INT. J. LANG. COMM. DIS., 2003, VOL. 38, NO. 2, 179–197

Taylor & Francis
healthsciences

Relationship between gestures and words in children with Down's syndrome and typically developing children in the early stages of communicative development

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(*Received 18 July 2002; accepted 28 October 2002*)

Abstract

Background: Previous research has emphasized the importance of gesture in early communicative development. These studies have reported that gestures are used frequently during the first two years of life and may play a transitional role in the language acquisition process. Although there are now numerous descriptions of the relationship between gesture and the developing language system in typically-developing (TD) children, relatively little is known about the nature and early development of the gesture-language system in children with developmental disorders involving specific profiles of language delay and/or impairment.
Primary objective: The aim of this study is to compare early word and gesture use in children with DS and in typically-developing children to investigate potential differences in the relationship between gestural and verbal communication in early language development.
Methods and Procedures: Ten children from upper-middle class families participated in the study. The five children with DS (3 boys and 2 girls) had an average chronological age of 47.6 months, an average mental age of 22.4 months, and an average language age of 18 months. Each child with DS was matched to a typically developing child on the basis of gender, language age, and observed expressive vocabulary size. Children were videotaped for 30 minutes as they interacted spontaneously with their mothers. All communicative and intelligible gestures and words produced by the children were transcribed from the videotapes. Data analyses focused on: a) overall production of gestures and words (i.e., gesture and word tokens); b) the size of children's gestural and verbal repertoires (i.e., gesture and word types); and c) production and informational content of gesture-word combinations.
Main outcomes and results: Although children with DS had significantly smaller

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International Journal of Language & Communication Disorders
ISSN 1368-2822 print/ISSN 1460-6984 online © 2003 Royal College of Speech & Language Therapists
http://www.tandf.co.uk/journals
DOI: 10.1080/1368282031000062891

gestural repertoires than their language age-matched peers, there was no reliable difference between the two groups in the overall use of gesture. In addition, with DS produced two-element combinations (primarily gesture-word combinations) and did so at a rate comparable to that observed among their TD counterparts. However, no two-word combinations were observed among children with DS, and there were also group differences in the information contained in children's gesture-word combinations.

Conclusions: Taken together, these findings suggest that in addition to the well-documented global delays in early communicative development, children with DS may exhibit additional pockets of delay, specifically in making the transition from one- to two-word speech. Results are further discussed in terms of their implications for understanding the organization of the developing gesture-language system and for the assessment of gesture in young children with communicative delays and disorders.

Keywords: gestures, early development, Down's syndrome, communication, language.

Introduction

In typically developing (TD) children, spoken language and gesture develop in parallel during the initial stages of communicative development. First gestures and first words emerge at around the same time (e.g. Caselli 1990); children initially add both words and gestures to their communicative repertoires (e.g. Iverson *et al.* 1994); and achievements in gesture predict progress in verbal language abilities (Camaioni *et al.* 1991, Capirci *et al.* 1996). Thus, for example, onset of pointing is a reliable predictor of the appearance of first words (Bates *et al.* 1979), and the production of gesture–word combinations that convey two distinct pieces of information predicts the emergence of two-word speech (Butcher and Goldin-Meadow 2000). In addition, gesture is a moderately sensitive index of the likelihood that early language delay will be temporary (Thal *et al.* 1991, Thal and Tobias 1992).

Although there are now numerous descriptions of the relationship between gesture and the developing language system in TD children, relatively little is known about the nature and early development of the gesture–language system in children with developmental disorders involving delayed or deviant language. Studies of such populations would contribute to our understanding of the link between gesture and language by providing information about the development of gesture in the face of specific profiles of language delay and/or impairment. Questions include: What is the role of gesture in relation to language when language is developing atypically?; and How do patterns of gesture use vary in relation to specific profiles of language impairment?

The present study begins to address these questions by focusing on the gesture–language relationship in young children with Down's syndrome (DS), a genetically based neurodevelopmental disorder characterized by a delay in language development beyond that which would be predicted by general cognitive delays (e.g. Chapman 1995, Vicari *et al.* 2000). Although language development is delayed, it appears to follow the typical path in children with DS. However, language abilities are not uniform: comprehension is usually at a level consistent with general cognitive abilities, but the development of expressive language appears to proceed at an even

slower pace relative to comprehension and to TD children (Beeghly and Cicchetti 1987, Miller *et al.* 1992).

There is now much work documenting the nature of the language profile displayed by children with DS. However, relatively few studies have examined the relationship between gesture and developing language in these children; and most of these studies have focused exclusively on pointing (e.g. Mundy *et al.* 1989, 1995, Franco and Wishart 1995). Recently, however, two studies have examined production of a wider range of gestures in children with DS using data obtained from parent questionnaires. In one, the MacArthur Communicative Development Inventory (CDI; Fenson *et al.* 1993) was administered to parents of 39 US children with DS (Singer Harris *et al.* 1997). These authors reported that the children with DS had significantly larger gestural repertoires relative to groups of TD children matched on the basis of comprehension and production vocabulary size respectively.

In a second study, Caselli *et al.* (1998) administered the Italian counterpart of the Words and Gestures form of the MacArthur CDI, the Primo Vocabolario del Bambino (PVB; Caselli and Casadio 1995), to the parents of 40 Italian children with DS. Comparing the children's scores on the Actions and Gestures section of the PVB with those of a group of TD children from the normative sample matched on the basis of comprehension vocabulary size, they reported that the children with DS had significantly larger gestural repertoires than the comparison group. However, this difference only emerged at higher comprehension levels, i.e. among children with comprehension vocabularies above 100 words.

Based on these results, both groups of investigators concluded that children with DS exhibit enhanced gestural abilities relative to TD children. However, this interpretation is limited by the fact that inventories such as the PVB and CDI only provide information about whether or not a particular behaviour is in a child's repertoire; the data cannot indicate the *frequency* with which children produce gestures when communicating. This issue was addressed in a qualitative study of word and gesture production by three children with DS during toy play with their mothers (Caselli *et al.* 1997). Mothers were also asked to complete the PVB, and the scores were used to establish a language age for each child. The size of the word and gestural repertoires and the frequency of word and gesture production by children with DS during the session were compared with group means obtained from a group of TD children whose chronological ages matched the language ages of the children with DS and who were observed in a comparable setting. Results indicated that the gestural repertoires of all three children with DS were larger than those of the TD children, but that only one of the children with DS produced gestures at a rate above the comparison group mean.

Although these findings are suggestive, they are somewhat difficult to interpret, especially in light of recent work indicating that there may not be a gestural advantage among children with DS during the prelinguistic period (Chan and Iacono 2001). At issue here is the fact that comparing children with DS of a given language age to TD children of corresponding chronological ages is based on the assumption that language and chronological ages are roughly equivalent among TD children (e.g. that TD 16-month-olds have the language skills of 16-month-olds). In light of the high degree of individual variability in the relationship between chronological and language age that has been observed in children in this age range (Fenson *et al.* 1994), however, this may not be warranted. A more precise matching procedure would be preferable.

The present study was designed to employ such a procedure in comparing the use of gesture and language by children with DS during communicative interaction with their mothers to that of a group of TD children. We sought to address the limitations of previous studies in two ways. First, we examined gesture use in terms of *both* repertoire size and frequency of production. Second, children with DS were individually matched to TD comparison children on the number of different words produced during a 30-min observation. This was done in an effort to ensure greater similarity in the productive language abilities of children with DS and TD children.

An additional goal was to describe the way in which children with DS use gesture in relation to words. Previous work indicates that TD children produce gesture–word combinations (e.g. POINTING at a cup while saying 'cup') before the onset of two-word combinations (e.g. Goldin-Meadow and Morford 1990, Capirci *et al.* 1996). And as previously described, the age at which children first produce supplementary gesture–word combinations (in which the gesture and the word convey different pieces of information about the referent, e.g. POINTING at a cup while saying 'mommy') is positively correlated with the age of onset of two-word combinations (e.g. Butcher and Goldin-Meadow 2000). To date, however, these phenomena have not been explored in children with DS. Thus, in addition to analysing the verbal and gestural repertoires of children with DS and TD comparison children and the frequency with which words and gestures are produced, we also examined the production of two-element combinations and the informational relationship between gestures and words produced in combination. Our aim was to determine whether gesture and language development in children with DS proceeds in a similar way as for TD children, or whether gesture production may be influenced by DS children's specific difficulties with expressive language.

Methods

Participants

Participants in this study were five children with DS and five TD children. All the children came from upper-middle class families living in the Rome area and were native speakers of Italian. The five children with DS (three boys, two girls) ranged in age from 37 to 56 months ($M = 47.6$, SD = 7.96) and had mental ages (based on scores from the Brunet–Lézine Scale; Brunet and Lézine 1955/1967) between 18 and 27 months ($M = 22.4$, SD = 4.16). The Brunet–Lézine scale assesses the development of children from 1 to 36 months of age in four domains: postural control and motoricity; language; oculomotor coordination or adaptation to objects; and social and personal relationships.

All the children had been receiving regular therapy beginning at age 2. Therapy sessions for all children focused exclusively on cognitive and motor abilities; language abilities were not targeted by the therapists. Therapeutic activities primarily involved enrichment of symbolic and representational abilities (e.g. construction and elaboration of symbolic play episodes, puzzle assembly, completion of verbal and non-verbal sequences) and enhancement of psychomotor skills (e.g. games involving rhythmic motion, games emphasizing body scheme awareness and spatial exploration). None of the children with DS received speech/language therapy or had any exposure to sign language or gesture training. At the time of the study, they attended therapy sessions twice a week at the clinic where the observations

were conducted. Three of the children were firstborn, one was secondborn and one was thirdborn.

The five TD children (three boys, two girls) were selected from a larger sample of children described in previous work on communicative development at 16 and 20 months (Iverson *et al.* 1994, Capirci *et al.* 1996). The 16-month observation was used for two children; data from the 20-month observation were used for the other three children. One child was firstborn, three children were secondborn and one was thirdborn.

Matching DS and TD children

Our primary concern in identifying a TD comparison group for the DS children was that the two groups be at comparable levels of productive language ability. Because no data on mental or language age were available for the TD children, and to maximize comparability, children with DS were individually matched to TD children using the following four-step procedure. First, parents of children with DS completed the PVB (Caselli and Casadio 1995), and a total vocabulary score (total number of words produced, as reported by parents) was calculated for each child with DS (for information regarding the validity of this instrument for use with parents of children with DS, see Miller *et al.* 1992, Caselli *et al.* 1998). Second, each child's vocabulary score was compared with the PVB standardization data and the child assigned a language age equal to that at which 50% of the normative sample attained that score. Thus, for example, child C (with DS) had a total vocabulary score of 57 words on the PVB. This falls near the score for 20-month-old children at the 50th percentile in the normative sample (53 words). Thus, the child was assigned a language age of 20 months. Similarly, child A had a total vocabulary score of 18 words on the PVB. He was assigned a language age of 16 months because 18 words is the median number of words produced by 16-month-olds in the normative sample. Third, subgroups of TD children whose gender and *chronological age* generally corresponded to the gender and *language age* of each child with DS were identified.[1] Finally, from within each of these subgroups of TD children, that child whose observed vocabulary size (i.e. the number of *different* words, excluding repetitions, produced in the course of the observation) matched that of the child with DS as closely as possible (within six words) was identified as the child's individual match. Observed vocabulary size was chosen as the final matching criterion because it has been shown to be highly correlated with children's total scores on parental vocabulary checklists (e.g. the MacArthur CDI; Fenson *et al.* 1994).

In sum, children in the TD and DS groups were individually matched on the basis of: (1) gender; (2) correspondence between the TD child's chronological age and the DS child's language age; and (3) observed vocabulary size. Preliminary analyses confirmed that the groups were not significantly different either on chronological/language age (Mann–Whitney U-test = 12, n.s.) or observed vocabulary size ($U = 10.5$, n.s.). Information about the children with DS and the children in the TD comparison group is summarized in table 1.

Procedure

Children in both groups were videotaped with their mothers for 30 min during free play with toys. Mothers were encouraged to play with the child as normal. Sessions

Table 1. Characteristics of Down's syndrome and typically developing children.

Child	Sex	Chronological age (months)	Mental age (months)	Language age (months)	Observed word vocabulary size
Children with Down's syndrome					
A	M	37	18	16	7
C	M	56	24	20	17
G	F	44	27	20	14
I	F	55	25	17	22
V	M	46	18	17	13
Mean		47.6	22.4	18.0	14.6
SD		7.95	4.16	1.87	5.5
Typically-developing children					
D	M	20			5
Lu	M	20			20
Ld	F	16			13
C	F	16			24
F	M	20			19
Mean		18.4			16.2
SD		2.19			7.4

for the children with DS took place in the clinic room where their twice-a-week therapy sessions took place; this setting was familiar and comfortable for mothers and children. Sessions for the TD children took place in their homes. Before viewing the tapes for coding purposes, they were previewed to ensure that the interaction had proceeded smoothly and that both the parent and the child had been active participants in the session.

Coding

All the children's communicative and intelligible gestures and words were transcribed from the videotapes. The criterion for coding a gesture or word as communicative was the presence of clear evidence of effort to direct the listener's attention (e.g. through eye gaze, vocalization or repetition of the signal). Children were given credit for having produced a word if the vocalization sounded like an Italian word (e.g. 'cane' <dog>; 'più' <all gone>), or if a sound pattern was used consistently to refer to the same referent (e.g. 'baubau' <dog>; 'pù' <all gone>). Movements were coded as gestures if they were communicative and did not involve direct manipulation of an object or person. With the exception of SHOWING (see below), actions on objects were excluded. Utterances were also coded according to whether they contained one or more elements, and those consisting of multiple elements were further described in terms of their structure (i.e. gesture + word, gesture + gesture, word + word).

Gestures were classified into one of two categories. *Deictic gestures* indicate referents in the immediate environment, and their meaning is thus context bound. Three types of deictic gestures were coded: (1) SHOWING, or holding up an object in the listener's potential line of sight; (2) POINTING, or extending the index finger in the direction of a referent; and (3) RITUALIZED REQUESTS, or abbreviated reaches

toward a desired object, usually accompanied by repeated opening and closing of the palm and gaze alternation between the listener and the desired object.

Representational gestures

Representational gestures stand for specific referents, and thus their basic semantic content does not change appreciably with the context (e.g. raising the arms high for TALL; waving the hands for TOO HOT). Also included in this category were culturally defined gestures such as nodding the head YES, waving BYE-BYE and rotating the index finger on the cheek for GOOD.

Words were classified into two categories. *Deictic words* are personal, possessive, and demonstrative pronouns and adjectives and locative expressions (e.g. 'I', 'yours', 'this', 'there'), words whose meaning is determined by their context of use. All other word types were classified as *representational words* (e.g. nouns, verbs, adverbs).

Reliability

Intercoder reliability was assessed by having two trained coders independently transcribe a 10-min segment from each of the observations of the children with DS and all observations of TD children. For DS observations, mean per cent agreement was 97% for identification and classification of gestures and 100% for identification and classification of words. For TD children, previously calculated reliabilities were 80% for identification of communicative words and gestures and 95% for classification of words and gestures (Iverson *et al.* 1994, Capirci *et al.* 1996).

Results

This study was designed to examine the relationship between language and gesture in children with DS and to compare it with that observed in TD children at similar levels of language development. Because of the small sample sizes and high degree of individual variability, data analyses were carried out using non-parametric techniques (Siegel 1956).

We begin by describing word and gesture production by children in both groups, first in terms of types (i.e. number of different words and gestures) and then in terms of tokens (i.e. number of items produced, including repetitions). Next, we present data on the structure of children's two-element combinations and conclude with a description of the informational content conveyed by these combinations.

Word and gesture production

Types

The mean numbers of deictic and representational gesture and word types produced by children in the two groups are shown in figures 1a and b, respectively.

With regard to the two categories of gesture types, all three deictic gestures (SHOWING, REQUESTING, POINTING) were produced by all of the TD children and by three of the five children with DS (one child did not produce SHOWING; a second did not produce SHOWING or REQUESTING). However, group differences became evident when representational gesture types were examined. On average, DS children had fewer representational gestures in their repertoires relative to TD children

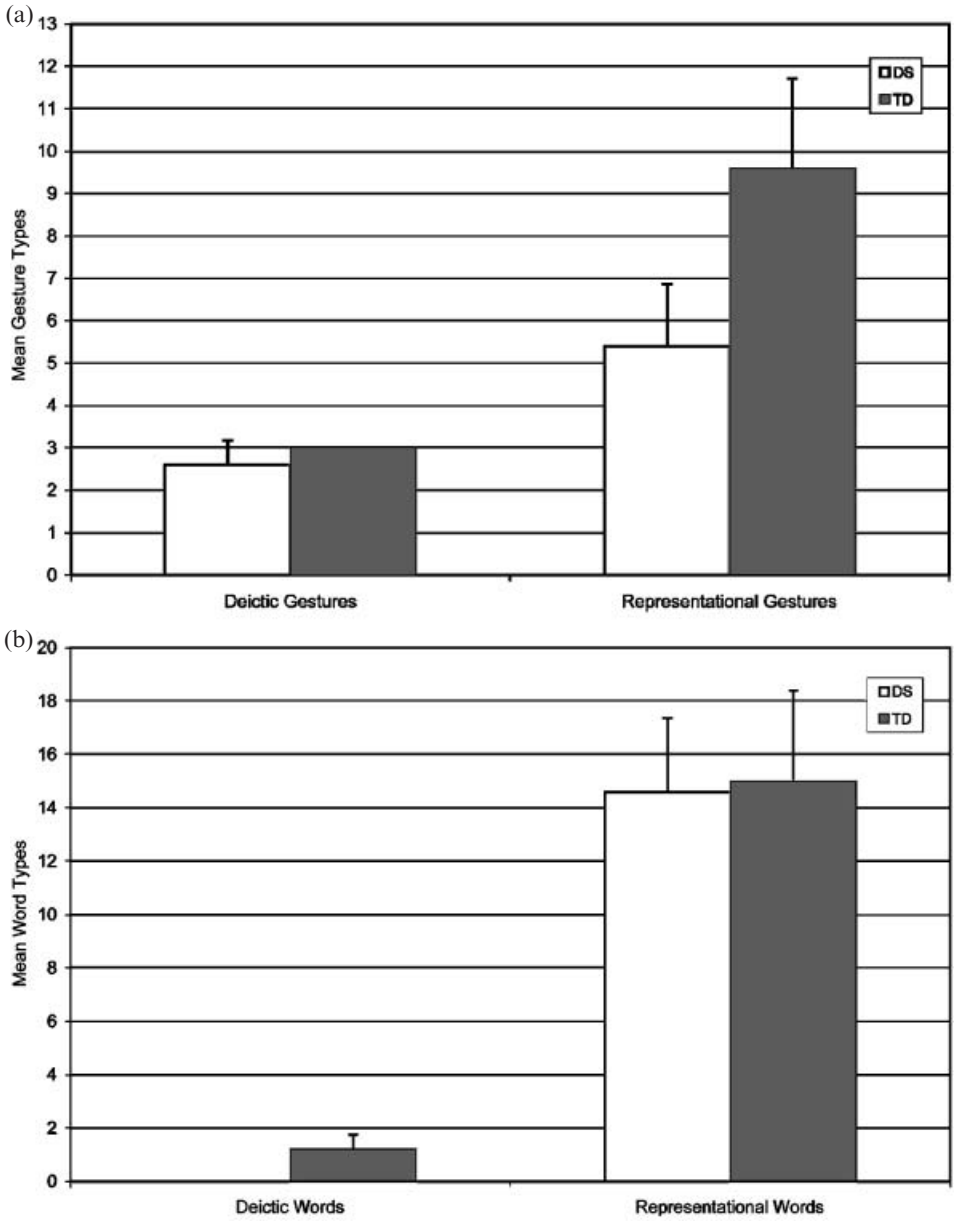

Figure 1. (a) Gesture types produced by Down's syndrome and typically developing children. (b) Word types produced by Down's syndrome and typically developing children.

($M_{DS} = 5.4$, SD = 2.86; $M_{TD} = 9.6$, SD = 4.22). This trend was confirmed by an examination of individual children's patterns of production. Children in each group were classified according to whether the size of their representational gesture repertoires fell above or below the mean for the other group. This analysis revealed that the number of representational gestures in all five of the TD children's repertoires fell above the mean for the DS group, while only one of the children

with DS fell above the mean for TD children, a distribution significantly different from that expected by chance ($p < 0.04$, Fisher's exact test).

Although, as previously described, children were matched on the basis of the number of total word types produced in the session, a group difference nevertheless emerged in the production of deictic words. Specifically, deictic words were entirely absent from the vocabularies of all of the children with DS, but they were produced by four of the five TD children ($M = 1.20$, SD = 1.10; $U = 2.5$, $p < 0.02$).

Tokens

Children's overall communication was assessed by calculating the numbers of gesture and word tokens produced by each child in the course of the observation. The total number of communications produced during the 30-min session (i.e. word tokens + gesture tokens) was relatively comparable across the two groups (M_{DS} = 104.60, SD = 35.93; M_{TD} = 111.0, SD = 55.48; $U = 12$, n.s.).

We then examined gestures and words separately to determine whether there were differences in the production of deictic and representational items. The mean numbers of deictic and representational gesture and word tokens produced by children in the two groups are shown in figures 2a and b, respectively.

Looking first at gesture production, the overall amount of gesture produced by children in the two groups was fairly comparable (M_{DS} = 58.80, SD = 29.20; M_{TD} = 66.0, SD = 47.72; $U = 10$, n.s.). In addition, children with DS did not differ significantly from their TD counterparts in use of deictic (M_{DS} = 33.2, SD = 20.5; M_{TD} = 42.6, SD = 24.75; $U = 9$, n.s.) or representational gestures (M_{DS} = 25.6, SD = 19.2; M_{TD} = 23.4, SD = 24.4; $U = 12$, n.s.).

With regard to word production, the total numbers of word tokens were similar across the two groups (M_{DS} = 44.2, SD = 13.31; M_{TD} = 45.0, SD = 31.99). The vast majority of words produced by children with DS and by TD children were representational (M_{DS} = 44.2, SD = 13.31; M_{TD} = 41.0, SD = 29.39). Consistent with the findings for word types described above, deictic words were produced infrequently by TD children ($M = 4.0$, SD = 5.79), but they were not observed at all in the production of children with DS ($U = 2.5$, $p < 0.02$).

To summarize the findings thus far, the children with DS and the TD children in this study were similar in terms of the size of their communicative repertoires and the total amount of communication produced in the 30-min sessions. There was no indication of a 'gesture advantage' for children with DS at this stage in communicative development, either with regard to the size of the gestural repertoire or the overall production of gesture. Although children with DS tended to have *smaller* representational gesture repertoires, they produced gesture with comparable frequency to TD children. Finally, the children with DS lagged behind their matched TD counterparts in the production of deictic words.

Production of two-element combinations

We now turn to data on production of two-element combinations, focusing first on the types of elements (verbal or gestural) incorporated into these combinations, and then on their informational content.

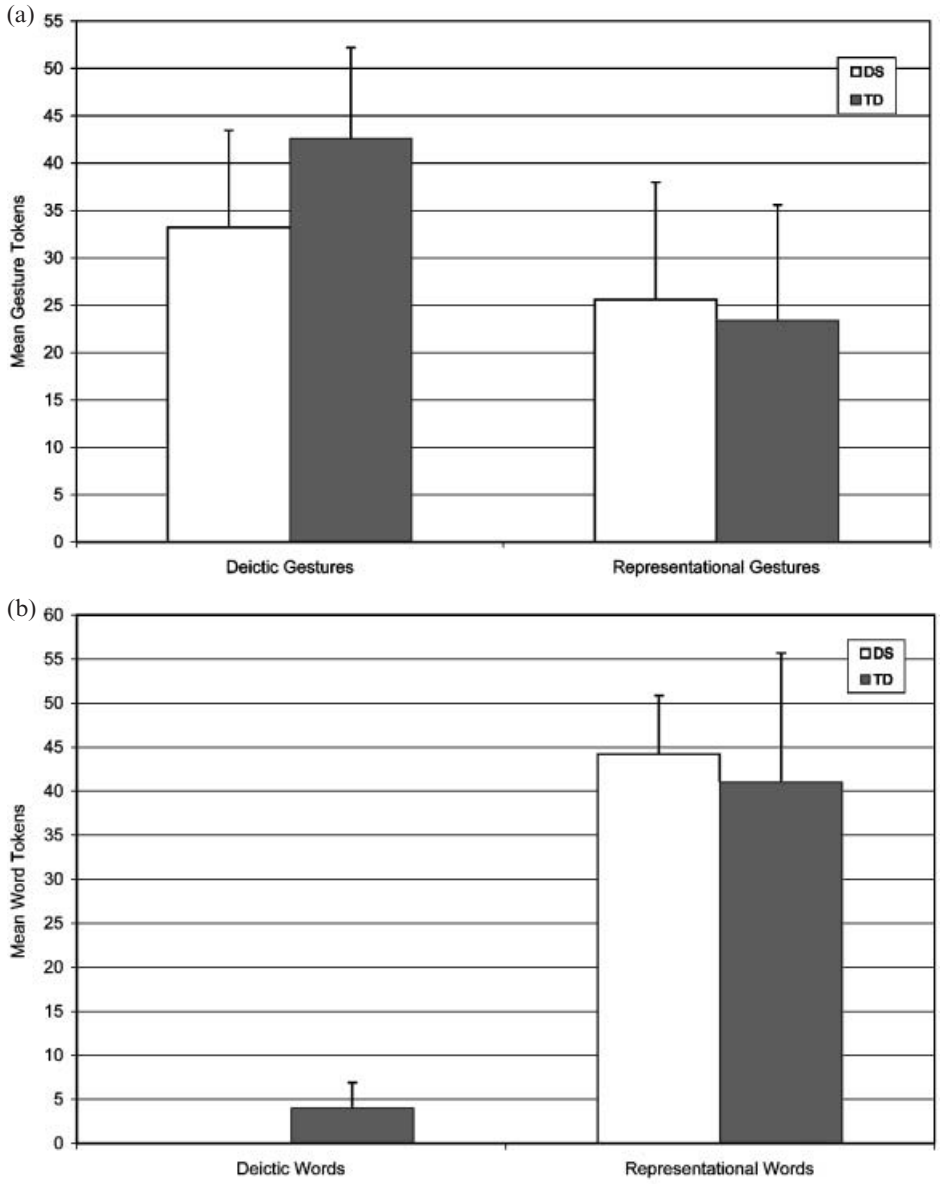

Figure 2. (a) Gesture tokens produced by Down's syndrome and typically developing children. (b) Word tokens produced by Down's syndrome and typically developing children.

Combination structure

Two-element combinations were defined as instances in which two communicative elements were produced simultaneously or in immediate sequence (with no intervening pause or relaxation of the hand). All combinations were further classified according to the types of elements they contained (i.e. two gestures, a gesture and a word or two words). Figure 3 presents the mean numbers of combinations in each category produced by children in the two groups.

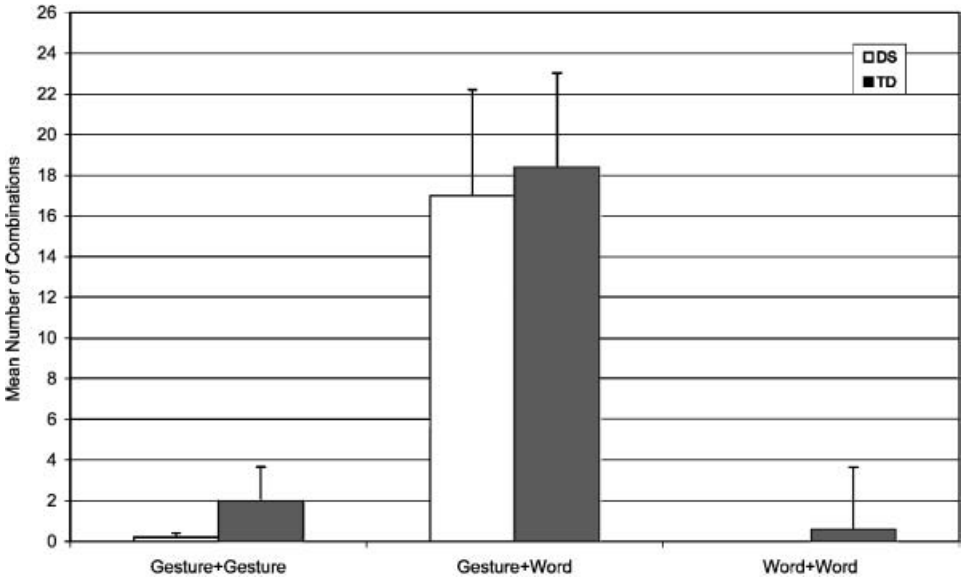

Figure 3. Combination structures produced by Down's syndrome and typically developing children.

Gesture + word combinations (e.g. POINT to flowers + 'flowers'; GOOD [with index finger rotated on the cheek] + 'good') were observed in the production of all of the children in both groups. As is apparent in the figure, this type of combination was also the most frequently produced ($M_{DS} = 17.0$, SD = 11.66; $M_{TD} = 18.4$, SD = 15.98). Relatively few gesture + gesture combinations were observed (e.g. POINT to a bottle of water + POINT to a cup; POINT to toy + head nod YES); they were produced by 1 child with DS and 3 of the TD children. Finally, while three of the TD children each produced a single word + word combination (e.g. 'allgone' + 'water'), this structure was not observed in any of the children with DS.

Informational content

We next examined the information conveyed in children's gesture + word combinations. We focused specifically on these combinations because they accounted for almost all of the two-element combinations produced by children in both groups.

For this analysis, gesture + word combinations were divided into three categories based on the informational relationship between the component elements (Goldin-Meadow and Morford 1985, Capirci *et al.* 1996). *Equivalent* combinations consisted of two representational elements that referred to the same referent and conveyed the same meaning (e.g. headshake NO + 'no'; wave BYE-BYE + 'bye').

In *complementary* combinations, the gestured and spoken elements also referred to the same referent. However, these combinations differ from equivalent combinations in that they typically consist of a deictic element (gestural or verbal) that provides non-redundant information by singling out the referent indicated by the accompanying representational element (e.g. POINT to flowers + 'flowers'; head nod YES + 'that'). Combinations of two deictic elements, which were less frequently observed, were also included in this category (e.g. SHOW toy car + 'this'). In this

case, the deictic gesture (SHOW) provided more precise information about the toy referred to by a relatively ambiguous demonstrative ('this').

Supplementary combinations differed from the other two combination types in that each of the combined elements (which could be either deictic or representational) added information to the other one. Thus, these combinations could refer to either a single referent (e.g. POINT to picture of bird + 'sleep'; ALL GONE + 'water') or to two distinct referents (e.g. POINT at cup + 'mommy'; POINT to game + 'you').

The mean numbers of gesture + word combinations in the three categories are shown for both groups in figure 4. As is apparent, the distribution of combinations across categories varied by group. On average, children with DS produced approximately twice as many equivalent but half as many complementary combinations as their TD counterparts, although neither of these differences was statistically reliable (equivalent $M_{DS} = 11.4$, SD = 13.09; $M_{TD} = 5.2$, SD = 3.70; complementary $M_{DS} = 5.2$, SD = 6.8; $M_{TD} = 10.4$, SD = 10.36). Supplementary combinations were rarely observed among children with DS; they were produced by four of the five TD children ($M_{DS} = 0.6$, SD = 0.89; $M_{TD} = 5.6$, SD = 6.8). Inspection of individual children's production of supplementary combinations revealed that all of the children with DS fell below the TD group mean, while four of the TD children fell above the mean for the DS group ($p < 0.05$, Fisher's exact test).

In sum, children with DS produced two-element combinations and did so at a rate comparable with that observed among their TD counterparts. The majority of combinations produced by children in both groups consisted of a single gesture and a single word. Whereas some of the TD children appeared to have reached the transition to two-word speech, as evidenced by production of a few two-word utterances in the course of the observation, none of the children with DS was observed to combine two words. There were also group differences in the information contained in children's gesture–word combinations. When children with DS combined two elements, they tended to be informationally equivalent; very few

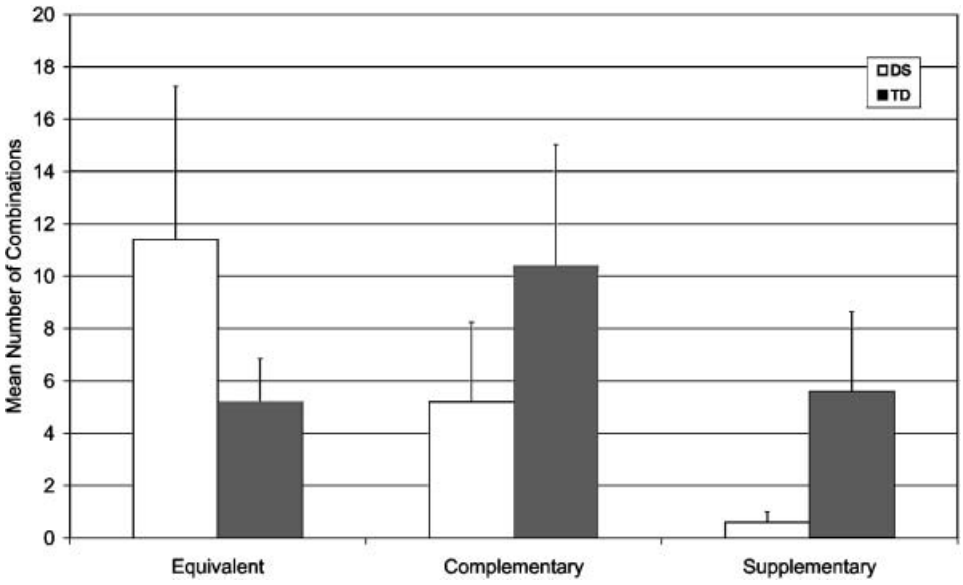

Figure 4. Information conveyed in gesture + word combinations.

combinations conveyed two distinct, supplementary pieces of information, and these were produced by only two children. In contrast, most of the TD children's combinations were complementary, and supplementary combinations were observed in all but one of the children.

Discussion

This research was designed to examine the relationship between gesture and language in children with DS during the early stages of communicative development. The primary goal was to compare the relative use of gesture and speech and the relationship between gestural and verbal communication in the spontaneous production of children with DS with that of a group of TD children matched on the basis of productive language. Findings indicated that while DS and TD children were generally similar in the size of their gestural repertoires and the overall use of speech and gesture to communicate, the two groups differed in the production of deictic words and in the informational content conveyed in gesture–word combinations. Following a discussion of these findings, we turn to a second, unanticipated result of this study—the absence of a 'gestural advantage' in DS relative to TD children, a finding inconsistent with other reports in the literature (e.g. Singer Harris *et al.* 1997).

Relationship between language and gesture in children with DS

Our findings provide evidence for a tight link between gesture and language in children with DS, a link that holds despite specific difficulties with some aspects of expressive language characteristic of this population. Relative to their language-matched TD peers, children with DS produced similar amounts of gesture and speech during the course of the 30-min play session and combined single gestures with single words at comparable frequencies. In short, the overall use of gesture in the DS group was entirely consistent with what would be expected on the basis of their level of language production rather than on the basis of their greater chronological age.

Despite these similarities, however, there were two striking differences between the two groups. The first was in production of deictic words. Although the TD children did not produce many deictic word tokens overall, they were present in the vocabularies of four of the five children. In contrast, no child with DS produced deictic words. The use of deictic words may pose a particular challenge to children with DS at this stage of development because of their unique relationship to their referents. For most representational words, it is possible to establish a one-to-one mapping between a particular word and its referent class (i.e. 'cat' refers to furry, four-legged animals that meow). Moreover, this mapping holds across variations in context: 'cat' always refers to the same referent class. Deictic words differ on both of these dimensions: they do not have fixed referents, and their meaning is entirely context dependent. Thus, 'that' can refer to a potentially infinite set of referents, and its meaning shifts constantly, even in the course of a single interaction.

Our results and those of others (e.g. Franco and Wishart 1995) indicate that children with DS do not appear to have general difficulties with deictic reference, as indicated by their extensive use of communicative pointing and other deictic gestures. It may be the case that relative to the link between deictic words and

their referents, the link between a deictic gesture and its referent is more concrete; the gesture is physically linked to the referent (either through direct auditory and/or visual contact or orientation), and as long it is held, serves as a reminder of the identity of the referent. The relationship between deictic words and their referents, in contrast, is highly abstract (i.e. there is no physical link between word and referent) and ephemeral, and because of this, children with DS may require more time to master this link before deictic words begin to emerge.

The second group difference was in the distribution of gesture–word combinations across informational categories. When children with DS combined gestures and words, they did so primarily in an informationally redundant fashion. The vast majority of combinations produced by these children, in other words, were equivalents: combinations in which the two representational elements referred to the same referent and conveyed the same meaning (e.g. headshake NO + 'no'; wave BYE-BYE + 'bye'). Complementary combinations, in which a gesture is typically used to single out a referent that is being simultaneously labelled in speech (e.g. POINT to flowers + 'flowers'; head nod YES + 'that') were uncommon; and supplementary combinations, in which combined elements add information to one another (e.g. POINT to picture of bird + 'sleep'; ALL GONE + 'water') were virtually non-existent. TD children, on the other hand, made wide use of both complementary and supplementary combinations. Since complementary and especially supplementary combinations are cognitively more sophisticated (i.e. convey greater amounts of information) than equivalent combinations, this suggests that children with DS may be somewhat delayed in the production of combinations.

This interpretation is further supported by data concerning supplementary gesture–word and two-word combinations. Supplementary gesture–word combinations are a reliable predictor of the emergence of two-word utterances (Butcher and Goldin-Meadow 2000). In a longitudinal study of children at 16 and 20 months of age, Capirci *et al.* (1996) reported that at both ages, children who produced two-word combinations also produced supplementary combinations. There were, however, some children who produced supplementary combinations but no two-word utterances at 16 months; all were observed to combine words at the 20-month observation. Thus, the presence of supplementary gesture–word combinations appears to signal the imminence of the transition to two-word speech. In contrast to production-matched TD comparison children who produced supplementary and some two-word combinations, the children with DS produced very few supplementary and no two-word combinations. Taken together, the prevalence of informationally equivalent gesture–word combinations, the relative absence of supplementary gesture–word combinations, and the lack of two-word combinations among the children with DS is suggestive of a specific delay in the transition from communication about a single referent to communication about two referents through gesture–word combinations and later in two-word utterances.

'Gesture advantage' in children with DS

An unexpected finding of this study was that children with DS did not make more extensive use of gesture than TD children; indeed, their repertoires of representational gestures were significantly *smaller* than those of language-matched comparison children. Although our findings are based on a relatively small sample size and must therefore be interpreted with caution, they are nevertheless in a direction

opposite to those reported in other investigations of early communicative development in children with DS (e.g. Caselli *et al.* 1997, 1998, Singer Harris *et al.* 1997). These studies have reported that relative to a variety of different comparison groups, children with DS make enhanced use of the gestural modality for communicative purposes, a finding often interpreted as suggesting that children with DS compensate for poor productive language abilities through greater production of gestures. While it is possible that a 'gesture advantage' is apparent in the spontaneous communication of children with DS at a later point in development (see below), the data reported here indicate striking similarities between young children with DS and TD children in the use of gesture during spontaneous communication.

There are three possible explanations for the discrepancy between our findings and those previously reported in the literature. The first has to do with methodological differences in the assessment of gesture. In this study, we examined gestural communication in the context of a 30-min free play session with a primary caregiver. Thus, we could assess children's gesture use in terms of *both* the size of the gestural repertoire *and* the frequency with which gesture was produced during the observation. In other studies, however, parental report measures such as the CDI and the PVB have been employed (Singer Harris *et al.* 1997, Caselli *et al.* 1998). Both questionnaires contain a section entitled 'Actions and Gestures' that contains items regarding specific gestures, action production and imitation of adult actions. While these measures have the advantage of providing a picture of children's communicative skills beyond that which can be obtained during a relatively brief observation period, they are limited in one important respect. The standard definition of communicative gestures employed by most researchers (e.g. Butcher and Goldin-Meadow 2000) specifies two primary criteria that must be satisfied if an action is to be considered a gesture: (1) the signal must be accompanied by effort to attract the attention of the communicative partner (e.g. through eye contact); and (2) the signal must not involve direct manipulation of an object. Unfortunately, the number of items regarding gestures such as pointing, showing and waving bye-bye is relatively small. The majority of the behaviours included in the CDI and PVB are social routines (e.g. pattycake, peekaboo), actions with objects (e.g. throwing a ball, eating with a spoon), pretend play (e.g. rocking a doll, dressing it) and imitation (e.g. putting on glasses, pretending to drive), behaviours that would be specifically excluded from consideration as communicative gestures in most studies of spontaneous communication since they do not meet criterion (2). Further, no information on the status of the behaviours with respect to criterion (1) can be obtained from these measures.

Thus, the 'gesture advantage' in children with DS reported by Singer Harris *et al.* (1997) and Caselli *et al.* (1998) could be explained by the presence of a relatively greater number of behaviours related to routines, object play, pretending and imitation in the repertoires of DS relative to TD children. In other words, children with DS may not have larger repertoires of *communicative gestures* than comparison children; they may instead have a larger repertoire of other behaviours that are subsumed under the category of gestural behaviours on the CDI and PVB. Some support for this possibility is provided by Caselli *et al.*'s (1998) observation that compared with comprehension-matched TD children, children with DS produced a higher percentage of the pretend play actions listed on the PVB. Such behaviours were excluded from the present study, and this may explain our failure to find evidence of a gesture advantage, at least with respect to the size of the gestural repertoire.

A second explanation has to do with the nature of the measures used to match TD children to children with DS. In both Singer Harris *et al.* (1997) and Caselli *et al.* (1998), children with DS were matched to TD children on the basis of a single measure (CDI or PVB) assessing level of word comprehension. One problem with this approach is that neither of these measures assesses the child's ability to comprehend words in a context-independent fashion. For example, when parents indicate that their child understands the word 'cat' on the CDI, no information is available about whether the child's comprehension of the word is highly context bound (e.g. only apparent in the presence of the family cat) or whether it is more decontextualized (e.g. evident even when the cat is not present in the room). To the extent that children with DS may require contextual support for comprehension in ways that TD children do not, this procedure may result in groups that are not, in fact, at the same levels of word comprehension. Any such differences could account for the reported differences in gestural behaviour.

In the present study, this problem was addressed by matching TD children individually to children with DS on the basis of two relatively precise measures: (1) correspondence between the chronological ages of TD children and the language ages of children with DS; and (2) observed expressive vocabulary size. Moreover, expressive vocabulary was measured in a single context that was relatively similar for both groups of children. Using this procedure, we observed a close relationship between communicative gestures (those that met our coding criteria) and words.

A final explanation may be that the gesture advantage for children with DS emerges somewhat later in communicative development. There is ample evidence that the gap between cognition and language (especially language production) skills becomes progressively wider with development among children with DS (Smith and von Tetzchner 1986, Chapman 1995, Fabbretti *et al.* 1997). For example, older children with DS perform below their mental ages on measures of morphosyntax and phonology, while younger children with DS do not differ from mental age-matched TD children (Fowler 1990). It may be the case that at the stage of communicative development observed here, there is no gesture advantage for children with DS. Gesture and language may indeed be developing in parallel at this stage in development (Chan and Iacono 2001). However, with increasing cognitive skill and social experience and progressively greater difficulty with productive language, children with DS may be able to make use of actions produced in the context of object-related activities and social routines as communicative gestures. Once this happens, they may begin to develop relatively large repertoires of gestures and make enhanced use of gesture to compensate for poor productive language, particularly if they are encouraged to do so through the provision of sign language input (for a review, see Abrahamsen 2000).

Some support for this possibility comes from ongoing work on language–gesture relationships in older children with (DS) and TD children (Capirci *et al.* 2001). The children with DS in this study have slightly higher mental ages and more complex language than the children described here. Preliminary analyses indicate that the children with DS produced approximately four times as many gestures overall and made use of a larger repertoire of gestures in a 20-min free play session than mental age-matched TD children. Thus, gesture and language may develop in tandem during the early stages of communicative development in children with DS, but the nature of the gesture–language link may begin to change as children's cognitive abilities begin to outstrip their productive language skills.

In sum, we have found that during the early stages of communicative development, the relationship between gesture and language in children with DS is highly similar to that observed in TD children with similar language production abilities. Although the children with DS exhibited some specific pockets of delay, namely in the use of deictic words and in the production of complementary and supplementary gesture–word combinations, there was no evidence that they compensated for difficulties with language production through enhanced use of gesture. However, these findings do not exclude the possibility that in successive stages of development, gesture may begin to assume different functions. For example, in addition to reinforcing or adding information to the verbal message, gesture may play an enhanced role in lexical access when verbal abilities are limited (Bello *et al.* 2002). Further research is clearly needed to explore the ways in which the role of gesture in relation to speech changes developmentally and the extent to which this role may vary among individuals with language difficulties.

Acknowledgements

Portions of this work were presented at the 12th International Conference on Infant Studies, Brighton, UK, July 2000. The authors thank the Ospedale S. Lucia for generously making their facilities available for data collection; M. G. Colombini, P. Gentili, R. Pisaneschi and M. R. Pizzamiglio for assistance with data collection; and the children and parents who participated in the study.

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Notes

1. When data on the mental ages of TD comparison children are not available, a common approach is to form a comparison group by selecting TD children whose chronological ages match the mental ages of the children who are the primary focus of the investigation (see Chapman 1995 for a review). However, preliminary analyses

carried out within the group of children with DS revealed that, as in other studies (e.g. Miller *et al.* 1992, Vicari *et al.* 2000), the children's mental ages were significantly ahead of their language ages ($z = -2.02$, $p < 0.05$). Because the primary goal of this study was to examine the relationship between gesture and *language* in children with DS and TD children during the early stages of communicative development, we selected TD children for the comparison group on the basis of a match between their chronological ages and the *language* ages (rather than the mental ages) of the children with DS.