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The Challenge of Linguistic Mastery in Down Syndrome

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In this chapter I will speak to a number of questions about language learning in persons with Down syndrome (DS), informed by recent research. I first consider whether language merits particular concern in DS; despite well-documented success stories, research suggests that persons with DS are at high risk for language difficulty. I then ask whether the linguistic challenges faced by persons with DS can be attributed to across-the-board learning difficulties; this does not seem to be the case, in light of evidence from other neurodevelopmental disorders in which language is not as severely and consistently affected, but where general cognitive function is as impaired as, or more impaired than, it is in DS. The third question concerns specific areas of weaknesses within language; research suggests that persons with DS are especially vulnerable to difficulties with grammatical function (morphology and syntax), with relative sparing of semantic knowledge (i.e., vocabulary), and with communication skills that extend beyond language per se.

On these issues, researchers are in agreement, by and large. The question for which we continue to seek answers is *why* persons with DS are at such risk for language failure. And why do some, but not other, persons with DS succeed in achieving full linguistic mastery? My goal is to review and motivate informed hypotheses presently under consideration, acknowledging that existing data are consistent with several different hypotheses. In this paper, I choose to place particular emphasis on the link between grammatical difficulties and more fundamental phonological weaknesses (including articulation, speech perception, naming, and verbal memory capacity). In exploring how these phonological weaknesses may contribute to linguistic function more generally, I draw parallels with a growing body of research implicating phonological difficulties in normally intelligent children and adults with specific reading and/or language impairment.

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Although research to date offers no definitive answer as to why persons with DS have particular language difficulties, I wish to draw attention to the potential role that fundamental phonological processes may play in achieving full linguistic function. My hope is that more intensive intervention efforts will be made toward improving phonological function in persons with DS at all ages. Ultimately, research is necessary to determine whether improving phonological function (articulation, perception, naming, and memory) leads to demonstrable gains in grammatical function. However, even if such a link is not supported, and we must explore other means to improve grammatical function, I would argue that we already have ample evidence to suggest that improving phonological function is a worthwhile end in its own right.

IS LANGUAGE AN AREA OF PARTICULAR CONCERN IN DS?

Despite improved educational opportunities and heightened expectations, full mastery of the linguistic system remains a major challenge for many persons with Down syndrome (DS). Notable exceptions notwithstanding, many schoolchildren, adolescents, and adults with DS continue to experience frustration in making themselves understood and in mastering the intricacies of grammar* so readily achieved by most young children without DS. And yet, recent research suggests that these linguistic difficulties cannot be dismissed as a reflection of general cognitive function. Nor is it the case that all persons with DS are equally affected.

Evidence of the linguistic difficulties faced by persons with DS derives from a variety of sources. Particularly compelling are parent reports suggesting that language difficulty can be a major barrier to fulfilling their children's potential. In one recent survey involving 937 families, 58% of the parents reported that their children with DS "frequently" had difficulty being understood, whereas only 5% reported that their children "rarely or never" experienced difficulty (Kumin, 1994). In contrast, Kumin notes that children without disabilities typically achieve 100% intelligibility by 4 years of age. Intelligibility problems were similarly prevalent in a group of British adolescents studied by Buckley and Sacks (1987). Although between 78 and 88% of their parents reported being "usually" able to understand what their adolescents were trying to communicate, they acknowledged that between 32% (girls over 14 years) and 67% (boys between 11 and 14 years) had "frequent" difficulty being understood

*Morphosyntax—or grammar—refers to knowledge and use of rules governing word formation and sentence structure. Examples of word formation (morphology) include use of inflectional morphemes to modify nouns (e.g., plurals and possessives), verbs (e.g., progressive or past tense markers), and auxiliaries (e.g., to indicate subject–verb agreement for tense and number). Examples of syntactic knowledge include canonical word order in English and how this must be permuted for passive voice sentences, wh-questions, or relative clause constructions. Such grammatical knowledge of language structure can, in principle, be distinguished from knowledge of individual word meanings (semantic, vocabulary, or lexical knowledge), from pronunciation of those words (phonology, articulation), and from appropriate usage in a social context (pragmatics, communicative function). In practice, of course, it is often difficult to distinguish between a grammatical (failure to mark plural endings) and a phonological weakness (failure to pronounce a final "s") or even a semantic one (failure to distinguish single from multiple forms). In order to improve overall communicative function, our challenge is to see if we can tease apart— and remediate—more specific risk factors that may jeopardize communication in general.

by strangers. Although these difficulties surely reflect significant phonological problems, only about half of the parents also reported that their adolescents "speak in full sentences," with approximately 20% stating that their children speak in sentences of three words or fewer.

Research studies involving direct assessment of language skill confirm these parental impressions and indicate that linguistic problems are greater than would be expected solely on the basis of overall cognitive function. For example, when compared to typically developing youngsters of equivalent mental age, older children with DS typically produce shorter, less complex sentences with only limited use of grammatical devices (for reviews and some representative studies see Miller, 1987; Fowler, 1990; Scarborough et al., 1991). Although general verbal comprehension appears to be less impaired than speech production in older children with DS (e.g., Chapman, 1991; Marcell et al., 1990), studies targeting comprehension of particular grammatical constructions have revealed some striking difficulties with grammatically complex structures (e.g., Naigles et al., 1995; Fowler, 1984; Marcell et al., 1994; see Fowler, 1997, for a review).

Comparisons across a variety of neurodevelopmental syndromes provide further evidence that DS puts persons at particular risk for language difficulties. As a group, persons with DS typically display more severe language impairments than comparison groups matched in age and overall level of cognitive function. This is almost always the case when the comparison group is of "unspecified" or "mixed" etiology. That it is not necessarily the case is evident from research on individuals with fragile (X), who may be even more severely affected in language and communication than persons with DS (e.g., Dykens et al., 1992). Intriguingly, though still open to much interpretation, persons with autism can sometimes master complex grammatical function, far more advanced than typically seen in DS, but at the same time be far less sophisticated than persons with DS in their use of verbs and pronouns that depend on social inferencing skills (e.g., Tager-Flusberg, 1994).*

Perhaps the most dramatic evidence of a dissociation between grammar and cognition derives from recent research on Williams syndrome (WS), a rare disorder leading to moderate to severe retardation and uneven cognitive profiles. Whereas very young children with WS, like those with DS, begin with markedly delayed syntactic development, the children with WS, *unlike* most with DS, typically move ahead to acquire full syntactic complexity by middle to late childhood. By adolescence, the WS language advantage is pronounced. When IQ- and age-matched adolescents have been compared, those with DS produced only short, simple, and grammatically inaccurate constructions, whereas those with WS displayed extensive and spontaneous usage of passives, questions, embedded clauses, conditionals, and multiple embeddings, with nearly accurate grammatical morphology (Bellugi et al., 1990). When

*The case of autism is particularly problematic owing to well-appreciated difficulties in diagnosis and the wide range of cognitive levels associated with the condition. What can be learned, however, from comparing the linguistic effects of DS to those of other established neurodevelopmental conditions is the demonstration of distinctive cognitive profiles. Linguistic difficulties do not extend equally across all areas of communication, nor can they be dismissed as an inevitable outcome of general cognitive weaknesses.

presented with models to imitate, the group with DS could reproduce very few constructions; the group with WS could imitate sentences of almost any verbal complexity. When asked to tell the story depicted by a wordless picture book, adolescents with DS provided minimal descriptions using ill-formed sentences, while those with WS produced three times as many utterances speaking in complex well-formed sentences three or four times as long as the DS utterances (Reilly et al., 1991),

What is especially interesting about these comparisons is that the linguistic deficits in DS do not indicate more severe cognitive deficits across the board. Rather the linguistic weaknesses in DS are offset by some striking visual-spatial deficits in WS. Adolescents with DS can reproduce simple shapes, draw figures from memory in a recognizable fashion, and navigate in space sufficiently well that they often achieve considerable self-sufficiency in adulthood, riding buses, participating in a variety of sports, and living in independent apartments. In contrast, the impressive linguistic skills in WS coexist with severe impairments in reconstructing even the simplest shape or figure from memory; extreme spatial limitations create huge obstacles to independent living.

These comparisons across syndromes make it clear that language difficulties are not a direct reflection of general cognitive ability, but require intervention specific to an individual child's cognitive–linguistic profile. Bellugi and her colleagues make much of the fact that language has somehow been "spared" in the effects of WS; I would argue that equal attention should be paid to the fact that language has somehow been "impaired" in DS. It is intriguing that receptive vocabulary level exceeds general cognitive level in adolescents with WS; it is distressing that grammatical function in DS tends to lag even further behind their already weak receptive vocabulary scores (e.g., Chapman, 1993; Fowler, 1990; Miller and Chapman, 1984).

Although the typical person with DS has more difficulties with language than would be predicted on the basis of overall cognitive function, absolute levels of final attainment vary dramatically. For example, it is clear that the adolescents with DS selected by Bellugi et al. (1990) for comparison with the WS group do not adequately represent what *can* be achieved by persons with DS; they may not even be representative of what is typically achieved. For example, Rondal (1994a, 1994b) presents the case of a mildly retarded young woman named Francoise whose spontaneous productions are both long and complex (with utterance averaging 12 morphemes in length), whose grammatical morphology (and comprehension) is consistently accurate, and whose phonological skills include absolutely normal articulation, fluency, and intonation patterns. Although Francoise's case is unusual in the extent to which it has been studied, numerous articulate young people with DS, including a trilingual young woman from Spain, have begun speaking and writing in their own voices (see Levitz and Kingsley, 1995; Nadel and Rosenthal, 1995; Seagoe, 1964).

Longitudinal research has documented significant variation in the rate at which language is acquired and in the achievements that are ultimately attained in persons with DS. For example, Miller et al. (1995) measured the rate at which preschoolers with DS acquired their early language milestones (first words, size of spoken vocabulary, and two-word combinations); resulting growth curves suggest two quite dis-

tinct trajectories differentiated by progress or no progress. Working with somewhat older ages, Fowler (1988) tracked language development over a period of several years in 11 children with DS. Three youngsters made steady improvements in sentence length and complexity between 6 and 9 years of age; during these very same years, another four children attending the same classes in the same school remained stalled at limited language levels, speaking in simple two- to four-word phrases. Four older children whose linguistic development was followed from when they were 10 or 11 years old began with the limited skills evident in the "slower" trajectory at the early ages and made upward progress only late in adolescence after years of nongrowth. Two of their adolescent peers had already acquired complex syntax by 10 or 11 years and maintained a sizable advantage throughout the teenage years.

Apparently, some children with DS are far more restricted in language development than others; the limited data available suggest this difference may be evident early on and persist over time. To document and understand better the incidence and context of linguistic proficiency in DS within a larger sample, my students and I (Fowler, 1995; Fowler et al., 1995) interviewed 33 young adults, aged 17 to 21 years, who were referred through word-of-mouth as representing what might be achieved in terms of language when provided with adequate medical care, dedicated commitment of parents, and informed educational practices. Despite having skewed our sample toward high achieving, hard-working, and self-assured young adults, we found that the only verbal measure to exceed general cognitive levels was receptive vocabulary, as assessed on the Peabody Picture Vocabulary Test (Dunn and Dunn, 1981). Where comparative data on verbal and non verbal tasks from a single test (Kaufman and Kaufman, 1983) could be submitted to statistical analysis, verbal scores were consistently and significantly below nonverbal scores. A statistically significant nonverbal advantage was evident in the individual profiles of more than half of our sample; a statistically significant verbal advantage was observed exactly once. Even in this high-functioning sample, verbal skills were identified as a significant weakness relative to overall cognitive profile in more than half the sample (Doherty, 1993; for similar findings, see Pueschel, 1988).

Among this group, we were fortunate in interviewing a group of five impressively articulate—and literate—young adults, with reading and language levels not unlike those reported by Rondal (1994a, b) for Francoise. These young people had acquired the receptive vocabulary of a typical 11 year old, the arithmetic skills of a 9 year old, and listening and reading comprehension skills near an 8-year-old level. Reading skills in word recognition and decoding exceeded 12-year-old levels. In terms of spoken language, these adults could imitate sentences with complex verbal auxiliaries. And yet, in terms of their cognitive profiles, these most proficient adults were quite similar to the larger group as a whole, and to persons with DS generally. Three of the five displayed a significant "strength" on a nonverbal measure, and only one a strength on a verbal measure.

Such well-documented cases of linguistic proficiency make it clear that DS does not categorically preclude linguistic mastery. A "ceiling" on linguistic success in DS has not been established, and is not likely to exist. At the same time, however, lin-

guistically proficient individuals seem to be have cognitive profiles that are quite similar to persons with DS generally. What this seems to suggest is that despite also being "at risk" for language impairment, these young adults have somehow managed to gain spoken and written proficiency in English. The strategy in the second half of this chapter is to consider risk factors for linguistic failure. To this end, I shall introduce characteristics that distinguish DS from other developmental disorders less associated with difficulties in learning language. I shall make the case that these same factors also appear to distinguish *among* persons with DS who differ in linguistic proficiency, as well as among normally intelligent children and adults with and without specific difficulties in language and literacy.

POSSIBLE FACTORS CONTRIBUTING TO LANGUAGE DIFFICULTIES

Language Learning Strategies

To account for specific difficulties in acquiring grammatical structure, it is conceivable that children with DS posit different kinds of rules or entertain hypotheses not observed in the normal process of language learning. However, as has been reviewed extensively, quests for "deviant" processes have proven futile to date: both the structures acquired by children with DS and the errors made in the process are indistinguishable from those observed in much younger nondisabled children matched on language level (see Fowler, 1990; Fowler et al., 1994; Miller, 1987; Naigles et al., 1995). Importantly, studies of other subgroups characterized as language-delayed have also yielded little support for deviant language processes within the area of morphosyntax, suggesting that development in both production and comprehension largely parallels that observed in typically developing children, even if stopping short of full mastery. As but one example, in a study refuting prior suggestions that children with mental retardation apply "abnormal" strategies to understand passive voice sentences, Bridges and Smith (1984) demonstrated that the erroneous strategies observed constituted a normal language "stage" also seen in younger children, rather than a "deviant" strategy. (For a review of the extensive literature reporting "delay without deviance" in a variety of populations, see Fowler, 1997; Johnston, 1988; Rosenberg and Abbeduto, 1993).

Critical Period Hypothesis

In an alternative explanation for limited language learning in DS, Lenneberg (1967) suggested that the capacity for language learning slows dramatically in adolescence after a biologically imposed shutdown of the critical period for language acquisition. Recent estimates, looking at effects of age on first and second language learning (including sign language), place the end of this hypothesized critical period at approximately 7 or 8 years age (Newport, 1990), emphasizing that the shutdown is not absolute. The limited longitudinal data currently available for children with mental retardation suggest relatively rapid growth in the preschool years, followed by more limited growth in the school-age years and beyond (Dykens et al., 1994; Fowler, 1988; Fowler et al., 1994; Miller; 1988, Tager-Flusberg et al., 1990). Consistent with

a slowdown rather than shutdown, Fowler (1988) observed a modest increase in syntactic comprehension and production during late adolescence among persons with DS observed (see also Chapman, 1993; Marcell et al., 1994).

As was illustrated in the earlier discussion of children with WS, general cognitive delay apparently exerts a strong and consistent effect at the very earliest stages of language learning across a variety of syndromes. Where children with DS seem to stand apart more dramatically is during the school years. For example, Smith and Stoel-Gammon (1983) report that children with DS display a slower rate of improvement in phonological skill over time, lagging further and further behind the language-matched controls on which they were initially matched. We noted a similar pattern in longitudinal research: children with DS made their most rapid gains between 4 and 8 years of age, making only brief and inconsistent gains beyond that point (Fowler, 1988; Fowler et al., 1994).

Newport (1990) raises the possibility that these critical period phenomena may stem from changes in overall cognitive function: whereas young children are forced to analyze utterances to accommodate their cognitive limitations, older children are more likely to store unanalyzed utterances. Such an explanation cannot, however, account for the slowdown in children with MR, who by those standards should be open to language learning for many more years. In a somewhat different approach to critical period phenomena, Locke (1994) has argued that impoverished language results when the child is deprived of a full data base (from either environmental or cognitive factors), during what he refers to as a "critical period for activation of species-typical linguistic mechanisms" (page 37). Beyond that time, the child can continue to acquire "utterances," which Locke describes as a right brain function, but these will not undergo the kind of analysis that characterizes early language learning.

Clearly, more definitive data are needed to evaluate these hypotheses better, both within and beyond the relatively well-studied case of DS. The growing disparity between mental age and language level even in children without DS is of interest (e.g., Abbeduto et al., 1989), but it would be especially worthwhile to learn just when highly verbal children with DS (or WS or autism) achieve their impressive skills. It would also be of great interest to examine susceptibility to language therapy as a function of chronological age and language status.

Specific Linguistic Deficit

As one alternative to deviant learning strategies, it is been suggested that focuses on certain linguistic relationships are not—and potentially cannot be—appreciated in individuals with language difficulties. That is, what *is* acquired is acquired normally. More interesting perhaps is what is *not* acquired. In the most explicit account of such a hypothesis, Gopnik (1990a, b) speculated that some particularly pronounced cases of specific language impairment (SLI) may stem from a (genetically transmitted) insensitivity to grammatical features (plural, gender, tense). As evidence, she cited data from an extended family of affected individuals, none of whom produced morphological overgeneralizations. Although the hypothesis is appealing in its simplicity, in SLI, as in DS, the evidence for such an isolated deficit is not well substantiated. In-

vestigators familiar with the family studied by Gopnik report both that some grammatical morphemes *are* acquired and that the ostensibly isolated deficit extends well beyond grammatical morphemes to affect other aspects of syntax, semantic naming, phonological memory, and receptive vocabulary (Fletcher, 1990; Vargha-Khadem and Passingham, 1990). Although a frequent failure to acquire the complexities of verbal auxiliary system suggest that this may qualify as an area of weakness (e.g., Fowler et al., 1995) the fact that some persons do and others do not move beyond this apparent linguistic ceiling makes it highly implausible that there is a "missing piece" in the language learning apparatus of persons with DS.

Although it is unlikely we will find evidence for a syndrome-wide gene that categorically precludes mastery of some linguistic feature, it remains possible that certain prerequisites to complex syntax are specifically affected in language-impaired groups. For example, describing specific syntactic deficits associated with SLI, Clahsen and colleagues (Clahsen, 1989; Clahsen et al., 1992) point to particular problems in establishing agreement relations in grammar. If that is an accurate account of the pattern observed, plurals (which are a semantic marker not dependent on agreement within the sentence) should not be problematic for language-impaired children, despite their status as a syntactic–semantic feature and despite their low acoustic salience. In contrast, the theory would anticipate difficulty with verbal auxiliary markers, gender agreement within noun phrases, and subject–verb agreement. Clahsen reports just such a pattern in German-speaking children with SLI, suggesting they do not have a general morphological deficit, but one specific to agreement relations (See also Rice and Oetting 1993).

Although Clahsen's data have not been specifically tested in DS, his account is consistent with the facts on face value. Children with DS do acquire plurals with relative ease, and have tremendous difficulty with agreement relations. If this is in fact an apt characterization of their deficits, however, one is left to ask *why* agreement relations are so difficult. This is one of several reasons to look to the processing deficits that may underlie the difficulties with grammatical relations.

Verbal Memory Limitations

Quite apart from current work on morphosyntactic weaknesses in DS, researchers have long identified specific and dramatic weaknesses in verbal memory* as a hallmark of the cognitive profile associated with DS (e.g., Bilovsky and Share, 1965; Graham, 1974; Hulme and MacKenzie, 1992). Unfortunately, however, given the complexity of the memory system, and the diversity of ways to assess morphosyntax, we have little understanding as yet as to how verbal memory bears on morphosyntactic development. We can only note intriguing parallels.

*Although verbal memory has, over time, been referred to as verbal short-term memory, immediate-span, working memory, and, most recently, phonological memory, I refer here to the ability to encode information (presented verbally or visually) into a verbal store, to maintain that information in memory for a brief period, and to reproduce it (orally or otherwise) as it was initially presented (e.g., Baddeley, 1986).

The cognitive profile of persons with DS is characterized not only by weaknesses in morphosyntactic function, but by a memory span well below what is ordinarily achieved. When presented with a random sequence of digits (1 through 9) at a rate of one per second, English speaking adults display an average "digit span" of 7, plus or minus 2, recalling the initial and final digits with greatest accuracy. Persons with DS, presented with the same task, show the same pattern, but recall far fewer digits. Most recall no more than two or three, and very few achieve a span greater than four digits. For example, only 25% of the 16-year olds studied by Hulme and MacKenzie (1992) and 33% of the young adults studied by Fowler (1995) could recall four digits in order; exactly one adult across these two studies reliably reproduced five digits in the correct order. The linguistically proficient young woman studied by Rondal (1995a, b) also had a span of four digits. The consistently limited span observed in persons with DS can be contrasted with the variability observed in IQ-matched adolescents of "mixed etiology," also studied by Hulme and MacKenzie (1992): in that sample, half recalled four, some recalled six, and virtually none recalled fewer than three digits.

Providing further evidence for a specific linguistic weakness, the verbal memory limitations in DS contrast with relatively intact skills in visual or motor sequencing (e.g., Doherty, 1993; Marcell and Weeks, 1988; Marcell and Armstrong, 1982; Pueschel, 1988). Most people find it easier to remember the serial order of items, such as letters or familiar shapes that can be named, than of items, such as nonsense doodles, that cannot be easily labeled. However, this standard verbal advantage is not usually found in persons with DS. For example, when adults with DS were compared to typically developing youngsters with comparable digit spans, the standard advantage was evident only in the non-DS group (Racette, 1993). Wang and Bellugi (1994) also failed to find the usual verbal advantage in adolescents with DS, but did observe it in an IQ- and age-matched group with WS. Importantly, the verbal memory limitations in DS cannot be contributed to simple auditory or articulatory difficulties; weaknesses in remembering namable stimuli remain evident whether or not the presentation is visual or oral (e.g., Varnhagen et al., 1987), and whether the response requires speaking or pointing (Marcell and Weeks, 1988).

Like grammatical function, verbal memory in DS is relatively independent of progress and variation in general cognitive factors. For example, despite a relatively high correlation between memory and cognition in typically developing 4 to 8 year olds, MacKenzie and Hulme (1987) report a substantially weaker correlation among schoolchildren (with and without DS) with moderate levels of impairment. In a further parallel with grammatical function, growth in memory span seems to slow with in creasing age in persons with DS. In adolescents studied by MacKenzie and Hulme, digit span was below mental-age-level expectations at age 10 and fell further and further behind, with mean span increasing only from 3.1 to 3.6 over the next 6 years. This contrasted with an average of 16 months' growth in general cognitive development over the same period.

Although somewhat independent of general cognition, verbal memory appears to be more closely allied with production and comprehension of grammatically complex

structures in persons with DS and other disabilities (e.g., Graham, 1974). For example, adolescents and adults with DS studied by Marcell et al. (1990) achieved overall language comprehension scores equivalent to those of an IQ- and age-matched comparison group, but performed considerably less well on measures of verbal memory, sentence production, and comprehension of complex structures, all of which were strongly correlated with each other in both groups. An association between sentence production and memory was also observed in the sample of young adults studied by Fowler (1995); those participants with a memory span of less than four digits were uniformly unable to reproduce complex verbal auxiliaries modeled for them. An association between memory and syntax is also evident across populations. Whereas verbal memory is consistently an area of weakness in DS, it is an area of relative strength in cases where morphosyntax is spared despite generally low cognitive function, such as in people with WS (e.g., Crisco et al., 1988; Wang and Bellugi, 1994), and some highly functioning persons with autism (Tager-Flusberg et al., 1990).

If, in fact, limited phonological memory is an obstacle to acquiring complex syntax, there may be a minimum threshold for full linguistic mastery. Such a threshold would be not only consistent with the results from Fowler (1995), but also in keeping with the findings of Rondal (1994a, b) and Cromer (1994). Both these authors express surprise that the complex syntax they observed could coexist with a span of only four digits. This should not be surprising, however, in light of the fact that highly complex syntax is *typically* acquired in the first four or five years of life, apparently before memory span exceeds four digits (see Racette, 1993, for relevant data). Although verbal memory may not be relevant to degree of syntactic skill in language learners who meet the minimum threshold, a more limited memory capacity may constitute an important obstacle to linguistic success.

UNDERLYING PROCESSING DEFICITS THAT MAY CONTRIBUTE TO DEFICITS IN MEMORY AND MORPHOSYNTAX

Although verbal memory deficits in DS are undeniable, and parallels with grammatical function merit further investigation, the specific relevance of memory for morphosyntactic development is not clear in any group of language learners. On the one hand, measures of morphosyntactic function surely vary in their dependence on memory, depending upon whether they involve production, comprehension, and imitation, and whether additional demands are made by syntactic or phonological complexity or by lexical unfamiliarity. On the other hand, limitations on memory span may derive from poor initial encoding, weak or absent rehearsal, and delayed access to long-term memory, which itself may be impoverished. Competing demands for attention, weak formulation skills, and output difficulties also contribute to failure on the digit span task (e.g., Brady, 1997; Dempster, 1981). Indeed, these various factors may contribute to variability within a given child across tasks, across content areas, and across days (Lahey and Bloom, 1994).

As a result of this complexity, combined with the possibility of a threshold effect of memory on language learning, a failure to obtain a correlation between any two measures of syntax and memory does not categorically rule out an important role for mem-

ory in language function. We must, for instance, consider carefully how to interpret two studies that have tested for and failed to find any correlation between syntactic comprehension and digit span in non-DS adolescents with developmental disabilities (e.g., Dewart, 1979; Natsopoulos and Xeromeritou, 1990). At the same time, a positive association by itself tells us little about *how* verbal memory bears on language learning. In this regard, we are fortunate that a growing body of research is examining the intersection of memory and language in a number of subgroups, with potential for converging evidence across studies. I review here three recent explanations of individual and developmental differences in memory derived from various subgroups, and consider their potential relevance for explaining language difficulties in DS.

Rehearsal Strategies

One hypothesis for individual differences in memory derives from Baddeley's model of working memory, in which verbal material is temporarily stored and rehearsed in an articulatory loop (Baddeley, 1986). In typical adults, there is substantial evidence that the amount of material that can be articulated in a brief period of time is a good approximation of the amount of material that can be maintained in working memory; we can, for example, recall more monosyllabic than multisyllabic digits in working memory. Furthermore, study of developmental changes in working memory, and of individual differences among normally intelligent adults, suggests that variation in speed of articulation may set a limit on the amount of information that can be stored and rehearsed within an articulatory loop (Gathercole and Baddeley, 1990; Hulme et al., 1984).

Although this research is potentially relevant to explaining gains in memory observed after typically developing children reach school age, the major milestones in morphosyntactic development have already been achieved by this point in development. There is little evidence for rehearsal in very young children (e.g., Gathercole and Adams, 1993) or in persons with DS (e.g., Varnhagen et al., 1987). Hence it is unlikely that rehearsal in the articulatory loop is an important factor in basic acquisition of grammar.

Speech Perception

Yet a different account of variation in memory span refers to the initial perception (or encoding) of the verbal information to be stored and retrieved. This line of research, primarily involving poor readers with memory deficits, has documented a strong association between poor perception and poor short-term memory. Indeed it would seem that lowering the perceptual quality of stimuli limits memory in any listener (see Brady, 1997, for a recent discussion).

If poor perception limits memory, then a plausible link with morphosyntactic weaknesses can be constructed. For one thing, consistent with Gleitman and Wanner's (1982) phonological salience hypothesis, the very markers that are most often omitted in immature speech, and about which agreement relations must be inferred, are just those that are acoustically nonsalient (see the forthcoming volume by Morgan and Demuth for several papers considering the relevance of phonology to early syn-

tactic function in typical development). An emphasis on perception also makes sense in light of the fact that perceptual deficits are highly prevalent in the language-delayed population (e.g., Leonard et al., 1992), just as language problems are highly prevalent in children first diagnosed for phonological impairments (Shriberg and Kwiatkowski, 1988). Arguing that specific language impairment (SLI) may have its roots in more basic phonological skill, Leonard et al. (1992) found that even 4- and 5-year olds with SLI who produced appropriate phonemic contrasts in spontaneous speech were less able to discriminate such contrasts as das/dash, ba/da, or dabiba/dabuba than age-mates with normal language development.

With regard to DS and other neurodevelopmental syndromes, the parallels are obvious but as yet untested. Persons with DS are well-known to have perceptual weaknesses (e.g., Marcell, 1992), just as they are to have weaknesses in morphosyntactic development. Conversely, unexpected strengths in syntax often co-occur with well-developed phonology, as is true in persons with WS and other cases of exceptional language recently discussed in the literature (e.g., Curtiss, 1988a, 1988b; Cromer, 1994; Rondal, 1994a, b). It remains to be determined whether variation in perception accuracy among persons with DS or WS—or in typically developing language learners—is causally linked to variation in grammatical skill.

Lexical Retrieval

A still different account of verbal memory deficits attributes individual differences to variation in speed of lexical retrieval from a long term store (Gathercole and Adams, 1993; Hulme et al., 1991). For instance, Gathercole and Adams (1993) found that slower access to the names of individual digits is associated with shorter spans in very young children.

Varnhagen et al. (1987) observed severe deficits in speed of lexical retrieval from a long-term store in persons with DS; in that group there was a significant correlation between retrieval speed and memory span not found in other children (see also Marcell et al., 1990). In contrast to the slow word retrieval skills observed in DS, IQ- and age-matched adolescents with WS displayed rapid lexical access when asked to generate names of animals. The group with WS produced twice as many items over trials, including such unlikely choices as *unicorn, Brontosaurus, yak, ibex,* in contrast to more typical responses from the adolescents with DS (Bellugi et al., 1990).

SUMMARY AND CONCLUSIONS

In this chapter, I have considered a number of possible explanations for the challenges faced by many persons with DS in attaining full linguistic mastery. Despite generalizations that can be drawn about morphosyntactic and phonological difficulties in many people with DS, we are much encouraged by the fact that variation exists among persons with DS, and that some individuals do succeed. This variability suggests that the obstacles that do exist may be overcome and lends greater urgency to the need to identify factors relevant to linguistic success.

I have placed particular emphasis in this chapter on the parallels that exist between verbal memory capacity and grammatical proficiency in DS, in part because these do-

mains have been studied separately until very recently. Despite the plausibility of such an account, further research is required to establish definitively that it is phonological factors that limit morphosyntactic development; such research must involve language learners with and without DS. Observations worth pursuing in a more systematic fashion include parallels between the weak gains in verbal memory and the weak gains in morphosyntax among older disabled children, and the association between memory and grammatical skill within and across linguistically diverse samples.

It is important to acknowledge that many investigators are skeptical about the association between phonology and syntax. As noted earlier, some are struck by the low memory levels observed in linguistically proficient adults studied. Others are pessimistic about constructing meaningful and appropriate tools for assessing verbal memory capacity, morphosyntax, and even phonology. Clearly, we must continue to develop cleaner measures of morphosyntax (separate from semantics) and of phonology (separate from articulation) than are currently available. It will be essential to consider production separately from comprehension, and within comprehension to better identify the grammatical devices in question. Crucially, if a threshold is important, we should focus on potentially relevant stages of language and memory development.

In seeking the source of grammatical deficits, an important goal for future research will be to assess more accurately any syntactic competence that may be masked by processing difficulties, guided by recent methodological advances with very young language learners. One possible approach is to examine implicit knowledge of whether a given utterance is grammatical or not, a skill that turns out to be intact in agrammatic aphasics who show extreme impairment in production and comprehension of grammatically complex constructions (e.g., Linebarger et al., 1983). Although use of standard grammaticality judgment tasks has previously been restricted to normally intelligent schoolchildren and high-functioning persons with mental retardation (e.g., Bellugi et al., 1994; Cromer, 1994), the serendipitous results of a recent study suggest that it may be possible to assess sensitivity to different grammatical structures in more typical persons with mental retardation. In that study, we noticed over the course of testing that children, with or without DS, took significantly longer to begin acting out those sentences that violated constraints on verb argument structure (e.g., *the lion fall the giraffe*) than to initiate enactment of sentences that were grammatically sensible. Both groups displayed this apparent sensitivity to grammatical structure even when their comments and enactments did not reveal the same degree of understanding (Naigles et al., 1994). Relying on these and other manipulations that reduce processing demands, it may be possible to reveal intact grammatical capacities that have been masked in the more traditional measures relied on to date. It is possible that limited memory capacity does not prevent acquisition of grammatical knowledge as much it precludes demonstration and use of this knowledge in production and comprehension tasks.

Because verbal memory capacity is itself a multi-faceted skill, I also spent some time considering what factors specifically limit memory in DS, noting that some more basic weakness may affect both memory and grammatical development. In fact, it seems unlikely that we will be able to isolate just one factor that puts persons with

DS at risk for memory difficulties, given the evidence for slow word retrieval and speed of articulation, poor linguistic perception, and lack of strategic rehearsal. On the other hand, whatever the precise mechanism(s) involved, it seems clear from a wide variety of studies that individual differences in verbal memory depend importantly on one or more aspects of phonological processing. A better theoretical understanding of verbal memory may require further isolation of critical factors, but it seems already clear that intervention efforts should focus on promoting accurate and efficient production and perception of linguistic information. Whether this phonological intervention leads to improved grammatical development is an empirical question that merits investigation. Independent of that outcome, improved articulation, perception and word retrieval are important goals in their own right.

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