HANDBOOK OF CHILD LANGUAGE DISORDERS

SECOND EDITION

EDITED BY RICHARD G. SCHWARTZ

ROUTLEDGE

HANDBOOK OF CHILD LANGUAGE DISORDERS

The acquisition of language is one of the most remarkable human achievements. When language acquisition fails to occur as expected, the impact can be far-reaching, affecting all aspects of the child's life and the child's family. Thus, research into the nature, causes, and remediation of children's language disorders provides important insights into the nature of language acquisition and its underlying bases and leads to innovative clinical approaches to these disorders.

This second edition of the *Handbook of Child Language Disorders* brings together a distinguished group of clinical and academic researchers who present novel perspectives on researching the nature of language disorders in children. The handbook is divided into five sections: Typology; Bases; Language Contexts; Deficits, Assessment, and Intervention; and Research Methods. Topics addressed include autism, specific language impairment, dyslexia, hearing impairment, and genetic syndromes and their deficits, along with introductions to genetics, speech production and perception, neurobiology, linguistics, cognitive science, and research methods. With its global context, this handbook also includes studies concerning children acquiring more than one language and variations within and across languages.

Thoroughly revised, this edition offers state-of-the-art information in child language disorders together in a single volume for advanced undergraduate students and graduate students. It will also serve as a valuable resource for researchers and practitioners in speech-language pathology, audiology, special education, and neuropsychology, as well as for individuals interested in any aspect of language acquisition and its disorders.

Richard G. Schwartz is a Presidential Professor in the Ph.D. Program in Speech-Language-Hearing Sciences at the Graduate Center of the City University of New York.

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Edited by Richard G. Schwartz

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This book is dedicated to my daughters, Lindsay, Brandi, and Helene.

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PREFACE

My own interests in developmental processes and what can go awry began in high school with a focus on biology. Although my specific focus changed throughout my undergraduate and graduate studies, this core interest remained the same. I became interested in language and ultimately in the mechanisms of language acquisition and disorders of that process. Although I suspect the authors of the following chapters came to this interest along various paths, we all have arrived at the same destination in our focus on language impairments that affect children. This handbook is intended to bring our interests in these different groups of children together, for the first time in a single volume.

As has often been noted, the acquisition of language is one of the most remarkable human achievements. It is achieved without effort or direct teaching for the vast majority of children, a remarkable interaction of biology and environment that occurs with seemingly wide individual variation, yet with remarkable consistency. Besides its intimate relationship with human cognition, language is also the thread that binds our social lives.

When language acquisition fails to occur as expected, the impact can be far-reaching, affecting all aspects of the child's life and the child's family. Impairments in language affect social development, academic performance, employment, and quality of life. Research into the nature, causes, and remediation of children's language disorders provides important insights into the nature of language acquisition and its underlying bases and leads to innovative clinical approaches to these disorders.

In this second edition we sought to update the information in this field. The book is still organized into four sections: Typology; Bases; Language Contexts; Deficits, Assessment, and Intervention; and Research Methods. Because the focus is the children, we begin with the general diagnostic categories of children's language disorders in Part I, Typology. In Part II, Bases, the authors provide overviews of linguistics, cognitive science, neurobiology, memory and attention, speech perception and production, genetics, and cognitive science that underlie these disorders. Part III, Language Contexts, considers the implications of variation for children's language disorders when children acquire more than one language, across languages, and in other dialects. The chapters in Part IV, Deficits, Assessment, and Intervention, examine the deficits in specific areas such as pragmatics, syntax, semantics, morphosyntax, reading and writing, as well as in processing speed, attention, and perception. The final section, Part V, explores the Research Methods used in the study of production, comprehension, translational and implementation research, and neuroscience in children with language disorders.

Determining the most appropriate level for the book continues to be a challenge. We wanted to bring state-of-the-art information in child language disorders together in a single volume for advanced undergraduate students and graduate students in speech language pathology, special education, and neuropsychology, as well as for clinicians and active researchers in these disciplines. We believe we have accomplished this balancing act by including introductory-level information as well as advanced, state-of-the-art reviews of current theories and research.

I want to acknowledge the generous and outstanding contributions of my fellow chapter authors, who all took time from their busy research and writing lives to contribute to this volume. I also want to thank my teachers, colleagues, students, and the children from whom I first learned about language disorders and from whom I continue to learn about the nature and impact of these disorders. The National Institutes of Health, particularly the National Institute on Deafness and Other Communicative Disorders (NIDCD), has funded my research for almost 40 years and has funded the research of my colleagues who have written chapters. Other authors in the volume have received support from the National Institute on Child Health and Development. The preparation of this volume was supported by a grant from the NIDCD. I also want to acknowledge the important role played by the Symposium on Research on Child Language Disorders (SRCLD) at the University of Wisconsin, Madison, founded by my friend and colleague Jon F. Miller, which has provided a home for research in child language disorders for 40 years. A portion of the royalties from this book will be donated to the SRCLD.

Richard G. Schwartz
Brooklyn
2016

PART I

Typology of Child Language Disorders

1

SPECIFIC LANGUAGE IMPAIRMENT

Richard G. Schwartz

Terminology: "How Shall a Thing Be Called?" (Brown, 1958)

Roger Brown considered how children come to attach a word to things and categories of things in the world. Attaching words or names to things and categories is basic to human language—the label *Specific Language Impairment* (SLI) is one example. Our field came to this terminology through a long history, but recently some researchers have raised questions about its use and have suggested alternatives. I will consider some of those issues before describing this clinical category of child language disorders.

Reports of language learning disabilities in the absence of other developmental disabilities first appeared in the 19th century and grew exponentially beginning in the second half of the 20th century (see a recent review in Reilly et al., 2015). These children have been varyingly described as having congenital aphasia, congenital word deafness, congenital auditory agnosia, and congenital developmental aphasia, among other terms. Many of these earlier labels were based on inferred etiology and, to some degree, reflect *parts of the elephant* as described by the proverbial blind men. More recent terminology has included language disorder, delayed language, developmental language disorder, specific language deficit, specific language impairment, and, most recently, primary language impairment. Consistent among these terms is the assumption that these children have a language disorder in the absence of autism, general developmental/cognitive delays, identified genetic syndromes, hearing impairments, and seizures or other neurological conditions. These disorders are only specific in that exclusionary or idiopathic sense.

Two recent papers (Bishop, 2015; Reilly et al., 2015) have approached this issue of terminology in different ways. Capturing all of the carefully considered perspectives of these two keynote papers and all of the commentaries is beyond the scope of the discussion here, but I will briefly summarize some of the key points. Bishop considered the many advantages and disadvantages of labels and found that the former far outweigh the latter. Among the benefits of clinical labels can be in defining research populations, identifying children clinically, identifying strengths as well as weaknesses, and providing needed services including assessment, accommodations, and intervention. She noted that the wide variety of Language Learning Impairment (LLI) terms have divided the field and that although SLI has not been adopted outside of the research community, it is the most widely used term in the research literature.

Reilly et al. critically evaluated exclusionary and inclusionary criteria, revealing the weaknesses in the definition along with the quantitative criteria. All are certainly good points regarding the potential heterogeneity of deficits, language and non-language, and use this heterogeneity to argue for terminological change. I share the perspective offered by Leonard (2015), Rice (2015), and other commenters, that none of the other terms offered solve all the problems of SLI. There is good reason to suspect that, at some point in the future, SLI will no longer be viewed as idiopathic; we will identify neurobiological and genetic bases for SLI, along with their specific and universal cognitive-linguistic manifestations. An alternate term at this point would further divide the research literature as it already has been by terms like Language Impairment (LI—also the same as the abbreviation for Long Island) and Primary Language Impairment (PLI—also the abbreviation for Pragmatic Language Impairment). It is not clear what LLI would add. As several of the commenters noted, one of the most critical issues is the lack of use of SLI outside of research environments and the general lack of public awareness. Few efforts, other than the Raise Awareness of Language Learning Impairments campaign (RALLIcampaign, 2012) in the United Kingdom, have been made by researchers or by state, local, and national organizations to raise public awareness of not only the term but the impairment. It is this situation that must change, not the terminology. None of the other terms suggested seem to be any more palatable than SLI, and there is the now-established history.

Studies of specific language impairment (SLI) have become ubiquitous over the last four decades (Bishop, 1997; Leonard, 2014). A Google Scholar search (July 12, 2016) yielded 1,520,000 results for SLI, far more than for any other term (Bishop, 2015). This large body of research has significantly enhanced our general understanding of these impairments, while leaving us still uncertain about important aspects of their exact nature. We still do not know their cause(s), their range of manifestation, the course of their development, or the most effective remediation approaches. Our knowledge base has increased exponentially, allowing investigators to propose better-informed models of SLI, links to other childhood language disorders, and approaches to assessment and intervention.

SLI affects approximately 7% of the population, with boys affected slightly more often than girls (Tomblin et al., 1997). SLI may occur at the same rate in other populations of children with language disorders. If this is true, subgroups of children with autism, children with genetic syndromes, and children with hearing impairments may have SLI co-morbidly to their primary impairment. There is mounting evidence that SLI is genetically transmitted, and thus we expect to see familial patterns (see Chapter 10 by Tomblin). Siblings of children who have already been diagnosed with SLI are approximately four times as likely to have SLI as are children without a family history.

The definition continues to be primarily one of exclusion. SLI is an impairment of language comprehension, language production, or both in the absence of hearing impairment, the absence of a general developmental delay (i.e., a normal performance IQ), the absence of any neurological impairment (e.g., perinatal bleeds, seizure disorders), and no diagnosis of autism. It is only in this singular sense that this language impairment is specific. Despite these definitional exclusions, there is evidence that children may have co-occurring deficits. The SLI criterion for deficits in production and comprehension varies widely across research studies and schools. Cutoffs have included 1.00, 1.25, 1.3, or 1.5 standard deviations below the mean on one or more measures of language production and comprehension or performance in the lowest 10th percentile on such measures. There is no universal agreement on the quantitative criteria that identify children who are at risk for communication failures, academic failure, or social disvalue due to limitations in one or more components of language production or comprehension. A recent article argued that the cutoff should be 1.25 SDs below the mean, but of course this is arbitrary, and this area requires further research.

Children with SLI may have various limitations in general auditory and speech perception; limitations in central cognitive domains such as memory, attention, and executive functions; deficits in other cognitive functions such as problem solving, mental rotation, and mathematics; and deviations in neurological structure and function. They also have a relatively high incidence of dyslexia and other, more global, reading and writing disabilities, along with attention deficit disorders. The nature of these limitations and their relation to SLI remain controversial.

In this chapter, I provide a review of theoretical proposals concerning the bases of SLI, an overview of the language and related cognitive deficits common to SLI, and the relation of SLI to other language disorders in children. The threads that run through the chapter are the identification and subcategorization of SLI, the biology of SLI, the role that underlying cognitive deficits may play in the origins and maintenance of language deficits, and the relationships between SLI and other disorders.

Theories of SLI

Theories of SLI can be divided into two general groups: (1) those that explain SLI as a result of deficits in linguistic knowledge, typically attributed to delayed maturation or a deficient representation of language, and (2) those that explain SLI in terms of domain-general (with respect to language) or domain-specific deficits in cognitive or cognitive-linguistic processes. A number of proposals have emerged over the last several decades. The greatest limitation of many of these theories is that they are not sufficiently comprehensive to account for all of the deficits associated with SLI. Other proposals are, as yet, too vague. Finally, others still lack convincing evidence or have been demonstrated to be untrue. Accurate or not, these proposals are important for the research direction they provide and for their potential implications for assessment and intervention.

Linguistic Knowledge and Computational Explanations

Among the earliest proposals of linguistic knowledge deficits in children with SLI is the extended optional infinitive (EOI) account (Rice & Wexler, 1996a, 1996b; Rice, Wexler, & Cleave, 1995). This proposal maintains that children with SLI extend a period that occurs in typically developing children during which tense is optionally marked on verbs that occur in main clauses. The result is that finite verbs are produced without markers such as tense and number. The extended unique checking constraint (EUCC) account is an elaboration of the EOI account (Wexler, 1998, 2003). In the required linguistic operation of checking, a feature in a phrase must check all of the relevant functional categories in order for an element to be produced. According to this proposal, children with SLI experience an extended period in which they are limited to checking a single functional category. For example, for the third-person singular and for auxiliary and copula forms, both tense (TNS) and agreement (AGRS) must be checked, but a child with SLI can check only one of these functional categories, and thus production is blocked (see Chapter 13 by Leonard for a detailed discussion of this proposal). Although this proposal better accounts for morphosyntactic deficits in SLI across languages than the original EOI proposal does, other, processing-based explanations (described in following section) have also been offered for these deficits (e.g., see (Chapter 11 by Joanisse and Chapter 13 by Leonard)).

The Representational Deficit for Dependent Relations (RDDR) proposal (van der Lely, 1998; van der Lely & Stollwerck, 1997) suggests that children with SLI have a limitation in building long-distance dependencies that include any kind of syntactic movement affecting passives, wh-questions, object relative clauses, and pronoun or reflexive antecedent relations (referred to as anaphoric dependencies), as they are governed by binding principles. Movement is characterized as optional in children with SLI, which leads to deficient production of sentences with these structures as well as their interpretation. Simply put, the various versions of RDDR propose that children with SLI lack the linguistic structural knowledge necessary to establish anaphoric relations between pronouns and their antecedents, or long-distance relations between nouns or pronouns, or as gaps in relative clauses and in wh-questions.

Van der Lely (2005) revised this proposal and renamed it the computational grammatical complexity (CGC) hypothesis. According to this view, children with SLI are impaired in the linguistic representation or computations that underlie hierarchical, structurally complex forms in one or more components of language (i.e., syntax, morphology, phonology). For syntax, the proposal implicates the optionality of an obligatory linguistic operation called *Move* that increases complexity with each application. Complexity is the result of one or more applications of this operation, with each adding to the complexity of the sentence. Although the same level of detail is not provided for morphology and phonology, this makes the proposal more general, and thus it is more capable of explaining deficits in language domains other than syntax. The notion of optionality and the distinction between a representation versus linguistic operation deficits have yet to be specified.

A related proposal provides additional focus to this notion that children with SLI have a deficient grammar affecting certain complex sentences with long-distance grammatical relations (e.g., Friedmann & Novogrodsky, 2004, 2007; Novogrodsky & Friedmann, 2006; see also Chapter 6 by Schwartz, Botwinik-Rotem, & Friedmann and Chapter 17 by Fletcher & Frizelle). Although children with SLI appear to have the same general structural linguistic knowledge as their typically developing peers, their grammar seems to be deficient in the syntactic process of phrasal movement affecting reversible passives (Adams, 1990; Bishop, 1997; Leonard, Wong, Deevy, Stokes, & Fletcher, 2006; van der Lely & Harris, 1990; van der Lely & Stollwerck, 1996), relative clauses (Adams, 1990; Friedmann & Novogrodsky, 2004, 2007; Novogrodsky & Friedmann, 2006), and wh-questions (Deevy & Leonard, 2004; Ebbels & van der Lely, 2001; van der Lely & Battell, 2003). Notably, these same deficits have been reported in children with hearing impairment (see Chapter 6 by Schwartz, Botwinik-Rotem, & Friedmann and Chapter 4 by Waldman DeLuca & Cleary). According to this proposal, the challenge presented by these sentences does not lie in establishing long-distance dependencies but, rather, in the underlying phrasal movement and, even more specifically, in the assignment of thematic roles (e.g., agent, patient) to noun phrases that appear in noncanonical or atypical locations because of phrasal movement (Friedmann & Novogrodsky, 2007; Novogrodsky & Friedmann, 2006).

These latter proposals and the studies on which they were based focused on children with SLI who exclusively have grammatical deficits, a subgroup I discuss later. The strength of these proposals lies in their detailed theoretical underpinnings (Fletcher, 1999; Chapter 17 by Fletcher & Frizelle) and their focus on the language deficits of a narrowly defined and infrequently occurring subgroup of children with SLI. Their overall weakness is that they are not intended to address the full range of language deficits in children with SLI.

Process-Based Explanations

As mentioned earlier, a large body of evidence has revealed limitations in speech perception, working memory, and slowed reaction times, as well as suggestions that children with SLI have deficits in attention and in various executive functions. These deficits in psychological processes have formed the basis for several accounts of SLI. One central question concerning these accounts is whether these deficits are general (domain-general), affecting both linguistic and nonlinguistic cognitive processing, or whether they are specific to language (domain-specific). *Domain-specific* and *domain-general* (e.g., Marinis & van der Lely, 2007) have been used to differentiate views that propose underlying deficits in linguistic knowledge or operations, such as movement from those that propose deficits in general or language-specific related cognitive processes (e.g., general auditory perception, speech perception, phonological working memory, processing speed, etc.). Here these terms are used to distinguish general deficits in language-related cognitive processes (e.g., working memory, auditory perception) and deficits in these same processes that are specific to language (e.g., phonological working memory, speech perception).

Speech Perception

Beginning with a series of seminal studies in the 1970s (e.g., Tallal & Piercy, 1973, 1974), Tallal and colleagues found that, as a group, children with language impairments (some children in the initial studies had mild hearing impairments) exhibited poorer performance on temporal order judgments, discrimination, and categorization of tones and sounds. It is worth noting that there were individuals in the two groups whose perception performance overlapped. These deficits have been varyingly characterized over years and across a number of studies as impairments in the ability to perceive stimuli that are presented rapidly, stimuli that are brief in duration, and stimuli that have components (e.g., formant transitions) that change rapidly. This deficit has also been characterized more generally as a deficit in temporal processing. The interpretation of this deficit has varied over the years from being a general processing deficit affecting all modalities to a general auditory deficit and to a deficit specific to speech processing. It has led to the development of an intervention program, *Fast ForWord*, designed to improve the speech perception and, consequently, the language abilities of children with SLI. Several findings (e.g., Bishop et al., 1999; Rosen & Eva, 2001) argued against a direct causal relationship between auditory perception deficits and the language deficits seen in these children. Furthermore, the identical deficits Tallal and colleagues (Tallal, 1984) had reported in children who were poor readers were more aptly characterized (Mody, Studdert-Kennedy, & Brady, 1997; Studdert-Kennedy & Mody, 1995) as impairments in differentiating less discriminable sounds (e.g., fricatives such as /f/ and /th/). Other studies (e.g., Sussman, 1993) have indicated that children with SLI discriminate accurately (e.g., /ba/ vs. /da/), but have different boundaries in categorization tasks and appear to have more uncertainty than their age-matched peers at the category boundary. More recently, a study (Burlingame, Sussman, Gillam, & Hay, 2005) directly examined sensitivity to formant transition durations along two continua (/ba/ to /wa/ and /da/ to /ja/). On the first continuum, the children with SLI were less sensitive to phonetic changes and made more identification errors, whereas on the second continuum, the children with SLI were similar to their typically developing peers in identification at the longer formant transitions but poorer on the short transitions. Some investigators have suggested that task effects such as the stimuli employed or the memory demands may affect the performance of children with SLI. For example, in a series of tasks involving categorical perception of words (e.g., *bowl/ pole*) and nonword syllables (*ba/pa*), children with SLI performed comparably to age-matched peers on word perception but more poorly on identification for syllables, whether they were synthetic or natural speech (Coady, Evans, Mainela-Arnold, & Kluender, 2007; Coady, Kluender, & Evans, 2005).

A recent study (Schwartz, Scheffler, & Lopez, 2013), relying on the Ganong effect (Ganong, 1980), sheds some light on the relation between speech perception and language processes. This effect occurs when a continuum of a phonemic contrast (e.g., [d] vs. [t]) is embedded in a word-nonword pair (e.g., *dish* vs. *tish*). Listeners identify more of the tokens as having a "d" because of the influence of lexical knowledge. The *t-d* category boundary shifts from the one found with non-meaningful syllables. Children with SLI differed from their age-matched peers in that they exhibited a great deal of uncertainty at category boundaries, and some children never actually established a clear boundary. Children with SLI relied more heavily on their lexical knowledge, perhaps attempting to compensate for a deficit in categorical perception. Thus, deficits in categorical perception appear to alter the overall process of lexical access, forcing children with SLI to place greater reliance on existing phonological representations in making categorical decisions. Coupled with evidence of weaker phonological representations of lexical items (see Lexical and Semantic Deficits section), deficits in perception may affect lexical access both directly and indirectly.

Event-related potentials (ERPs) measuring electrical brain responses (see Chapter 7 by Epstein & Schwartz and Chapter 24 by Shafer, Zane, & Maxfield) have revealed more detailed information about the nature of these perceptual deficits. Two of these studies used ERP and behavioral methods to study vowel perception in children with and without SLI. Children with SLI exhibited poor categorization of long (250-millisecond [msec]) and short (50-msec) vowels. Their discrimination of short vowels was also less accurate than that of their peers, and ERP data revealed the absence of a left anterior discriminative response. Importantly, there were two conditions in the ERP study: one in which the children's attention was directed toward the auditory stimulus by asking them to report embedded tones and a second in which their attention was directed toward a silent video. In the latter condition, the children without SLI exhibited an ERP discriminative response that was not seen in the children with SLI. These findings suggest that typically developing children continue to process speech automatically even when their attention is focused elsewhere. A follow-up study reanalyzing these data provides further evidence that these perceptual deficits distinguish children with SLI from their age-matched peers on the basis of their overall brain response to these vowel distinctions (Shafer, Ponton, Datta, Morr, & Schwartz, 2007). Another pair of studies examined brain responses in a backward-masking task to tones differing in frequency and followed up with the same subjects 18 months later (Bishop & McArthur, 2005; McArthur & Bishop, 2004). One-third of the individuals with SLI had poorer behavioral frequency discrimination thresholds, but the majority had age-inappropriate late ERP components. At follow-up, these individuals exhibited ERPs that were improved but were still outside the range of those of their typical language controls. In some cases, the ERPs were simply immature, whereas in other cases ERPs were unlike those of younger typically developing individuals. Although these latter studies are limited by the wide age range of a relatively small number of subjects, most of the children with SLI had immature brain responses to tones differing in frequency. McArthur and colleagues (McArthur, Atkinson, & Ellis, 2009) found that regardless of the auditory stimuli (tones, rapid tones, vowels, or consonant-vowels), only one-third of children (6;0–12;0) with SLI or children with specific reading disability (SRD) exhibited atypical, lower amplitude N1-P2 auditory brain responses compared to their typically developing peers. These researchers (McArthur, Atkinson, & Ellis, 2010) then examined the effect of customized and individualized auditory training on one or more of four auditory discrimination tasks (tones, backward-masked tones, vowels, and consonant-vowels) on ERPs. Although the children's behavioral performance improved, their ERPs remained atypical. The fact remains that some, but not all, children with SLI have a deficit in the underlying neurophysiology of perception. Thus, the nature of this deficit and its relation to the language impairments in these children remains undetermined. Auditory perceptual deficits seem unlikely to be a primary causal factor for SLI. For the children who do exhibit these deficits, training does not change their brains' responses to these stimuli.

Two studies have examined the synchrony of auditory and visual processing in older children with a history of SLI (Kaganovich, Schumaker, Macias, & Gustafson, 2015; Kaganovich, Schumaker, Gustafson, & Macias, 2015). In the first study, event-related potentials (ERPs) and behavioral responses were recorded in response to visual stimuli that depicted a flash and a tone that occurred simultaneously, preceding, or following the picture; children had to judge whether the picture and tone occurred simultaneously. As a group, the children with H-SLI (history of SLI) were far less sensitive behaviorally to temporal asymmetry than were their typically developing peers, who in turn were less accurate than young adults. Children with H-SLI who had higher language test scores were more accurate, and attentional abilities, measured by a scale, predicted performance but did not fully explain the group differences. Inspection of the figures suggests that, despite the group differences, there is overlap in performance for some children with H-SLI and some children with typical development, again suggesting the possibility of subgroups. The ERPs indicated that the children with H-SLI had typical early auditory encoding responses, but atypical visual responses, which could lead to auditory-visual integration deficits, but the range of individual differences was unspecified.

The second study examined the McGurk effect in these children. This effect involves a mismatch between the sound produced by a speaker's face (ka) and the sound on the audio track (*pa*); listeners report hearing a third sound (ta) reflecting auditory-visual integration. One-third of the children with H-SLI were more likely to report hearing *pa* than *ka*. The fact that all of the children with H-SLI performed well in conditions where the stimuli matched was interpreted as evidence of intact early auditory-visual integration, whereas the absence of the McGurk effect reflects deficits in later stages of integration for some children.

One of the more controversial aspects of the perceptual account of SLI is the relation between the presumed perceptual deficits and the various language deficits exhibited by these children. One view is that of Tallal and her colleagues (e.g., Merzenich et al., 1996; Tallal, Miller, Bedi, Wang, & Nagarajan, 1996). They have fashioned an intervention approach called *Fast ForWord*, in which children are exposed to speech and language stimuli that have been altered temporally and spectrally in a variety of tasks with feedback. Although the initial reports suggested that this approach was effective in improving language performance on several standardized measures, subsequent research questioned the effectiveness of this method in improving language performance.

An important proposal growing out of this research that relates perceptual deficits to language acquisition is the Surface Account of the morphosyntactic deficits in SLI (Leonard, 1989; see also Chapter 15 by Oetting & Hadley and Chapter 13 by Leonard). It suggests that these deficits result from the relative (to surrounding syllables) lack of perceptual salience of morphological markers (Leonard, McGregor, & Allen, 1992), in combination with the processing demands of establishing morphological paradigms. Specifically, for children with SLI, markers that have low phonetic substance require more exposure to become established because of the processing demands required by their poor perception. This view is supported by extensive evidence from English and by the varying patterns of morphosyntactic deficits in children across languages, reflecting the variations in the phonetic substance of certain morphosyntactic markers (see Chapter 13 by Leonard). One specific characterization of these deficits is that children have particular difficulty perceiving brief syllables when they are embedded between two longer syllables (Leonard, Bortolini, Caselli, & McGregor, 1992).

In summary, it seems clear that only a subset of children with SLI have deficits in auditory or speech perception. The specific nature of these deficits and, more critically, their relation to the language deficits observed remain unresolved. One promising suggestion is that these deficits may be related to some more general deficit in attention (e.g., Dispaldro et al., 2013), which may also affect other aspects of language. Their perceptual deficits may also reflect more general task demands (Coady et al., 2005), including attention, working memory, or attentional control. Children with SLI who have deficits in auditory or speech perception may represent a subgroup of SLI, as I will discuss later.

Memory

Children with SLI have deficits in working memory that may underlie their language deficits (see Chapter 8 by Gillam, Montgomery, Gillam, & Evans). Verbal working memory was the largest contributor to statistical models of SLI language performance (Leonard, Davis, & Deevy, 2007). These working memory deficits, however, are only meaningful in their direct relation to the language deficits observed in these children. Working memory models vary widely, including those that emphasize capacity and forgetting attributable to decay (lack of rehearsal or time elapsed), those based on focus of attention and more limited capacity, those based on content addressable memory (much like computers), and those that emphasize interference, binding of information. These models of working memory, along with views of language acquisition and language processing, characterize the relationship in different ways, from domain-general working memory that is assumed to affect language in various ways, to working memory that is unique to and inherent in language processing (e.g., MacDonald & Christiansen, 2002).

A large body of evidence for working memory deficits in SLI comes from a task called nonword repetition (NWR), which is the most widely used means of assessing phonological working memory. In this task, children are asked to repeat nonwords of increasing syllable length. Typically, children repeat nonwords ranging in length from one to four or five syllables (Dollaghan, Biber, & Campbell, 1995; Dollaghan & Campbell, 1998; Gathercole & Baddeley, 1990; Weismer et al., 2000). These productions are typically scored as the number of nonwords produced correctly and, in some studies, the number of consonants and vowels produced correctly. Children with SLI diverge from their typically developing peers (age-matched and younger) once the nonwords reach three syllables in length (Archibald & Gathercole, 2006; Botting & Conti-Ramsden, 2001; Dollaghan & Campbell, 1998; Ellis Weismer et al., 2000; Gathercole & Baddeley, 1990; Montgomery, 1995). This is true for children with SLI ranging from preschool age through adolescence. It holds true across languages, as well as in bilingual children. This deficit also notably appears to occur more frequently across monozygotic than across dizygotic twins (Bishop et al., 1999). Although the deficit is characterized as severe (Gathercole, 2006), because age-matched children typically perform at or near ceiling, the quantitative differences between the groups are quite small when the scores are the number of nonwords repeated correctly. The quantitative differences are magnified somewhat when the number of correct consonants or segments is compared. The groups do not differ in the production of one- and two-syllable nonwords. Several of these studies have demonstrated clearly that this task very successfully distinguishes children with SLI from their typically developing peers. Nonword repetition may be a potentially useful clinical marker for SLI (e.g., Redmond, 2016), though not necessarily a good measure of working memory. It also appears to be culturally unbiased (Ellis Weismer et al., 2000) in that it is unrelated to maternal education level (Alloway, Gathercole, Willis, & Adams, 2004) or race (Campbell, Dollaghan, Needleman, & Janosky, 1997). Although still controversial, nonword repetition is assumed to reflect a deficit in the capacity of working memory that is most closely related to vocabulary growth and development. It is not clear that the working memory capacity deficit revealed by children's partially inaccurate repetition of nonwords of three, four, and five syllables could feasibly account for the range of language deficits of these children. To some extent, this deficit may reflect their familiarity with less frequent, multisyllabic words. Evidence comes from a study (Kohnert, 2002) in which bilingual Spanish-English children with SLI did not exhibit poorer performance than their typically developing peers on longer nonwords. Multisyllabic words are much more frequent in Spanish than in English. Although nonword repetition may not be an ideal measure of working memory, it may reveal information about lexical production abilities and about phonological knowledge (e.g., Danahy Ebert, Pham, & Kohnert, 2014).

A number of other tasks have been used to examine working memory in children with SLI. They are similarly impaired on tasks such as scanning, which involves deciding whether a target item was heard in a previous list; serial list recall; and listening span tasks, in which children are asked to repeat the sentence-final words for a series of sentences (e.g., Gillam, Cowan, & Day, 1995; Henry, Messer, & Nash, 2012; Marton & Schwartz, 2003; Montgomery, 2000a, 2000b; Sininger, Klatzky, & Kirchner, 1989; Weismer & Evans, 1999). One particularly interesting set of findings has emerged from a series of listening span studies by Marton and colleagues. In English, memory limitations were a function of syntactic complexity in the sets of sentences, not the sheer amount of material being held in working memory. The listening span task was also administered to Hungarian-speaking children with SLI (Marton, Schwartz, Farkas, & Katsnelson, 2006). Because, in contrast to English, Hungarian is a very highly inflected language with relatively free word order, structural language complexity resides in the morphology, not in the syntax. The children with SLI performed more poorly when the sentences were morphologically complex than when they were longer. Thus, one way of characterizing the working memory limitations of these children is that their working memory is challenged by linguistic complexity, regardless of how it is reflected in a given language, in comparison to their typically developing peers.

Phonological working memory is reported to be most closely related to vocabulary acquisition, whereas other measures of working memory may be more closely related to language comprehension and syntactic processing. Working memory plays a role in language acquisition because it allows children to analyze and to determine the structural properties of the language to which they are exposed. Early in development a short working memory span may be developmentally adaptive because it enables children to focus on short-distance grammatical relations (e.g., subject-verb in canonical sentences). As memory span increases, children are assumed to be increasingly able to determine and establish longer distance relations such as pronouns and antecedents or displaced elements such as object relative clauses. Once language has been acquired, working memory is critical for processing language because, in at least one view, building syntactic and discourse structures requires relating linguistic units across a number of intervening words and syllables and a lengthy time-span. A continuing question in the psycholinguistic literature has been the specifics of the relation between working memory and language. Caplan and Waters (1999, 2013) have proposed a model in which working memory for language is divided into short-term and long-term components. They argue that interference effects occur in short-term working memory but that sentence processing depends more on long-term working memory. Although this idea is intriguing, the empirical evidence remains limited for typically and atypically developing children.

The direct relationship between working memory and syntactic processing has not been extensively studied in children with SLI. Most of the studies (e.g., Deevy & Leonard, 2004) examined off-line sentence comprehension and, thus, do not reveal how children manage working memory demands while language is being processed. Several studies that examined working memory demands in off-line complex sentence comprehension more directly (e.g., Deevy & Leonard, 2004; Montgomery, 1995, 2000a, 2000b) initially concluded that sentence length, not complexity, was the key factor in the poor performance of children with SLI. A re-analysis of Montgomery's data indicated that sentence complexity, not length, was the key factor. In more recent studies, Montgomery and colleagues (e.g., Montgomery, Evans, & Gillam, 2009) examined correlations between off-line sentence comprehension and a sentence span task and a nonword repetition (NWR) task. NWR was highly correlated with simple sentence comprehension but not with complex sentence comprehension. The span task, not surprisingly, was correlated moderately with complex sentence comprehension. This research has certainly pointed the way to the relationship between working memory and the comprehension of complex sentences, but it has provided little definitive information about this relationship for several reasons. The range of syntactic structures has been limited, and at times the sentences have been poorly manipulated and motivated. Even with some manipulations meant to vary the memory or processing load, the bulk of this research relies on correlations between working memory tasks and sentence comprehension. Finally, the tasks and the models of memory upon which they are based are not consistent with current views of memory and its relations to sentence comprehension.

Recent advances in working memory (e.g., Lewandowsky, Oberauer, & Brown, 2009; Martin & McElree, 2008; McElree, 2000, 2001; Oberauer, 2005a, 2005b; Oberauer & Lange, 2009; Oberauer & Lewandowsky, 2008) have led to models in which forgetting is not the result of decay but rather is due to interference and failures of information binding. These models have also proposed new ways of considering capacity, including a very narrow (one item) focus of attention and the view that capacity is not adequately assessed by single measures because of task-induced effects. Also, there is evidence that memory for sentence comprehension is not a matter of remembering lists of words or syllables but rather is specialized and content addressable. These changes have led to tasks that better assess working memory in general and working memory as it is related to language comprehension (e.g., Glaser, Martin, van Dyke, Hamilton, & Tan, 2013; Lewandowsky, Oberauer, Yang, & Ecker, 2010; van Dyke & Johns, 2012; van Dyke & McElree, 2006, 2011). Marton, Campanelli, Eichorn, Scheuer, and Yoon (2014) demonstrated that children with SLI exhibit greater susceptibility to proactive interference than do their age-matched or language-matched peers. This finding might have been attributed to differences in relative activation levels for children with SLI. Item repetition (practice) revealed that children with SLI needed more repetitions than their typically developing peers to strengthen representations, and once those representations were strengthened, performance on the immediately following item was negatively affected. The authors suggested this finding might reflect a deficiency in these children's ability to bind content and context, with potentially important implications for language processing deficits and language intervention.

Another, markedly different, proposal concerning a causal underlying memory deficit in children with SLI as well as deficits in other populations (agrammatic aphasia, Parkinson's disease) relies on a distinction between two types of memory: procedural and declarative (Ullman & Pierpont, 2005; Ullman & Pullman, 2015). Procedural memory includes motor and cognitive abilities that involve a series of steps generated by a set of rules (i.e., procedures) that govern these steps (e.g., playing solitaire, folding origami, forming the regular past tense of verbs). Declarative memory includes facts or items that are stored and recalled individually and cannot be generated by rule (e.g., Mickey Mantle's jersey number, words in vocabulary, irregular past tense forms of verbs, etc.). It should be noted that this view of regular and irregular past tense is not uncontroversial (see Chapter 11 by Joanisse), and the same is true for the general distinction between procedural and declarative knowledge. That said, this proposal maintains that children with SLI (and other clinical populations) have deficits in procedural memory that affect their linguistic and nonlinguistic abilities to form and execute such rule-based behavior. The proposal offers a detailed description of the neurobiology of the proposed deficit and cites supporting evidence from structural brain studies of SLI. When procedural memory is deficient, the declarative memory system is believed to compensate. This means that aspects of language typically generated by rules (e.g., regular past tense) will, in children with SLI, be learned and produced instead on an instance-by-instance basis via declarative memory.

Ullman and Pullman have extended this proposal beyond SLI to include dyslexia, autism spectrum disorder, Tourette syndrome, and obsessive-compulsive disorder. Language evidence for this deficit continues to come from reports of regular past tense deficits in children with SLI, from the apparent preservation of declarative memory (e.g., Lum, Ullman, & Conti-Ramsden, 2015) and from other declarative and nondeclarative memory measures. Specifically, declarative memory performance appeared to be more closely related to overall working memory scores than to language abilities, providing some support for this model. There is, as yet, no strong evidence from syntax or phonology suggesting that children with SLI rely on declarative memory for language production or comprehension. Though this proposal continues to be intriguing, empirical support is limited.

Processing Speed

There is a long history of using reaction time (RT) to measure cognitive processing globally, and, when complex cognitive tasks can be subdivided into additive processes, the component operations can be inferred from the additive relation among the time each takes (Donders, 1969). RT decreases with age, particularly during adolescence and through early adulthood (Kail, 1991; Kail & Miller, 2006), and then begins to increase again later in the life-span, reflecting a gradual decline in processing efficiency (e.g., Cerella & Hale, 1994). A meta-analysis revealed slower RTs across a number of studies on a variety of tasks (Kail, 1994), leading to the claim that children with SLI have cognitive slowing, which might account for their language impairments (see Chapter 20 by Windsor). The slowing hypothesis posits that children with SLI differ from their age-matched and even language-matched peers in their overall speed of processing. Subsequent meta-analyses (Windsor, 1999; Windsor & Hwang, 1999; Windsor, Milbrath, Carney, & Rakowski, 2001) also found evidence of slowing in children with SLI but raised issues concerning the way in which RT data are analyzed. Although one analysis supported the slowing hypothesis, the other indicated slower RTs in children with SLI that were not significantly different from typically developing peers and were highly variable. A more extensive study of RT in children with SLI across a number of linguistic and nonlinguistic tasks generally supported the slowing hypothesis (Leonard, Weismer et al., 2007; Miller, Kail, Leonard, & Tomblin, 2001). Taken as groups of tasks, the linguistic and nonlinguistic tasks each yielded slower reaction times for the SLI children than for their age-matched typically developing peers. However, when the tasks were further subdivided, motor and lexical tasks did not yield slower RTs for the children with SLI.

Furthermore, individual analyses revealed that not all children with SLI exhibited slowing. A follow-up study five years later at age 14 (Miller, Leonard, & Kail, 2006) revealed similar findings. In general, children with SLI were slower than their age-matched peers, but some of these children did not exhibit slowing. Reaction times (RTs) at age 9 did not predict their RTs at age 14, and although the children with SLI were consistent across domains as a group, individual children were not. The investigators concluded that other factors may play a role in RT. If processing speed were a causal factor in SLI, it should be related to the severity of the impairment, but that does not seem to be the case (Lahey, Edwards, & Munson, 2001). A more recent study (Leonard, Weismer et al., 2007) paints a different and more complex picture in which predictive models suggest that working memory and speed measures separately are related to language performance scores, accounting for almost two-thirds of the variance in these scores.

Reaction time may reflect global cognitive developments such as speed of processing, speed of response generation, or derivative developments such as automaticity or linguistic complexity. Although the slowing hypothesis is intriguing and seems to fit well with the notion that children with SLI have deficits in processing and in their processing resource capacity, it has some limitations. For example, reaction time on linguistic versus nonlinguistic tasks may reflect very different cognitive processes. Even within the language domain, detection tasks (e.g., monitoring, match-to-sample or same-different, simple lexical decision or word/nonword tasks) and on-line language processing tasks (e.g., lexical priming, cross-modal word interference, sentence processing with cross-modal priming, eye tracking) tap the speed of some overlapping low-level processes, but an otherwise very different set of cognitive-linguistic processes and knowledge.

A novel perspective concerning processing speed has emerged from some recent, but as yet unpublished, work (Swinney, personal communication, 2000) and receives some support from several studies of children with SLI as well as with adults who have agrammatic aphasia. According to this view, the "slowing" in SLI directly reflects an impairment in the rate at which language can be processed. Thus, by slowing the rate of presentation, performance improves in clinical populations (see also Montgomery, 2005; Weismer & Hesketh, 1996), yet the slowed rate of presentation impairs sentence processing in nonclinical populations. For example, in two studies, children with SLI did not exhibit priming for the filler (first) noun in the "gap" (*) of an object relative sentence (e.g., *The zebra that the hippo kissed *ran far away*) or for antecedents at pronouns or reflexives(*) (e.g., *The leopard that chased the tiger washed himself**) at a normal rate, but did exhibit priming when these sentences were presented at a slower rate (Love et al., 2007). The typically developing, age-matched children exhibited priming at normal rates but did not when the rate was slowed. The specific mechanism underlying these findings has yet to be explicated.

Executive Functions and Attention

Executive functions (EFs) include a wide range of abilities that permit the control, monitoring, and planning of other, more basic cognitive functions. The category at times becomes unwieldy and difficult to manage, define, and measure. Using a factor analysis and structural equation modeling, Miyake et al. (2000) found three correlated but separable functions that emerged in the tasks: Shifting (Wisconsin Card Sorting Task), Inhibition (Tower of Hanoi), and Updating (Operation Span). Though each of these EFs can be examined in far greater detail, this is an important study in the focus it provides for work in this area. It is important to note that working memory in the form of operation span, inhibition (i.e., competition/interference), and shifting all may be part of working memory. Henry et al. (2012) found that children with SLI or children with low language functioning (low nonverbal IQ or limited language abilities) performed more poorly than typically developing peers on six out of ten executive function areas: verbal and nonverbal executive-loaded working memory, verbal and nonverbal fluency, nonverbal inhibition, and nonverbal planning. IQ and verbal abilities did not account for the group findings. Because all EF tasks engage more than one EF, closer examination of these abilities and deficits seems warranted.

Attention is a basic component of cognitive and perceptual processing (see Chapter 20 by Windsor). It is often treated as a unitary phenomenon when, in fact, it can be subdivided into at least orienting, selective attention, divided attention, and sustained attention. Executive functions refer to control of attention and other cognitive processes such as shifting attention, inhibition, planning, and so on. Attention and executive processes are closely intertwined with working memory. Individual and developmental differences and variations in working memory and executive functions within and across groups of children have led to controversy concerning the control and allocation of processing resources. A variety of models (e.g., Conway & Engle, 1996; Cowan, 1997; Just, Carpenter, & Keller, 1996) have challenged Baddeley's (1986) model in which a phonological memory store does not directly interact with the central executive. In these alternative models, working memory capacity is tied more directly to attentional control in explaining performance on tasks that involve distraction or interference (Barrett, Tugade, & Engle, 2004). Individual differences in working memory capacity appear to be related to performance reflecting more general executive functions (e.g., Conway & Engle, 1994). Working memory span reflects attentional control (Engle, Kane, & Tuholski, 1999) in task-switching ability (Towse, Hitch, & Hutton, 1998) and in the ability to inhibit irrelevant information (Hasher, Stoltzfus, Zacks, & Rypma, 1991). Working memory performance improves with greater abilities to control attention, to suppress irrelevant information, to avoid distraction, to focus on task-relevant thoughts, and to coordinate simultaneous processing and storage (Engle et al., 1999; Lustig, May, & Hasher, 2001; Miyake, 2001).

To date, few studies have examined attention in children with SLI. Hanson and Montgomery (2002) used the Auditory Continuous Performance Test (Keith, 1994), in which the children listened to 600 monosyllabic words and indicated when they heard the word *dog*. The children with SLI did not differ from their typically developing peers in their identification accuracy (hits). Although this task is characterized as examining sustained selective attention, it actually confounds sustained and selective attention. Armstrong (1997) found that an auditory version of the Continuous Performance Test (Mirsky & Cardon, 1962) failed to differentiate sustained from selective attention. Therefore, this particular task may not be sensitive to the attentional deficits that may occur in children with SLI. Limiting the dependent measure to accuracy may also have concealed deficits in attentional processes. More recent studies focused on visual sustained attention (Finneran, Francis, & Leonard, 2009) and on temporal visual attention masking Dispaldro et al., 2013). In the first case, they found sustained visual attention deficits in children with SLI, and in the latter case, there were temporally conditioned visual attention deficits that predicted language abilities. Although these findings are intriguing, deficits in the control of attention as inadvertently first observed in working memory tasks may be more directly related to language processing.

Several studies of working memory have incidentally revealed that children with SLI have poor cognitive control. Children with SLI have exaggerated (i.e., better recall) recency effects compared to their typically developing peers in the recall of one-syllable words following a set of digits (Gillam & McFadden, 1994). In working memory studies that require the recall of words and sentences, these children frequently provide irrelevant items from other sentence positions when the required response is the final word from previous items (Marton & Schwartz, 2003; Weismer & Evans, 1999). These findings suggest that children with SLI have difficulty inhibiting linguistic information that is not relevant to the required response.

Despite these findings, few studies have directly examined attentional control in children with SLI. In a sentence processing and memory task, these children had greater difficulty than typically developing peers in inhibiting irrelevant information (Lorsbach, Wilson, & Reimer, 1996). Similarly, Norbury (2005) found that children with SLI had slower reaction times and made more errors than did typically developing children in inhibiting secondary word meanings in ambiguous contexts (e.g., John stole from the *bank*.—picture of a *river*). However, this finding was influenced by more limited knowledge of secondary word meanings in the children with SLI. There is a similarly limited finding concerning the nonverbal control abilities of children with SLI (Noterdaeme, Amorosa, Mildenberger, Sitter, & Minow, 2001). Their inhibition of predominant responses (interference task) and motor responses when presented with irrelevant stimuli (go/no-go task) was similar to that of typically developing peers. Both of these tasks had low levels of cognitive conflict, because there were equal numbers of the go/no-go and compatible/incompatible stimuli. In such tasks, the goal is generally to provide a higher level of conflict by manipulating the relative percentage of the two stimulus types. Bishop and Norbury (2005) provided clearer evidence of cognitive verbal and nonverbal control deficits in children with SLI on a task requiring inhibition of a verbal response and on an inhibition task requiring sustained attention but no verbal response. A large battery of verbal and nonverbal tasks (Im-Bolter, Johnson, & Pascual-Leone, 2006) revealed that children with SLI perform more poorly than typically developing children on verbal and nonverbal tasks requiring the activation or inhibition of task-relevant information and in working memory updating.

Epstein and colleagues (Epstein, Shafer, Melara, & Schwartz, 2014) found that children with SLI exhibit immature ERP and behavioral responses to conflict. In attempt to examine attentional control in the context of language, specifically lexical access, Victorino and Schwartz (2015) combined auditory cross-modal lexical decision (match/mismatch the picture shown) and dichotic listening with direction to an attended ear to examine selective attention in children with SLI (9;0–12;0) and age-matched typically developing peers. Although accuracy was similar across groups, reaction time differences indicated that the children with SLI had difficulty controlling their auditory attention in all conditions, with particular difficulty inhibiting distractors of all types.

These studies provide evidence of domain-general and domain-specific deficits in executive functions. Such deficits may be related to findings concerning processing speed, speech perception, working memory, and the deficits in language acquisition and processing that have been identified in children with SLI. These cognitive control abilities must be directly examined in language comprehension or production tasks before we can conclude that they are directly related to the language deficits associated with SLI.

Emergentist Perspective

A final proposal concerning the nature, origins, and maintenance of SLI is perhaps the broadest of those discussed so far. It is in the general category of an emergentist view, as discussed in Chapter 11 by Joanisse and Chapter 6 by Schwartz, Botwinik-Rotem, and Friedmann. According to this view, typical language development depends heavily on the regularities of language input, and patterns such as morphosyntax and syntax, along with phonology and the lexicon, can be extracted from the input by the child. Thus, what are characterized as linguistic rules and representations emerge from an interaction of the child's general cognitive or learning processes with the input (e.g., Goldberg, 2006; Leonard, 2014; Tomasello, 2003). Proposals in this framework are sometimes instantiated in connectionist models (see Chapter 11 by Joanisse). Briefly, these computer models consist of multiple levels of units that are fully connected with adjustable weights reflecting the strength of connection and are sometimes presented as metaphors for neural networks. These networks take input of various sorts (e.g., a present tense verb) and produce outputs (e.g., past tense verb form). One of their most interesting characteristics is that they are capable of learning (i.e., becoming more accurate) with feedback. Connectionist models have been developed for lexical access in word production, subject-verb agreement, and past tense formation, among other aspects of language and language learning. Another interesting aspect of these models and of an emergentist view is that they offer a different perspective of SLI and other childhood language disorders related to dynamical systems or general systems theory. Many views of childhood language impairments entail an assumption that there is an impaired or deficient underlying developmental mechanism (e.g., general or specific linguistic knowledge, working memory, etc.). In this framework, a disorder may arise from more peripheral deficits (e.g., speech perception, attention), which may, downstream, manifest themselves as broader deficits (e.g., Thomas & Karmiloff-Smith, 2003).

A recent study has applied the emergentist or construction-based perspective to morphological errors seen in children with SLI. Leonard and Deevy (2011) examined the extent to which input can account for morphological deficits observed in children with SLI. The study was based on numerous observations that typically developing children's language productions (e.g., Tomasello, 2003; see Chapter 6 by Schwartz, Botwinik-Rotem, & Friedmann) can be attributed to input characteristics. Based on this, Leonard and Deevy surmised that nonfinite utterances (e.g., *The clown laughing*) seen in young typically developing children and more persistently in children with SLI may reflect adult utterances such as *We saw* ***the clown laughing***. In the first of two experiments, they found that after hearing sentences with novel verbs preceded by the auxiliary *was* (e.g., *Just now the horse was channing*) and sentences with other novel verbs in grammatical nonfinite contexts (e.g., *We saw the horse channing*), a production probe focusing on obligatory contexts for *is* revealed that children with SLI were less accurate in general and more likely to produce ungrammatical nonfinite verbs if the verb had been heard in a grammatical nonfinite context. In the second experiment, the children with SLI made more errors comprehending sentences with real verbs such as *The pig sees* ***the chicken running***, and were more affected than their typically developing peers by the nonfinite clause. Thus, children with SLI may be unduly influenced by certain input characteristics that lead them to ungrammatical productions in other similar contexts. Unlike their typically developing peers, they cannot easily distinguish when nonfinite contexts (or other such structures) presented grammatically in input lead them to ungrammatical utterances in other contexts. There may be other similar input conditions that can explain production and comprehension deficits in SLI. The specific deficit that leads to this incorrect generalization of clausal patterns in input remains undertermined.

Subgroups of Children with SLI

Although the definition of children with SLI is relatively specific and can be quantified, the specific profiles of language deficits vary widely. This magnifies the typical variation we encounter in the course of normal language acquisition. In typically developing children, production performance seems to lag behind comprehension performance—though comprehension is often more difficult to test, and even production may not always fully reflect the children's underlying knowledge—and components of language develop at different rates across and within children. When we consider variations across children or groups of children with SLI, it is important to recognize the limitations of our measurements, the variation that occurs in and across typically developing children, and the extent to which these variations fit an explanatory framework.

One of the first groupings of children with SLI was a distinction between children who have expressive deficits only and those who have expressive and receptive deficits (Edwards & Lahey, 1996). Such a distinction should be viewed with some caution because of the limitations of our comprehension instruments. These standardized tasks typically ask children to point to one of four pictures in response to a word or a sentence containing critical contrastive elements. Most language comprehension tests do not examine the semantics of lexical comprehension in depth, the comprehension of contrastive morphosyntactic features in detail, or the comprehension of sentences with complex syntactic structures. The pointing response occurs at the end of comprehension; thus, the tests reveal little about the processes leading to the pointing response. Even the production data we obtain may have some limitations. Although some of the data in the literature come from systematically elicited productions, particularly focusing on morphosyntax, most production data come from spontaneous language samples. A number of studies have revealed that typically developing children's syntactic knowledge may be revealed through production priming and more sensitive elicitation tasks (Crain & Thornton, 1998; Shimpi, Gámez, Huttenlocher, & Vasilyeva, 2007). Leonard (2009) has argued that language production deficits occur in the context of language knowledge deficits and deficits in the processing of language input. As a result of his extensive review, it seems unlikely that any children with SLI could ever have a focal and exclusive deficit in language production.

Another approach to subgrouping children with SLI recognizes that some children have deficits across language components, whereas other children have deficits focused primarily in a single component (Bishop, 1997; Leonard, 2014). One such group appears to have deficits that are specific to syntax, grammatical SLI (GSLI). This is an outgrowth of a proposal mentioned earlier (van der Lely, 2005), in which these children were first characterized as having difficulty establishing long-distance grammatical relations and subsequently as having a broader structural deficit in knowledge or processes that affect hierarchical syntactic, morphosyntactic, and structural knowledge or processes. Although this is an interesting proposal, there are some reasons to question the status of this subgroup.

In a rather large-scale study of children with SLI, only a very small number met the criteria for GSLI (Bishop, Bright, James, Bishop, & van der Lely, 2000). Specifically, out of 37 same-sex twin pairs with at least one member identified as SLI, and of 104 pairs selected generally, only 2 children met all five criteria, and 9 met four criteria for GSLI. Most of the children who made grammatical errors exhibited deficits in other areas of language. This is not surprising, given that studies involving these children are spread over a very wide age range. The speed of response and the priming effects may be highly variable in the group because they develop with age. Even if these chronologically heterogenous children with SLI are individually age-matched to controls, both groups will have high variability. A more critical limitation is the fact that some of the tasks employed may not accurately reflect the deficit. The assumption is that these children fail to establish grammatical relations at a distance in complex sentences or may do so inconsistently. Experimental tasks that involve answering questions about pictures or pointing to pictures in comprehension tasks provide valuable information, but they do not provide information about the automatic processes of sentence processing for production or comprehension.

Adults with agrammatic aphasia exhibit slower activation and slower decay of information during sentence processing in online tasks (Prather, Shapiro, Zurif, & Swinney, 1991). Even when such online sentence processing methods are applied, they need to be designed in a way that permits the observation of processes that may be delayed compared to typically developing controls. In an online study with GLSI children, Marinis and van der Lely (2007) examined question processing to determine whether the filler noun (*Who/Matt*) is reactivated at the gap (*) (*Lindsay gives Matt a thick book in the office. Who did Lindsay give a thick book to* in the class?*) using a cross-modal picture priming task. Children with SLI did not reactivate at the gap, but it is possible that they may do so later. There is evidence from a study of pronouns, reflexives, and antecedents that children with SLI do activate such information later (Schwartz et al., 2005). When presentation rate is slowed, children with SLI show normal reactivation at gaps (Love et al., 2007). It is not that they fail to establish certain long-distance grammatical relations, but, rather, that they fail to do so in a timely fashion and that their brains process this linguistic information atypically (Hestvik, Tropper, Schwartz, & Shafer, 2007).

Despite these concerns, Friedmann and Novogrodsky (2004; Novogrodsky & Friedmann, 2006) have provided supporting evidence for a subgroup of syntactically impaired children with SLI (S–SLI) who have been identified in greater numbers by a relative clause probe. Similarly, investigators, including Friedmann and colleagues, have identified groups of children with SLI who seem to have lexical deficits as their primary impairment (Dockrell & Messer, 2007; German & Newman, 2004; McGregor & Waxman, 1998; Messer & Dockrell, 2006).

Another subgroup of children with SLI are characterized as having pragmatic impairments (Bishop, 2000; Botting & Conti-Ramsden, 2003). These are children who exhibit atypical social behaviors, irrelevant utterances, atypical interests (e.g., obsessive focus on a particular topic), atypical conversational behaviors (e.g., misses nonverbal facial or intonational cues, poor coherence), poor use of conversation context (e.g., misses social cues such as politeness), and other communication limitations. This characterization is based on the *Children's Communication Checklist* (CCC, Bishop, 1998, 2006). The *Diagnostic and Statistical Manual of Mental Disorders* (*DSM-5*, American Psychiatric Association, 2013) includes a category of Social (Pragmatic) Communication Disorder (SPCD) that involves persistent difficulties in verbal and nonverbal communication for the purposes of social interaction. This occurs in the absence of the repetitive and restrictive behaviors characteristic of autism. Some children with SLI exhibit these characteristics. Most of the CCC items that identify these children address nonlinguistic issues in social interaction and the use of language for social purposes (see Chapter 18 by Fujiki & Brinton), but some of the items address the ability to produce and comprehend structural and prosodic aspects of discourse. Many of the former characteristics define children with pervasive developmental disability, autism, or Asperger's syndrome (see Chapter 3 by Gerenser & Lopez). Typically, such children are excluded from research studies on SLI. The question remains whether at least some of these children might be better characterized as children with autism who have SLI. Bishop's (1998) solution to this issue was to distinguish between children with primary pragmatic language impairment (PLI) without autistic-like behaviors (PLI pure) and those with such behaviors (PLI plus). A battery of standardized and nonstandardized tasks successfully discriminated with a high degree of accuracy among PLI pure, PLI plus, autism spectrum disorders (ASD), and SLI (Botting & Conti-Ramsden, 2003). I will return to children with ASD and language impairments in the later section on co-morbidity.

Although the profiles and severity of language impairments vary across subjects, we have yet to identify, with certainty, subgroups of children with SLI that have clear implications for theories or for differential approaches to intervention. Even in the subgroups defined thus far, no one claims that children have exclusive deficits in a given component of language. Instead, claims are made regarding primary deficits. Clinicians can certainly respond to varying profiles in how they select and prioritize goals in intervention, but researchers continue to face a challenge in the heterogeneity of children with SLI. One solution in research may be to abandon group-driven statistical analyses in favor of analyses that permit the examination of multiple factors nested within subjects in relation to the outcome of experimental tasks. Hierarchical linear modeling (Bryk & Raudenbush, 1992; Schonfeld & Rindskopf, 2007), also called multilevel modeling, is an approach that has been frequently used for growth curve monitoring, but it has not yet been widely used for this purpose (e.g., Jacobson & Schwartz, 2002, 2005). With the use of this and other related approaches, we may be better able to determine how varying profiles of linguistic and nonlinguistic abilities are related to a child's classification as SLI and to the child's specific pattern of language deficits.

Language Deficits

The various areas of language deficits that characterize SLI are summarized briefly here; they are discussed in great detail in other chapters in this volume. These deficits may be more prominent in some language domains than in others; the profiles of deficits vary across children with SLI, and in given children all domains may be affected.

Lexical and Semantic Deficits

Children with SLI are delayed in the emergence of first words, exhibit limited vocabularies, appear to have incomplete or underspecified phonological representations of words, have limited elaboration of the semantic information underlying words, and atypical organization or access to their mental lexicon (see Chapter 16 by McGregor). Verbs seem to present particular problems for these children. Finally, lexical access for production and comprehension appears to be atypical in children with SLI.

The general course and speed of lexical development is delayed in children with SLI. Their first words emerge much later than in their typically developing peers, and their word comprehension is also delayed (e.g., Clarke & Leonard, 1996). Children who are late talkers are variously identified as having fewer than 50 words and no word combinations at 24 months (Rescorla, 1989), as children who, on the MacArthur-Bates Communicative Development Inventory (Fenson et al., 1996), score below the 10th percentile at 24 and 30 months of age (e.g., Irwin, Carter, & Briggs-Gowan, 2002; Moyle, Weismer, Evans, & Lindstrom, 2007; Weismer & Evans, 2002), or the 15th percentile on the Communicative Development Inventory (CDI; Thal, Reilly, Seibert, Jeffries, & Fenson, 2004). Late talkers who exhibit receptive delays are more often identified as having SLI than are late talkers who seem to have normal receptive vocabulary development (Thal et al., 2004). The outcomes for these children in language abilities at age 13 are predicted by their language abilities at age 2

(Rescorla, 2005). Those children who appear to catch up may actually have an *illusory recovery* in that they reach a plateau that masks continued deficits not apparent in standardized testing (Scarborough & Dobrich, 1990). Preschool children with SLI continue to exhibit delays in receptive (e.g., Clarke & Leonard, 1996) and expressive (Thal, O'Hanlon, Clemmons, & Fralin, 1999; Watkins, Kelly, Harbers, & Hollis, 1995) vocabulary. Older school-aged children with SLI may have even more apparent deficits in vocabulary (Haynes, 1992; Stothard, Snowling, Bishop, Chipchase, & Kaplan, 1998). These children seem to have sparse lexical semantic representations (McGregor, Friedman, & Reilly, 2002) and deficits in semantic category knowledge (Kail & Leonard, 1986).

Some measures of lexical diversity in language samples (number of different words, total number of words) suggest that children with SLI have less lexical diversity than their age-matched peers, but they may be similar to mean length of utterance (MLU)-matched peers (Goffman & Leonard, 2000; Klee, 1992; Leonard, Miller, & Gerber, 1999; Watkins et al., 1995). A more recently developed lexical diversity measure, D (Malvern & Richards, 2002)—a repeated calculation of the type-token ratio (TTR) over a range of tokens (35–50) related to sample size that is then compared to a mathematical model of TTR—may provide a more accurate picture of lexical diversity in SLI. Owen and Leonard (Owen & Leonard, 2002) found no difference in D between children with SLI and their age-matched peers, although within both groups, older children had higher scores than younger children. Wong, Klee, Stokes, Fletcher, and Leonard (2010) found that a composite score of D, MLU, and age did not successfully differentiate Cantonese-speaking children with and without SLI.

Some children have apparent word-finding problems not unlike those associated with adult-acquired anomia (Dockrell & Messer, 2007; German & Newman, 2004; Lahey & Edwards, 1999; Leonard, Nippold, Kail, & Hale, 1983; McGregor et al., 2002; Seiger-Gardner & Schwartz, 2008). These children have difficulty in naming-on-demand tasks, use circumlocutions, exhibit pauses and hesitations, and have limitations in production vocabulary.

Vocabulary skills and the growth of vocabulary appear to be the aspects of language development that are most closely correlated with phonological working memory (Gathercole, 2006). However, as noted above, when the measure *D* is used, children with SLI do not differ from their age-matched peers (Owen & Leonard, 2002). Furthermore, children with SLI rarely have difficulty with phonological working memory when the nonwords to be repeated are one or two syllables in length. In English and a number of other languages, the vast majority of words are no more than two syllables in length.

A number of experimental studies conducted by Leonard and Schwartz and their colleagues (e.g., Leonard, 1982; Schwartz, 1988; Schwartz, Leonard, Messick, & Chapman, 1987) have examined word learning in young children with SLI. These were novel or unfamiliar real words for objects and actions that were presented in 10 sessions over a month or so with comprehension and production testing. In general, the groups were similar, but children with SLI were less likely to extend the learned words to novel exemplars in a comprehension test. They were also more likely to make errors on experimental words that differed from their errors on those target sounds in their spontaneous language. This suggests that children with SLI do not relate novel words to existing phonological representations of word production.

Several studies have used fast mapping (short-term limited exposure word learning) to examine early lexical abilities (Dollaghan, 1987; Rice, Buhr, & Nemeth, 1990; Rice, Buhr, & Oetting, 1992; Rice, Oetting, Marquis, & Bode, 1994). The findings vary somewhat, but children with SLI acquired a novel object word in comprehension, but not in production, with a single presentation; with five presentations embedded in a video story, children with SLI did more poorly than their peers; children with SLI did not learn object and action names with only three presentations; and even after 10 presentations they did not maintain their word learning. A fast mapping study (Alt & Plante, 2006) revealed that children with SLI perform more poorly overall and that their performance is particularly impaired when they only receive visual information, when the task complexity increases, and when they are asked to learn words with low phonotactic (sound and sound sequence) probability.

It is difficult to dissociate the syntactic and semantic (argument structure vs. thematic role) bases for these children's difficulties with verbs (Conti-Ramsden & Jones, 1997; Ingham, Fletcher, Schelleter, & Sinka, 1998; Loeb, Pye, Richardson, & Redmond, 1998; Oetting, Rice, & Swank, 1995; Watkins & Rice, 1991). However, it is clear that verbs pose a significant challenge for these children, in particular a special category of verbs—those that encode mental states (Johnston, Miller, & Tallal, 2001).

The word-finding difficulties mentioned earlier may well reflect issues in lexical access for production or spoken word recognition. A variety of tasks have been used to examine lexical access. Auditory lexical list priming with a lexical animacy decision (Velez & Schwartz, 2010) revealed priming for children with SLI, but only in a repetition condition, unlike their typically developing peers who exhibited phonological and semantic priming as well. This suggests deficits in access or the organization of the mental lexicon in children with SLI. Eye tracking provides continuous data on spoken word acquisition. McMurray, Samelson, Lee, and Tomblin (2010) examined lexical access in adolescents with SLI using an auditory word and four pictures (the target, a picture representing a word with the same beginning consonant-cohort, a picture representing a word that rhymes, and an unrelated foil). The adolescents with poor language scores exhibited fewer looks to the target and more looks to the cohort and rhyme than did children with stronger language scores, regardless of IQ. Exploration of the findings using modeling revealed that this atypical eye gaze behavior and the inferred lexical access patterns is attributable to lexical decay, particularly as it applies to the target, allowing higher continuing activation for the cohort and rhyme. A more recent eye tracking study (Aharodnik et al., 2016) found that for semantic and phonological priming, children with SLI (7;0–11;0) did not differ from their peers in looks to target, but the typically developing children exhibited phonological cohort and semantic interference effects from pictures representing words related to the target, whereas the children with SLI did not exhibit these effects, suggesting a deficit in lexical organization or access.

Similarly, children with SLI exhibit both typical and atypical lexical access in production. This study used a task called Picture-Word Interference, which requires the child to name a picture when the picture is presented after, simultaneously with, or before an auditory word (interfering stimulus) that is related (semantically or phonologically) or unrelated to the word represented by the picture. By comparing the reaction times for related and unrelated conditions, it is possible to infer what information is active. The children with SLI exhibited typical phonological facilitation but atypical lingering semantic inhibition and a late semantic inhibition effect. The disparity between phonological and semantic effects in processing for lexical production and lexical access/comprehension does not have an obvious explanation. A within-child comparison of processing for production and recognition might contribute to an understanding of when and why this may happen.

Morphosyntactic Deficits

The morphosyntactic deficits associated with SLI have been studied extensively in English (see Chapter 15 by Oetting & Hadley) and in other languages (see Chapter 13 by Leonard). It is the most studied language deficit in children with SLI. In English, children with SLI have particular difficulty with verb morphology, functional morphemes that mark finiteness (i.e., tense, agreement), often producing bare stem verbs (e.g., *jump*) without third-person singular or past tense endings. These deficits are part of a more general pattern of morphosyntactic deficits in English during the preschool years, with deficits in finite verb morphology becoming more pronounced when MLU reaches 3.50 and continuing to be prominent up to 8 years of age. Notably, measures of finite verb morphology are remarkably sensitive (97% accuracy) in distinguishing children with and without SLI. In general, children with SLI perform more poorly than age-matched and language (MLU)-matched typically developing peers and exhibit distinct growth curves in development of these morphosyntactic markers. The patterns hold true across regional dialects of English and for children who speak African American Vernacular (see Chapter 14 by Newkirk-Turner & Green). There is behavioral evidence from twins (Bishop, Adams, & Norbury, 2006) that these specific deficits are heritable. In older children with SLI, morphosyntactic deficits may persist (e.g., Marshall & van der Lely, 2006), but they are no longer a reliable indicator of the language status (Conti-Ramsden, Botting, Simkin, & Knox, 2001).

Studies of other verb-related morphological forms such as past participles have yielded mixed findings. Some indicated that children with SLI produce participles comparably to language-matched controls (e.g., Redmond & Rice, 2001), whereas others (Leonard et al., 2003) revealed deficits. Children with SLI were more likely to mark participles correctly than simple past tense.

The extent to which these deficits affect noun-related morphology (i.e., plurals, articles) is still unknown. Although some studies revealed deficits in noun plurals (Leonard et al., 1992; Leonard, Eyer, Bedore, & Grela, 1997), others revealed minimal deficits (Oetting & Rice, 1993; Rice & Wexler, 1996b). McGregor and Leonard (1994) and Rice and Wexler (1996b) found lower degrees of article use by children with SLI than by TD-MLU-matched children, but another study (le Normand, Leonard, & McGregor, 1993) did not find a difference.

Case marking (subject versus object) for pronouns in English is also impaired in children with SLI compared to language-matched controls (Loeb & Leonard, 1991; Loeb et al., 1998). However, not all children with SLI make these errors, and the error rates differ between *he* and *she* (Pine, Joseph, & Conti-Ramsden, 2004; Wexler, Schütze, & Rice, 1998). Thus, the nature or underlying cause of this particular deficit remains unknown.

Similar patterns have been observed in bilingual children with SLI. Bilingual French-English children with SLI omitted tense markings in both languages (Paradis, Crago, Genesee, & Rice, 2003). Sequential Spanish-English bilinguals perform more poorly than typically developing bilingual children on past tense marking in English (Jacobson & Schwartz, 2005). Young typically developing children produced these forms correctly or, at least, demonstrated knowledge of rules for regular past tense in overregularizations (e.g., *goed* for *went*). The children with SLI overregularized infrequently, but more frequently they produced bare stem infinitive forms (e.g., *jump* for *jumped*). In Spanish, bilingual children exhibited verb tense errors as well as article and clitic errors in number and gender (Bedore & Leonard, 2001; Gutiérrez-Clellen, Restrepo, & Simón-Cereijido, 2006; Gutiérrez-Clellen & Simon-Cereijido, 2007).

Patterns of morphological deficits in languages reflect the prosodic (Demuth & Tomas, 2016) and structural characteristics of the given language (see Chapter 13 by Leonard). Whereas English-speaking children with SLI omit unstressed past tense markers and produce a bare stem infinitive form, in many other languages infinitives are different forms of the verb, not bare stems, and thus the specific errors manifest themselves differently. Even in languages that are similar, the error patterns seem to differ. For example, Italian-speaking children with SLI tend to omit object clitic pronouns, whereas Spanish-speaking children with SLI tend to produce substitute forms that have errors in gender or number. The nature of SLI in languages other than English (both similar and dissimilar) is critical to our understanding of the underlying deficits characteristic of SLI (e.g., Krok & Leonard, 2015).

Phonological Deficits

Children with phonological disorders are routinely excluded from studies of SLI in order to avoid including children whose speech production limitations might be the result of apparent nonlinguistic limitations in language production. However, it is clear that a significant number of children with SLI have phonological impairments in production, perception, and phonological awareness. Furthermore, deficits in other areas of language, such as morphosyntax, may be conditioned by phonological factors. There are several ways to consider phonological deficits in children. One is the extent to which children with phonological disorders and children with language impairments overlap. One-third of the children with speech delays of unknown origin had significant deficits in language comprehension, and language-production abilities were deficient in almost 80% of these children (Shriberg & Kwiatkowski, 1994). Furthermore, cognitive-linguistic status is strongly associated with short-term and long-term normalization of phonological disorders (Shriberg, Gruber, & Kwiatkowski, 1994; Shriberg, Kwiatkowski, & Gruber, 1994). An additional study revealed that 11–15% of 6-year-old children with speech delay had SLI, and 5–8% of children with SLI had speech delay (Shriberg, Tomblin, & McSweeny, 1999).

There are a number of other ways to consider phonological deficits in children. As discussed earlier, children with SLI have deficits in speech perception—notably, in categorical perception. Nonword repetition may also reflect phonological deficits and may, in some respects, be a more accurate measure of phonological abilities than working memory. Findings from a lexical decision task (Edwards & Lahey, 1996) have been interpreted as indicating deficits in phonological representations. In contrast, a cross-modal interference task requiring children to name pictures while they heard phonologically related and unrelated words revealed a similar time course for the availability of phonological information in naming for children with SLI and their peers for highly familiar words (Seiger-Gardner & Schwartz, 2008). Less familiar words may have revealed group differences.

There is substantial evidence that deficits in the production of morphosyntax and function words may be attributed to phonological factors (see Chapter 11 by Joanisse; see also Gallon, Harris, & van der Lely, 2007; Leonard, Davis et al., 2007; Marshall & van der Lely, 2006, 2007). Children with SLI are less likely to produce past tense *-ed* overall in novel words but were even less likely to do so when the word stem was low in its phonotactic (sound sequence) probability, whereas typically developing MLU-matched peers were not influenced by phonotactic probability (Leonard, Davis et al., 2007). Children with SLI were also less likely to produce the past tense when the addition of *-ed* formed a consonant cluster that does not occur in uninflected English words (Marshall & van der Lely, 2006). The production of inflections and function words also may be influenced by the prosodic structure of words and phrases (McGregor & Leonard, 1994). For example, unstressed syllables are more likely to be omitted when they don't fit the trochaic (strong-weak) syllable pattern of English.

Another aspect of phonological deficits concerns phonological awareness. This includes a variety of metalinguistic abilities that have been related to dyslexia and reading disabilities (see Chapter 5 by Shaywitz & Shaywitz and Chapter 19 by Hook & Haynes). It includes tasks such as identifying the number of syllables or identifying the word that is formed when a segment is omitted (e.g., *bat/at*) or added, providing rhymes. Children with SLI exhibit mild deficits in phonological awareness, whereas children with dyslexia and SLI exhibit more severe deficits (Catts, Adlof, Hogan, & Weismer, 2005).

An important line of research has examined motor aspects of speech production in children and related motor deficits (e.g., Brumbach & Goffman, 2014). Children with SLI exhibit speech motor and general motor performance deficits. These speech motor deficits may impact various aspects of segmental and prosodic phonology, and they highlight the embodiment of language in a physical world.

Syntactic Deficits

Early in development, children with SLI exhibit delayed growth in the syntactic complexity, beginning as early as the onset of syntactic comprehension and production. They also exhibit persistent difficulty producing and comprehending syntactically complex sentences. We now know a great deal about specific syntactic deficits of children with SLI (see Chapter 17 by Fletcher & Frizelle). The vast majority of what we know comes from studies of language samples, although some more recent studies have used targeted elicitation, and a small number of studies have tested comprehension using off-line and on-line tasks. Children with SLI have difficulties comprehending and producing sentences that involve long-distance dependencies, such as wh-questions (Deevy & Leonard, 2004; Hansson & Nettelbladt, 2006; Marinis & van der Lely, 2007; Stavrakaki, 2006) or relative clauses (Friedmann & Novogrodsky, 2004, 2007; Håkansson & Hansson, 2000; Novogrodsky & Friedmann, 2006; Schuele & Tolbert, 2001). It should be noted that some of these studies included children with SLI who speak languages other than English, and thus, it appears to be a more global deficit. One view is that children with SLI construct grammars in acquisition where long-distance dependencies are optionally represented. Thus, in a sentence with a relative clause (e.g., *The zebra* that the hippo kissed *t* on the nose ran far away), the relationship between *the zebra* and its trace position (*t*) may not be established. The deficit in establishing long-distance relations or in a more recent view is specific to a grammatical operation called *Move*. A related proposal from Friedmann and colleagues is that children with SLI have a problem in movement, which, in turn, causes a problem with the assignment of thematic roles.

An alternative view is that for children with SLI, the challenge of these complex syntactic structures lies in the processing of these sentences for comprehension affecting acquisition and the continuing comprehension of these structures and, perhaps, in production as well. Among the candidate deficits that might explain these difficulties are working memory (Deevy & Leonard, 2004; Marton et al., 2006; Montgomery, 2000a, 2000b, 2003), attention, control of attention, and processing speed (Leonard, Weismer et al., 2007). As discussed earlier in the chapter, deficits in these cognitive processes may be general, affecting domains other than language, or specific to language processing. One proposal in line with current views of working memory is that inference occurs between elements (e.g., nouns) in a sentence, particularly in long-distance relationships (e.g., van Dyke & Johns, 2012). A recent study (Leonard, Deevy, Fey, & Bredin-Oja, 2013) explored sentence comprehension when included adjectives were contrastive with respect to the picture array and when the adjectives did not serve to distinguish the picture choices. Children with SLI and younger typically developing children performed more poorly when the adjectives mattered. Leonard et al. assumed this to be the result of increased processing demands, which might include the interference of one of the two adjectives matching a referent in the foils. Further exploration of this and other types of potential interference in sentence processing would be informative.

There is also evidence of deficits in other structures with complex syntax such as passives (e.g., Leonard et al., 2006; Marshall, Marinis, & van der Lely, 2007) that may be due to factors other than syntactic complexity. Sentences with finite complement clauses also seem to pose problems for children with SLI (e.g., Owen & Leonard, 2006). Children with SLI also exhibited atypical, non-asymmetrical behavioral responses to wh-subject and wh-object questions and exhibited generally poor comprehension of both types (Epstein, Hestvik, Shafer, & Schwartz, 2013). Their ERP responses suggested again that children with SLI did not exhibit the asymmetry between question types and exhibited attenuated responses. In two experiments using a picture-pointing paradigm, Fortunato-Tavares et al. (2012) found that children with SLI exhibit deficits in the interpretation of long-distance adjective attachment and reflexives, suggesting a lack of hierarchical structure for these sentence types. A working memory manipulation to increase the distance (noun-adjective or antecedent-reflexive) negatively affected performance for the children with SLI and their typically developing peers. Finally, children with SLI have syntactic deficits in argument structure that affect production and comprehension (Grela & Leonard, 2000; Loeb et al., 1998; Thordardottir & Weismer, 2002). Many of these deficits persist into adolescence (Nippold, Mansfield, Billow, & Tomblin, 2009). Processing studies of these and the preceding deficits are still limited in number and need to be the subject of future research.

Pragmatics

Children with SLI have deficits in the social use of language, overlapping to some degree and apart from the deficits seen in other populations of children with language disorders (see Chapter 18 by Fujiki & Brinton and Chapter 3 by Gerenser & Lopez). Pragmatics is a heterogeneous category of language abilities including presuppositions about the knowledge and social status of the listener, the communicative intent or function of utterances, the structure of narratives and discourse and conversation, as well as the more global use of language and nonlinguistic means of communication (e.g., tone of voice, facial expression, and gesture for and in social interaction). One of the challenges posed by this category is that it combines social behavior with aspects of language that are truly structural. In the heyday of pragmatics, investigators initially focused on identifying and categorizing the communicative functions of children's utterances. Children with SLI performed similarly to their language-matched peers in the communication functions expressed and in their relative frequencies (Fey, 2006; Leonard, 1986), but they may do so less appropriately or efficiently (Brinton, Fujiki, & Sonnenberg, 1988; Conti-Ramsden & Friel-Patti, 1983). These deficits have been taken as indications of structural language deficits rather than a lack of pragmatic knowledge (Craig, 1985).

Children with SLI also have deficits in conversation that may reflect either social deficits or structural language deficits. Children with SLI produced fewer adequate responses to adult requests for information (Bishop, Chan, Adams, Hartley, & Weir, 2000). Within the group of children with SLI, those defined as having pragmatic SLI were more likely to give no response (not even nonverbal) to such requests. A child who does not even acknowledge the obligation to respond clearly has a more general deficit with conversational turn-taking and social interaction than a child who gives an inadequate response due, perhaps, to a comprehension deficit. Brinton and colleagues (Brinton, Fujiki, & Powell, 1997) reported a similar observation.

There is further evidence that children with SLI have structural deficits in conversational interaction, particularly as it affects the contingency and coherence (structural or semantic relatedness) of successive utterances (e.g., Craig & Evans, 1993). Children with expressive and receptive deficits exhibited fewer conversational interruptions and relied more on lexical ties than on conjunction connective, and more on incomplete cohesive ties that were ambiguous or incorrect, than did children with just expressive deficits. There were a small number of children in this study, and it would be worthwhile to have more information on this structural aspect of pragmatics.

Several studies have revealed deficits in the narratives of children with SLI. In general, children with SLI produce narratives that are less structurally complex and less cohesive, include morphosyntactic errors, are syntactically less complex, have omitted information, and exhibit poor event sequencing (e.g., Botting, 2002; Liles, 1993; Norbury & Bishop, 2003; Reilly, Losh, Bellugi, & Wulfeck, 2004). One study examined story-telling and conversation in adolescents with SLI (Wetherell, Botting, & Conti-Ramsden, 2007). The children with SLI performed more poorly than their typically developing peers on both narrative types, with story-telling being more difficult in terms of productivity (total number of morphemes and number of different words), syntactic complexity (number of different syntactic units and number of complex sentences), syntactic errors, and performance (amount of examiner support and prompts, total number of fillers, and total number of dysfluencies). This confirms previous findings concerning these kinds of deficits and indicates that these deficits continue into adolescence.

Although there is a large body of literature on discourse processing and comprehension, including the establishment of inferences across sentences, this has not yet been applied to children with SLI. It seems likely to be a significant area of deficit for older children and may reveal deficits that have not been apparent in studies of narrative production.

The area of social interaction and its use has also received relatively limited attention, even though it is apparent that language deficits pose social problems for these children as well as for other groups of children with language impairments. Children with SLI have early difficulties in establishing peer relationships that extend into adolescence (e.g., Conti-Ramsden & Botting, 2004; Conti-Ramsden et al., 2001). Pragmatic abilities such as initiating conversations, contributing to conversations, communicating intentions clearly, addressing each child as part of joining a group, and adjusting to listeners' needs are critical to establishing positive peer interactions (Brinton & Fujiki, 1999; McCabe, 2005). Children with SLI have deficits in social initiation (e.g., Craig & Washington, 1993), in participation in social interactions (Hadley & Rice, 1991; Rice, Sell, & Hadley, 1991), in conflict resolution (Brinton, Fujiki, & McKee, 1998), and with appropriate responses to social bids (Brinton & Fujiki, 1982). Besides observations of these deficits, parent responses to questionnaires such as the *Child Behavior Checklist* reveal deficits across all social skills and in some internalizing behaviors, but not in externalizing behaviors (Stanton-Chapman, Justice, Skibbe, & Grant, 2007). These questionnaires revealed clinically significant problems in socialization, but not in behavior. A broad range of pragmatic deficits, including structural discourse deficits, deficits in the use of language for social interaction, and deficits in social skills affect children with SLI. Although experimental pragmatics is a burgeoning field in language acquisition and psycholinguistics, a number of such areas remain unexplored in SLI.

Genetics

The first hint that SLI might be genetically transmitted (see Chapter 10 by Tomblin) came from interview studies of families with affected children. These were followed by studies in which family members were evaluated directly. As a whole, these studies provided convincing evidence that SLI is a heritable disorder (Beitchman, Hood, & Inglis, 1992; Choudhury, Leppanen, Leevers, & Benasich, 2007; Neils & Aram, 1986; Rice, Haney, & Wexler, 1998; Tallal, Ross, & Curtiss, 1989; Tomblin, 1989; Whitehurst, Arnold, Smith, & Fischel, 1991). With the exception of one, in all of these studies some increased rates of speech, language, or reading problems were reported for family members of children with SLI in comparison to children without SLI. The frequency of this varied because these were reports and because the history questions were asked in widely different ways. Tomblin (Chapter 10) indicates that having a first-degree relative with SLI increases your chances of being affected by approximately four times (the typical rate of occurrence is approximately 7% in the general population). This has strong implications for early assessment and intervention for children of parents who are affected and for children with affected siblings. Of course, family patterns do not conclusively demonstrate heritability. The next step in the accumulation of evidence for heritability was a series of twin studies (e.g., Bishop, North, & Donlan, 1995; Bishop et al., 2006; Lewis & Thompson, 1992; Tomblin & Buckwalter, 1998). Comparing monozygotic (100% shared genes) to dizygotic (50% shared genes) twins provided further evidence for those aspects of development that are heritable versus those that are attributable to environmental factors. These studies have revealed a greater degree of occurrence for SLI in general, phonological working memory deficits. Some studies have also revealed some more specific information about the relation between heritability and the discrepancy between IQ and language scores: there is greater heritability of SLI when no discrepancy is required (Bishop et al., 1995; Eley, Bishop, Dale, Price, & Plomin, 2001; Hayiou-Thomas, Oliver, & Plomin, 2005; Newbury, Bishop, & Monaco, 2005). More recently, Bishop et al. (2006) found that both grammar and grammar deficits are heritable and some evidence that these deficits arise from different genes.

One of the greatest leaps in our understanding of the genetics of SLI has come from the study of a single family in the United Kingdom, known as the KE family, with 15 family members who have severe speech and language impairments across three generations and 37 living members (Vargha-Khadem et al., 1998). It is important to note that although these affected family members do have expressive and receptive language deficits, they have apraxia of speech or oral facial apraxia (Hurst, Baraitser, Auger, Graham, & Norell, 1990; Vargha-Khadem et al., 1998). Crago and colleagues (Crago & Gopnik, 1994; Gopnik, 1990; Gopnik & Crago, 1991) omitted any description of the apraxia and described these individuals as having a morphosyntactic deficit that reflected missing underlying features of morphosyntax. Because of the apraxia, these individuals would not fit the commonly used definitions of SLI. Nevertheless, this family has revealed a great deal about the genetic bases of language impairments. Molecular geneticists have identified the *FOXP2* as a location of anomaly that was consistent across the 15 affected members and a single case study of speech and language impairment (Lai et al., 2000; Lai, Fisher, Hurst, Vargha-Khadem, & Monaco, 2001). Follow-up studies revealed that the affected family members were differentiated from unimpaired members in intelligence, language, and limb and oral facial findings (Watkins, Dronkers, & Vargha-Khadem, 2002). Nonword repetition was the strongest predictor for being affected. These deficits were then associated with brain structure (Watkins, Vargha-Khadem, et al., 2002) and functional imaging findings (Liégeois et al., 2003). Among the structural findings were abnormalities in the caudate nucleus, putamen, cerebellum, temporal cortex, inferior frontal gyrus, motor cortex, and the inferior frontal gyrus. Functionally, affected individuals exhibited lower activation during language tasks in Broca's area, the right inferior frontal gyri, and the putamen. They exhibited higher activation in traditionally nonlanguage areas such as posterior parietal, occipital, and postcentral regions. These findings were interpreted as indicating that the genetic abnormality interfered with the caudate development and results in procedural learning deficits, consistent with a proposal by Ullman and Pierpont (2005), as mentioned earlier.

Despite the KE family findings, several research groups (Meaburn, Dale, Craig, & Plomin, 2002; Newbury et al., 2002; O'Brien, Xuyang, Nishimura, Tomblin, & Murray, 2003) have not found *FOXP2* abnormalities in children with SLI, but suggestions of other gene associations have emerged. Now that genome-wide analysis is more readily available, further rapid progress seems likely (e.g., Evans et al., 2015; Simpson et al., 2015; see Chapter 10 by Tomblin).

Neurobiology

Developmental cognitive neurosciences is still very much in its infancy, particularly as it has been applied to children with SLI, but new research is now emerging at a rapid pace (see Chapter 7 by Epstein & Schwartz). Some of the reasons this research has emerged more slowly than behavioral research is the challenges of employing some of these methods with children (see Chapter 24 by Shafer, Zane, & Maxfield). The research to date has examined the underlying neurobiology of SLI using magnetic resonance imaging (MRI), functional magnetic resonance imaging (fMRI), and electrophysiology (ERPs). These studies have revealed structural and functional differences between the brains of children with SLI and their typically developing peers.

The characterization of the neurobiology underlying SLI begins with autopsy studies of adults who had histories of reading disabilities and a girl who had a history of a language disorder (e.g., Cohen, Campbell, & Yaghmai, 1989; Galaburda, 1985; Humphreys, Kaufmann, & Galaburda, 1990). The primary finding of interest was that these individuals seemed to lack hemispheric asymmetry in an area called the planum temporale (PT). The PT is an area defined by landmarks on the inferior portion of the Sylvian fissure. It is considered to be an area involved in receptive language that roughly corresponds to Wernicke's area. In previous studies, autopsies revealed that in adults with a history of normal language status, the planum temporale was larger in the left hemisphere than in the right (e.g., Geschwind & Levitsky, 1968).

MRI has been used to examine the relative size and volume of various brain areas and structures in living subjects. Plante and her colleagues have reported findings from a pair of dizygotic twins involving a boy with SLI and his twin sister with typical language development (Plante, Swisher, & Vance, 1989), a group of boys with SLI (4;2 to 9;6), and controls with typical language development (Plante, Swisher, Vance, & Rapcsak, 1991), as well as the parents and siblings of a subset of these children (Plante, 1991). Overall, these studies suggest that children with SLI, their siblings, and their parents tend to lack asymmetry or have atypical asymmetry (right hemisphere larger than left) in the perisylvian area, which includes the planum temporale. All of these findings should be considered against the finding that the presence of this asymmetry may vary with gender, with males being more likely to show asymmetry (Lane, Foundas, & Leonard, 2001). A more extensive MRI study (Jernigan, Hesselink, Sowell, & Tallal, 1991) was conducted of 20 children (8;0–10;0) with substantial receptive and expressive language delays and severe learning disabilities, along with 12 age-matched children with typical language development. The language-impaired children had leftward asymmetry in the superior parietal region and rightward asymmetry of the inferior frontal region, whereas asymmetry was reversed in the typically developing children. The language-impaired children had lower volumes for most of the structures measured and for their overall left hemispheres, particularly for posterior perisylvian regions, which include the planum temporale. Subcortical structures, including the caudate nucleus, had bilaterally smaller volumes. Similar findings regarding subcortical structural abnormalities have been reported in studies of the KE family discussed above (Belton, Salmond, Watkins, Vargha-Khadem, & Gadian, 2003; Liégeois et al., 2003; Watkins, Vargha-Khadem et al., 2002). Such findings are consistent with the proposal that deficits in procedural memory underlie SLI and that motor deficits may be related.

Only a small number of studies have employed MRI to examine the structural neurological basis of SLI. In the first of these studies, Weismer and colleagues found that children with SLI exhibit atypical brain activation patterns during a working memory task. A final MRI study (Gauger, Lombardino, & Leonard, 1997) focused on the planum temporale (in Wernicke's area) and the pars triangularis (in Broca's area). In the children with SLI, there was atypical rightward asymmetry of the planum temporale and the poster ascending ramus, a smaller left pars triangularis, and a narrower right hemisphere.

A recent MRI study (Girbau-Massana, Garcia-Martí, Martí-Bonmatí, & Schwartz, 2014) used a relatively new technique called optimized voxel-based morphometry. The children with SLI had a lower volume of gray matter (neuronal cell bodies, dendrites, myelinated and unmyelinated axons, glial cells, synapses, and capillaries) overall and specifically lower gray matter volume in the right postcentral parietal gyrus (BA4), and in the left and right medialoccipital gyri. They also had a greater volume of gray matter in the right superior occipital gyrus, which may reflect a compensatory re-organization. They also had great cerebrospinal fluid volume. Children with SLI and reading disability had a greater volume of white matter (myelinated nerve cell projections that connect areas of gray matter) in the right inferior longitudinal fasciculus. The origins of these differences and whether they change over time remains unknown.

To date only two studies have employed fMRI to investigate SLI. In the first, Weismer and colleagues (Weismer, Plante, Jones, & Tomblin, 2005) examined brain differences during a modified listening span task focusing on sentence encoding and final word recognition for previous sentence sets. The adolescents with SLI exhibited lower activation during encoding in the left parietal region, associated with attentional control, and in the precentral sulcus, a region associated with memory processes, and lower activation during recognition in language processing regions, compared to their typically developing peers. They also exhibited different patterns of coordinating activation among brain regions during encoding and recognition compared to the typically developing adolescents, suggesting that their brains have a less well-established functional network for such tasks. Another fMRI study (Niemi, Gunderson, Leppäsaari, & Hugdahl, 2003) compared the brain response of five family members with SLI and six control subjects to isolated vowel sounds, pseudowords, and real words. The family members with SLI exhibited reduced brain activation in areas associated with speech processing and phonological awareness located in the temporal and frontal lobes, most notably in the middle temporal gyrus bordering the superior temporal sulcus.

Electrophysiology is the most widely used method to date that has been applied to children with SLI. Event-related potentials (ERPs) have been used to examine speech perception, lexical-semantic processing, and syntactic processing in these children and in family members of these children (see Chapter 7 by Epstein & Schwartz). ERP studies have revealed that children with SLI exhibit atypical responses, such as immature N1-P2-N2 responses, on a backward-masking frequency discrimination task (Bishop & McArthur, 2005; McArthur & Bishop, 2004, 2005); smaller MisMatched Negativity discrimination responses to syllables and vowels (e.g., Shafer, Morr, Datta, Kurtzberg, & Schwartz, 2005; Uwer, Albrecht, & von Suchodoletz, 2002); absent left hemisphere responses or rightward asymmetry to speech, tones, and the word *the* in discourse (Bishop, Hardiman, Uwer, & von Suchodoletz, 2007; Shafer, Schwartz, Morr, Kessler, & Kurtzberg, 2000; Shafer et al., 2005); larger N400 to semantic anomalies (Neville, Coffey, Holcomb, & Tallal, 1993); lack of the typical leftward asymmetrical response to function words (Neville et al., 1993); and very delayed responses to gaps in sentences with relative clauses (Hestvik, Tropper, Schwartz, Shafer, & Tornyova, 2007). Some of the most interesting ERP findings regarding SLI involve the absence of N400 responses at 19 months of age in children who at 2;6 exhibited poor expressive language abilities (Friedrich & Friederici, 2006), as well as delayed positive mismatch response in 2-month-old infants from families with a history of SLI (Friedrich, Weber, & Friederici, 2004).

Shafer et al. (2007) used a global field power analysis to determine attention allocation in speech perception tasks where the child had to attend to a visual stimulus and ignore the speech or attend to the speech. The children with SLI reached an attentional peak later than their peers with typical language development (TLD), and when attention was directed towards the visual stimuli, the children with TLD still directed some attention resources to the speech, whereas the children with SLI did not. Evidence of deficits in selectional attention during story processing not apparent in a behavioral task was revealed by ERPs (Stevens, Sanders, & Neville, 2006). Although imaging and ERPs have been used to examine the outcomes of intervention in adults with aphasia, few studies have done this in children with SLI. Popescu, Fey, Lewine, Finestack, and Popescu (2009) employed a classic N400 paradigm using sentences with and without semantic anomalies. There was no difference in response to the two sentence types before intervention but a significant difference afterwards. The difference was due to a decrease in the N400 to the final word in the non-anomalous sentences. As noted elsewhere throughout the chapter and in Chapter 7, we are only beginning to tap the potential of this method in examining the neurobiology of SLI and using it to examine the effects of intervention.

The great challenges remaining in the study of the neurobiology of SLI include the continuing establishment of relations between neurological findings and behavior, determining the specific cognitive and linguistic implications of anatomical and functional differences between children with SLI and their typically developing peers, the use of these methods to provide early identification of children who are at risk for SLI, as well as their use to measure changes following intervention.

Assessment

Clinical assessment of SLI predominantly relies on the use of standardized tests of syntax, semantics, vocabulary, and phonology. These can be supplemented by tests of cognitive abilities, including performance IQ and working memory. Researchers use the same tools to identify children for research studies, but there are some serious concerns about the psychometric value of such tests (e.g., Fidler, Plante, & Vance, 2011). Although Fidler and colleagues focused on adults with language disorders in this particular paper, the questions about reliability and validity, as well as sensitivity and specificity, they raise apply more widely to language tests. Many standardized language tests have limitations in sensitivity and specificity, reliability, and validity and are not amenable to examinations of language use in context (pragmatics) or of language processing. Furthermore, they often do not provide sufficient information to plan therapy because they are designed to survey various language abilities rather than to provide in-depth testing on any given aspect of language. Despite all of these limitations, standard tests remain the pillar of language assessment for SLI. At the very least, researchers and clinicians need to ask questions about these things for any test or battery of tests they use to identify children with SLI.

Language samples have been an important supplement to standardized testing for some time. They have the advantage of permitting assessment of some pragmatic features and providing data about children's use of language structure (syntax and morphosyntax) and vocabulary in a more natural, communicative context. Several computer programs are available to analyze language samples. The programs that are most widely used are Systematic Analysis of Language Transcripts (SALT, Miller & Iglesias, 2008), Computerized Language Analysis (CLAN, MacWhinney, 2000), and Computerized Profiling (Long, Fey, & Channell, 2004). All permit calculation of mean length of utterance (MLU) and other syntactic, morphosyntactic, and lexical analyses.

One issue that has been addressed by a number of investigators (e.g., Plante, 1998) and by clinicians is whether children are judged to be SLI by reference to their performance IQ (MA referencing) or to the mean language score(s) for their chronological age (CA referencing). MA referencing was intended to ensure that there is a language impairment rather than a more general developmental delay, but this may be affected by issues with MA (e.g., one year below chronological age means something very different for a 3-year-old than for a 12-year-old). CA referencing compares children to their age-matched peers, assuming that the normative data have been collected from a representative sample. Most research studies use a single omnibus language test with supplemental tasks (performance IQ, working memory, etc.) and set a criterion (e.g., 1.25 standard deviations [*SD*] below the mean on two or more subtests of a standardized language test). In many studies, the children have had performance/nonverbal IQs within normal limits (i.e., 85 or above).

Some years ago, compelling arguments, along with some evidence, led to the suggestion that the nonverbal IQ criterion for identifying children with SLI is, at best, ill-advised (Plante, 1998; Tomblin & Zhang, 1999). Tomblin and Zhang found no differences on omnibus test score patterns between groups of children above (SLI) and below (nonspecific language impairment [NLI]) the 85 cutoff, but further studies examining more specific measures have revealed a mix of similarities and differences (tense marking and narrative measures) in performance (e.g., Nippold et al., 2009;

Rice et al., 2004). In research studies IQ should be treated as a potential predictor, without using a cutoff. Children with SLI have generally intact speech production abilities (but see DiDonato, Brumbach, & Goffman, 2014 for evidence of co-occurring speech-motor and generalized motor deficits), normal hearing, an absence of diagnosed neurological issues (e.g., no perinatal bleeds, seizure activity, etc.), and no evidence of autism spectrum disorders. However, despite the seeming clarity of these definitions, researchers and clinicians encounter some difficulties identifying these children, especially across ages, when the specific deficits associated with SLI may vary in severity and the available tests may vary in their sensitivity to subtle deficits in complex language. Some alternative measures such as nonword repetition and verb morphosyntax may add sensitivity (identifying all or most children with SLI) and specificity (accurately labeling a child as SLI) to omnibus language tests.

Clinical definitions used to determine eligibility for services also vary widely. Many school districts or government regulations permit some latitude in the means for identifying children with SLI. Generally, standardized tests are required, but language samples and, particularly for younger children, other observational and structured measures may be used.

Alternatives to published omnibus tests include published and standardized tests that focus on a single language domain (e.g., morphosyntax—Rice & Wexler, 2001), language samples (Miller, 1981), and nonstandardized language probes (Leonard, Prutting, Perozzi, & Berkley, 1978; Miller, 1981). In recent years, researchers have found that a battery including measures of tense marking, nonword repetition, and sentence recall appear to be sensitive and specific clinical markers of SLI (see Pawlowska, 2014, for a review; Redmond, 2016). Using a battery designed by Tomblin, Freese, and Records (1992) as a starting point, Fidler and colleagues (Fidler et al., 2011) found that three measures—the Modified Token Test, a 15-word spelling test, and the Word Definition subtest of the Clinical Evaluation of Language Fundamentals, Fourth Edition (CELF-4)—consistently contributed to accurate identification. Each of these approaches has great potential to add to the assessment information for identifying SLI and for planning intervention.

One challenge that faces researchers and clinicians is the identification of SLI in children who speak African American English (AAE) and in children who are bilingual. Children who are speakers of AAE are overidentified as having language impairments because some dialect and SLI features overlap (see Chapter 14 by Newkirk-Turner & Green). Some language tests include procedures for distinguishing dialect features from SLI patterns. Only one test, the Diagnostic Evaluation of Language Variation (DELV; Seymour, Roeper, & de Villiers, 2004), provides information on dialect use in children. Analyses of language samples and nonstandardized probes may be more useful in identifying SLI in these children (e.g., Craig & Washington, 2006). Some alternative approaches such as nonword repetition (Campbell et al., 1997) or reaction-time-based tasks (see Chapter 20 by Windsor) are less affected by cultural, linguistic, or dialect factors and, thus, may serve as useful approaches to the identification of children with SLI from these groups. Behavioral computer-based tasks, eye tracking, and event-related potentials (see Chapter 21 by Seiger-Gardner & Almodovar, Chapter 22 by Deevy, and Chapter 24 by Shafer, Zane, & Maxfield) have become increasingly well established as methods for measuring language production and language comprehension in research studies and may have a future role in the clinical assessment of language.

Intervention

Intervention remains among the least studied aspects of SLI. Fewer intervention studies have been published to date than other types of investigations, in part because of publication limitations and because of the general challenges of intervention research (see Chapter 23 by Finestack & Fey). There has been sufficient research published to demonstrate that language intervention is effective and has the best outcome when it begins early in development. Children with SLI are at risk for undertreatment. The majority of individuals in longitudinal studies did not receive intervention during their school years (Tomblin, 2014). Intervention for SLI can be described by the specific method, the activity, the physical context, and the social context using a framework initially proposed by Fey (1986). The specific methods were divided into trainer-oriented, child-oriented, and hybrid approaches. The activity, physical, and social contexts can be characterized on a continua of naturalness (e.g., drill to organized games to daily activities; clinic to school to home; clinician to teacher to parents). This brief overview of research on intervention for SLI focuses on some selected methods of intervention and some of the variables that have been examined to determine their effect on outcomes of intervention.

Trainer-oriented approaches include methods such as operant procedures (e.g., Gray & Ryan, 1973) and social learning approaches (Leonard, 1975). Although these procedures are effective in establishing the production of new language forms, the extent to which these gains are maintained and generalized to communicative situations is limited (Fey, 1986).

Child-oriented approaches include facilitative play involving self-talk (the adult talks about her/his activities) and parallel-talk (the adult describes the child's activities) without requiring a response from the child (Van Riper, 1947). Expansions (the adult repeats the child's preceding utterance, adding grammatical and semantic information). Recasting is a form of expansion in which the adult takes the child's utterance and changes it into a different form (e.g., *I'm a scary monster. You're a scary monster, aren't you?*). Recasting has been extensively researched by Camarata, Nelson, and colleagues (e.g., Camarata & Nelson, 2006; Camarata, Nelson, & Camarata, 1994; Nelson, Camarata, Welsh, & Butkovsky, 1996) as well as other investigators (e.g., Proctor-Williams, Fey, & Loeb, 2001). Across these studies, recasting was demonstrated to be a successful procedure for establishing new syntactic structures in children with language impairments that generalize to language samples. Recently, Proctor-Williams and Fey (2007) examined the effects of recast density in teaching novel irregular verbs over five sessions to children with SLI and to a younger group of children with TLD. They presented recasts at three frequency levels: none, conversational level, and intervention level. The children with TLD were more successful at producing the novel verbs presented with conversational density than those presented without recasting, but this was not true for the children with SLI. The children with SLI did not produce the verbs more accurately at the intervention-density level, and the children with TLD also performed more poorly in this condition. The authors suggest that one explanation for the findings is that the short period of intervention with high recast density is not efficient for word learning. Thus, *dosage is an important variable in intervention.*

Hybrid approaches include planned activities that modify the environment to motivate the use of certain linguistic forms (Lucas, 1980), focused stimulation (Fey, 1986), and incidental milieu teaching (e.g., Finestack, Fey, & Catts, 2006; Hancock & Kaiser, 2006; Hart & Risley, 1980). The latter two have been studied extensively. Fey, Cleave, Long, and Hughes (1993) employed focused stimulation in which the intervention agents—clinicians or parents—frequently modeled grammatical targets, provided recasts that included the target forms, and created activities designed to maximize opportunities and obligate the production of these forms. One purpose of this study was to examine whether the less costly approach using parents as primary intervention agents with support from clinicians would be as effective in establishing language target structures in spontaneous speech as an approach that only involved clinicians as intervention agents. The more costly clinician-only approach appeared to be more effective. A follow-up study (Fey, Cleave, & Long, 1997) with 18 of the participants confirmed the results and led to fewer gains than the first five-month intervention. It was successful in establishing recasting in the parents, especially for the younger children. This does not mean that parents are not effective intervention agents alone or in conjunction with clinicians, particularly for younger children (e.g., Girolametto, Weitzman, & Greenberg, 2006; Kaiser & Hancock, 2003).

Most of the preceding research has focused on preschool and young school-aged children. Two recent studies have examined intervention for more complex syntax in older children with SLI. The first study (Ebbels, van der Lely, & Dockrell, 2007) examined intervention for argument structure deficits using syntactic-semantic, semantic, and a control therapy to which they were randomly assigned. The semantic-syntactic therapy used shapes and positions to illustrate constructing syntactic structures and provided semantic information in terms of the category/function of verbs (change of location vs. change of state) along with unique association to question words (*where* vs. *how*). Based on video probes, both approaches led to improvements, but the syntactic-semantic therapy led to increased use of optional arguments. In a single-subject study, Levy and Friedmann (2009) taught syntactic movement to a 12-year-old child with SLI who had deficits in this area using targeted comprehension, repetition, and elicitation of semantically reversible sentences. Performance improved on a probe compared to baseline and, in some cases, reached that of age-matched typically developing children. Generalization was noted, and the performance was maintained when reassessed 10 months later. Together these studies demonstrate that complex sentence structures can be taught to older children with SLI. Very often such children are no longer enrolled in speech-language therapy in public schools. The outcome of these syntactic interventions also has a role in evaluating theories of the syntactic deficits in SLI.

Two other disparate but widely used intervention methods warrant some attention: *Fast ForWord* and sensory integration. *Fast ForWord* is a commercially available program (Scientific Learning Corporation, 1998) based on the notions that perceptual deficits underlie SLI and that the brain is sufficiently plastic to be changed by relatively short-term participation in a computer-based intervention administered at a clinic or at home (Merzenich et al., 1996, 1999; Tallal et al., 1996). There are seven components: three sound tasks involving discrimination and identification and four word tasks in isolation or in sentence contexts. The sounds, words, and sentences used are lengthened, and selective frequencies are amplified in a way that is assumed to facilitate the child's perception of speech. These modifications are reduced adaptively as the child successfully proceeds through the program. Merzenich, Tallal, and colleagues (Merzenich et al., 1996; Tallal et al., 1996) provided initial evidence for the effectiveness of this approach. The claim is that children's language age scores may increase by as much as three years. These initial studies were conducted by researchers who are the founders or are connected with the Scientific Learning Corporation (SLC). A more recent review by individuals associated with the SLC (Agocs, Burns, De Ley, Miller, & Calhoun, 2006) presented data that have been collected from a national field trial, a school pilot study, and more recent users, all of which suggest a more positive outcome. There were a number of methodological limitations in these initial studies, including a rather mixed group of subjects and measurement instruments that mirrored the intervention tasks too closely. Studies by independent investigators have revealed a much more mixed efficacy story. For example, in a randomized control trial of children with severe receptive-expressive language disorder, they found no difference in outcome among children who received *Fast ForWord*, children who received other commercially available programs to enhance language, and children who received no treatment (Cohen et al., 2005). All the children made gains, but there was no difference among the groups, suggesting that this approach is not effective for these children. Similar concerns have been raised in case studies about the lack of or inconsistent outcomes from this approach (e.g., Friel-Patti, DesBarres, & Thibodeau, 2001; Loeb, Stoke, & Fey, 2001; Troia & Whitney, 2003). A large-scale randomized controlled trial revealed that children with poor backward-masking scores assigned to a *Fast ForWord Language* condition did not make any more improvement in language or temporal processing than children assigned to a general academic enrichment program or to a language intervention program without acoustically modified speech (Gillam et al., 2008).

Sensory integration was initially proposed to explain the relationship between learning disabilities and motor learning deficits in children who exhibit sensory processing disorders (Ayers, 1979). Clinical observations suggest that children with language impairments may also have motor planning deficits, poor attention, or difficulties with emotional or behavior regulation that are characterized as sensory processing deficits. Although sensory integration approaches do not directly address language, they appear to have some positive impact on reading scores for children with auditory-language learning disabilities (Ayers, 1979). There is no direct evidence of the effectiveness of this approach in facilitating language development in children with SLI. Given the proposal (Ullman & Pierpont, 2005; Ullman & Pullman, 2015) concerning the relationship between procedural learning (in motor and other domains) and SLI, such an approach may be worth further investigation. This proposal assumes that children with SLI will have motor deficits that reflect the limitation in procedural memory. An important line of research by Goffman and colleagues (e.g., DiDonato Brumbach & Goffman, 2014) has revealed motor speech and general motor deficits in children with SLI. We need to think of language as embodied and that such an approach could lead to an evidence-based approach to intervention that includes consideration of speech motor and motor abilities.

This general typology of intervention approaches aside, a group of variables appears to influence intervention and should be taken into account by treatment researchers and clinicians alike. One general approach is to structure intervention around well-established principles of learning (e.g., Alt, Meyers, & Ancharski, 2012). These include variables such as the positive effect of variability in input, the advantage of distributed versus massed practice, and sleep or time consolidation of learning. For example, Plante et al. (2014) found that introducing a high variability of verbs in recasts led to more successful outcomes for children with language impairment. The same may be true for other types of variability, such as talker variability as well as other types of linguistic and nonlinguistic context variability, all harkening back to long-established principles of intervention. In typically developing children, there is evidence that distributed presentations (over sessions) of novel words leads to greater acquisition than the same number of presentations condensed into a small number of sessions (Childers & Tomasello, 2002; Schwartz, 2015; Schwartz & Terrell, 1983). Consolidation time, whether sleep or over time, in general is also critical to learning. Evidence that working on more complex linguistic elements or structures can lead to the acquisition of less complex elements or structures suggests an alternative approach to intervention sequencing. Finally, methods from research literature with typically and atypically developing children, such as production priming (e.g., Leonard, recasting, etc.), can all point to potential intervention methods.

Given the current emphasis on evidence-based practice, it seems critical that we continue to evaluate our current approaches to intervention as well as novel approaches before they are widely adopted. Although we often bemoan the paucity of intervention research, there is a great deal of evidence in the literature concerning variables, language learning principles, input conditions, and effects that can be adapted to intervention.

SLI and Other Disorders

With a still small number of exceptions, researchers have tended to focus on single clinical groups. However, it is apparent that groups of children with language impairments share certain deficits. This is even true in comparing deficits for children with developmental language disorders and adults with acquired language disorders. For example, adults with agrammatism appear to share deficits in morphosyntax and syntax with children who have SLI. Some of these apparently shared deficits may simply reflect weak points in the language that are affected by any general limitation in language production or comprehension or by deficits in related cognitive abilities. Another consideration is that SLI may occur in children from other groups with language disorders at the same rate as it does in the general population. For example, one proposal has suggested that the relationship between dyslexia and SLI can be characterized as quadrants: (1) children with normal language and no dyslexia, (2) children with dyslexia only, (3) children with SLI only, and (4) children with dyslexia and SLI (Bishop & Snowling, 2004). In general, these appear to be nonadditive disorders when they co-occur, but the evidence has largely been limited to nonword repetition, tense marking, and omnibus language tests. It is possible that if more detailed on-line or off-line language measures were used, we might see additive effects. Even with this apparent association/disassociation, there may be commonalities across these groups in language deficits and language-related deficits such as working memory, processing speed, neurobiological findings, and genetics.

The same may hold true for autism (Rice, Warren, & Betz, 2005; Warren et al., 2006). The *DSM-5* category of Social (Pragmatic) Communication Disorder (SPCD) might have simplified the earlier discussed confusion regarding Pragmatic Language Impairment and how it relates to SLI, but that doesn't appear to be the case. A diagnosis of SPCD involves impairments in all of the following: "using communication for social exchange, adapting communication style to the context, following rules of conversation or narrative convention and understanding implicit or ambiguous language" (Norbury, 2014, p. 209). Norbury (2014) argued that our current assessment instruments lack validity and reliability. Her review also raises questions about the extent to which this is a coherent and self-contained diagnostic category. As she noted, these are deficits that might be better considered as symptoms across a number of developmental disorders, including SLI, ASD, and ADHD, among others. Finally, conjoining social communication and pragmatics belies an unsophisticated view of pragmatics, which overlaps with structural knowledge of language (e.g., syntax and narrative structure) and with semantics. It would be useful to distinguish further among the pragmatic deficits associated with autism those that involve the structure and prosody of discourse, narrative structure, and semantics (e.g., the comprehension of scalar implicatures such as *some/all*) and those that represent the proficient use of language in social interaction. A more careful delineation will better enable us to understand the language and communication deficits associated with autism.

Attention-deficit hyperactivity disorder (ADHD) has an expected prevalence of 5–7% with regional variation (American Psychiatric Association, 2013; Redmond, 2016). In a review, Redmond (2016) noted that two-thirds of individuals diagnosed with ADHD have co-morbid disorders, with SLI being a common associated disorder. ADHD receives far more attention than SLI, by government agencies (e.g., the Centers for Disease Control), in public awareness, and in research (Bishop, 2010). Redmond cogently argued that studying the co-morbidity of SLI and ADHD can inform the search for stable markers of SLI, inform theoretical accounts with respect to nonlinguistic and linguistic deficits, impact clinical decisions regarding the mutual effect of co-morbidity on individuals, and direct public health care in the form of access to services. The identification of these disorders distinctly or co-morbidly is complicated and has varied widely in the literature, in part due to the instruments used and in part due to changes in the *DSM* definitions. Redmond, Thompson, and Goldstein (2011) found that focused measures of tense marking, nonword repetition, and sentence recall, and a standardized measure of narrative abilities, were highly successful in differentiating children with SLI from children with ADHD only, who performed similarly to typically developing controls. Perhaps most importantly, Redmond, Ash, and Hogan (2015) found that children with ADHD + (S)LI did not differ from children with SLI only in their production of tense markers, sentence recall, and nonword repetition. Furthermore, the children with AD + (S)LI with higher levels of ADHD symptoms performed slightly better than the SLI-only children, suggesting that there are no interactive or additive effects of these disorders.

Auditory processing disorders (APDs) are defined as deficits in one or more of the following: "sound localization and lateralization; auditory discrimination; auditory pattern recognition; temporal aspects of audition; auditory performance in competing acoustic signals; and auditory performance with degraded acoustic signals" (ASHA, 2005, p. 2). Individuals with APD have difficulties listening to background noise, following oral directions, and understanding rapid or degraded speech (Bamiou, Musiek, & Luxon, 2001), all in the presence of normal hearing thresholds. APD is often co-morbid with other developmental disorders such as SLI, reading disabilities, ADHD, or ASD (Miller & Wagstaf, 2011). Seventy-two percent of 68 children suspected had APD and almost half (47%) had APD in conjunction with language impairment and reading disorders. Of sixty-eight 7- to 12-year-old children who were either suspected of having APD by a parent or teacher or had received a diagnosis of APD, 47% had APD in conjunction with language impairment and reading disorders (Sharma, Purdy, & Kelly, 2009).

Two recent dissertations at the Graduate Center have examined children with APD and/or SLI (Rota-Donahue, 2014; Rota-Donahue, Schwartz, Shafer, & Sussman, 2016; Sylvia, 2016). In the first study, children with SLI and APD were found to have additive negative effects on behavioral and ERP response to small auditory frequency differences. Sylvia examined picture naming with auditory or visual interfering stimuli and found that in children with SLI, with and without APD, derived measures of temporal resolution and frequency resolution predicted reaction time when there was an auditory interfering stimulus but not when there was a picture interfering stimulus. This represents just a beginning to our investigation to the co-morbidity of APD and SLI, but this may lead to a better understanding of auditory abilities in child language disorders, as well as better focused approaches to assessment and intervention.

The challenge of further defining these commonalities and differences, as well as assessing their implications for theories, for phenotype, and for clinical considerations will certainly engage researchers in the coming decade.

Future Directions

Clearly, we know far more about the nature of SLI, its origins, and the scope and details of the deficits seen in these children than we did in the 1970s, when the modern era of this research began. Although we now know something about the neurobiology and genetics of SLI, the next decade will bring us many more details. We still know relatively little about basic cognitive processes such as procedural memory, attention and executive functions, and the role they play in the language deficits of SLI. There is a clear need for further research concerning the relative efficacy of various approaches to interventions and the variables that may facilitate language learning in these children (see Chapter 23 by Finestack & Fey). Finally, we need additional information about the relationships between SLI and other groups of childhood language disorders and possible subgroups of these children, so we have a fully integrated picture of childhood language disorders. Furthermore, researchers, clinicians, state and local associations, and families of children with SLI and with other child language disorders must engage in active advocacy. The following chapters are one step in this direction.

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