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8. The San Diego Longitudinal Study: Evaluating the Outcomes of Preschool Impairment in Language Development

In 1980 we began the San Diego longitudinal study to evaluate the multivariate outcomes of preschool impairments in language. This study was designed to make important theoretical and clinical advances in our understanding of the impact of language development and disorders on other important areas of a child’s development such as academic achievement, intellectual attainment, and social and emotional development. Being longitudinal in design, this study was also intended to increase our ability to develop profiles of various subgroups of language-impaired (LI) children. The predictive validity of the profiles can then be assessed directly within the same study on the basis of subjects’ subsequent performance on outcome measures of interest (namely, reading, mathematics, hyperactivity, conduct disorder, and so forth). This study was thus designed to link many of the current research theories with issues of clinical concern, such as diagnosis, prognosis, and remediation programs. The present chapter represents the final product of a major clinically applied research proposal. We hope that the format we have used to present this information will secondarily be helpful in demonstrating the organization, format, and cohesiveness of research that links theoretical and clinical concerns.

Introduction

That a certain degree of sensory, perceptual, motor, and cognitive functioning is a prerequisite for normal language development is obvious from clinical observation of language deficits in hearing-im-
paired and mentally retarded children as well as in children with serious motor deficits (such as dysarthria or cerebral palsy) that affect the oral musculature. The degree and pattern of impairment in these basic areas, however, and the precise manner in which they impact on language development are still very poorly understood.

Previous studies with language-impaired children have tended to focus on their sensory, perceptual, motor, cognitive, or linguistic abilities. While this dual approach acknowledges the probable importance of basic sensory, perceptual, motor, and cognitive abilities in the normal and abnormal development of a linguistic system, it fails to venture into the heretofore largely uncharted territory where these nonlinguistic and linguistic areas of development interface.

In order to begin to investigate the manner in which nonlinguistic and linguistic areas of development might interface, it is important to observe developmental (longitudinal) change over time in these areas to determine how these changes interrelate with each other. By observing longitudinally children who are normal and abnormal with regard to language development, we should be able to clarify these interrelationships. In this chapter we describe the (1) rationale, (2) objectives and specific aims, (3) hypotheses, and (4) experimental design of the San Diego longitudinal study of language development and disorders.

This longitudinal study has been developed principally using a model in which language is viewed as a neuropsychological system determined in part (1) by the basic sensory, perceptual, motor, and cognitive mechanisms which are prerequisite to its normal functioning and shape its character and (2) by mechanisms which may be language specific. This model simultaneously hypothesizes that impairment or delays in the development of basic sensory, perceptual, motor, and/or cognitive mechanisms will have a detrimental effect on language development and that impairment or maturational delays in the functioning of specific learning mechanisms underlying language acquisition will also have a detrimental effect on language development.

It is possible to elaborate on this general model of language disorders by applying to it the considerable data that are already available concerning the sensory, perceptual, motor, and cognitive, as well as linguistic, deficits of language-impaired children. From this more elaborate data-based model we have formulated specific hypotheses for this longitudinal study which address the issue of whether basic perceptual, motor, or cognitive deficits impact directly on the linguistic system at the phonological, morphological, semantic, syntactic, and
pragmatic levels or whether deficits in these linguistic systems are unrelated to more basic nonlinguistic deficits. Specific procedures have been developed for the purpose of testing these new hypotheses in an experimentally rigorous manner appropriate for young normal and language-impaired children.

Although it can be observed that certain basic sensory, perceptual, motor, or cognitive deficits may disrupt normal language development in some severe cases, some language disorders may nonetheless occur that are not related to these more primary deficits. The study we have designed will enable us to discover multiple types and patterns of language disorder. The experiments we have developed, by their very nature, will provide data in a systematic manner concerning both linguistic and nonverbal mechanisms that previous research has led us to hypothesize may be related to language disorders. We will be particularly interested in determining whether specific subgroups of language-impaired children have different profiles. The hypotheses we have developed should allow us to demonstrate diversity within populations as well as between populations.

Finally, the longitudinal basis of the study permits us to analyze the order and pattern of nonlinguistic and linguistic development and to determine whether such development is basically deviant from normal or is similar albeit delayed.

Background Literature

At present, the diagnosis of specific developmental language delay usually involves a process of elimination. That is, once it has been determined that a child is a year or more delayed in receptive and/or expressive language development, the investigator will next usually eliminate from consideration deficits of hearing, nonverbal intelligence, motor development, oral structural development, middle ear function, language environment, and emotional development. A child who demonstrates a significant delay in language development in the absence of all of these factors is usually diagnosed as having a specific developmental language delay or disorder, or developmental dysphasia. (In this chapter we use the terms “developmental language delay,” “developmental language impairment” or disorder, and “developmental dysphasia” interchangeably.)

Even a cursory examination of these criteria demonstrates that the diagnostic process at present emphasizes the exclusion of factors as possible identifiers.
possible contributing causes of the language disorder rather than the identification of those factors which may be descriptive of the disorder. Interestingly, none of the criteria required for a diagnosis of specific developmental language disorder for clinical purposes or to qualify a child for inclusion as a subject in a research study specifies, in any detail, the perceptual or cognitive abilities of the child or, perhaps more important, the nature of the language disability itself. There is evidently a greater consensus concerning what does not constitute specific developmental language impairment than concerning what does.

In attempting to understand the nature of developmental language disabilities better, research studies of language development and language disorders have either taken a linguistic approach or focused on investigating the basic sensory, perceptual, and cognitive mechanisms that are presumed to subserve language. Though each of these approaches has proven successful in enhancing our understanding of language disorders, few attempts have been made to relate data from perceptual or cognitive studies to those from linguistic studies or to determine the relationship between various defects observed in language-impaired children and their subsequent communicative, academic, and emotional development. In large part the reason is a lack of adequate data concerning the perceptual, motor, and cognitive abilities of language-delayed children and concerning their linguistic, academic, and emotional functioning. Another reason, however, is that we still have no adequate understanding of how motor, perceptual, and cognitive functions interrelate with linguistic development in normal children or in the language impaired. Thus, in the vast majority of studies, the two research approaches have developed in isolation from each other. That is, few, if any, studies of the development of linguistic abilities in children have simultaneously investigated the more primary nonverbal perceptual, cognitive, and motor factors that might subsume these linguistic abilities. Similarly, few direct studies of the development of perceptual, cognitive, or motor abilities in children have attempted to relate these abilities to the degree and pattern of language development or disorder.

Because of the dearth of studies in which perceptual abilities were investigated together with linguistic development, as Rees (1973) noted, it has not been possible to relate nonverbal perceptual dysfunction directly to language disabilities. Rees further suggested that nonverbal and verbal processing may even depend on mechanisms that reside in different cerebral hemispheres. Although subsequent studies
(Tallal and Newcombe, 1978) have demonstrated that specific nonverbal perceptual functions and verbal functions may well be subserved by similar mechanisms in the dominant hemisphere, Rees's critique nonetheless pinpointed a basic weakness of theories concerning the basis of dysfunction in language-impaired populations. That is, there was no evidence that nonverbal deficits reported in LI subjects were directly linked to the verbal disabilities in question. As a result, it was difficult to determine which aspect should be emphasized in planning assessment and treatment programs for these children.

Another difficulty in the literature pertaining to developmental language disorders is that few of the theoretical models lend themselves to a sustained investigation of the full range of systems that might be involved in communicative disorders. Instead, the literature is replete with fragmented studies which often appear, for the most part, to be asking isolated questions in the absence of a theoretical framework or model which could lead to further elaboration.

The Neuropsychological Approach

We were concerned with some of the same issues. In 1970, Tallal and Piercy began a series of studies with developmentally dysphasic children. The now large series of published studies by Tallal and colleagues has provided a working theoretical model concerning the role of neuropsychological mechanisms in the normal and abnormal development and maintenance of speech and language.

These studies began by investigating in detail the nonverbal detection, discrimination, association, sequencing, rate processing, short-term memory, and serial memory abilities of language-impaired children (Tallal and Piercy, 1973a, b). The results of these first studies demonstrated that, rather than showing a general auditory perceptual deficit, language-impaired children as a group had difficulty responding correctly to any task in which rapidly changing signals were presented. Thus some of these children were impaired on discrimination, sequencing, and serial memory tasks when stimuli were presented rapidly. They were unimpaired in responding correctly on the same tasks when the stimuli were presented more slowly, however. Further studies showed that this result was specific to the auditory modality for some subjects but not for others. It was hypothesized that this difference may indicate distinct subgroups within the language-impaired population (Tallal and Piercy, 1973b; Tallal et al., 1981) that...
might be distinguished by their perceptual abilities and that the characteristics of the subgroups may change as a function of age (Tallal et al., 1981).

In subsequent studies, difficulties in nonverbal processing were for the first time directly linked to the patterns of speech perception and production deficits of language-impaired children. Those children who demonstrated nonverbal perceptual deficits, affecting their ability to respond adequately to rapidly presented stimuli, were also shown to have the greatest difficulty in both perceiving and producing speech sounds (such as stop consonant-vowel syllables) that are characterized by rapidly changing acoustic spectra (Tallal and Piercy, 1974; Tallal, Stark, and Curtiss, 1976; Stark and Tallal, 1979). When the rate of change of acoustic information was extended within stop consonant-vowel (CV) syllables using a speech synthesizer, however, the speech discrimination abilities of these children dramatically improved (Tallal and Piercy, 1975).

Thus we were able to make predictions concerning the speech perception and production abilities of language-impaired children on the basis of our findings regarding their nonverbal perceptual abilities, predictions that were later sustained by experimental tests. These predictions concerned the processing of isolated syllables. In our more recent studies, we have extended our findings to describe the manner in which language-impaired children perceive and produce syllables that form real words (Tallal et al., 1979). The results of these studies, using syllables and real words, are strikingly similar to our previous findings using nonverbal complex tones and isolated CV syllables (Tallal and Piercy, 1973, 1974, 1975). That is, the same temporal mechanisms that disrupt the processing of nonverbal stimuli and CV syllables by dysphasics also seem to disrupt the processing of words. Dysphasics experienced difficulty sequencing syllables (which they had previously been able to discriminate) only when these syllables were presented as words at a rate comparable to that which occurs in normal speech. When the same words were presented with long intervals separating syllables, the language-impaired children's performance did not differ significantly from that of the controls (Tallal et al., 1985a).

These later findings, which have now led us to expand our studies to include the perception and production of isolated words, were obtained as part of an in-depth study of the sensory and perceptual abilities of young children with and without delayed language develope.
development. According to the results of a discriminant function analysis of the data obtained in this study, a combination of six sensory, perceptual, and motor neuropsychological test variables correctly classified 98% of the subjects studied as either normally developing or language impaired. These variables included: (1) rapid production of a word; (2) the ability to discriminate between stop consonant-vowel syllables, incorporating formant transitions of 40 msec duration (verbal association subtest of Tallal's Repetition Test); (3) a finger identification subtest from the neurodevelopmental test battery which required the child to indicate which two fingers had been stimulated simultaneously (out of the child's sight); (4) the ability to integrate the temporal order of two nonverbal stimuli that were presented very rapidly to two different sensory modalities, auditory and visual (cross-modal integration rate-processing subtest of Tallal's Repetition Test); (5) the ability to indicate motorically the temporal order of two graphemes (E and K) which were presented in very rapid succession with a 30 msec interstimulus interval (visual-rate-processing subtest from Tallal's Repetition Test); and (6) the ability to detect double simultaneous touch to the hands and/or cheeks. Using these six variables alone it was possible to classify correctly 31 of the 32 language-delayed children participating in the study and all of the 36 normally developing control subjects. It is important to note that none of these variables assessed what are commonly considered higher-level linguistic functions (Tallal et al., 1985a, b).

The results of our now large series of studies have provided a wealth of detailed information concerning the sensory, perceptual, motor, and cognitive status of normally developing and language-impaired children. The results of these studies indicate that language-impaired children, as a group, have particular difficulty responding to and correctly producing rapidly changing stimuli in a variety of modalities. On the basis of these findings, we have hypothesized that an inability to perceive and/or produce rapidly changing temporal acoustic events will significantly interfere with normal speech perception and production and result in delayed or disordered language development.

These studies take a first step in linking nonverbal perceptual deficits with speech perception and production disorders, but they do not fully clarify the role of perceptual and motor disorders in linguistic disabilities or the developmental patterns of these disabilities. It is quite likely that more or different mechanisms may be involved in perceiving and producing ongoing speech than are involved in processing isolated phonemes, syllables, and words. Now that we have developed procedures involved in articulation, however, we can investigate higher-level linguistic functions.

The Linguistic Impairment

Linguistic impairments resulting from language processing delays have been noted in studies of language-impaired children who, for many years (for review, see, for example, Ganz, 1976), have been implicated as being delayed in development to language development. Thus, phonology is a component of language impaired children's speech. The phonological organization of language is the least when perceptive-phonological impairments result in language-impairment. This has special relevance for the study of language-impaired children who have special weaknesses in the phonological system.

Phonology.

Language-impaired children have been found to have deficits in all aspects of phonological processing, including phoneme identification, segmentation, and production. These deficits are often associated with difficulties in other aspects of language, such as morphology and syntax. The relationship between phonological processing and language impairment is complex, and further research is needed to fully understand the role of phonology in language development.
developed procedures for maintaining experimental control over variables involved in the initial stages of speech perception and production, however, we are in a unique position to extend our research to investigate higher levels of linguistic functioning.

The Linguistic Approach

Linguistic investigations of language-impaired children date back over many years (for example, Hinckley, 1915, 1975). These studies have endeavored primarily to describe in detail the language of language-impaired children and to determine whether the patterns of language development that language-impaired children display are normal albeit delayed or are deviant as well as delayed. Most studies with language-impaired children have tended to concentrate on individual components of linguistic development (phonology, syntax, morphology, semantics, and, more recently, pragmatics). Few studies have attempted to compare or contrast performance across these levels within the same populations.

Phonology. The studies examining phonological development in language-impaired children highlight several interesting conflicts in the literature. First, studies by Compton (1970, 1975), Ingram (1976), Leonard (1973), and Oller (1973) reveal that, in some cases, "misarticulations" appear to result from faulty perception as well as from faulty production (that is, where a substitution of one sound for another is bidirectional). But the phonological substitutions of other language-impaired children appear not to result from misperception. Thus although the psychoacoustic literature and clinical literature pertaining to language-impaired children have demonstrated that a large percentage of language-impaired children manifest auditory processing and speech perception problems, the linguistic literature on language acquisition indicates that a far smaller percentage of language-impaired children demonstrate perception problems, at least when perception is examined at the level of the word. In addition, the language-impaired children who are described in detail in the phonological literature do not appear from language sample data to have special word production or perception problems with stop consonant distinctions (as opposed to distinctions involving fricatives or sonorants) or with voicing distinctions (that is, with distinctions involving the processing impairments found at the acoustic level). In marked contrast, research studies investigating the relation between...
speech perception and production problems in language-impaired children have demonstrated marked difficulty with both perception and production of stop consonants and consonant clusters in comparison with liquids and vowels (Tallal et al., 1976; Stark and Tallal, 1980).

Studies by Compton (1970), Farwell (1972), Ingram (1976), Oller (1973), Pollack and Rees (1972), and Schwartz et al. (1980) indicate that language-impaired children demonstrate phonological processes nearly identical to those found in the grammars of normal children. The processes characterizing the phonological systems of normal children—such as syllable and segment simplification and deletion, substitution of stops for spirants, and so forth—are the same processes that operate in the phonologies of language-impaired children.

In contrast, some data in the linguistic literature suggest that, in general, language-impaired children have deviant phonological systems in certain respects and that some language-impaired children have quite deviant phonological production. Edwards and Bernhardt (1973), Lorentz (1974), and Renfrew (1966) have all found that certain processes persist in the phonological systems of normal children, although different processes may persist in different children. Edwards and Bernhardt (1973) and Salus and Salus (1973) have also noted the high degree of variability in the language-impaired child’s use of specific phonological processes (that is, inconsistent use of rules). This aspect of deviance, however, may apply only to severely impaired children and is not found to exist in all LI children (compare Lorentz, 1972). In any event, persistence of certain processes and inconsistent rule application contribute directly to deviance in phonological production. In addition to rule persistence and variability, some LI children have been observed to use unusual phonological processes in their speech—for example, lisping, unexpected nasalization of consonants, and atypical consonant (including sonorant) substitutions, at times even violating natural class boundaries (Ingram, 1976). It remains to be investigated whether the children with the most severe and deviant phonological systems are those with the greatest auditory processing deficits.

Perhaps the most important aspect of deviant phonological production is the way in which it generally parallels deviance in other areas of the grammar (Menyuk and Looney, 1972; Leonard, 1978; Schwartz et al., 1980). Leonard (1978) suggested that LI children’s phonological development is tied to acquisition in other areas. Complexity in the syntax and/or semantics of a sentence may require sim-
Language-impaired children in comparison to normal children (Liberman et al., 1976), Oller (1980) indicate that normal processes are involved in all children. These studies by some point to the significance of early detection, subcategorization, and phonological processes in normal children.

It is suggested that, in normal children, the auditory system is sensitive to these processes (e.g., Tallal & Bistarelli, 1976). It has been noted that the auditory system is not only important in normal children, but also in language-impaired individuals (Liberman et al., 1976). The sensitivity of the auditory system to phonological processes is crucial in language development, as it allows for the differentiation of meaningful units of speech, such as words and phrases.

**Syntax.** The same psycholinguistic issues arise in studies of grammatical development. Is there a special dysfunction of grammar acquisition in LI children? Does their acquisition of syntax and morphology conform to normal developmental patterns, or is their grammar acquisition deviant as well as delayed? When LI children are compared to mean-length-of-utterance (MLU)-matched normals, several important findings have been noted. First, acquisition of major syntactic categories is reported to be normal for LI children (Menyk, 1964; Leonard, 1972; Morehead and Ingram, 1973). LI children omit major sentence constituents far more often than normal children, however (Leonard, 1972; Menyk, 1964), and use major syntactic categories in a more restricted set of grammatical contexts (Morehead and Ingram, 1973). Second, the rate of syntactic development from basic unelaborated simple sentences to morphologically elaborated sentences involving complements and embedded sentences is far slower than in normal development (Ingram, 1972; Morehead and Ingram, 1973). Syntactic developments, albeit protracted, are by and large normal, although certain rules may be used by LI children with substantially different frequency than is evident in their use by normal children (Leonard, 1972; Morehead and Ingram, 1973). The protracted rate of acquisition and the less frequent use of certain rules and operations parallel the kind of deviance seen in the phonologies of LI children and, in themselves, can contribute directly to the impression of syntactic deviance.

Some reports (Lee, 1966; Eisenberg and Ingram, 1972) indicate that LI children at times produce strings which seem to lack internal syntactic structure altogether. This may be one reflection of inconsistent rule use (that is, the kind of competence-performance disparity mentioned above). Or such strings may be the output of a subgroup of LI children who have an impairment specific to the acquisition of syntax and morphology, either in addition to or apart from other linguistic impairments. It remains to be determined whether children with an impairment specific to syntax acquisition acquire syntactic
structures and operations in the same order as normal children, decode syntactic structures in the same manner as normal children, and/or perhaps reach a plateau of grammatical complexity beyond which they cannot move.

Morphology. Studies of the acquisition of inflectional morphology and grammatical formatives ("minor syntactic categories") again indicate some important similarities between LI and normal children and some interesting differences. Johnston and Schery (1976) studied the acquisition of 14 inflectional and grammatical morphemes, those 14 on which there are considerable normal acquisition data for comparison (Brown, 1973; deVilliers and deVilliers, 1973). They examined which of these morphemes appeared during each "stage" of development (as determined by MLU and mean number of words per utterance). They reported that: (1) LI children appear to acquire inflectional and grammatical morphemes in approximately the same order as normal children; (2) although LI children used some of these morphemes at the earliest stage, that is, before normal children, the link between the appearance of specific grammatical morphemes and a specific stage of acquisition indicates that, to a large extent, the developmental relationship between MLU and use of grammatical morphology reported for normal children obtains for LI children; (3) LI children do not use these morphemes consistently (in obligatory contexts) until one or two levels later than normal children.

Work by Kessler (1975) appears to confirm these findings, but work by Ingram (1972) and Morehead and Ingram (1973) does so only partially. The latter investigators report data in which LI children appear to use certain grammatical morphemes at earlier stages of language acquisition than do normal children but then show a decrease in the use of these morphemes (as compared with normal children) in subsequent stages. In addition, Weiner (1974) reports persistent problems with grammatical and inflectional morphology in the case he studied. Even at adolescence, this LI child was still omitting articles, pronoun features, obligatory pronouns, complementizers, plurals, progressives, third singular /-s/, and tense holders ("do," "be" aux, and copula), and produced no regular past tenses at all.

Johnston and Schery (1976) noted that the apparent decrease in usage of certain grammatical morphemes reported by Morehead and Ingram (1973) may be an artifact of syntactic growth, which produces more obligatory contexts for certain realizations of such morphemes.
The effect of sentence length and complexity on morphological elaboration, however, has yet to be studied in this population.

**Semantics.** Studies matching groups by age and studies in which language-impaired and normal children were matched for language stage have shared one important result, namely, that LI children appear to express the same relational meanings and use and respond to individual lexical items in much the same way as normal children who are considerably younger. Leonard, Bolders, and Miller (1976) and Leonard, Steckol, and Schwartz (1978) found substantial differences between groups in the frequency with which certain semantic relations were expressed, with the language-impaired children using earlier acquired semantic relations (for example, agent-action, agent-object, and action-object) (Bloom, 1971; Bowerman, 1973; Brown, 1973) and a more restricted set of semantic functions.

Freedman and Carpenter (1976), however, appeared to find no such differences between the two groups. Both of these findings are surprising in light of the operational definition of LI children as cognitively and intellectually normal and the close relationship thought to exist between semantics and conceptual development (Greenfield and Smith, 1976; Corrigan, 1978; Ingram, 1978; Gleitman, 1981).

LI children may be restricted to the semantic functions and relations expressed by younger normal children because of their syntactic and morphological limitations. That is, since semantics is encoded through syntax and morphology, an impoverished syntax/morphology limits the range of encodable semantic relations. The higher frequency of usage of essive (naming) by LI children (Leonard et al., 1976), for example, may be attributable to a higher frequency of one-word utterances and/or noun phrases in their speech. The variety and range of semantic functions and relations used should be compared with the variety and range of syntactic structures used.

**Pragmatics.** One of the most important aspects of human language is the function it serves for its users. Recent linguistic work suggests that function interacts with form in important ways and, in certain cases, may directly influence, even govern, the utterance form used. It therefore of interest to determine whether children impaired in the acquisition of form, and therefore restricted in its use, can accomplish social and communicative functions effectively by means of language. Research on this question has not yet produced a clear answer. Studies
by Geller and Wollner (1976) and Snyder (1975) suggested that LI children are impaired in pragmatic aspects of language (do not exhibit as many communicative intentions and functions), although Snyder studied children younger than 2 years, who were probably too young to be identified conclusively as LI. Watson (1977) looked at LI and age-matched normal children and found that LI children elaborated old topics and introduced new ones with far less frequency than normal children and used linguistically restricted and undemanding ways of taking turns. In contrast, however, Bartak, Rutter, and Cox (1975) found that, unlike autistic children, LI children were quite skilled at conversational behavior such as turn-taking, introducing a topic, and elaborating on a shared topic. In support of Bartak et al.'s findings, Gallagher and Darnton (1978) found that LI children were able to make repairs using the same general sorts of repair techniques as do normal children but without paraphrase (Garvey, 1975; Reilly, 1978), although particular repair strategies were not coupled with language stage as they are in normal children. Meline (1978), examining the descriptive communicative abilities of LI and MLU-matched normal children, found no differences between the two groups in communicative effectiveness.

**Summary and Implications of Linguistic Studies.** Studies of language development in LI children have focused on the characterization of the acquisition of specific structures or components of the system and the issue of deviance versus delay. To date, they indicate that linguistic development is characterized by normal developmental orders of acquisition accompanied by the persistence of early acquired immature forms and usage and by inconsistent application of internalized rules. Examined in detail, different LI children show various linguistic profiles and may belong to separate subgroups, each of which has a different underlying dysfunction or combination of dysfunctions.

Continued investigation into the patterns and processes of language development in the LI child is crucial for improving assessment and remediation programs. The study of language development in LI children, however, can bear critically on current theoretical models of language acquisition.

There are currently three major theoretical positions on language development. The first, the "social/interaction" position (Snow, 1972, 1977; Ervin-Tripp and Mitchell-Kernan, 1977; Snow and Ferguson, 1977; Newson, 1978), places the burden of acquisition and its ex-
planation on factors in the environment which may facilitate the acquisition process for the child—namely, greatly reduced and simplified linguistic input serving as an “ideal” model for presenting the structural regularities of the system to the child, and the use of this input in social interactions and routines which elucidate the communicative underpinnings of the code. The second, the “cognitivist” position (which takes several forms), views language acquisition as an internally driven process but sees language as either just one instance of the semiotic function and a direct outgrowth of sensorimotor and then later cognitive achievements (Sinclair, 1975; Piaget, 1980), or as a cognitive system tied to specific cognitive abilities by underlying principles common to them both (Case, 1978; Ingram, 1978; Bates et al., 1979). The third, “autonomous linguistic” position (Roeping, 1972; 1978; Chomsky, 1970; 1980; 1986; Wexler and Culicover, 1980; Otro, 1983; Hyams, 1986; Roeping and Williams, 1987) holds that language, in particular the computational aspects such as syntax and complex semantics, may be based on principles unique to it, and the acquisition of language may be accomplished (at least in part) by task-specific learning mechanisms.

All of these positions acknowledge the importance of normally functioning perceptual systems. The first model takes no position on how perception and language acquisition may interact, however; the second model attempts to explain aspects of language acquisition on the basis of constraints in the perceptual/cognitive apparatus; and the third sees those constraints as demanding a powerful language acquisition device in order for acquisition to proceed, especially when the already constrained apparatus is impaired.

Studies of mentally retarded children by Curtiss (Curtiss, Yamada, and Fromkin, 1979; Curtiss, 1981, 1982, 1988) suggest the existence of special-purpose language-learning mechanisms which operate alongside more general mechanisms in the conceptual and linguistic development of normal children but which can remain selectively intact in certain abnormal children. It is of interest, then, to determine whether LI children, or a subgroup, may have intact language-learning mechanisms which aid them in language acquisition and eventually enable them to develop language despite their perceptual and (nonlinguistic) cognitive deficits. This possibility can be recognized only by long-term investigation, in normal and LI children, of both linguistic and nonlinguistic functions thought to be involved in language development. The data forthcoming from this study will help to decide which (if any) of the three major positions best accounts for the
language of both normal and impaired children. By examining all of the components of the linguistic/communicative system together with key aspects of perceptual and cognitive function in LI children over time, these as well as more “basic” issues, such as deviance versus delay and the academic consequences of preschool language impairment, can be addressed, many for the first time.

Conclusions

Tallal and colleagues have investigated in detail the sensory, perceptual, motor, and neurodevelopmental abilities of children aged four through nine with various types of communicative disorders (language, speech, and reading impairments) and of normally developing children. These investigators have developed procedures which allow for systematic investigation of nonverbal sensory, perceptual, and cognitive abilities in a variety of sensory modalities. These investigators have also studied in detail the relationship between speech perception and production abilities of language-impaired children at the level of phonemes, syllables, and isolated words. These studies have demonstrated that certain perception, motor, and neurodevelopmental test variables are highly predictive of speech, language, and reading ability. Furthermore, the variables that predict speech, language, and reading functioning in normal children differ from those that predict the same functions in language-delayed children. Thus these studies have increased our understanding of the nature of nonverbal perceptual and motor functioning in development and disorders of language and reading, specifically as they relate to the analysis of phonemes, syllables, and isolated words. Until now, however, no attempt has been made to conceptualize the ways in which such basic abilities may interrelate directly with the development of higher-level linguistic functions.

Curtiss has investigated the receptive and expressive language abilities of normally developing and developmentally disabled children. The data resulting from these investigations have led her to hypothesize that, although some aspects of language acquisition appear tied in development to nonlinguistic perceptual/cognitive functioning, others are relatively independent of this functioning and appear to be based on special-purpose mechanisms. For this research, she has developed novel experimental procedures to assess systematically and in detail the phonological, semantic, syntactic, and pragmatic abilities of young children.

These procedures are applied to the assessment of receptive and productive language functioning in children of preschool age through the elementary grades. This work provides the basis for understanding the nature of language impairment in children at risk for reading disorder.
young children with and without normal language development. These procedures have been designed to permit separate analysis of receptive and expressive language skills as well as comparison.

We have broken fairly new ground in postulating the ways in which basic perception, production, and cognitive development interface with higher-level linguistic development. Although basic neuropsychological functions are assumed to interact with normal language development, the precise interaction between these areas and the degree of intactness necessary for normal language development are not well understood. It is not clear, for example, whether basic perception, production, or cognitive mechanisms subserve language development or are prerequisites to language or whether language develops parallel to the development of, or in even some instances in advance of, these neuropsychological functions. For example, the manner and extent to which memory capacity enhances language development and/or language development enhances memory capacity remains to be determined for normal and language-impaired children.

In developing hypotheses concerning the perceptual, motor, and cognitive deficits of language-impaired children, we consistently questioned how previously reported deficits in these areas might impact specifically on linguistic development and disorders. Language-impaired children, for example, have been shown consistently to have specific deficits in processing rapidly changing information. In precisely what way higher-level linguistic structures might be expected to be most directly affected by this basic perceptual dysfunction, however, has yet to be addressed experimentally. This question and similar ones formed the basis of the linguistic hypotheses described below. In developing each hypothesis we took as our goal the translation of general assumptions or questions concerning developmental language impairments into statements that would lend themselves to direct experimental test with the populations of interest. With the added powerful tool of observation of change over time, it should be possible to begin forming a foundation for a greater understanding of the interface between nonlinguistic and linguistic dysfunction in language-impaired children.

The project described below specifically aims to determine the outcome of language impairments of preschool-aged children for the purpose of determining which children or subgroups of children are most at risk for subsequent academic difficulties (affecting the acquisition of reading, spelling, and math skills) and/or emotional disorders. We
propose to achieve this goal by investigating certain aspects of sensory, perceptual, motor, and cognitive functions that are presumed to subserve language development and which previous research has demonstrated to be deficient in language-impaired children while simultaneously assessing receptive and expressive language development at the phonological, morphological, semantic, syntactic, and pragmatic levels. Specific hypotheses have been developed for this purpose.

Language does not develop in a vacuum but rather is affected by and affects the social and emotional development of children. The influence of a child's family, educators, and peers may contribute to the outcome of developmental disabilities. In addition, similarities and differences in family history specifically related to developmental disabilities may influence the course and/or outcome of early language disorders. These factors may help to shape the environment of the child, which, in turn, may affect the manner in which the child copes with disability and the strategies adopted to compensate for the disability. Therefore, to investigate aspects of nonlinguistic development and to attempt to relate these to the linguistic and academic development of language-impaired children in the absence of concomitant data concerning the children's relationships with peers and adults or their abilities to perform similar tasks in different environments might be an empty pursuit. Only by systematically evaluating all of these factors simultaneously, and observing how they change throughout development, can we hope to determine which variables or patterns of variables are most important in determining the eventual outcomes of early language disorder.

The Longitudinal Study

Objectives and Specific Aims

The long-range goal of this project is to improve our understanding of language development and disorder so as to improve the diagnosis, assessment, and treatment of young children with delayed or disordered language development. More precisely, we want to determine the outcome of language impairments of preschool-aged children in order to determine which children, or which subgroups of children, are most at risk for subsequent language, academic, social, and/or emotional disorders. These objectives will be approached in three stages. First, we will assess the relationships between social, emotional, and language development for normal children as the following.

1. Whether normal children...
2. Whether...
3. Whether...
4. Whether...

From these steps, we will be able to assess the relationships between social, emotional, and language development for normal children as the following.

1. Whether normal children...
2. Whether...
3. Whether...
4. Whether...
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stages. First, by assessing the perceptual, motor, cognitive, social and emotional, and demographic profiles of language-impaired and normal children as they develop, it should be possible to determine:

1. Whether there are differences between language-impaired and normal children’s abilities in any of these areas;
2. Whether various neuropsychological, social, or emotional abilities change in each population studied as a function of age;
3. Whether change in these abilities that occurs with age is different for language-impaired and normal children;
4. Whether subgroups of 4-year-old language-impaired children are characterized by different neuropsychological, social, emotional, or demographic profiles and whether the characteristics of these subgroups change throughout development;
5. Whether children who are impaired in language development in the preschool years have a greater frequency of positive family histories for developmental disorders of language, speech, and reading than their normal peers and, if so, whether these positive histories for developmental disorders affect the outcome of impaired language development.

Second, within the framework of specified hypotheses, we will assess the receptive and expressive speech and language abilities of language-impaired children, age-matched controls, and language-age-matched controls.

From these studies, we will determine:

1. Whether there are differences between language-impaired and normal children in all areas of linguistic development or whether specific patterns of linguistic difficulties emerge;
2. Whether patterns of linguistic difficulty change in language-impaired children as a function of age;
3. Whether patterns of change over time in linguistic ability differ for language-impaired and normal children and, if they do, whether such change reflects delay or deviance of function;
4. Whether subgroups of 4-year-old language-impaired children are characterized by different linguistic profiles and, if so, whether the linguistic profiles of these subgroups remain constant or change throughout development.

Finally, by simultaneously collecting case history information, investigating the development of neuropsychological and emotional...
functioning, and assessing the receptive and expressive language and academic capabilities of language-impaired and normal children, it should be possible to determine:

1. Whether different profiles of children at age 4 can predict subsequent linguistic, academic, emotional, or IQ outcomes at age 8;
2. Whether the same abilities that at age 4 years most closely predicted subsequent linguistic, academic, emotional, or IQ outcomes at age 8 change with age as change occurs in the outcome they predict (if not, do they differ in mean and/or scope of function?);
3. Whether different or similar combinations of abilities at ages 5, 6, and 7 predict linguistic, academic, emotional, or IQ outcomes at age 8 than predicted these same outcomes at age 4;
4. Whether, at each age, specific combinations of abilities predict linguistic, academic, and/or emotional status at the same age and whether these profiles are the same or different at each age.

Hypotheses

The specific aims of this longitudinal study have been operationalized as a series of specific hypotheses. These hypotheses were developed to address five basic areas: (1) nonverbal (NV), (2) linguistic (L), (3) nonverbal/linguistic interface (NV/L), (4) formal versus experiential testing (FE), and (5) outcomes (O).

Nonverbal (NV). 1. Descriptions of language-impaired children have consistently included reference to perceptual and memory deficits. Whether memory deficits reflect more primary perceptual deficits or independent deficits specific to memory is unclear from previous research. The purpose of this study is to monitor the course of development of specific nonverbal perception and memory abilities in normal and language-impaired children. We will analyze the extent to which perceptual and memory functions develop separately from each other, or interact, in language-impaired and normal children.

2. The extent to which perceptual and memory deficits are modality specific or reflect a more general, multimodality deficit remains controversial. Recent data suggest that the pattern of perceptual abilities may change as a function of age and sensory modality. The purpose of this study is to determine whether the pattern of perceptual and memory deficits in language-impaired children reflects unimodal or multimodal specificity of normal children.

3. Similar deficits have been reported by researchers in the purpose of this developmental and environmental context to differences in cognitive functioning.

4. Cognizance of the majority of findings regarding normal and/or differences in the frequency and normal children, developmental context to differences in cognitive functioning.

Linguistic (L). 1. Their language hypothesis is the difficulty demonstrated by children with “crucially acquired” both normal and impaired children.

2. Auditory particular aspect of these deficit is not understood. The purpose of this study is to determine whether the pattern of perceptual and memory deficits in language-impaired children reflects unimodal
or multimodality involvement and whether these patterns in modality specificity change over time differently for language-impaired and normal children.

3. Similarities in degree and pattern of perception and production deficits have been reported in language-impaired children, causing researchers to propose a link between these basic mechanisms. The purpose of this hypothesis is to study the pattern and course of development of basic nonverbal perception and production abilities in normal and language-impaired children to determine whether developmental changes observed for these functions are essentially similar to or different from each other.

4. Cognitive deficits, in particular deficiencies in figurative symbolism, have been reported for language-impaired children, but the majority of language-impaired children appear to develop normally with regard to other aspects of concrete operational thought. This study seeks to examine the development of seriation (which includes both figurative thought and operational thought) in normal and language-impaired children and to determine whether development of the separate aspects of seriation is different for language-impaired and normal children in sequence or timing.

Linguistic (L).

1. Language-impaired children are frequently reported to have a nonlinguistic sequencing deficit, and this deficit and their language impairment may be linked. The purpose of this hypothesis is to test whether language-impaired children have particular difficulty acquiring linguistic structures in which key information is signaled by the sequential order of linguistic elements. The acquisition of "crucially sequenced" linguistic structures will be compared to the acquisition of other structures that do not depend on sequencing in both normal and language-impaired children.

2. Auditory perceptual deficits in language-impaired children for particular acoustic events are well documented. The extent to which these deficits impact on language development is unclear, however. The purpose of this hypothesis is to determine whether language-impaired children demonstrate differential impairment with linguistic structures that rely on the particular acoustic cues in question as compared with otherwise equivalent structures and as compared with normal children.

3. The acquisition of lexical semantics and thematic relations is widely held to be driven by conceptual development, and language-
impaired children are operationally defined as having normal nonverbal conceptual abilities. This chapter will consider whether language-impaired children more closely resemble their age-matched peers or their language-age-matched peers in the development of these conceptually based aspects of language.

4. Vocabulary size has been reported to be significantly correlated with mental age (MA), including nonverbal MA, and language-impaired children are operationally defined as having normal nonverbal intelligence. The purpose of this study is to determine whether language-impaired children have more difficulty possessing and encoding morphologically coded information than information signaled by full lexical items. We will compare the performance of language-impaired and normal children.

5. Studies of language-impaired children leave unresolved the issue of whether their language is merely delayed or is deviant as well as delayed. We will attempt to determine whether the patterns of language development for language-impaired and normal children are essentially similar or different from each other.

6. Redundant information can either aid or impede processing under different circumstances. We will compare the effects of linguistic redundancy on language-impaired and normal children.

7. Language-impaired children have frequently been reported to have auditory short-term memory deficits. Knowledge of linguistic structure is also widely held to aid short-term memory for sentences in normals. Our hypothesis in this case tests whether the effects of sentence length and complexity are similar or different for language-impaired children and normal children.

8. Current research has not determined whether language-impaired children demonstrate impairments in expressing pragmatic functions and intentions. The purpose of this study is to compare conversational skills in language-impaired and normal children.

9. Linguistic studies of language-impaired children have not yet investigated whether language-impaired children have more difficulty with one component of the linguistic system than another. The purpose of this hypothesis is to compare development of phonology, semantics, morphology, and syntax in language-impaired and normal children.

**Nonverbal Linguistic Interface (NV/L).** There is still considerable controversy in the literature concerning whether language-delayed children are differentially impaired on verbal and nonverbal percep-
tion, production, and/or cognitive operations. We will consider this question using a series of perception, production, and cognitive (learning and memory) tasks that have been developed specifically in equivalent forms, using both verbal and nonverbal materials. The purpose of these studies will be to determine whether there are differences in nonverbal and verbal perception (hypotheses NVL 1, 2, 3), production (hypotheses NVL 4, 5), and/or cognitive (hypotheses NVL 6–10) abilities in language-impaired and normal children and whether these relationships change with age differently for language-impaired and normal children. These hypotheses will also directly assess the interfacing of specific aspects of nonverbal perception, production, and cognitive development with those aspects of linguistic development that are being investigated in the linguistic hypotheses described in an earlier section.

1. If, as has been argued, language-impaired children have specific temporal deficits regardless of whether verbal or nonverbal information is being processed, then the ability to process both nonverbal and verbal stimuli that incorporate rapid temporal change should follow a similar course of development in these children. In order to test this hypothesis, we will evaluate the rate-processing abilities of LI and normal children with nonverbal stimuli and verbal stimuli and follow the course of development of these abilities from 4 to 9 years.

2. This hypothesis follows directly from linguistic hypothesis 1. In this hypothesis, we will assess the direct relationship between the development of nonverbal sequencing and the development of linguistic structures that are or are not signaled by temporal order. If nonverbal sequencing deficits in language-impaired children are directly related to their language deficit, then we might expect the degree of difficulty they have on nonverbal sequencing to correlate more highly with their ability to process and produce those linguistic structures that are signaled by temporal order than those that are not.

3. This hypothesis follows directly from linguistic hypothesis 2. In this hypothesis, the relationship between the development of nonverbal rate processing and the development of linguistic structures that are or are not signaled by auditory distinctions requiring rapid analysis will be directly evaluated. If nonverbal rate-processing deficits in language-impaired children are directly related to their language deficit, then we might expect the degree of difficulty they have on nonverbal rate-processing tasks to be more highly correlated with those linguistic structures that are signaled by auditory distinctions requiring rapid analysis than with those that are not.
4. Language-impaired children have been found to have difficulty repeating syllables and naming words rapidly in succession. The extent to which these abilities reflect a specific verbal deficit or a more basic nonverbal deficit in sequential motor programming has not been investigated experimentally. Testing of this hypothesis will compare the development of verbal and nonverbal sequential motor abilities.

5. This hypothesis is equivalent to hypothesis NV/L 2 except that, instead of assessing the relationship between the development of perceptual sequencing and linguistic skills, testing focuses on the development of sequential motor skills and their relationship to the development of linguistic structures that either are or are not signaled by temporal order.

6. It has been hypothesized that, rather than having a specifically linguistic deficit, LI children may have a more general deficit in representational skills. This hypothesis will be tested by evaluating the development of equivalent verbal and nonverbal representational abilities in LI and normal children between the ages of 4 and 9 years.

7. Like hypotheses NV/L 2, 3, and 5, this hypothesis has been developed to integrate directly one of the linguistic hypotheses (L 7) with a specific nonverbal process (memory). In this hypothesis, the actual nonverbal serial memory abilities of LI and normal children between the ages of 4 and 9 years will be compared with their development of specific language structures. We might expect that, if nonverbal memory deficits directly affect the pattern of linguistic development, then greater decrement in language performance would result from increased sentence length than from increased sentence complexity.

8. LI children have been hypothesized to have memory deficits that may relate to their language deficit, and remediation programs have been developed in an attempt to improve memory capabilities. Whether LI children's memory deficits are specific to verbal material, however, or also encompass the ability to remember nonverbal information has not been established conclusively. Similarly, the types of strategies (verbal, visual imagery, and additional practice) that may help to enhance memory ability in LI and normal children between the ages of 4 and 9 years have not been documented. We will evaluate these aspects of memory in connection with this hypothesis. In addition, we will evaluate the ability of LI and normal subjects to transfer newly learned strategies to new tasks.

9. In testing this hypothesis we will investigate the direct relationship between performance IQ and the development of various components of vocabulary in LI children. If LI children have highly verbalized, highly articulated, well-coded grammatical structures, testing will be conducted in figure-ground tasks with the linguistic component made the same.
ponents of the linguistic system. Current research suggests that vocabulary acquisition is closely tied to intelligence in normal children. If LI children are of normal intelligence, then their comprehension of information coded lexically may be expected to correlate more highly with their IQ than their comprehension of similar information coded grammatically.

10. In studies of normal and abnormal language development, some aspects of language have been found to be more closely related to conceptual/cognitive development than others. How the development of figurative and operational thoughts fits into this pattern of relationships has not been investigated, however, even though language-impaired children have been reported to show particular deficits in figurative thought. In formulating this hypothesis we seek to investigate the relationship between mastery of different components of the linguistic system and achievement of the operational and figurative components of seriation and to determine whether that relationship is the same or different for normal and language-impaired children.

*Formal Testing versus Spontaneous Testing (F/S).* It is important to assess whether significant differences in performance occur depending on whether the data are elicited through a formally structured means, such as a test, or in a more "spontaneous" manner. The following hypotheses consider the extent to which the structure of the testing situation may impact on performance and whether differences occur in this regard between LI and normal children.

1. Formal tests to elicit speech artificially constrain the input to the child, eliminate communicative intention from the child’s response, and attempt to constrain the child’s response. These parameters may make elicited speech different from naturally occurring speech. The purpose of this hypothesis is to investigate whether the difference between performance on elicitation items and free speech performance is similar or different for different subgroups of language-impaired children and for normal children.

2. Confrontation-naming tasks impose special burdens on lexical access and retrieval. Performance on such tasks may be particularly difficult for language-impaired children who have difficulty processing information rapidly and may therefore greatly undermine their spontaneous vocabulary. In testing this hypothesis we investigate whether the relationship between confrontation-naming performance and spontaneous vocabulary use is the same for different subgroups of language-impaired children and for normal children.
Outcome (O). One of the major goals of this longitudinal study is to determine whether specific profiles or patterns of variables predict the major outcomes of interest in the study; receptive and expressive language, articulation, reading and other academic skills, intelligence, and/or emotional status. More specifically, it is important to determine whether (1) specific profiles observed in 4-year-old normal and language-impaired subjects are predictive of their subsequent language, speech, academic, intellectual, and/or emotional status at age 8; (2) whether the same or different profiles correlate concurrently with these same outcomes of interest at ages 4, 5, 6, and 7 when subjects are tested annually; and/or (3) whether profiles predictive of outcomes of interest differ for language-impaired and normal children throughout development. The following variables or groups of variables will be clustered in determining both predictive and concurrent validity with outcome measures: (1) nonverbal perceptual, motor, and cognitive variables; (2) verbal receptive, expressive, and cognitive variables; (3) demographic, family, medical, and educational history variables; (4) social and emotional variables; and (5) IQ.

General Methods

Three groups of subjects are participating in this longitudinal study. Group I consists of children with specific developmental language impairment. Group II has age-matched controls. These children are tested annually for 5 years from ages 4 to 8. Members of group III were matched to the language age of a subgroup of the language-impaired children at the time of induction into the study. They receive language testing only and are tested 5 times at 6-month intervals.

Group I comprises 100 4-year-old subjects with specific language disability who are without other primary sensory, motor, cognitive, emotional, or neurological impairments. In order to be included as a subject in this group, a child had to have:

1. a nonverbal performance IQ of 85 or better on the Leiter International Performance Scale;
2. a mean language age (when computed from expressive and receptive test scores) at least 1 year below both performance mental age and chronological age;

1. The Sequenced Inventory of Communicative Development (Hedrick, Prather, and Tobin, 1979); the Token Test (DeRenzi and Vignolo, 1962); the Northwestern Syntax Screening Test (Lee, 1969); the Carrow Elicited Language Inventory (Carrow, 1974) were used to derive receptive and expressive language ages.
3. normal hearing acuity, no motor handicaps, no oral structural or motor impairments affecting nonspeech movements of the articulators;
4. an English-language background without significant dialectal or language differences in the home environment;
5. language skills equal to or greater than those expected at 1 year of normal development;
6. no obvious signs of infantile autism or emotional difficulties (according to DSM-III criteria); and
7. no known neurological disorders (that is, no seizures, hemiplegia, and so forth).

Group II comprises 60 4-year-old normally developing subjects matched on the basis of IQ, age, geographic, and schooling characteristics to the subjects in Group I. In order to be included as an age-matched control in this group, a child had to meet each of the following criteria:

1. a nonverbal performance IQ of 85 or better (and not greater than the highest IQ demonstrated by a language-impaired subject) on the Leiter International Performance Scale;
2. a mean language age (when computed from expressive and receptive test scores) not more than 6 months below chronological age;
3. speech articulation age not more than 6 months below chronological age;
4. normal hearing acuity, no motor handicaps, and no oral structural or motor impairments affecting nonspeech movements of the articulators;
5. no emotional or neurological problems (according to DSM-III criteria);
6. an English-language background without significant dialectal or language differences in the home environment.

Group III comprises 30 normally developing subjects matched to a select subgroup of Group I on the basis of language development. In order to be included as a language-age-matched control in this group, each child had to meet all of the following criteria:

1. a nonverbal performance IQ of 85 or better (and not greater than the highest IQ demonstrated by a language-impaired subject) on the Stanford Binet Intelligence Test;
2. a mean language age (when computed from expressive and receptive test scores on the Sequenced Inventory of Communication
Development, or SICD), not more than 6 months below performance mental age and chronological age;
3. normal hearing acuity, no motor handicaps, no correctable visual impairments, no oral structural or motor impairments;
4. an English-language home environment without significant dialectal or language differences;
5. normal emotional and social development for chronological age; and
6. no neurological problems.

Questionnaires were used to determine socioeconomic status, demographic variables; family history for the presence of developmental disabilities; and medical history, including prenatal, birth, and postnatal health, educational and therapy history, speech and language development history, and language environment. Only data pertaining to (1) languages spoken in the home, (2) chronic ear infection, (3) current medication, (4) neurological or emotional disorder, and (5) socioeconomic status obtained from questionnaires were used for subject selection. The remaining data collected from these questionnaires will be used in the longitudinal study in assessing specific hypotheses related to demographic variables (family, genetic, medical, and educational history). The questionnaires were completed by a parent or guardian during the 1st year of the study. Each year thereafter, a brief current status questionnaire is completed to provide supplemental demographic data. These data will be used to determine whether significant demographic differences occur between language-impaired and normal children. These data will also be used in multivariate analyses to determine whether any demographic variables are good predictors of the various outcomes of interest (that is, subsequent linguistic development, academic achievement, and social and emotional development).

A pediatric neurological evaluation was given to each subject. The neurological exam consisted of an assessment of cranial nerves, motor responses, sensation, reflexes, and cerebellar functions. In addition, an examination for gross body anomalies or stigmata of the head, eyes, ears, mouth, and feet was given. Those children who were found to have evidence of frank neurologic dysfunction (for example, seizure disorders, cerebral palsy, or dysarthria) were excluded from the study. In addition, those children who evidenced grossly abnormal social or emotional development (such as autism or hyperactivity) were also excluded. Neurodevelopmental "soft-sign" measures which have been found in paired children. Soft-sign tests were not used in this study, rather as methods for investigating the early development of normal children.

The standard neurosensory examination included, at least, the 250, 500, 1,000, and 2,000 Hz frequencies (ANSI S3.6, 1969) with a history of any hearing loss before these ages. This study was designed to investigate the effect of neurosensory and behavioral tests of speech and hearing on language development. An oral speech pathology team, using the Lode Touchon, right or left persistent dysarthria, were sufficient to exclude hearing losses.

The Leitner and the modified Leitner are used to potential IQs and IQs below 250, 500, 1,000, and 2,000 Hz were excluded by 1960. They were used for subjects and IQs below 250, 500, and 1,000 Hz were excluded.

The recent efforts to define the IQ and IQs below 250, 500, and 1,000 Hz were excluded.
and greater than 4 years. The battery provides for a separate assessment of receptive and expressive language skills.

In addition to the SICD language assessment battery, the Token Test (DeRenzi and Vignolo, 1962), the Northwestern Syntax Screening Test (Lee, 1971), and the Carrow Elicited Language Inventory (Carrow, 1974) were given. Articulatory abilities were assessed using the Arizona Articulation Proficiency Scale—Revised (Fudala, 1980).

Each subject in the longitudinal study is tested individually for approximately 6 to 10 hours per year, between ages 4 and 8 years. The longitudinal study battery has been developed specifically to address each of the hypotheses on which the study is based. Both standardized and experimental procedures (developed specifically for this study) are given annually. These procedures (listed in Table 8-1) include the detailed assessment of receptive and expressive speech and language, neuropsychological (perceptual, motor, memory, and cognitive) development, preacademic and academic (reading, spelling, and math) achievement, intellectual development, and social and emotional development. Wherever possible, knowledge is assessed in more than one format to evaluate the relationship between product and process of acquisition and testing constraints. Both elicited and spontaneous language formats, for example, are used to assess components of expressive language development. Finally, methods that allow for a maximum of individual differences, as well as the assessment of change over time, have been included in the longitudinal test battery.

The basic design for the study can be conceptualized as a 2 × 5 split-plot arrangement. A split-plot design is one in which there are between-groups comparisons for some independent variables and within-groups comparisons for other independent variables. For this study, the between-groups factor is for group: the subjects will be chosen to be in either the language-impaired group (Group I) or the age-matched control group (Group II). The within-subjects factor is for time of testing, and there will be five time periods. Testing will occur for each subject at ages 4, 5, 6, 7, and 8. The design allows for estimates of the effects of group (impaired versus nonimpaired) and the effects of age. In addition, interactions between age and group can be evaluated. These interactions will tell us whether there are effects associated with unique combinations of age and impairment. In other words, the interactions will reveal whether there is a differential rate of growth between language-impaired and nonimpaired subjects.

In addition to the two groups in the longitudinal study, there will be a third paired group used to observe children who there is evidence of developmental changes, which are to be analyzed in a 1 × 3 design. A comparison will be made with which a more refined analysis of differences in performance at the different periods, the first, second, and third, for receptive, expressive, and more precisely analyzed with the nonimpaired measures and analyses with another group of control subjects.
be a third group which is normal and matched to the language-impaired group on language variables (Group III). This group will be used to determine how the development of language for impaired children differs from normal language development, specifically if there is evidence of deviance or delay in language development.

One of the major issues to be considered is whether changes occur throughout development in language, speech, perceptual, motor, and cognitive skills among language-impaired children. To assess these changes, we will focus on the language-impaired group that will be selected at age 4 and will be tested at ages 4, 5, 6, 7, and 8 years of age. To determine within-groups changes that may occur throughout development, we will study the data for the language-impaired group in a $1 \times 5$ factorial design. In other words, the data for this comparison will be treated as a randomized block design. The data will be analyzed in two phases. First, there will be a univariate phase in which a $1 \times 5$ repeated-measure analysis of variance will be performed for each outcome measure relevant to language, speech, perception, production, and cognition. Trend analysis will be used, and first- through fourth-degree polynomials will be evaluated to gain a more precise description of the growth pattern. Later, multivariate analysis of variance will be used to determine whether there are differences in mean vectors for the age categories. Beyond the question of whether the language-impaired children differ at different time periods, the multivariate analysis should help clarify how they differ. It will do so by identifying the specific linear combinations of variables which define the differences between the language-impaired children at the different points in time.

The second question is whether the children who are language impaired at age 4 develop to within the normal range at ages 5, 6, 7, and 8. For the purposes of this study, “normal” will be defined as the level of performance of the age-matched normal group (Group II). Stated another way, the question is whether the language-impaired group and the matched, nonimpaired group continue to differ on language, speech, listening, and learning skills through age 8. This question will be evaluated by comparing the language-impaired and the nonimpaired group on the composite of language and learning measures at each of the time periods. Both multivariate and univariate analyses will be used for this purpose. The analysis will be performed by considering each time point separately. In latter phases of the study, all time points will be considered in a single analysis.

Another approach which will be used to evaluate this question has
its roots in cancer statistics. This method, which was originally
developed by Kaplan and Meier (1958), plots “survival” curves. In medical
research, this procedure literally means breaking down a cohort
according to mortality. In the present study, we will call those who
remain in the language-impaired classification survivors. Over the
course of the study, some children who were originally evaluated as
language impaired are expected to be assessed in the normal range.
By analogy, the analysis will consider these cases as mortalities. The
proportion of children who remain in the impaired group will be
plotted over the course of years. Using Cox’s hazard functions, which
have the advantage of being able to include censored data, other curves
can be drawn which are theoretically related to the first curve.

An extension of the question pertaining to the differences in lan-
guage and neuropsychological skills is whether there are differences
in the patterns of development between the two groups. Using the
terminology of analysis of variance, question 2 might be concerned
with a main effect. This third question would examine an interaction.
The interaction is between group (impaired versus nonimpaired) and
age (4 through 9 years). A significant interaction would imply that
the rate of change in language, speech, and neuropsychological skills
would differ for the two groups of children. More detailed analyses
using multivariate methods could demonstrate how the patterns differ
between groups by identifying the linear combinations of variables
for each group which best describe the changes over the five testing
periods.

In addition to questions concerning effects of early language im-
pairment upon later language and learning skills per se, there may be
other results of early language difficulties. The fourth series of data
analyses will examine the effects of early language impairment upon
the development of academic achievement skills. For all practical
purposes, these analyses will be the same as those used in question 3
above to assess language and neuropsychological problems, except
that in this case the dependent variables will be measuring academic
achievement. A series of univariate and multivariate tests will be
performed using the 2 × 5 split-plot design. The results should be re-

tant to the differences between language-impaired and normal children
in academic achievement and should also provide information
about the rates of growth in these skills for each group.

Questions 5 and 6 repeat the analysis with different dependent
variables. The measures to be considered in the fifth set of analyses
are demographic. The variables relate to family and to medical and
educational history. The sixth set of analyses considers behavioral and conduct problems and relationships with peers and family. Each of these analyses will be performed using the $2 \times 5$ split-plot multivariate analysis model.

We will also include two questions about the relationship between language development and family history. For each child in the experiment, we will determine whether there is a positive family history for developmental disorders of language, speech, and reading. The seventh set of statistical analyses will use simple nonparametric statistics (chi-square tests) to determine whether language-impaired children come from families with histories of language impairment significantly more often than do normal children.

The eighth analysis probes the differences between language-disabled children with and without positive family histories for learning disabilities. These analyses will be rather extensive. First, information on family history will be used to divide the language-impaired group into two subgroups. One subgroup will consist of children with positive family histories of communication disorders, and the other subgroup will encompass children with no known family history of these problems. If these groups are of near equal size, we will again conceptualize the analysis as a $2 \times 5$ split MANOVA. All of the children in the analysis will be language impaired, but the between-groups factor will be the new dichotomy for positive family history. Using this design, we will estimate the differences between these two groups for language and learning variables, reading and writing, other cognitive variables (learning, memory, and scholastic achievement), and behavioral and conduct problems.

A final set of analyses will be used to determine which aspects of the language disability at age 4 best predict speech, language, academic achievement, IQ, and emotional status at ages 5, 6, 7, and 8. To answer this question, multiple regression equations will be developed. These equations will use performance on a specific measure such as language, reading, emotional status, or intellectual ability on the left side of an equation and performance on specified measures at earlier ages on the right. This analysis will give us a specific model for each aspect of the language disability.

In addition, a canonical correlation analysis will be used. Canonical correlation is similar to multiple regression, except that there are many variables on each side of the equation. This analysis will find those linear combinations of variables at age 4 which maximally predict other linear combinations of variables at age 8.
We intend to use the survival-curve analysis to answer this question. Separate curves will be drawn for children who have specific problems at the time of the first testing. Using these curves, we will determine how many children remain impaired based upon several observations taken at age 4. Peto Analysis can be used to determine the extent to which the curves are similar.

Finally, a series of analyses will compare the language-impaired children with the group of younger children who are matched on language skills. These comparisons present some unique problems because the language-age-matched groups will be younger and may differ in other significant ways from the language-impaired children. For this reason, comparisons will be made only for language development variables. The analysis will be designed to answer three distinct questions. First, are there differences in the rate at which the children in these two groups acquire language? This analysis will compare the number of months it will require for subjects in the different groups to reach a variety of language-based criteria. Other analyses will evaluate absolute differences in language acquisition as well as the order of acquisition. One way that order effects may be evaluated is by using Scalogram analysis. For the normal children, we will determine the order in which specific aspects of language skills appear. Whether or not the language development of language-impaired children also follows this cumulative order can be evaluated using the Guttman procedure. Scalogram analysis or Guttman scaling can give a precise estimate of developmental sequence as a coefficient of reproducibility. Nonparametric methods will be used to test for statistical significance for differences in order of development for each group. We will make more detailed analyses for the comparison of these two groups during the development phase of the project.

A final problem will be to identify subgroups of language-impaired children that might exhibit different patterns of developmental disabilities. In order to identify these subgroups we will use Q-factor analysis. Q-type factor analysis is similar to the more traditional form of factor analysis (R-type) except that it begins with a matrix of correlations between pairs of individuals. After a matrix of correlations between individuals has been obtained, the principal components of the matrix are obtained. Then the principal components are rotated to a varimax solution in order to obtain distinctive subgroups. This factor analysis will include all of the variables from all of the hypotheses.
Conclusions

Other groups of investigators could undoubtedly produce different models and hypotheses of language disorders to investigate that would be quite different from the ones we have developed but equally valid. We have attempted to construct a state-of-the-art theoretical framework based on the data presently available concerning developmental language disorders and upon which we could develop specific hypotheses that lend themselves to experimental investigation. We have tried to deal with the need to be specific in the formulation of our hypotheses while at the same time being broad enough to encompass the basic aims of the longitudinal study. Throughout every aspect of the development of this study, we have been critically aware of the practical constraints intrinsic to this endeavor: (1) the need to develop procedures for assessing abilities that develop from the age of 2, in some cases, to the age of 9; (2) the need to develop a series of experiments broad enough to meet the requirements of the study while at the same time not being more extensive than can be analyzed effectively within the constraints of the number of subjects to be included in the study; and (3) the need to develop procedures for young normal and language-impaired children that are both interesting and concise enough to keep them willing to participate for the 5 consecutive years of the longitudinal study.

At the time of this writing, all of the anticipated 100 4-year-old language-impaired children meeting all of the criteria for inclusion in Group I have been inducted into the longitudinal study. All of the 60 4-year-old age-matched control children meeting the criteria for inclusion in Group II have also been inducted, as have all of the 30 language-age-matched controls in Group III. Care has been taken to match the subjects in these groups as closely as possible. These subjects have all completed their fourth longitudinal testing, and some have completed their fifth testing.

Subjects have been referred from a wide variety of sources, including the public schools, private speech therapy clinics, local pediatricians, local preschools and day care centers, television and radio public service announcements, and word of mouth. Considerable organization, public relations, and persistence has been necessary to locate these subjects. This effort will continue until all of the necessary subjects have completed all 5 years of the study.

We anticipate publishing the data derived from this longitudinal
study as they become available. The first manuscripts reporting data from this study are currently in progress. Results of annual testing as well as the compiled results from the 5-year longitudinal testing will be published as they become available. We hope that these results will help clarify the many questions raised in the stated hypotheses. Preliminary results are already leading us to develop new and more refined questions and hypotheses for subsequent research. The data that we are just beginning to see from the study are both exciting and very far-reaching. They will no doubt enhance our understanding of the etiology as well as prognosis of early language impairment. They may also lead to a better definition of specific subgroups of language-impaired children and, subsequently, to more effective therapeutic intervention.

References


THE SAN DIEGO LONGITUDINAL STUDY


