing gestural ability can provide predictive evidence of later spoken-language levels. Pointing schemes, accompanied by eye contact with an adult, that function to seek confirmation or approval are a precursor to spoken and signed naming (Bates et al., 1975; Folven & Bonvillian, 1991). Capirci et al. (1996) found single gestures and gesture–word combinations produced at 16 months of age to be significantly correlated with total vocal production at 20 months. In particular, there was a significant relationship between the combinations of deictic or representational gesture with representational words at 16 months and total vocal production at 20 months. Morford and Goldin-Meadow (1992) also found this to be true. Although the toddlers in their study presented with similar production profiles, those who produced supplemental information in their spontaneous gestures (e.g., PALM-UP REACH + "juice") produced more spoken words in a free-play context than those who only produced redundant gestures with speech (e.g., POINT TO MAN + "man").

Gesture and Language Reveal Symbolic Operations

The sequence of deictic gesture development reveals the gradual distancing of self from object that underlies symbolic development. Infants first begin to extend their arms to show an object when they have no intention of relinquishing it. Early SHOW behavior is characterized by the child already playing with an object and looking toward the observer with extended arm. This evolves to the child looking around for objects not already being manipulated to show adults. Soon after, the object is given over to the adult (Bates et al., 1975).

At approximately the same time GIVE gestures surface, referential POINT gestures emerge. Pointing is an integral part of referential cognitive ability. It seems to emerge as a self-orienting mechanism used to explore objects, but it is eventually coordinated with social interactions that are contextually appropriate (Locke, Young, Service, & Chandler, 1990). Early pointing is used while alone or with others but does not involve a search for adult attention. Harris, Barlow-Brown, and Chasin (1995) found that occurrences of pointing (defined as a spontaneous extension of the index finger toward an object or event outside the child's immediate proximity; p. 26) and the first evidence of object name comprehension emerge at the nearly identical median ages of 10 months, 21 days and 10 months, 22 days, respectively. Here, comprehension was determined by parental report and confirmed with forced choice testing.

Play scheme symbols appear to share underlying cognitive functions with spoken symbols (Bates, Bretherton, Snyder, Shore, & Volterra, 1980; McCune-Nicolich, 1981). Bates et al. (1980) found that 13-month-old infants who were less reliant on referent cues (e.g., could imitate incongruent actions such as drinking from a toy car) had larger expressive vocabularies than those who were more reliant on such cues. In other words, it appeared that the ability to abstract the phonological form from its physical referent was related to another symbolic activity, that of abstracting a gestural scheme from its referent. Furthermore, Bates and colleagues found that receptive vocabulary was related to accuracy in linking gestural schemes using a featureless object (e.g., completing a bedtime script in which a wooden block is patted, put to bed, covered with a blanket, and kissed goodnight). Context may be a mediating parameter for how language and play schemes hang together in these tasks (Bates & Dick, 2002). The infant relies on recognition ability, using contextual cues available during the linked schemes task and provision of the word for comprehension, in these tasks. In contrast, both word production and imitation of a single scheme with no contextual support require greater processing for full recall of a well-established, internally represented, symbolic form. Full recall is far less supported externally and therefore the internal representation needs to be richer.

Development of empty-handed, representational gesture seems to parallel spoken development in the symbol types and contexts in which they are learned (Acredolo & Goodwyn, 1988). Similar trends of early spoken vocabulary are found in gesture vocabulary, including a high proportion of object labels in both. In fact, spoken vocabulary development is related to the extent of a child's object gesture repertoire just as it is related to spoken nominal vocabulary (Bates, Bretherton, & Snyder, 1988; Nelson, 1973). Children with more object gestures in their repertoire tend to have larger vocabularies and meet their first 10-word milestone earlier than children

with fewer object gestures (Acredolo & Goodwyn, 1988). The large majority of these object gestures emerge from an infant's own experience with objects, although others may emerge from within interactive routines (e.g., the eensy-weensy-spider song/activity). These gestures are iconic. They often take the form of the actions associated with objects; more rarely, gestures depict perceptual qualities (e.g., two extended fingers to represent the ears of a bunny; Acredolo & Goodwyn, 1988; Iverson et al., 1994). The preference for function over form may reflect the child's concept of an object (Acredolo & Goodwyn, 1988).

Gestures Facilitate Language Development

Infants attend to and use gesture models that adults produce in their environment (Goodwyn & Acredolo, 1993; Goodwyn, Acredolo, & Brown, 2000; McGregor & Capone, 2001; Namy, Acredolo, & Goodwyn, 2000). Iverson, Capirci, Longobardi, and Caselli (1999) found a gestural analogue to the motherese of speech directed to 16- and 20-month-old children. Mothers' gestures co-occurred with speech. Approximately 15% of maternal utterances were supported by gesture. Gestures were conceptually simple, referred to the immediate context, and reinforced spoken messages (p. 70).

Capitalizing on symbolic gesturing can foster language development through the second year of life (Namy et al., 2000). Specifically, when parents are encouraged to model gesture–word pairs in daily interactions with their infants, symbol use begins earlier (Goodwyn & Acredolo, 1993; McGregor & Capone, 2001), and infants who are explicitly taught to use gestural representations demonstrate greater use of them than is observed spontaneously (Goodwyn et al., 2000). For example, the infants studied by Goodwyn and Acredolo (1993) demonstrated a mean age of first gesture and first spoken word at 11.94 months and 13.05 months, respectively, representing a manual advantage of 1.10 months. The first five symbols were acquired by 13.55 months for gestures and 14.50 months for spoken words, representing a 0.79-month advantage for the manual modality. While the gestural advantage was statistically significant, its clinical significance has not yet been determined. One study is suggestive (Goodwyn et al., 2000).

In 2000, Goodwyn and colleagues compared three groups of normally developing infants: a control group without intervention, a second group in which parents were encouraged to increase their spoken labeling behavior, and a third group in which infants were exposed to gesture-plus-verbal input from their parents as often as possible. Results showed a larger lexicon of gestures (20.38) for the infants exposed to gesture-plus-verbal input than was previously reported for spontaneous repertoires (5 reported by Acredolo & Goodwyn, 1988). Furthermore, language development measures administered over time showed that the group exposed to bimodal input outperformed the control groups at 19 and 24 months on receptive language measures and at 15 and 24 months on expressive measures. Between-group language performance also approached, but did not reach, a significant difference at 30 and 36 months. While it is possible that the effect gesture has on language development is temporary, it is also possible that the instruments used to measure language skills at older ages were not sensitive to the effects. These findings are experimental evidence that the provision of gestured input acts as an intervention to enhance, not hinder, language development.

Gesture Complements Spoken Language Functions

Pointing becomes increasingly integrated with spoken language during the second and third years of life, particularly to supplement spoken messages (Capirci et al., 1996; Iverson et al., 1994; Nicoladis et al., 1999). For example, Iverson et al. (1994) and Capirci et al. (1996) found that pointing made up a significant proportion of infants' gesture repertoires at 16 and 20 months of age when development of spoken vocalizations was well underway. In fact, a significant increase in pointing occurred between 16 and 20 months; pointing accompanied representational words more often than any other deictic gesture.

Play schemes can also serve a complementary function to spoken language. Bretherton et al. (1981) found 13-month-olds used a play scheme more often than a spoken label on sight of or while handling an object. However, by 20 months, a significant increase in spoken labels was observed with a decline in object-related gestures. Further, by 20 months of age, toddlers begin to replace object-in-hand play schemes with empty-handed gestures that depict the function of these same objects (Capirci et al., 1996; Iverson et al., 1994). The gradual distancing from the self seen with deictic gestures is again observed with play schemes. Specifically, children gradually decontextualize sensorimotor schemes from referents to create abstract symbols (Werner & Kaplan, 1963). The ability to decontextualize is important, as it is related to the ability to use a spoken or written label in the absence of a referent and to generalize labels to novel exemplars.

Representational gestures also complement early spoken forms (Acredolo & Goodwyn, 1988; Goodwyn & Acredolo, 1993; Iverson et al., 1994) and show more of a

transitional function later in the second year (Capirci et al., 1996; Iverson et al., 1994). Between 12 and 18 months of age, gesture and spoken vocabulary are generally mutually exclusive, but gestures are eventually replaced by words—and not vice versa (Acredolo & Goodwyn, 1988; Capirci et al., 1996[3]; Caselli, 1990; Iverson et al., 1994). Iverson et al. (1994) found 16-month-olds to have a preference for either spoken or gestured communication, but by 20 months there was a significant increase in types and tokens of spoken words. Caselli (1990) reported that the infant in her case study initially used referential gestures to clarify misunderstood deictic requests. On one occasion the child pointed to a radio; his mother then named it. However, that was not his intent, and he proceeded to dance while looking at his mother to clarify that he was requesting the radio be turned on, not labeled. Acredolo and Goodwyn (1988) hypothesized that gesture facilitates communication while articulatory and phonological systems are still developing.

Toddlerhood to Preschool Years

During toddlerhood, children come to prefer verbal to gestural expression. Furthermore, by 28 months they come to expect a spoken label to reference objects and their categories. They no longer accept an abstract gesture as a symbol of objects as they did at the end of their second year (Namy & Waxman, 1998). Nevertheless, gesture is far from extinguished as children come to rely more on spoken forms. Beginning in toddlerhood, representational gestures decrease, but deictic gestures and words (e.g., POINT, "this", "that") increase (Iverson et al., 1994). A child's ability to engage in play schemes continues to be associated with receptive language ability. In addition, a new gesture type emerges. These hand movements, known as beat gestures, provide emphasis while speaking but convey no semantic information (e.g., moving the hands up and down; Nicoladis et al., 1999).

The use of gesture develops from a language symbol in infancy to a form that can be exploited to supplement, clarify, or scaffold spoken language performance in both receptive and expressive domains (Capirci et al., 1996; McNeil, Alibali, & Evans, 2000; Morford & Goldin-Meadow, 1992; Tomasello, Striano, & Rochat, 1999). In this section we focus on the continued relationship between gesture and language, and the functions gestures serve in facilitating advancing cognition.

[3] It should be noted that Capirci et al. (1996) and Iverson et al. (1994) analyzed gestures that included play schemes as long as they were communicative in status. This procedure differs from the work of Acredolo and colleagues (e.g., Goodwyn & Acredolo, 1993), who excluded object-in-hand gestures in analyses.

Gesture Use Is Associated With Advances in Expressive Language

Gesture becomes more tightly integrated with spoken language during the preschool years. For example, Nicoladis et al. (1999) found that children 24–42 months of age typically use gestures with speech rather than gesture alone, and that they do so at levels comparable to adults. In their study of English–French bilingual preschoolers, Nicoladis et al. found iconic and beat gestures were related to mean length of utterance in both languages, whereas deictic gestures were not. For example, utterances that were accompanied by iconic gestures were longer than those accompanied by deictic gesture or by no gesture at all. More consistent use of iconic and beat gestures accompanied the language of greater proficiency in these young bilinguals. Furthermore, the use of iconic gestures was found to co-occur more often with verb, adjective, and adverbial phrases than with noun phrases. The results illustrate the continued presence of spoken and manual co-expression but suggest that the relationship between gesture and language extends to the domain of morphosyntax as children advance in these areas.

Gesture Use Is Associated With Advances in Receptive Language

Gesture and receptive language continue to demonstrate a parallel relationship into the preschool years. O'Reilly, Painter, and Bornstein (1997) examined the relationship between overall receptive language development (via the Reynell Developmental Language Scales–Revised; Reynell & Huntley, 1985) and symbolic gesture abilities longitudinally from 24 to 48 months of age. Symbolic gesture ability was assessed at 24 months using a play scheme production task in which a featureless block was substituted for an object. At 36 and 48 months the gesture task was pantomime comprehension (e.g., an adult pretending to peel a banana) in which children stated the actions gestured. Receptive language ability at 24 months was related to pantomime comprehension at 36 months, and the ability to engage in a play scheme with a featureless block at 24 months was related to receptive language abilities at 36 months. In a follow-up experiment with 4- and 5-year-olds, receptive language skills were assessed using the Test for the Auditory Comprehension of Language–Revised (TACL-R; Carrow-Woolfolk, 1985), which allows measurement of lexical, morphological, and syntactic comprehension. Pantomime comprehension was related to lexical comprehension and this relationship was independent of age and nonverbal IQ. It appears then that the receptive vocabulary–gesture association found early in development continues into the preschool years.

Cross-Modal Combinations Scaffold Advancing Language

Between 18 and 22 months an important language milestone is reached—the emergence of two-word combinations (Bates et al., 1988). However, two concepts are also being expressed in the gestural modality in unimodal (gesture-plus-gesture) and cross-modal forms (gesture-plus-verbal; Capirci et al., 1996; Goldin-Meadow & Morford, 1985). Combinations can be equivalent (BIG + "big"), complementary (e.g., SHOW + "water"), or supplementary (e.g., POINT to water + POINT to a glass indicating the water be poured in the glass). In Capirci et al.'s (1996) study of 16- and 20-month-old infants, they found cross-modal combinations to be common at both ages, but the most common cross-modal combination, a deictic gesture-plus-representational word (POINT + "water"), increased significantly by the 20-month mark. Cross-modal combinations of two representational elements were produced at both ages, but these were limited in occurrence. Multi-element combinations (more than 2 items) increased significantly over time and were most often cross-modal. Gesture-plus-gesture combinations were rare at both milestones (see also Morford & Goldin-Meadow, 1992), and of course, two-word combinations had increased significantly by the second year's end.

Toddlers comprehend cross-modal combinations. Morford and Goldin-Meadow (1992) found a facilitating effect on language comprehension when gesture–speech combinations were used. Toddlers at the one-word stage of development participated in a task that required them to follow simple one-step directions using actions and objects (e.g., "open the box" + POINT to the box). Of five conditions in the study, three are relevant to this discussion. These were a no gesture condition (two spoken words), a redundant gesture condition (e.g., GIVE ME + "give the clock"), and a replacement gesture condition in which different information was conveyed cross-modally (e.g., GIVE ME + "clock"). The comparison of the redundant and no gesture conditions provided information regarding the enhancing effects of gesture on auditory comprehension. The comparison of the replacement and no gesture conditions provided information regarding a toddler's ability to integrate the two modalities. Performance on the redundant gesture trials and replacement gesture trials was better than on trials with no gestural information. No significant differences in performance between the redundant and replacement gestures conditions were found. These results show that, at the one-word stage of expressive development, children can integrate gesture and speech and use it to enhance comprehension performance.

The ability of preschoolers to use gesture to scaffold language performance was illustrated by McNeil et al. (2000). In their study of simple and complex direction following, they found preschoolers to be more accurate when a gesture reinforced spoken directions than when no gesture was used. This was only true when directions were considered complex and therefore on the cusp of mastery. When considered along with the results of Morford and Goldin-Meadow (1992), this study supported the characterization of gesture and spoken language as an integrated system with gesture being used to bootstrap into spoken language as needed.

Gesture Scaffolds Conceptual Development

Gesture can be exploited as a scaffold for advancing cognition in general, not just language. Tomasello et al. (1999) showed that gesture scaffolds the ability to decontextualize symbols for comprehension at 18, 26, and 35 months of age. In their comprehension task, children were required to identify increasingly abstract symbols. These symbols were either representational body-part-as-object gestures (e.g., fixing hair with extended fingers to signify comb) or substitute objects (e.g., use of a cup on the head to signify hat). As tasks increased in difficulty, older children did better than younger children, but gesture was more readily identified than substitute objects by both younger and older children. These results suggest that gesture may serve as a scaffold in situations requiring comprehension of decontextualized symbols.

With increasing maturity, children in the preschool years can be asked directly to iconically gesture semantic features of objects (e.g., "Can you pretend to talk on the phone?"). Two types of gestures are produced during this time: body-part-as-object (BPO) gestures, in which the body part serves as a substitute object, and imaginary object (IO) forms (e.g., a closed fist moved beside the hair to represent a comb). These gestures tap developmental trends in conceptual development, specifically the ability to decontextualize a symbol from its referent.

As children develop from 3 to 5 years of age, they appear to rely less on BPO gestures and transition to the use of IO gestures to demonstrate what objects do (Boyatzis & Watson, 1993; O'Reilly, 1995). Four-year-olds demonstrate a transition from one to the other by using BPO and IO gestures equally. O'Reilly (1995) found comprehension of IO, but not BPO, gestures to increase with age. However, item effects were found such that 3-year-olds comprehended IO gestures earlier than expected for some objects. Several factors may be contributing to item effects, including the amount of sensorimotor experiences with the objects used in the probes (see O'Reilly, 1995, for additional discussion of factors). In a more recent study of novel object word learning (Capone, 2003), 28-month-olds comprehended

IO gestures at above-chance levels of responding within a few exposures to an object. For example, after the children's initial use of the objects, they identified each from an object array when presented an IO gesture conveying its function (i.e., "where's this one?" + IO gesture). These data suggest that even toddlers comprehend IO gestures and that sensorimotor experiences within a child's repertoire may contribute to their conceptual development and performance on this task.

School-Age Years

During the school-age years the use of gesture continues to scaffold spoken expression of concepts that are on the cusp of mastery, but it also appears to drive conceptual acquisition itself. Goldin-Meadow and colleagues have pursued a rich line of research that shows use of gesture to access formal thought in children as young as 5 years old (Church & Goldin-Meadow, 1986; Evans, Alibali, & McNeil, 2001; Garber, Alibali, & Goldin-Meadow, 1998; Goldin-Meadow, Nusbaum, Garber, & Church, 1993; Kelly & Church, 1998; Perry, Church, & Goldin-Meadow, 1988). When young school-age children are asked to explain concepts such as Piagetian conservation (e.g., liquid quantity, length, and number) and mathematical equivalence, they spontaneously use gestures as well as spoken forms in their explanations (Church & Goldin-Meadow, 1986; Perry et al., 1988). For example, when asked to explain a length equivalence solution, a child responded "push them close together" while pointing along the length of a vertical stick and a horizontal stick (Church & Goldin-Meadow, 1986, p. 52).

These cross-modal combinations take on certain forms depending on the stage of concept development being tapped (Alibali & Goldin-Meadow, 1993). Initially, when incorrect solutions are explained, children tend to express the same, incorrect, information in gesture and speech. As they enter the transitional knowledge state, gesture–speech mismatch occurs. That is, information expressed in gesture differs from that of speech. For example, when explaining a mathematical equivalence solution, a child may state that he or she is adding the numbers on only one side of the equation but point to numbers on both sides of the equals sign. Accurate information tends to be found in the gestural component of mismatch combinations, and so the manual modality has greater access to correct representations than does speech while the child is in a zone of proximal development (Goldin-Meadow, Alibali, & Church, 1993). During this transitional knowledge state, multiple hypotheses about a concept are activated while solving problems (Goldin-Meadow, Nusbaum, et al., 1993). This causes some information to be expressed via gesture and other information via speech. Gesture is thought to make the child aware of these conflicting hypotheses and move him or her into an integrated state of concept acquisition. Subsequently, children produce accurate explanations in which gesture information matches that of speech once again. Of the children who use gesture–speech combinations, it is those who provide different information cross-modally who are most apt to learn and retain accurate concepts when training is provided (Alibali & Goldin-Meadow, 1993). Gesture–speech mismatch combinations index transitional learning states for both science and math concepts, suggesting they are a general cognitive phenomena and not task specific.

Gesture is suggested to have a direct effect on the learning process, acting as a "cognitive crutch" (Goldin-Meadow, 2000, p. 232) that scaffolds the child's understanding by providing an alternative modality of expression before verbal explanations are well integrated. It reduces demands on cognitive resources and aids a child's thinking about the task at hand (Alibali & Kita, 2003; Goldin-Meadow, Nusbaum, Kelly, & Wagner, 2001). Alibali and DiRusso (1999) found both spontaneous and elicited gestures, via instruction to do so, have a facilitating effect over a no gesture condition during a math activity (i.e., counting). Gesture can have an indirect effect on concept acquisition as well, because communicative partners who show an awareness of information contained in gesture can alter teaching accordingly (Goldin-Meadow, 2000; Goldin-Meadow, Alibali, & Church, 1993; Kelly & Church, 1998).

Summary

In summary, gesture emerges in the second half of the first year of life. The emergence and evolution of gesture is naturally occurring and predictable in developmental sequence. The first intentional use of communication is via the sequence of deictic gestures, which predicts the emergence of first words. Soon after, symbolic play schemes and representational gestures emerge and complement spoken forms. As toddlers approach their second birthday, a preference for spoken words is evident. However, gesture continues to scaffold performance on more complex cognitive tasks, including comprehension of language or to clarify their own spoken messages. Gesture shares underlying cognitive skills with both receptive and expressive vocabulary. As children advance to school age, their expression of complex concepts emerges in gesture before the spoken modality and gesture can drive conceptual development.

Language-Impaired Populations

Children with language impairments would seem to benefit from the same functions that gesture serves

in normal development. For example, just as is true for normally developing 12-month-olds, gesturing by children with language impairments may provide a vehicle for them to communicate when articulatory and language systems are not fully developed. Language learning opportunities between language-impaired children and the adults in their environment may be enhanced if gesture is recognized as a communication attempt. Evidence suggests that the development of gesture and language profiles are associated in language-impaired populations much as they are in normal development. As such, the gesture–language profiles of affected children provide converging evidence of the robust developmental relationship between manual and spoken modalities. This evidence is reviewed below.

At-Risk Children

Children born at biological (e.g., prematurity) or social (e.g., poverty, neglect) risk are a unique population in which to study the genetic, environmental, and biological contributions to language and gesture development. For example, the robustness of deictic gesture development was illustrated by McGregor and Capone's (2001) longitudinal study of quadruplets who presented with high biological risks. Gestured and spoken symbol acquisition was tracked and compared across siblings to determine what contribution the risk factors made toward their symbol development. Consistent with previous studies, the emergence of deictic gestures followed a predictable developmental sequence and preceded spoken words, even for the sibling who presented with the greatest biological risks—and the greatest language delay. This longitudinal case study suggests that the order of prelinguistic and linguistic development is preserved even when that development is delayed.

Late Talkers

Late talkers have difficulty imitating play schemes, and this may predict persistent language impairments (Thal & Bates, 1988; Thal & Tobias, 1994; Thal, Tobias, & Morrison, 1991). When toddlers first present as late talkers, they typically fall at the lowest 10th percentile for expressive vocabulary development on formal measures such as the MCDI and have failed to advance to two-word combinations by 18–24 months of age. Thal et al. (1991) compared late talkers and age-mates (18–29 months) in terms of their abilities to imitate play schemes in isolation and sequenced within a familiar script (e.g., feeding a teddy bear). At that time late talkers demonstrated poor single play-scheme imitation, but their ability to imitate sequences was comparable to age-mates. However, retrospective analysis 1 year later showed that late talking toddlers who recovered (i.e., those considered late bloomers) demonstrated gesture performance and receptive language that was comparable to age-mates at first presentation.[4] Truly late talkers (i.e., those who did not recover by 3 years of age) had been poorer on all gesture tasks than late bloomers. The work of Thal and colleagues shows that expressive vocabulary performance may be insufficient to differentiate late talkers from late bloomers; rather, comprehension and gesture performance may be better indicators of potential recovery.

Late bloomers use gesture to serve a compensatory function in communication, and they express more communicative intent via this modality than do truly late talkers. Thal and Tobias (1992) showed late bloomers to produce significantly more communicative gestures, both deictic and symbolic, than truly late talkers. When compared to age- and language-matched groups who were normally developing, late bloomers still produced significantly more deictic gestures and symbolic gestures than language-mates. Symbolic gestures were on par with those of age-mates. In addition, late bloomers used gesture to express two communicative intentions, initiating and responding, at levels that equaled or bettered their age-mates. Truly late talkers used fewer initiating and responding communicative gestures than late bloomers. It appeared that late bloomers, as a group, used gesture early on to compensate for their oral expressive deficits whereas truly late talkers did not.

Specific Language Impairment

The quality of representational gestures produced by children with specific language impairment (SLI) is immature. Just as their language ability parallels younger children, so too does their gesture performance. Children with SLI perform like young motor-matched children on tasks that require them to gesture common actions such as brushing their teeth or cutting paper with scissors. Hill, Bishop, and Nimmo-Smith (1998) compared children with SLI and children with developmental coordination disorder, a disorder in which motor skills are selectively impaired, to age- and motor-matched children. Children with SLI demonstrated accurate representations, although the quality of the gestures differentiated them from age-mates. For example, they demonstrated prolonged use of BPO gesture or produced gestures with spatial or orientation errors. These results suggest an overall immaturity in brain development rather than deviant performance, as these were the types of errors made by younger motor-matched children.

[4] Research by Rescorla and colleagues (e.g., Rescorla, 2002; Rescorla, Dahlsgaard, & Roberts, 2000; Rescorla, Roberts, & Dahlsgaard, 1997) has shown that a proportion of late talkers with good comprehension at intake continue to have weaknesses or delays in language (e.g., morphology, syntax, reading) into the preschool and school-age years.

Despite their immature gesture ability, older children with persistent language impairments eventually come to use gesture to compensate for their expressive language deficits. Evans et al. (2001) examined the use of gesture in 7–9-year-old children with SLI during their explanations of Piagetian conservation tasks. A slightly younger comparison group of typical developers was matched to children with SLI for their performance on conservation judgements (i.e., judging whether two quantities were the same or different). Comparison between the groups was made for their explanations of these judgements. Results revealed that children with SLI and judgement-matched peers gestured at similar rates during their explanations. However, the children with SLI more often expressed information in gesture that was not present in their speech and expressed more advanced knowledge when speech and gesture were combined than in speech alone.

Ellis Weismer and Hesketh (1993) conducted one of the few studies that examined the direct effect gesture has on spoken-word learning in language impaired populations. Novel word acquisition in 8 children with SLI and 8 normally developing peers was investigated under linguistic input conditions that varied systematically in rate of speech (fast, normal, slow), prosodic stress of target words (emphatic, neutral), and the use of visual cues (gestures, no gestures). Only learning under conditions of gesture or no gesture is reviewed here. In the gesture condition, iconic gestures associated with each of the target words conveyed the spatial relations *away from*, *on top of*, and *beside*. Participants were given a single exposure to three target words and then probed for production and comprehension. When gestures accompanied spoken language, better comprehension resulted for both normally developing and language impaired groups. Children with SLI who demonstrated more severe comprehension deficits showed the greatest benefit from gesture cues. No significant effects for learning to produce words were found for the groups, but individual analysis revealed that 3 children with SLI benefited from the gesture condition.

Down Syndrome

Gesture production is a strength for children with Down syndrome (DS) relative to their receptive and expressive language skills (e.g., Abrahamsen, Cavallo, & McCluer, 1985; Caselli et al., 1998; Chan & Iacono, 2001; Singer Harris, Bellugi, Bates, Jones, & Rossen, 1997). Chan and Iacono studied 3 children with DS for 5 months beginning when they were 17 to 19 months of age. Gestural production patterns evinced in normally developing children were also true of these children with DS. Gestures emerged before spoken words, and there was a preference for gesture use. Toddlers with DS produced a variety of gestures, including conventional (e.g., bye-bye), deictic (e.g., pointing), enactive play scheme, expressive (bodily movements to express emotion), and symbolic types (play scheme produced with a substitute object). Conventional, deictic, and enactive naming gestures were most often produced. Failure to produce cross-modal combinations differentiated children with DS from normally developing toddlers.

Caselli et al. (1998) reported that children with DS show significantly larger repertoires of gesture than do normally developing children matched for word comprehension on the MCDI. In fact, between the ages of 10 months and 4 years, expressive vocabulary was similar for children with DS and younger comprehension-matched children. However, for children with DS, development of symbolic communication (e.g., gesturing HOT), pretend play schemes, and gestures that involve symbolic transformation (e.g., using a stick as a spoon) outpaced that of their normally developing comprehension peers. This was particularly true of children with DS who evinced receptive vocabularies above 100 words. Similar findings were reported by Singer Harris et al. (1997). When data of children with DS (12- to 76-month-olds) were compared to normative data of children with similar word comprehension and production levels, the children with DS were at the 77th percentile and 80th percentile, respectively, for gesture production (as measured by the MCDI). A group of children with Williams syndrome (WS) was also studied; whereas DS and WS children were comparable for receptive and productive vocabularies, the overall total number of gestures was greater for children with DS than for those with WS. Also, children with DS more often performed above the 50th percentile for gesture production than would be predicted by chance, whereas children with WS did not.

Children with DS benefit from teaching paradigms that exploit the manual modality. Abrahamsen et al. (1985) enrolled a group of children with DS,[5] developmental ages between 7 and 18 months, in their Toddler Sign Program (TSP). In this program, experimenters provided the children with bimodal input for a target vocabulary at least twice weekly. Parents and teachers, who were also trained, were encouraged to use sign–speech pairs throughout the week. The TSP differed from the gestures discussed in this article because they were linguistic signs borrowed from American Sign Language. The results showed that children with DS were able to use signs more often than words to meet communicative needs.

Gesture provides a clinically useful scaffold for children with DS. Wang, Bernas, and Eberhard (2001) showed that 7-year-olds with DS responded to a teacher's

[5] Normally developing and developmentally delayed groups were also enrolled in the TSP but are not discussed here.

scaffold more often if it contained gesture than if it was spoken. For example, children focused longer on tasks and more often completed tasks successfully when gesture was used alone or in combination with speech. Teachers did not always recognize the advantage of manual scaffolding when teaching their students. Even though the children with DS benefited most from gesture cues, teachers used spoken scaffolds more often. Similarly, in their observation of three children with DS, Chan and Iacono (2001) found mothers sometimes missed their child's initiation of communication via gesture. When mothers did not respond to gestured communication, children did not re-initiate their messages. This suggests that children with language and developmental delays may be missing crucial opportunities for communication and language learning.

Autism

Children with autism present with deviant language development. Their gesture development also deviates from normal (Goodhart & Baron-Cohen, 1993). Children with autism demonstrate impairments in pointing (e.g., see review by Charman, 1998) related to social–emotional, rather than referential, aspects of the behavior (Charman, 1998; Goodhart & Baron-Cohen, 1993). Goodhart and Baron-Cohen studied autistic children with mental ages ranging from 1 to 7 years of age. Ninety percent of them used pointing as a nonverbal naming activity, without eye contact, while looking at a picture book, whereas only 25% of the group used pointing that was combined with eye contact for joint activity. This was significantly different from a language-age/mental-age matched control group who often demonstrated both types of pointing. Therefore, the dissociation in autism appears to fall between referential and social uses of symbols, not between symbol types (e.g., spoken, gestured). However, like other children with language impairments, children with autism can use iconic gestures to augment their communication in conversational contexts (Capps, Kehres, & Sigman, 1998). This evidence is promising, as the manual modality may play a useful role for atypical language learners.

Summary

In summary, gesture and language are developmentally linked in populations of childhood language impairment, much as they are in normal development. An inability to produce play schemes can act as a prognostic indicator of late talking toddlers. Also, attention to the types of gestures a child uses can guide appropriate intervention goal setting. For example, if a young child does not yet have spoken words it is useful to observe, and perhaps facilitate, his or her use of deictic gestures. Work with clinical populations, including children with SLI, DS, and autism, shows that gesture can be used to compensate for limitations in spoken language development and may facilitate language learning. However, clinicians may need to train the adults in a child's environment to exploit alternative modalities such as gesture.

Clinical Implications

Analysis of Children's Gesture Usage May Yield Valuable Diagnostic and Prognostic Evidence

The purpose of this review was to present empirical evidence that attention to gesture in assessing and treating children with language impairments has validity. Gesture development has already been included in several assessments of young children, including the RITLS and MCDI. However, informal observations can also be made in spontaneous and directed play tasks to supplement more formal measures or to screen the need for more formal testing. Table 1 summarizes the timeline of gesture development in children. The development of gesture is robust and emerges in predictable ways. Attention to a child's gestural repertoire will help to locate him or her on this developmental continuum. For example, children who are neither talking nor producing deictic gestures are likely more delayed than children who are pointing to communicate; children who are not yet producing two-word utterances but who are in a stage of bimodal combinations may be on the cusp of emerging spoken combinations. Further, observing a child's spontaneous use of gestures to communicate may provide a prognostic indicator for late talking toddlers. Those who compensate for delays in verbal communication with gesture may be less likely to show persistent language impairments.

Observation of play schemes may be useful as a complement to formal measures of receptive language or perhaps as an alternative to formal measures in children who cannot tolerate direct testing. For example, an inability to imitate sequences of play schemes with contextual props may be a sign of comprehension delays. This will also have implications for prognosis, with better potential outcomes for children who can complete this task. Play schemes can also be observed as an alternative modality of expression to evaluate what a child knows but cannot express verbally. For example, in a play-based context, a child may respond to questions by actions with objects. Play schemes may also serve as a window into a child's semantic knowledge. Observing a child's use of toy combinations (e.g., bottles,

Table 1. A timeline of gesture development.

10–13 months	12–13 months	15–16 months	18–20 months	2–5 years	School age
Showing Giving Pointing Ritualized request	Representational gestures, play schemes	Gesture or vocal preference	Spoken word preference, gesture-plus-spoken combinations	Speech–gesture integration, beat gestures emerge	Mismatched gesture-plus-spoken combinations
POINT predicts first words	First words emerge		Significant increase in words (types, tokens)	Gesture scaffolds spoken expression and comprehension	Mismatches indexes the transitional knowledge state
Other prelinguistic behaviors include eye contact, joint attention, and turntaking	Gesture serves a complementary function to spoken forms		Increased pointing in combination with spoken words	Transition from BPO to IO gestures	Gesture aids in the transition to concept acquisition
			Transition to empty-handed play schemes	Iconic and beat gestures accompany longer utterances	

Note. BPO = body part as object; IO = imaginary object.

babies, pacifiers) can help clinicians understand the child's organization of the world around thematic relationships. In another example, a toddler may mouth play food (pretending to eat) but not dishes and utensils. This may indicate categorization of items, food versus utensils, whereas mouthing all toys may indicate object interactions more typical of infancy.

Gesture May Enhance Progress Toward Language Intervention Goals

A prominent theme in this review bears repeating. That is, empirical findings support the hypothesis that gesture enhances, not hinders, language development. Gesture can be exploited to further a variety of language intervention goals. Take as an example a typical goal such as improving the child's ability to follow verbal directions. It may be useful to show objects first (i.e., identify the intended target of action) before providing the spoken command. In this way, vocabulary demands may be reduced and isolated from other components of the direction-following task. Also, pointing along the path of action while producing the directive can aid follow-through by the child (e.g., "put the apple on the plate" while pointing from the apple to the plate). Iconic gestures highlighting verbs and prepositions (e.g., GIVE ME, IN) are also potential visual cues. Gesture cues can be systematically faded over time as the child becomes more proficient with the auditory modality.

But what about the low functioning child who does not yet comprehend or use gesture? Models of and opportunities for prelinguistic behaviors seem essential for such children. Goals that target deictic showing, giving, and pointing may be useful. Providing a child enriched experiences with object manipulation and turn-taking with objects (i.e., showing, giving, or pointing to the object) may establish prelinguistic behaviors in the child's repertoire. Therapeutic goals that target the establishment and expansion of play schemes, particularly the ability to use symbolic play schemes that transcend object cues, may facilitate symbolic development in both verbal and nonverbal domains. Experiences within a play-based context that build on the child's existing schemes by introducing new ones may be more likely to promote development than relying only on picture naming tasks. For example, if a child bangs her cup on the table the clinician can first engage the child in imitation by also banging the cup. Once the child is engaged in turn-taking of this behavior, the clinician can expand the scheme by modeling drinking from the cup after banging it on the table. Subsequently, narration of the scheme (e.g., "I'm drinking") can integrate spoken language into the activity (for additional experience- and play-based techniques, see Linder, 1993, and Manolson, 1992).

Clinicians should keep in mind that gesture provides children a means of communicating when the spoken modality is not fully developed. Parents often report tantrums and disruptive behaviors that are associated with communication breakdown in late talking toddlers, children with pervasive developmental delays, and others with language impairments. The use of gesture may enable the child to communicate wants and needs, thereby diffusing very frustrating situations for the child and his parents. Parents and other caregivers often need training to recognize and accept these gestural

expressions as communication. In this way, gesture can act as an indirect agent on development. Successful communication and family interactions can build the child's self-esteem as well as language abilities. This can be an important goal for late talking toddlers who demonstrate good prognostic indicators as well.

For older children, too, clinicians should be aware that the gestures that accompany children's speech provide a window into their internal representation of ideas. What is already represented conceptually can be targeted for verbal expression in therapy. For example, if during a semantic enrichment activity a child expresses semantic information in gesture that is not available to spoken expression, the clinician may imitate the child's gesture while providing the spoken translation. Also, children who do not spontaneously gesture can be prompted "show me" so that the clinician can provide a subsequent gesture + verbal model. The clinician can eventually use gestural models to cue the child's verbal recall.

These are just a few of many potential avenues for enhancing language development and communication through gesture. The implications for diagnosis and treatment suggested here are intended to be an impetus for clinicians to begin to problem-solve the ways in which their charges may benefit from the manual modality. As stated, this review article is meant to be an initial step toward bridging the gap between what is considered best clinical practice and empirical findings. Research that experimentally manipulates the efficacy of gesture in diagnosis, prognosis, and treatment is lacking.

Future Directions in Research

To date, very few investigators have examined the effectiveness of gesture as part of diagnostic, teaching, and intervention protocols. Five overarching areas of needed research include (a) validation of gestural indicators of cognitive and language development in clinical populations, (b) efficacy of gesture as part of programs for enhancing language development, (c) expanded investigation of gestural input effects on a variety of word classes as well as on morphosyntax, (d) long-term effects of gesture as an intervention, and (e) how the efficacy of gestured input varies across diverse populations with language impairment (e.g., late talkers vs. children with autism).

Conclusion

This review is meant to provide those who work with young language-impaired populations with additional information about the development and functions of gesture. Gesture and language development are intrinsically linked, and gesture serves many functions as children navigate spoken language acquisition. The clinical utility of gesture in both assessment and intervention seems abundant. Attention to a child's gesture development can provide evidence of symbolic development, aid in prognosis regarding persistent language impairments, and guide developmentally appropriate intervention goals. Observing a child's gestures provides a window into his or her concepts, and these can be targeted for linguistic expression. Preliminary evidence of gesture's utility as a scaffold for language learning has been provided here as well. There is a dearth of evidence on the role of gesture in the development of children with language impairments. This is a most fruitful area for future intervention research.

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