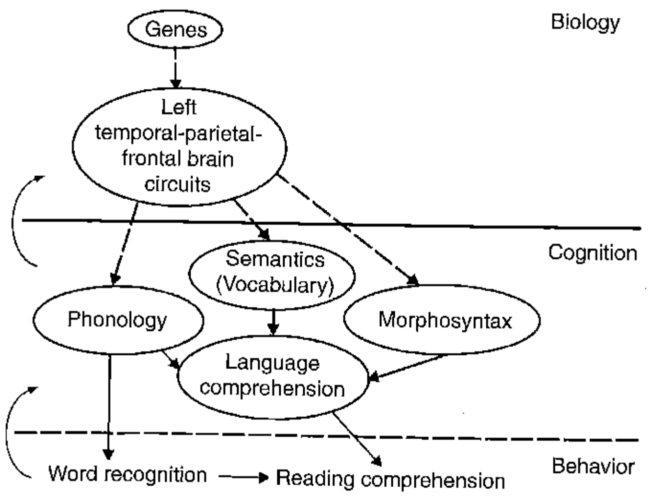


Figure 3.10 Path model showing possible sources of reading comprehension deficits.

Figure 3.10. Together, these basic deficits can be expected to affect the growth of vocabulary knowledge and the ability to make inferences while reading (processes that are essential to text integration) that are part and parcel of the poor comprehender profile. In turn, persistent problems with comprehension may affect the development of metacognitive strategies, such as the "lookback" strategy and compromise comprehension monitoring. Such semantic and grammatical problems may also relate to differences in the way that verbal information is encoded and stored in memory. In this sense we agree with Perfetti, Marron, and Foltz (1996, p. 159) that problems of reading comprehension can be seen as consequences of more basic language comprehension impairments: "the operation of basic processes that identify words, activate their meanings, configure phrases, assemble meanings and so forth." It seems likely that problems with comprehension monitoring may develop as a consequence of reading comprehension difficulties and there is some evidence that intervention programs can effectively foster the development of such strategies.

In conclusion, we started this chapter with the Simple View of Reading model and within this model poor comprehenders are children with good decoding but poor listening comprehension skills. Such children's difficulties can also be related to the triangle model. When viewed in terms of this model, poor comprehenders have set up the phonological pathway proficiently but have impairments in the semantic pathway, possibly as a consequence of deficient semantic representations. But as we have seen, the problems of poor comprehenders extend well beyond single word reading. As yet, the causal connections between different language skills and the different components of reading comprehension are not well understood and we badly need more longitudinal studies to understand the processes that are operating.

4

Specific Language Impairment

Problems in understanding or producing language are among the most frustrating and isolating handicaps that a child can experience. The term specific language impairment (SLI) is used to refer to children whose oral language skills are much worse than expected given their nonverbal ability (NVIQ) and where other known causes (e.g., deafness) cannot explain the disorder. Recent evidence suggests that SLI is a neurobiological disorder, the development of which depends heavily upon genetic risk factors. However, there is considerable heterogeneity among children with SLI in the pattern of language difficulties that they show; as we shall see, some children with SLI have speech difficulties while others do not, some have difficulties with the social use of language, and others may be effective communicators despite difficulties with expressive language skills.

Definition and Prevalence

The term *Communication Disorders* is used in DSM-IV (American Psychiatric Association, 1994) to describe children who are referred to clinically as SLI whose scores obtained on individually administered measures of language development are below expectation given "nonverbal intellectual capacity." The term can also be applied if a child has suffered an accompanying sensory deficit, learning difficulties, or environmental deprivation, provided that the language difficulties are in excess of those usually associated with these other problems. DSM-IV goes on to distinguish several types of communicative disorder, including expressive disorder (primarily affecting language production), mixed expressive–receptive disorder (affecting language comprehension and production), and phonological disorder (affecting the use of speech sounds to signal meaning). (DSM-IV also has the diagnostic categories of Stuttering and Communication Disorder Not Otherwise Specified. These categories are not relevant to the discussion of SLI as they refer to difficulties with, for example, fluency or voice that impede communication but are not associated with a disorder of language development.)

In a similar vein, ICD-10 (World Health Organization, 1993) lays out criteria for SLI as a child having language skills more than two standard deviations below average for age and at least one standard deviation below nonverbal IQ. It distinguishes receptive from expressive language disorder and excludes children with neurological, sensory, or physical impairments that affect the use of language. Both classification schemes also exclude children who have a pervasive developmental disorder such as autism.

In practice the criteria used to identify children suffering from SLI are quite variable. Typically, to be diagnosed as having SLI a child needs to obtain a low score on a subset of standardized language measures but have no other impairment (such as deafness or a low nonverbal IQ) that might provide an adequate explanation for the language problems (Bishop, 2001). However, in making the diagnosis, different researchers have used different language tests and different levels of impairment as cut-offs. For example, the SLI Consortium (2004) diagnosed children as having SLI if composite scores from the Clinical Evaluation of Language Fundamentals (CELF-R) tests (Semel, Wiig, & Second, 1992) for expressive or receptive language (or both) were at least 1.5 standard deviations (SD) below the average for their age and if their nonverbal IQ was at least 80 (children with lower IQs were excluded).

One of the largest epidemiological studies of SLI is that of Tomblin, Records, and Zhang (1996). In this study tests were used to assess three domains of language function (vocabulary, grammar, and narrative) and two modalities (receptive and expressive). For each of these five areas of language function, composite scores were created to represent a child's performance relative to their age. To qualify for a diagnosis of language impairment children had to perform at least 1.25 SD below average on at least two out of these five language composite scores. In addition, to qualify for the label of specific language impairment (SLI) a child also had to obtain a nonverbal IQ of at least 85 and have typical sensory and socio-emotional development.

Depending on the precise criteria used for diagnosing language impairment, different numbers of children will be identified and the characteristics they show will vary. Prevalence estimates range from 3 to 6% but are complicated by the fact that SLI is not a static condition and some children may resolve their language difficulties as they get older (Bishop & Edmundson, 1987; Tomblin et al., 1997). As with many other developmental disorders, more boys than girls are affected with SLI (3 : 1–4 : 1), although the epidemiological study of Tomblin et al. (1997) reported a more even ratio of 1.33 : 1 boys to girls.

The Persistence of SLI

There are now a number of studies investigating both the short-term (e.g., Aram & Nation, 1980; Conti-Ramsden, Botting, Simkin, & Knox, 2001; Stark et al., 1984) and longer-term outcomes of children with language impairments (e.g. Aram, Ekelman, & Nation, 1984; Botting, 2005; Conti-Ramsden, Simkin, & Botting, 2006; Felsenfeld, Broen, & McGue, 1992; King, Jones, & Lasky, 1982; Stothard, Snowling, Bishop, Chipchase, & Kaplan, 1998). Many children with SLI are recognized in the preschool years, and many cases of language problems in this period resolve as children get older. However, studies suggest that 50–90% of children with SLI continue to exhibit language difficulties through childhood and many go on to have reading difficulties (Bird, Bishop, & Freeman, 1995; Bishop & Adams, 1990; Catts, 1993; Catts, Fey, Tomblin, & Zhand, 2002; Magnusson & Naucler, 1990). However, where the language difficulties are mild or very specific in form the outcomes are generally better.

In an 18-month follow-up of 87 children who, when aged 4 years, exhibited speech–language difficulties, Bishop and Edmundson (1987) identified some of the factors associated with variations in outcome in the short term. On the basis of assessments at age 4 years, the children were classified as having specific language impairment (SLI) or having impaired speech–language skills coupled with impairments of nonverbal IQ (2 SD below the mean – the general delay group). Overall, for some 37% of these children, their language impairment had resolved by age 5½ years. For the SLI children, there was a good outcome for 44% while some 89% of the general delay group continued to show language difficulties. Thus, children with higher IQs had a better chance of overcoming their language difficulties. Bishop and Edmundson went on to show that a subset of three language tests, together with nonverbal IQ, predicted outcome status correctly for 86% of children. The relevant tests were a narrative test requiring the expression of semantic relationships, a test of picture naming, and a test of expressive semantics and syntax. In fact, outcome for 83% of the children could be classified using the narrative task alone.

Bishop and Adams (1990) followed up 83 of the children from the Bishop and Edmundson study when they were 8½ years old. For children whose language impairments had resolved at 5½ years, outcomes at 8½ years were generally good in terms of both their oral language and reading skills. This "resolved" group showed some mild difficulties on two measures of oral language comprehension (*TROG*, a test of receptive grammar, and *WISC* comprehension, a test of social understanding) but otherwise showed average scores on measures of language, reading, and spelling. In contrast the group whose language skills had been impaired at 5½ years continued to show impairments in all aspects of oral language and reading skills, with reading comprehension being on average worse than reading accuracy. Perhaps not surprisingly, the group who showed general delay at 5½ years (poor language and low NVIQ) had the worst outcome, with quite severe impairments on all tests of language and cognitive function at 8½ years.

Stothard et al. (1998) managed to follow up 71 of the children from the original Bishop and Edmundson (1987) study when they were 15–16 years old. In this case the picture had changed slightly in comparison to the pattern reported for these children when they were 8½ years old. For the children with persisting language difficulties and the children with general delay at 5½ years, the pattern remained similar and these children had quite severe impairments in all aspects of language and reading at age 15½ years. In fact there was some evidence that the language skills and nonverbal IQ of the children with persisting language difficulties had shown further declines at this point in time. However, for the children whose language skills were considered to be resolved at 5½ years there was evidence that they were now

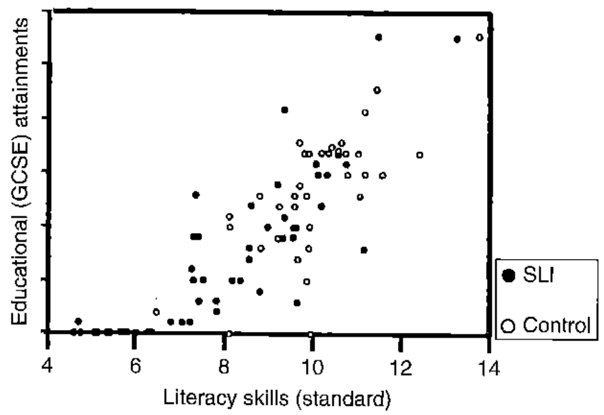


Figure 4.1 Relationship between literacy skills and educational attainments in young people with a history of language impairment. (Data from Stothard et al., 1998.)

performing less well than controls on measures of phonological skills and literacy at age 15 years. These children had shown essentially typical reading skills at age 8½ years, so there is evidence here for late-acting effects that served to impair the development of their phonological and reading skills. It is heartening that for this group of children their oral language skills remained normal at this time point. However, Snowling, Adams, Bishop, and Stothard (2001) found that the grades obtained by these children in school-leaving examinations (GCSE) were lower than for age-matched controls of similar levels of reading skill, and as expected the children whose language problems had persisted at 5½ years had even poorer results. Figure 4.1 based on this same study shows that educational outcomes were quite closely tied to levels of literacy measured at the same point in time.

Overall, this long-term study following children from preschool to adolescence suggests that the prognosis for children whose early language impairments have resolved by the time they go to school is relatively good. However, these children clearly do show a raised risk of developing reading difficulties when they are older, although such problems may only emerge relatively late in development. Equally clearly, the language and cognitive outcomes for children with persisting language difficulties at age 5½ years are relatively poor and this is true for both children with good nonverbal IQ as well as for the children with general delay (whose outcomes, predictably, are worst of all).

Other studies that have assessed the academic skills of adolescents with a history of preschool language impairments confirm that academic difficulties are common (Knox, Botting, Simkin, & Conti-Ramsden, 2002). Aram et al. (1984) reported a 10-year follow-up of 20 children with an initial diagnosis of speech and language difficulties. At age 13–16 years, 40% of the children obtained a verbal IQ score below 80 and these children showed severe impairments on the tests of reading, spelling, and maths. Furthermore, only 25% of these adolescents were in regular classrooms. Aram et al. concluded that the language disorders recognized in these

children in the preschool years were only the beginning of longstanding language and academic problems. However, as their study was not restricted to children with normal intelligence, it is difficult to disentangle the specific effects of language disability from the more general consequences of low IQ.

A poor prognosis, even in the face of normal nonverbal intelligence, was also found in a study focusing upon the outcomes of children with receptive language disorders. Mawhood, Howlin, and Rutter (2000) reported a follow-up into adult life of 19 boys, initially diagnosed as having a developmental language disorder affecting comprehension. In this sample, language difficulties were still evident in adulthood; 47% had an oral reading score that fell at or below the 10-year level, 42% were at or below this level in reading comprehension, and 63% were similarly impaired in spelling. Furthermore, none had passed any national examinations at school, although two had later obtained vocational qualifications. A comparison group of children with autistic disorders showed comparatively better prognosis, possibly because they had been educated in specialist settings with educational programs attuned to their needs. Such placement was rare in the SLI group (see Clegg, Hollis, Mawhood & Rutter, 2005, for a report of longer-term outcomes).

Along similar lines, Tomblin, Freese, and Records (1992) identified from clinical records 35 young adults with a history of language difficulty. They were assessed on a large range of language measures when aged 17–25. These adults with a history of SLI differed on all language measures from controls (matched on childhood performance IQ) and also in current performance IQ. One finding of particular interest was that the performance IQ of 20 adults with a history of SLI had declined from 98.5 in childhood to 89.75 in adulthood. This is a similar pattern to that reported by Botting (2005) and Stothard et al. (1998).

To summarize, preschool language difficulties are frequently the precursors of language and academic difficulties that persist into adulthood but there is substantial variation in outcome. For children whose language difficulties do persist into the early school years there is some evidence that these children are likely to show further declines in both language and broader cognitive skills as they get older. Furthermore, even for children whose oral language skills may appear to have resolved in the early school years there is evidence that these children show an increased risk of reading problems, which again may take many years to develop. This pattern supports the claim of Scarborough and Dobrich (1990), who suggest that, even if early language delays appear to resolve, this might be "illusory recovery" with problems emerging once the child is confronted with the task of learning to read and write.

The studies we have considered so far have focused on the language and cognitive outcomes of children with SLI. However, because of the central importance of language skills to social interaction there have been a number of studies that have also assessed the psychosocial outcomes of children with SLI. Evidence from both cross-sectional and prospective longitudinal studies of children with speech–language disorders indicates that there is a heightened risk of psychiatric disorder in these children (Beitchman, Cohen, Konstantareas, & Tannock, 1996). Furthermore more than half of referrals to psychiatric services are children with language difficulties, many of whom were previously undiagnosed (Cohen, 1996).

Baker and Cantwell (1982) were the first to report that the risk of psychiatric problems is lower for children who only have speech disorders than for children with language difficulties. There is also some evidence of an association between lack of improvement in speech–language functioning and the development of a psychiatric disorder (Beitchman et al., 1996; Benasich, Curtiss, & Tallal, 1993). Similar findings were reported by Snowling, Bishop, Stothard, Chipchase, and Kaplan (2006) when they examined the psychosocial outcomes in adolescence of the SLI children recruited by Bishop and Edmundson (1987) at 4 years of age. Overall, the rates of psychopathology were low in this sample, particularly in children whose language difficulties had resolved by the age of 5½ years. The main problems of adolescents with persistent language impairments were difficulties with attention control and social impairments. These problems were somewhat independent of each other, and the language profiles of affected children differed: Attention problems tended to be associated with restricted expressive language difficulties, and social problems with the co-occurrence of receptive and expressive impairments. The comorbid pattern of attention and social problems was associated with globally delayed cognitive development. In line with the view that learning difficulties may mediate between language impairments and behavioral problems, the language-impaired children with the poorest psychosocial outcomes in adolescence also had the poorest poor literacy skills.

Aside from mental health issues, there also appears to be an increased incidence of autism spectrum disorders in follow-up studies of children with language impairments (Conti-Ramsden et al., 2006). However, it would be premature to conclude that such problems are a consequence of language difficulties. On the contrary, Bishop, Whitehouse, Watt, and Line (2008) have argued that contemporary diagnostic criteria for autism spectrum disorder in adulthood are such that many children with a history of language disorder now attract this diagnosis – a case of "diagnostic substitution." Thus in a follow-up study of 38 young adults who as children had been diagnosed with language impairment and not autism, between 8 and 25 (depending on the precise diagnostic criteria) now fulfilled criteria for an autism spectrum disorder and this was particularly common in the case of children who had had problems in the social use of language in childhood (pragmatic language impairment).

Comorbidities between SLI and Other Developmental Disorders

It is clear from the material we have already reviewed that the rates of comorbidity between SLI and other disorders are high and therefore cannot simply be due to chance. The evidence we have on this issue is from studies of clinical rather than epidemiological samples, which makes it impossible to give precise estimates of the true rates of comorbidity in the population. As we have already noted there is substantial comorbidity between SLI and reading disorders, which is a natural consequence of the fact that reading skills develop from a foundation of pre-existing oral language skills (Snowling & Hulme, 2005). There are also very substantial rates of motor coordination disorder among children with SLI, which led Hill (2001) to argue that we should question the use of the term "specific" in the case of children with SLI (because for so many of these children their difficulties are not specific to language). Finally, there is evidence that language problems are often associated with general learning difficulties (low NVIQ). Indeed, even children who satisfy the diagnostic criteria for SLI when they are young (by having an NVIQ in the normal range) may show declines in NVIQ as they get older (Botting, 2005). This pattern suggests that impairments of language in children may often signal quite serious and pervasive problems of development that are likely to have effects on other areas of functioning. In this light, children who really do satisfy the strict criteria for a "specific" language impairment may be quite unusual.

The Typical Development of Language: A Theoretical Framework

Before turning to discuss research investigating the nature and causes of children's speech and language impairments, it is important to outline the typical course of language acquisition as a framework for understanding how this usually robust process breaks down in children with SLI.

The structure of language

As Bishop (1997b) states "language is so readily acquired and so universal that it is easy to forget what a complex phenomenon it is" (p. 1). The language processing system is multicomponential and, as noted in Chapter 3, contains a number of specialized subsystems, namely phonology, grammar, semantics, and pragmatics. Phonology refers to the system of language that uses speech sounds to signal differences in meaning; the phonological difference between *cap* and *gap* signals that the first word means something you wear on your head and the second word means a space between things. Phonology itself contains two subsystems: segmental phonology, concerned with the speech–sound contrasts within words, and suprasegmental phonology, concerned with aspects of the intonation of speech such as tone, duration, and intensity. It is important to distinguish phonology from phonetics, which is concerned with the acoustic and articulatory characteristics of speech sounds. However, phonetic differences between sounds in different word positions do not necessarily signal meaning. For example, the phoneme /d/ is voiced in word-initial position [dog] but devoiced in the word-final position [mad] such that its phonetic realization is more like /t/. This is known as allophonic variation (the same phoneme /d/ is given different realizations in different speech contexts). While speakers of English are sensitive to phoneme differences between words that mark meaning, they are typically unaware of the phonetic differences between allophones (the different realizations of the phoneme /d/ in different contexts).

Most people understand the term "grammar" to mean a system of rules that governs how words can be put together to make coherent sentences. This system is more properly referred to as syntax. Formally, grammar is the system of language that comprises morphology as well as syntax. Morphology refers to the underlying structure of words and the units of meaning (morphemes) they comprise. For example, the word *boy* is a single morpheme but the word *cowboy* can be thought of as containing two morphemes, *cow* and *boy*. In English, there are relatively few words of the *cowboy* type; these are much more common in German or Danish where compounding is frequent. However, English words like *camping* or *camped* also contain two morphemes (camp + *ing*; camp + *ed*) and *decamped* contains three (de + camp + ed). The addition of morphemes to change the meaning of a base form in this way is known as inflectional morphology. Inflections are parts of words (e.g., *-ed*, *-ing*) that cannot stand alone but which, when combined with a word stem, serve a grammatical function. Inflectional morphemes denote contrasts, such as between past and present tense or between singular and plural forms.

Semantics is the system of language concerned with meaning both at the sentence and the word (lexical) level. It should be clear, therefore, that there is a strong relationship between grammar and semantics. The grammatical structure of a sentence (syntax) is usually closely tied to the meaning it conveys, such that different grammatical forms take particular semantic roles in the sentence (e.g., nouns specify agents or objects whereas verbs specify actions). It should be noted, however, that sentences can be grammatical whilst at the same time semantically implausible in terms of real-world knowledge (e.g., *the fish walked to the bus*). Lexical semantics is more concerned with vocabulary knowledge and might be considered a system in which words are categorized according to their function or meaning relations.

Finally, pragmatics is concerned with how language is used in context. According to Grice (1998), efficient communication depends upon the speaker and listener sharing certain assumptions. These are that communication should be both informative and relevant to the topic under discussion or to the situation: it should be truthful, clear, unambiguous, economical, and delivered in an orderly fashion (Sperber & Wilson, 1995). Violations of these assumptions include talking at length about topics not directly relevant to the present situation or using an inappropriate "register," such as speaking in an overly formal manner for the context. Pragmatic failure commonly occurs when the speaker does not take into account the listener's perspective and either provides too much or too little information to convey communicative intent (see Figure 4.2 for an illustration).

Language acquisition

For many years, theories of language acquisition were dominated by the view that language learning depends upon innate linguistic structures and, in particular, specialized mechanisms for the abstraction of grammatical "rules." Within this theoretical framework, some researchers have hypothesized that problems with grammar seen in SLI may reflect the operation of a single dominant gene (Gopnik & Crago, 1991). An alternative view is that language learning depends critically upon the

Figure 4.2 Cartoon illustrating pragmatic difficulties.

linguistic input to which the child is exposed. In contrast to the view that grammatical categories are innate, this view suggests that the acquisition of language is a gradual process that depends upon abstracting regularities from the language input that the child hears (Chiat, 2001; Tomasello, 2000). Space does not permit a comprehensive review of the very large body of research on typical language acquisition; interested readers are referred to Karmiloff and Karmiloff-Smith (2001) for a useful synthesis. We focus here on the aspects of language development that have been the back-drop to studies of children with SLI, namely the development of auditory and phonological skills, morphosyntax (grammar), and semantics.

The development of auditory and phonological skills

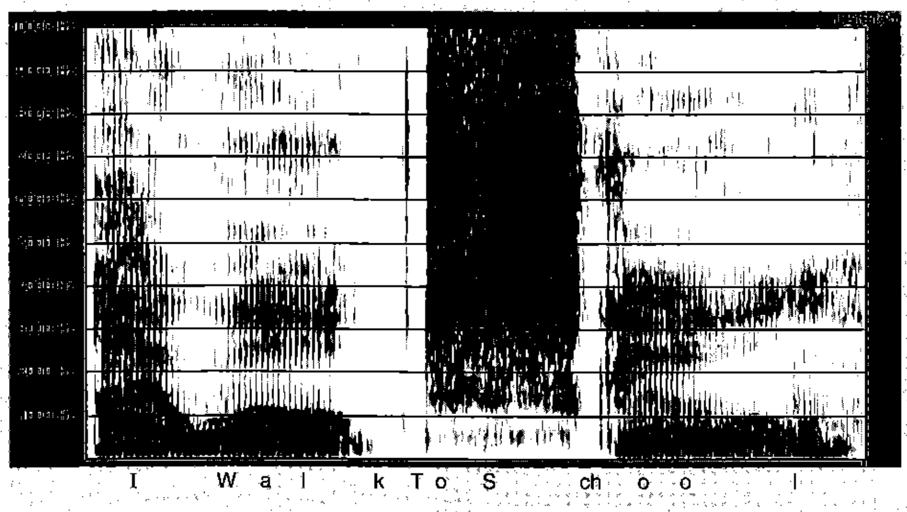
The typical development of language requires the young child to tune in to the acoustic cues that are relevant to the perception of speech (see Box 4.1). It is clear that auditory localization and attention are general prerequisites for this process. More specifically, the perception of speech draws on the capacity to detect word envelope cues signaled by variations in amplitude (loudness), to discriminate pitch changes, and to perceive gaps between different components of the speech signal. However, there are constraints on how learning operates; infants cannot perceive all distinctions in the speech stream and because language learning is social they only become attuned to the distinctions in the language they hear from the people with whom they interact (Kuhl, 2004).

While a number of studies in recent years have investigated the responses of human fetuses to auditory stimuli that might predispose them to attend to ambient speech, there have been relatively few studies of basic auditory processing in neonates and young infants. However, a significant body of research has examined infant speech perception. An influential view for many years has been that neonates are "preprogrammed" to perceive speech categorically, such that they have the potential for learning any one of the world's languages. This sensitivity to phonetic categories is gradually shaped during the first year of life to home in on the contrasts that are relevant in the native language (Mehler & Christophe, 1994) and by about 9 months infants are sensitive to the phonotactic patterns in the language, and prosodic cues enable them to identify potential words (Kuhl, 2004).

The development of speech production skills proceeds alongside that of speech perception and begins with babbling around 6 months of age, which typically involves repetitions of simple syllables. An important tradition in research on phonological development has been to compile inventories of the speech sounds

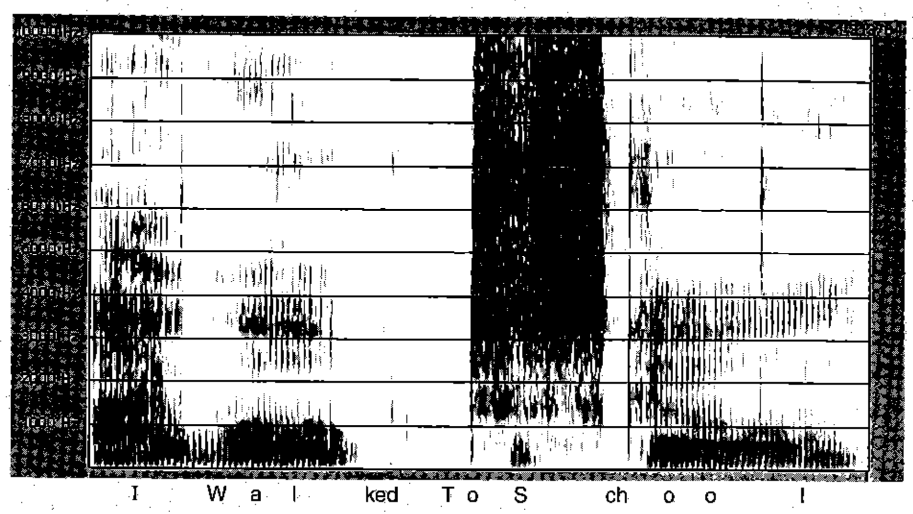
Box 4.1 Speech perception

The complexity of the processes involved in learning to perceive speech may be appreciated by trying to "read" a speech spectrogram of a spoken phrase. Such spectrograms show the frequency of sounds plotted on the vertical axis and time on the horizontal axis; the degree of darkness represents the amplitude (the energy) of the sounds. The figure below shows spectrograms of two very similar spoken phrases. The text at the bottom is spread out to approximate the timing of the sounds in the spoken words. The first thing to note is that it is difficult to identify the sounds represented in the spectrograms (the large amount of energy spread over a wide frequency range for the phoneme /s/ is an exception) or even to identify the boundaries between words. In practice there are no clear boundaries between spoken words in continuous speech where words run into each other and show "coarticulation." Note particularly that the difference in sounds between "walk" and "walked" is not really visible at all; the "-ed" past participle has low salience (low phonetic substance) in continuous speech. It is notable that marking the past tense forms in speech is something that children with SLI find very difficult to learn.



a) I walk to school

Box 4.1 *(cont'd)*



b) I walked to school

used productively by children and to document regularities and consistencies in their use to mark meaning (Ingram, 1981). Often, in the early stages of learning to talk, children use simplification processes to reduce the complexity of the speech they wish to produce. These include dropping word-initial weak (unstressed) syllables (e.g., saying "mato" for *tomato*), reducing consonant clusters (e.g., saying "bick" for *brick* or "wig" for *twig*, and a process called consonant harmony in which different consonants in the word are realized in the same place of articulation (e.g., saying "gog" for *dog* and "wowuway" for *go away*).

The development of grammar

Since the pioneering studies of Roger Brown (Brown & Fraser, 1964) a universal sequence of language development has been acknowledged, with children first communicating using single words, then combining words in two-word utterances before proceeding to use more complex sentence forms. Typically infants between the age of 18 and 24 months will begin to combine words into short phrases. This depends upon them having learned enough words to combine productively and the development of grammar is therefore intricately linked with lexical development (vocabulary knowledge). Lexical development continues into the school years and beyond, however grammatical development proceeds fairly quickly during the preschool period.

A significant hurdle for young children is to learn about the argument structure that underlies the sentences they hear. Argument structure refers to the role that different words play in a sentence (e.g., agent, action, attribute) and whether or not they are obligatory in the context. It is important for children to abstract generalizations about arguments if they are to produce well-formed sentences and also if they are to be able to use sentence frames to work out the meanings of new lexical items (particularly verbs), a process known as syntactic bootstrapping. For instance, in the sentence "mummy *kimmed* the ball into the hedge," knowledge of argument structure allows us to infer that *kimmed* represents an action that will move a ball from one place to another. In contrast, "mummy *kimmed* to the girl" suggests that the word *kimmed* is again an action but not one that moves an object from one place to another.

Many linguists consider that children possess adult syntactic categories and that failures to produce well-formed sentences are primarily the result of performance limitations. Researchers within this tradition analyze child language in order to specify how children's grammar differs from that of the adult. The alternative view is that children use cognitive processes to operate on the language input they receive, such that abstract grammatical categories are an emergent property of these operations rather than a hard-wired feature of language.

Tomasello (2003) is a major proponent of the cognitive view. He proposes that children's early language is acquired through imitative learning of words, phrases, and even whole speech acts, and is organized around these individual linguistic units. A striking example from English-speaking children is that, in their early language, they use the determiners *a* and *the* in relation to almost completely different sets of nouns (Pine & Lieven, 1997). However, from an early stage, children are able to combine various kinds of constructions in creative ways (e.g., *see daddy's car* could be created from *daddy's car* and *see daddy*) but they do not make generalizations until they possess a significant number of exemplars in their repertoire. Using the example of the acquisition of verbs, Tomasello (2000) argues against the view that children have knowledge of the subjects and objects of verbs in general, but rather that children know specific verbs and the relations they can express. For example, a child might know *boy hits*, *thing to hit with*, *hit ball* but not that *boy eats*, *thing to eat with* or *eat cake*.

Similar arguments can be made about knowledge of other grammatical forms, such as inflections. Inflections are the markers that are added to lexical items to signal changes in meaning that are relevant and in agreement with the context in which they are placed. For instance, in English, when there is more than one noun (plurality), *-s* is added to a noun (e.g., books); when the agent of the verb is one person (third person singular), *-s* is added to the verb stem (e.g., he jumps). Tomasello proposes that children only begin to abstract relations across items belonging to the same syntactic category at around their third birthday. An important implication of this view is that early child language may contain a variety of linguistic units together with what appear to be inconsistencies in grammatical ability.

Although it is common to think of language acquisition as following a universal sequence with some uniformity in the ages at which children reach different milestones, there is in fact considerable variation in the rate and style of language development across children. For some children there are also dissociations between

language comprehension and production and between different language components (e.g., lexical versus semantic skills). Bates, Dale, and Thal (1995) draw on data collected during the standardization of the MacArthur Communicative Development Inventories (*MCD-I*; Fenson, 1993) to illustrate some of this variability. The *MCD-I* comprises checklists for parents to complete as a way of documenting their children's language development. The infant version consists of a 396-item checklist of vocabulary items; parents are asked to indicate the words that the child understands (comprehension) and those that the child uses (production). The toddler version is more extensive; it requires parents to mark the words their children produce (from a possible 680 items) and the range of word combinations they use. Parents of 673 children aged 8–16 months completed the Infant version and parents of 1130 children aged 16–30 months completed the Toddler version of the inventory; in addition, a proportion of the parents completed the inventory again 6 months later to provide data on the stability of individual differences and the continuities between different stages of development.

Bates et al. (1995) reported that, for most children, evidence of word comprehension appears between 8 and 12 months, and by 16 months children have a median receptive vocabulary size of 169 words. Expressive vocabulary emerges somewhat later, usually around 12 months of age, with a mean of 64 words produced by the age of 16 months. However, these values mask considerable variation, as indicated in Figure 4.3.

In a similar vein, there is wide variation in the onset and development of combinatorial language from 16 to 18 months onwards. Moreover, measures of mean length of utterance indicate that typically developing children of the same chronological age

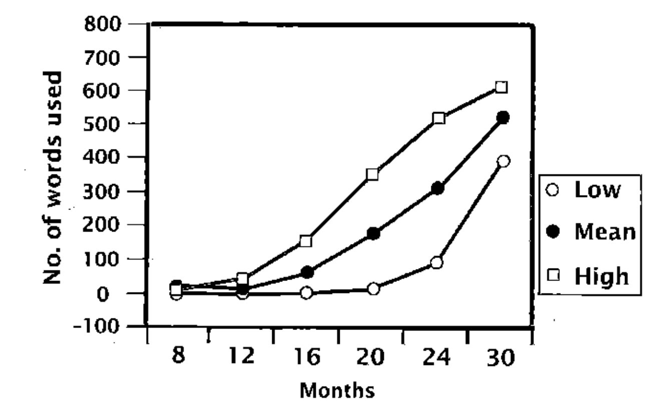


Figure 4.3 Growth in productive vocabulary for children rated as having an average vocabulary size and for those at the 90th centile (high) and the 10th centile (low). It can be seen that there is relatively little variation before the end of the first year but after this the growth trajectories of individual children diverge, with the largest variation being observed around 24 months, from a low of 89 words to a high of 534 words. (Adapted from Figure 4.7, p. 112, Bates, E., Dale, P. and Thal, D. (Eds – Fletcher, P. and MacWhinney, B.), Individual differences and their implications for theories of language development. In *The Handbook of Child Language*, Blackwell, 1995.)

can vary by as much as 6 months to 1 year in the level of grammar they use. One group of children who have attracted attention are so-called "late talkers" (Paul, 2000; Paul, Hernandez, Taylor, & Johnson, 1996). As the term implies, these children are delayed in the development of expressive language at 2 years though their understanding of language is normal; although most of these children catch up with their peers by school age, a substantial minority remain delayed, with problems of grammar and syntax being more common than problems of lexical development (Rescorla, Roberts, & Dahlsgaard, 1997; Rice, Taylor, & Zubrick, 2008).

Another source of variation seen in language development is in the relative rate of development of different language components. Thus, although there are strong correlations between language comprehension and production, some 10% of children show significantly better levels of comprehension than production, and this profile is often seen among late talkers. In contrast, there is little evidence for the dissociation between lexical and grammatical development for children within the normal range, though typically lexical development proceeds somewhat more quickly and is considered the pacemaker of grammatical development. Indeed children do not inflect words until they have used single words for a protracted period of time, and they only begin to combine words when their vocabulary reaches a sufficient size to contain function words, verbs, and adjectives, as well as a stock of common nouns. Together these data suggest that the cognitive underpinnings of receptive and expressive language may differ but there is more commonality to the substrate of grammar and vocabulary.

Language Development in Children with SLI

Arguably, the most striking characteristic of the language of children with SLI is its delayed onset and slow rate of development. As we have seen, the majority of typically developing children produce their first words by the end of the first year. However, the average age at which first words emerge among those with language impairment is around 2 years, with word combinations occurring much later. In addition, most children with SLI have some difficulties with phonology although these difficulties are frequently resolved by school age. The basic pattern in the early stages of language development in children with SLI therefore appears to be protracted development of single word utterances (i.e., slow lexical development) and a delay in learning to combine words into longer utterances. It is common for children with SLI to experience more difficulties with language production than with language comprehension, and there is evidence that children with receptive (comprehension) difficulties may have particularly poor outcomes (Rutter & Mawhood, 1991).

In general, the lexical (word-level) skills of children with SLI are better developed than their grammatical abilities, though they usually possess a restricted range of words for their age. A common manifestation of the lexical problem that children with SLI have is a word-finding difficulty, and their most frequent substitutions are of semantically related words ("goat" for *camel*). The other lexical difficulty that children with SLI typically exhibit is with the acquisition of verbs. It is possible, as

suggested by L. Leonard (1998), that this problem is a consequence of their syntactic difficulties because the meaning of verbs is only apparent within a sentence frame.

Children with SLI typically have great difficulty with aspects of receptive and expressive grammar. Their problems encompass syntax and morphology; to some extent these difficulties may be a consequence of slow lexical development but this is not the whole story (Bishop, 2006). A number of theorists have argued that children with SLI have specific difficulties in learning certain rules of syntax (van der Lely, 1994; van der Lely & Stollwerk, 1997; van der Lely, Rosen, & McClelland, 1998) and another difficulty centers on grammatical morphology, particularly verb morphology (Conti-Ramsden, Botting, & Faragher, 2001; Rice, Wexler, & Cleave, 1995). Nonetheless, it is noteworthy that, in most respects, the development of language in children with SLI is along typical lines with relatively few children showing disorder in terms of the type of errors they make. In other words, most of the errors that children with SLI make in their speech are similar to the errors made by younger typically developing children.

The nature and heterogeneity of language problems in SLI

To be classified as having SLI a child typically has to have quite severe problems in a number of domains of language (vocabulary, grammar, and phonology). This contrasts with the language difficulties described in children with dyslexia whose problems are restricted to phonology. Given the complex sets of measures that are used to identify children with SLI, it is not surprising that these children constitute a heterogeneous group with a wide range of language difficulties. There have been a number of attempts to classify children with SLI into subtypes. As we saw for dyslexia, such attempts are fraught with difficulty and most taxonomies leave a substantial number of children unclassified. It has been common to distinguish between problems with receptive language skills (comprehension) and problems with expressive language skills (production). One of the most widely cited classification systems is that proposed by Rapin and Allen (1987), shown in Table 4.1. This classification distinguishes between the domains of language that are affected, rather than according to whether the disorder affects expressive or receptive language function. However, there is inevitable overlap between the two approaches; within the framework proposed by Rapin and Allen (1987), verbal dyspraxia and phonologic programming deficit syndrome primarily affect expressive language skills, whereas receptive and expressive language skills are affected in verbal auditory agnosia, phonologic-syntactic and lexical-syntactic programming deficit syndromes, and more subtly in semantic-pragmatic disorder.

Conti-Ramsden et al. (1997) used a statistical technique known as cluster analysis to identify five profiles of difficulty in a large sample of children attending specialist language units within UK schools. These clusters were as follows:

1 Children with severe expressive and receptive language impairments who performed poorly on all language tests administered as well as in word reading. This was the largest subgroup identified.

Table 4.1 Main subtypes of language impairment according to Rapin and Allen's (1987) taxonomy

Language subtype	*Main characteristics*
Verbal auditory agnosia	Type of "word deafness" in which the child is unable to understand spoken language
Verbal dyspraxia	A disorder that affects the motor planning of speech but is not associated with a neurological disorder of speech production mechanisms (e.g., dysarthria)
Phonologic programming deficit syndrome	A disorder that affects the production and intelligibility of continuous speech in the absence of problems of comprehension
Lexical-syntactic deficit syndrome	A disorder resembling phonologic programming deficit syndrome in which grammar and sentence production are also affected, and comprehension may be poor
Phonologic-syntactic programming deficit syndrome	A disorder of expressive language, characterized by word-finding problems, limited vocabulary, and errors of sentence production. Speech sounds are normal. Comprehension may also be impaired
Semantic-pragmatic deficit syndrome	A disorder of the use of language for social communication. Utterances are well formed but may be inappropriate, conversation turn-taking is impaired, and language comprehension tends to be overliteral

2 Children with complex multiword deficits who had difficulties with word reading, grammar, and narrative skills but relatively good phonology and expressive vocabulary.
3 Children with expressive-phonological impairments who had adequate expressive vocabulary and comprehension, but poor word reading, phonology, and narrative skills.
4 Children with phonological and single word deficits who had poor expressive vocabulary but were otherwise similar to Profile 3.
5 Children with adequate phonology, expressive vocabulary, comprehension of grammar, and word reading who were considered by their teachers to have difficulties with the social use of language. These children could be considered to have pragmatic language impairments.

Using a similar procedure, van Weerdenburg, Verhoeven, and van Balkom (2006) identified four clusters of Dutch-speaking children with SLI according to their performance on tasks tapping lexical-semantic abilities (including morphology), verbal sequential memory, speech production (phonology), and auditory conceptualization, emphasizing the synergies between the clusters defined by different researchers.

We do not wish to advocate any particular system for classifying children with SLI into distinct groups. However, it is generally accepted that pure speech impairments (sometimes described as speech sound disorder, SSD) are different from the problems seen in children with language impairments (Bird, Bishop, & Freeman, 1995; Nathan, Stackhouse, Goulandris, & Snowling, 2004; Raitano, Pennington, Tunick, Boada, & Shriberg, 2004). It is also generally accepted that impairments affecting the form and structure of language are different in their nature to deficits in the social use of language for communication (Bishop, 1998; Bishop & Norbury, 2002). Such problems in language use for communication and social interaction are now usually referred to as pragmatic language impairment (PLI). Since children with PLI display characteristics usually associated with autism, and the region of overlap between autism and PLI is the subject of an increasing amount of research (Bishop & Norbury, 2002), this is an important group to consider. We focus in this chapter on children with the more classic form of SLI and return to PLI in Chapters 8 and 9.

Linguistic and Cognitive Theories of SLI

Much of the research on SLI has been conducted by psychologists and linguists and these two disciplines offer rather different theoretical explanations of the nature and causes of the disorder. One of the main theoretical accounts of SLI is rooted in the linguistic framework of generative grammar and attributes children's problems to a deficit in linguistic (i.e., grammatical) knowledge. An important assumption of this approach is that the mental representation of language is modular (Fodor, 1983) and operates independently of other cognitive functions. In this "linguistic" view SLI is best understood as a failure to develop (partly innate) grammatical rules. The alternative cognitive approach is grounded in psychology, and sees the problems in SLI as reflecting deficits in processing rather than knowledge of rules. This approach views language as dynamic and distributed in its nature and inherently interactive with many other elements of cognition. On this view, a grammatical deficit is unlikely to occur in isolation, and will be expected to be preceded by, or related to, more basic cognitive deficits. There is little doubt that both of these approaches have contributed to our understanding of SLI.

Linguistic accounts of SLI

Despite the heterogeneity of SLI, it is generally accepted that the use of morphemes and word order to signal meaning (morphosyntax) is an area of marked weakness for many of these children. English-speaking children with SLI use grammatical morphemes (notably inflections) in obligatory contexts much less frequently than do younger typically developing children whose language is at a similar level. A variety of "linguistic" theories of SLI have focused on explaining the grammatical deficits seen in children with SLI. The details of these theories differ considerably but at a fundamental level these theories have the same form: they relate the problems seen in SLI to a deficit in an underlying grammar. In each case the grammar is a formal set of rules that is postulated to underlie the grammatical competence of adult speakers of the language (a generative grammar in the sense first put forward by Chomsky, 1957).

SLI as a problem with grammatical paradigms

Pinker (1979) outlined a formal theory of language acquisition that has been used to investigate the grammatical difficulties seen in children with SLI. He called this theory "the learnability condition." The learnability condition assumes that the child acquires a generative grammar, distinguishable from other formal grammars by its lexical component.

According to Pinker, inflections are stored with the lexical items they relate to as a set of equations:

e.g., [sings] = [sing] + TENSE = present; + NUMBER = singular
[called] = [call] + TENSE = past
[running] = [run] + ASPECT = progressive

To account for how appropriate equations are learned, the theory proposes that children create "paradigms"; a paradigm can be conceived of as a matrix of cells each containing a related affix. At first, the child acquires word-specific paradigms that represent how a particular lexical item is inflected in its different forms. These word-specific paradigms gradually contribute to the development of general paradigms that can be thought of as matrix representations of affixes free of stems (see Box 4.2 for an illustration of how these representations might be conceived). Once general paradigms are in place, the child can use inflections productively to mark new lexical items. Thus, given a new noun, such as *wug*, an inflection is added to signal plurality (two *wugs*) (Berko, 1958) or, in the case of the verb *wug*, to indicate past tense (yesterday they *wugged*).

Using Pinker's theory as a framework, Gopnik (1990) proposed that individuals with SLI are "blind" to syntactic-semantic features, such as the significance of number, gender, animacy, tense, and aspect. This view can then explain why children with SLI will show grammatical impairments that include problems with the selection of correct determiners and the choice of appropriate pronouns. In support of this, Gopnik and Crago (1991) analyzed data from an extended family of children and adults with SLI, focusing on six of the older affected family members (aged 16–74) and making comparisons with data from six unaffected family members (aged 8–17). Although the two groups were not matched for age, the comparison was conservative in that it might be expected that the older group would show more evidence of possessing an adult grammar.

The language tests presented to members of this family included tasks in which the participant had to indicate understanding of a spoken sentence by following a command, to generate plural and derived forms for words and nonsense names and tests of syntactic comprehension tapping active and passive forms, pronouns, and possessives. Participants were also asked to make judgments about the grammaticality of sentences. Table 4.2 presents examples of the linguistic items in each task and summarizes the results.

As can be seen from Table 4.2, the SLI participants appeared to have problems on tests that required the generation of inflectional and derivational morphology and in correcting ungrammatical sentences that required feature marking. However, their performance was unimpaired on syntactic tests that required the comprehension of pronouns, plurals and possessives, and in grammatical judgments about the argument

Box 4.2 Pinker's word-specific and general paradigms for inflections

	Word-specific paradigm			General paradigm		
	Person			Person		
Tense	1st singular	3rd singular	Plural	1st singular	3rd singular	Plural
Present	Walk	Walks	Walk	-	-s	-
Past	Walked	Walked	Walked	-ed	-ed	-ed

In order to explain how paradigms are filled out, Pinker proposes that there is a hierarchy of notions relevant to each type of affixation. For example, inflections that have clear semantic correlates that tend to appear universally across language, such as NUMBER (plurality), will be filled out first, while abstract notions will enter the picture last. An example of an abstract notion would be the ASPECT of a verb, which reflects the way an event is spread out over time. Articles (a, the) are represented in paradigms much as inflections are. In English, there are only two articles; these are differentiated according to DEFINITENESS but in other languages, e.g., French, the article changes to mark GENDER (un/une; le/ la) and NUMBER (les). Importantly, as we shall see later, the phonetic characteristics of an inflection (how acoustically salient it is) also affect its position in the hierarchy.

structure of phrases. The SLI group was also worse on a narrative task in which a cartoon sequence of pictures had to be described. Rather than use a linguistic device such as a pronoun to refer to agents in previous pictures (using *he* to refer to the *man*), which would ensure cohesion across the narrative, the SLI group tended to use full noun phrases, and one participant produced a series of descriptions of the pictures rather than a narrative.

The interpretation of the findings of Gopnik and Crago (1991) is complicated by the small number of participants and the ceiling effects on some of the tasks. In addition, other researchers working with the same family have pointed out that the widespread phonological difficulties experienced by the family members make it difficult to be certain about what causes errors in their spontaneous speech. However, the authors argue that these findings must be understood in terms of the underlying grammar that these people possess. Specifically, they suggest that the level of the grammar that represents abstract morphological features is impaired and that this can explain many of the syntactic errors that they make.

Table 4.2 Examples of Gopnik and Crago's (1991) language tests summarizing the performance of family members with SLI and unaffected members of the same extended family

Task	*Examples*	*Differences between SLI and controls*
Pointing to objects (simple)	Please touch the book/s	No difference; however, three SLI individuals responded oddly to singular and plural items
Pointing to objects (complex)	Put the crayon on the balloons	
Generate plural forms for nonsense names in pictures	This is a zoop These are ....(zoops)	SLI impaired
Follow complex commands	Here are three crayons; drop the yellow one on the floor, give me the blue one, and pick up the red one	No difference but trend for SLI to make more errors
Matching reflexive and nonreflexive pronouns to one of four pictures	He washes him He washes himself	No difference
Matching gender pronouns to one of four pictures	He holds him/her He holds them	No difference
Matching to pictures: active and passive negatives	The truck does not pull the car The truck is not pulled by the car	No difference; in 4/7 pairs the SLI case did worse and in 1/7 better
Matching to pictures: contrastive possessives	The girl's baby The baby's mother	Performance of both groups near perfect
Grammaticality judgments and corrections	The boy kiss a pretty girl The little girl is play with her doll	SLI impaired in judging grammaticality and correcting sentences; they were slow to respond
Derivational morphology: complete the sentence	There is a lot of sun It is ---- *(sunny)*	SLI impaired and they were slow to respond
Grammatical Judgments of argument structure (thematic relations)	The girl eats a cookie to the boy	No difference
Tense marking: complete the sentence	Each day he walks 10 miles Yesterday he _____ *(walked)* 10 miles	SLI impaired and they were slow to respond

Source: Reprinted from *Cognition*, 39, Gopnik, M. and Crago, M. B. Familial aggregation of a developmental language disorder, 1–50, copyright (1991), with permission from Elsevier.)

One apparent problem for the idea that an impairment in abstract morphosyntactic rules is the explanation for the speech errors made by the SLI cases in this family is that, within individual affected family members, correct grammatical forms (e.g., "I like books") co-existed with incorrect forms (e.g., "I like python") in the same person. Similarly, although they could comprehend pronouns accurately, they tended not to produce them in narrative where pronominal reference would have been appropriate. There was also a tendency in the written work of two of the younger family members to produce correct forms of irregular words more often than of regular ones. These inconsistencies between different examples that apparently require a common underlying rule seem to pose problems for the idea that the individuals with SLI do not possess a given rule. However, Gopnik and Crago argue that these observations suggest that the SLI family members depend upon lexical learning to acquire new words as unanalyzed wholes rather than lexical items that are marked according to the parameters specified by general paradigms. While this might be true, such an explanation becomes very difficult to test. Whenever a given rule appears to operate this can be attributed to learning an item as an "unanalyzed" whole, and when a rule appears to fail it can be attributed to failure of the rule. Returning to Pinker's framework, Gopnik and Crago (1991) proceeded on the basis of these results to make the bold conclusion that "a single dominant gene controls for those mechanisms that result in a child's ability to construct the paradigms that constitute morphology" (p. 47).

Rather than positing a difficulty in acquiring morphological paradigms, van der Lely and colleagues (van der Lely, 1994; van der Lely & Stollwerck, 1997) propose a higher-level deficit in relating such paradigms correctly. The Representational Deficit for Dependent Relations (RDDR) theory predicts difficulties with agreement and tense marking. It also makes predictions regarding the use and comprehension of passive sentences (e.g., *The boy is chased by the girl*) and pronominal reference (e.g., *Baloo Bear says Mowgli is tickling him)*, both of which rely on long-distance syntactic relationships (van der Lely & Harris, 1990). Children with SLI have striking difficulties with these types of sentence and with other aspects of language that are structurally complex and hierarchically organized. According to the Computational Grammatical Complexity hypothesis (van der Lely, 2005), the heterogeneity seen in SLI is due to deficits in complex computation in at least one of three rule-governed systems in the grammar: syntax, morphology, or phonology.

SLI and the extended optional infinitive

Rice and Wexler and their colleagues (Rice, 2000; Rice & Wexler, 1996) have proposed a slightly different account of the grammatical difficulties observed among children with SLI. We will focus here on tense and agreement marking for verbs; in English, the marker *-ed* is typically used to indicate past tense, and *-s* to mark third person singular. As Figure 4.4 shows, whereas typically developing children have mastered the use of such grammatical markers by 5 years of age, children with SLI have not and do not appear to be on track toward the adult grammar.

The linguistic theory behind this account is complicated, though understanding its details is not necessary to understand the basic findings in relation to SLI. In order to describe the theory, it is necessary first to define "finiteness" in relation to verbs.

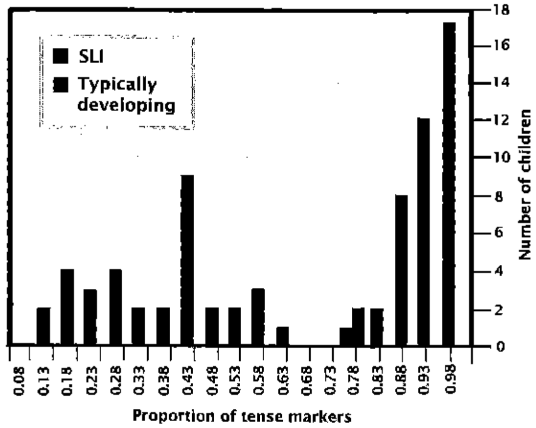


Figure 4.4 Number of 5-year-old children producing different proportions of tense markers correctly: (○) typically developing; (•) SLI. (After Rice, 2000, with permission.)

In English, verbs may take a finite or nonfinite form. Finite verbs can function on their own as the main verb of a phrase (e.g., he *sings*), whereas nonfinite verbs (e.g., *to go*) usually need to combine with another grammatical form in a phrase (e.g., *he wants to go* to school). The marking of finite verbs for agreement and tense is obligatory (he walks, she walk*ed*; see Box 4.3). In contrast, nonfinite verbs are not marked but take the bare stem (e.g., they liked to *walk*, she made him *walk*; in these two cases the bare stem of the verb is combined with the infinitival particle *to* or with an auxillary verb *made)*. To complicate matters further, in English this distinction is not always clear because a finite verb is not always marked by a surface form. For example, the singular present tense form *I walk* is finite and there is no grammatical marker on *walk*, but there would be if we changed this to *She walks*.

According to Wexler (1994), there is a phase in typical development in which children do not mark tense in main clauses yet they understand that finiteness has grammatical properties. Thus, at the same time as they omit tense and agreement markers, they will not use agreement where the adult grammar does not allow it. Wexler described this as the Optional Infinitive (OI) Stage. Since many errors in the speech of children with SLI appear to conform to this description well after the age at which such errors have been overcome in typically developing children, Rice, Wexler, and Cleave (1995) proposed that the grammatical development of SLI might be characterized as within an Extended Optional Infinitive (EOI) Stage.

To test the predictions of this theory for English children with SLI, Rice et al. (1995) compared the performance of a group of 21 children with SLI aged 55–68 months with that of two groups of typically developing children. The first was a group of age-matched 5-year-olds, and the second a group of 3-year-old children matched for mean length of utterance (MLU) to the children with SLI. The children in these groups were given a number of tasks to assess whether they were still showing signs of using OI constructions. The children's language was assessed by collecting spontaneous language samples and also in structured play settings that attempted to elicit particular grammatical structures. The simplest example to explain is the use of markings for past tense (adding *-ed* to the verb stem, as in "he walk*ed*"). To elicit

Box 4.3 Grammatical marking of finite verbs

Agreement of subject and verb
In the verb phrase "she walks," *-s* marks the agreement of the verb *walk* with the subject *she* (first person singular). If instead we said "she walk" that would be ungrammatical.

Tense marking
In the phrase "yesterday they walk*ed*," *-ed* conveys that walking occurred in the past. If instead we said "yesterday they walk" that would be ungrammatical.

A complication
In English, a finite verb is not always marked by a surface form. For example, the singular present tense form *I walk* is finite but there is no grammatical marker on *walk*; there would be if we changed this to *She walks*.

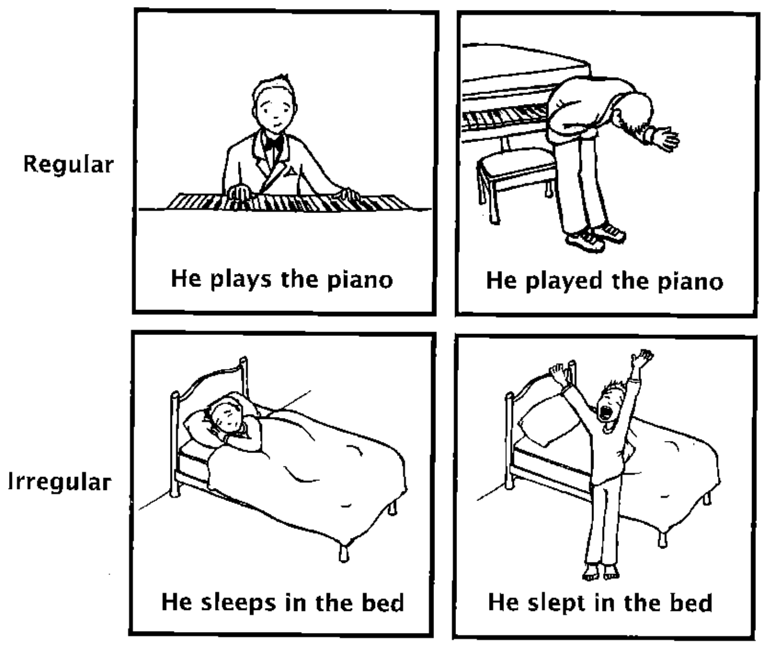


Figure 4.5 Illustration of past tense generation task.

the children's use of the past tense marker they were shown pictures. For example, they were shown a picture of a boy climbing up a ladder and were told "the boy is climbing the ladder." The child was then shown another picture where the boy had finished climbing the ladder, and asked "What did the boy do?" In this case an appropriate and grammatically correct response would include the phrase "he climb*ed* the ladder ..." or "the boy climb*ed* the ladder..." in which the past tense marked (*-ed*) form of the verb "climb" is used (see Figure 4.5 for an illustrative example).

The results were quite striking. In this setting the typical 5-year-old children used the marked past tense form of the verb (climb*ed*) correctly in 92% of their utterances, whereas the corresponding figures for the 3-year-olds was 50%, and for the SLI children it was only 27%. Thus the children with SLI were less likely than younger 3-year-old children to produce the correct *-ed* past tense form of verbs. (Similar patterns of results were obtained for marking the first person singular *-s* form of verbs, and for using the correct forms of the auxiliary verbs *be* and *do*.)

In summary, the SLI children showed specific difficulties in mastering an aspect of morphosyntax (marking verb forms for tense and agreement). In this respect their mastery of a grammatical rule was even less advanced than younger typical children who were matched for mean length of utterance (a commonly used measure of level of language development). This pattern suggests that this is more than simple delay in development and suggests they have specific difficulties in representing the finiteness of verbs. The deficit within the EOI theory is considered one of knowledge; the children do not know that tense marking is obligatory in the main clause. According to Rice and Wexler (1996), children with SLI use this immature grammar for much longer than unaffected children. Problems with tense-marking morphemes are present in comprehension (as tested by grammaticality judgments) as well as production (Rice, Wexler, & Redmond, 1999). Moreover, children with SLI do not catch up to their peers in their use of tense-marking morphemes, so that while most children reach adult levels of usage by 5 years of age, one might still hear a child with SLI at age 8 say "Granny see me" (Rice, Wexler, & Hershberger, 1998).

Evaluating linguistic (grammatical) theories of SLI

These linguistic or grammatical theories give rich descriptions of some of the more pronounced language difficulties that are common among children with SLI. There are, however, some difficulties with these theories as explanations of SLI. In each case the explanation amounts to postulating a deficit that is essentially an internal component of the language system: The children lack one or more components of an adult grammatical rule system. In terms of the approach we are advocating in this book such an explanation is unsatisfactory: We need an explanation for why such a component (or set of components) of the language system fails to develop. One reaction to this from proponents of these theories would likely be in terms of nativist theories of language acquisition. According to such theories language might be seen as a kind of "instinct" (Pinker, 1994) that depends critically upon innate knowledge for its development. Going even further some theorists might even see aspects of the grammatical system depending upon innate prespecified rules that allow the system to develop when given only certain rudimentary inputs. In this view then, children with SLI "lack a gene" for grammar (Gopnik & Crago, 1991). We do not find such nativist arguments convincing, though they continue to be debated widely (Crain & Pietroski, 2001; Sampson, 2005). Ultimately however, such explanations are always open to being reduced to more basic levels of explanation of the sort that have been pursued in the cognitive theories of SLI that we will consider below. At a more specific level, there are a number of forms of evidence that pose problems for grammatical theories of SLI.

To begin with, it is worth emphasizing that the deficits in using morphology seen in children with SLI are not absolute. It is not that these children never use certain morphological markers such as *-ed* to signify the past tense or that they show an absolute absence in understanding a given grammatical rule, but they produce such constructions or appear to follow certain rules less often and less consistently than typically developing children. In fact the types of morphological errors seen in children with SLI are usually the same as those seen in younger typically developing children learning the same language. It is also the case that children with SLI appear to use morphology productively, as shown by overgeneralization errors such as "he throw*ed* it." Such errors show that children with SLI appear to be learning the morphological system of the language in much the same way as younger typically developing children; it is just that they find such learning harder (as they do learning the lexical system of the language). Such graded patterns of performance seem hard to capture in terms of a rule deficit.

Further problems come from observations in children with SLI learning different languages. English is a language in which the morphological system is relatively simple. However, there are many other languages that have much richer morphological systems. Naively, if children with SLI cannot "learn the rules of morphology" we might expect this to pose greater problems in languages with richer morphological systems. In fact the opposite seems to be the case (see L. Leonard, 2000), with children with SLI who are learning languages with rich inflectional morphologies having less trouble with inflections than their counterparts learning English. For example, Italian-speaking children with SLI are similar to younger language-matched children in their comprehension and use of verb inflections, as well as adjective agreement and noun plural inflections, although this level is lower than that of age-matched controls (Bortolini & Leonard, 1996; Leonard, Bortolini, Caselli, McGregor, & Sabbadini, 1992). In a similar vein, the use of verb inflections is relatively robust for Spanish-speaking children with SLI (Bedore & Leonard 2001) and for those who speak Hebrew, which is an inflectionally rich language (Dromi, Leonard, Adam, & Zadunaisky-Ehrlich, 1999). These cross-linguistic observations create a challenge for linguistic accounts of SLI that place the deficit at the level of universal grammatical structures or rules. Rather, the problem may be in the identification and/or interpretation of the evidence in the input. Leonard (2000) speculates that there may be a number of aspects of the nature of the language input heard by English-speaking children that contribute to their difficulties in mastering inflectional morphology. In essence, this view aligns with cognitive theories of language acquisition (Tomasello, 2000).

Finally, we should note that the necessity of postulating formal grammatical rules to explain the patterns of verb morphology development in typically developing children has been questioned. For example, Freudenthal, Pine, and Gobet (2006) investigated the patterns of OI development in Dutch- and English-speaking children. They present a simple computational model that shows a bias to encoding the end of utterances. They argue that such a bias coupled with information about the pattern of utterances actually heard by children (from analyses of large databases of child-directed speech) can explain the key features of children's acquisition of verb morphology. The model also does a good job in accounting for differences in the pattern of learning between Dutch and English, which relates to differences in the pattern of input (child-directed speech) in the two languages. Once again, such evidence and theorizing aligns well with cognitive theories of language acquisition (Tomasello, 2000).

Cognitive theories of SLI

Cognitive theories of SLI seek to find problems in basic mechanisms that might account for the language learning difficulties shown by these children. Broadly speaking, the cognitive deficits underlying SLI have been conceptualized as either general or specific. One general factor is speed of processing. Language learning is a complex task that requires the use of general processing resources and it is therefore precisely the kind of task that might suffer in the face of limited cognitive processing capacity. Within this view, a general resource limitation may underlie SLI (Kail & Salthouse, 1994) and consistent with this idea is the finding that there is considerable shared variance between language skills and nonverbal abilities (Colledge et al., 2002). In contrast, the "specific processing deficit" view suggests a deficit in specific processes (e.g., certain auditory perceptual processes) that may be necessary for learning and using language effectively.

Speed and capacity limitations in SLI

Much of the evidence used to argue for a general capacity limitation in SLI comes from trade-offs between performance and task complexity observed during language processing tasks. In spoken language production, errors such as word omissions increase with sentence complexity, and this effect is more marked in children with SLI than in younger children with similar language levels. In experimental tasks, children with SLI show difficulties with fast mapping and novel word learning, and these difficulties are exacerbated at faster rates of presentation (Ellis Weismer & Hesketh, 1996). Children with SLI are also slower at word recognition in lexical decision and word monitoring tasks, and demonstrate inefficient sentence comprehension (Montgomery, 2000).

If a general capacity limitation rather than a language-specific impairment is involved in SLI, then deficits should also be apparent on a wide range of tasks, both verbal and nonverbal. Nonverbal examples include mental rotation and peg moving (Bishop, 1990; Johnston & Ellis Weismer, 1983), while verbal tasks include picture naming (Lahey & Edwards, 1996; Leonard, Nippold, Kail, & Hale, 1983) and grammaticality judgments (Wulfeck & Bates, 1995). Findings such as these have led to the proposal of a generalized slowing hypothesis (Kail, 1994). In the largest study to date to examine the issue of generalized slowing, Miller, Kail, Leonard, and Tomblin (2001) directly compared the response times (RT) across a range of linguistic and nonlinguistic tasks for children with SLI and IQ-matched controls, as well as for a group of children with nonspecific language impairment (NLI). Both language-impaired groups were slower than the control group, with the NLI group (who were of lower IQ) showing the greatest slowing.

If reduced speed of processing is causally involved in SLI, rate of stimulus presentation should affect language performance. Hayiou-Thomas, Bishop, and Plunkett (2004) used a novel experimental approach to simulate SLI in children with typically developing language. In this study, 6-year-old children were required to decide if sentences were grammatical or not when they were presented in compressed speech at 50% of the normal speech rate. Performance in this grammaticality judgment task resulted in a similar pattern of errors to that reported in SLI: good performance on noun morphology (plural *-s*) and very poor performance on verb morphology (past tense *-ed* and 3rd person singular *-s*). Similar results were obtained in a condition with increased memory load. The finding that an SLI-like pattern of performance can be induced in children with intact language by increasing processing demands provides some support for the hypothesis that a processing deficit may underlie language performance in SLI. However, the children also had difficulty in a control condition involving judgments about phrases containing prepositions (in, on, at), a difficulty not typically reported in SLI, reducing the strength of this evidence.

Auditory processing deficits in SLI

Another influential hypothesis of SLI proposes that it is caused by a low-level auditory processing deficit, which negatively affects language development by compromising speech perception. Much of the work in this area was originally motivated by the research of Tallal and colleagues, who used a procedure now known as the Auditory Repetition Task (ART); (discussed in Chapter 2). In this task the children first learn to associate two different sounds with two buttons, so that they can reliably press Button 1 for Sound 1 and Button 2 for Sound 2. After this pretraining the children go on to hear two-tone sequences and have to copy the sequence they hear by pressing the correct buttons in the correct order (1-1, 1-2, 2-1, or 2-2). Children with SLI had difficulty with this task when the tones were brief (75 ms) and the interstimulus interval between the tones was short (150 ms or less; Tallal & Piercy, 1973). This was interpreted as evidence for a temporal processing deficit in SLI that specifically affected the processing of rapidly changing auditory information. Speech, which by its nature comprises rapidly changing sequences of auditory information, is thus very vulnerable. Consistent with this idea, Tallal and Piercy (1974) went on to show that SLI children had difficulty "repeating" (by means of button presses) sequences of stop consonants (e.g., /ba/ and /da/) in which the critical contrast occurs in the first few milliseconds, but performed better on the same task with sequences of vowels in which the critical differences between the stimuli were of longer duration. However, a number of replications of Tallal's early studies have found that while SLI children may on average perform poorly on the ART task this difficulty is not restricted to the rapidly presented stimuli (e.g., Bishop, Bishop, et al., 1999).

A different task that has been used in this area is auditory backward recognition masking (ABRM). In this task a masking sound interrupts the processing of features of the test tones that have preceded it. This effect is particularly strong when the interval between test tone and masker is short. Wright et al. (1997) compared 8-year-old children with SLI and age-matched controls using the ABRM paradigm and reported a dramatic group difference in the thresholds at which the tone could be identified. In fact, there was no overlap in performance between the language-impaired and the control groups in this condition (compared with conditions when the masker was presented simultaneously with the tone or before it in a forward masking position). Performance was better for both language-impaired (LI) children and controls when the tone was presented in "spectrally notched" noise in which frequencies near to the frequency of the tone were excluded rather than in filtered (bandpassed) noise. However children with LI particularly benefited in the backward masking condition and derived less benefit in forward and simultaneous masking conditions. A further important finding was that subsequent testing of four individuals from the LI group showed that, when the spectral notch in the masker was increased, performance could be improved to control levels. Together these findings suggest that children with SLI experience severe auditory processing impairments in certain temporal and spectral contexts.

Following on from this finding, a growing body of evidence suggests that frequency discrimination may be problematic for at least a subgroup of children with SLI (Hill, Hogben, & Bishop, 2005; McArthur & Bishop, 2004a; Mengler, Hogben, Michie, & Bishop, 2005). It appears that across a number of studies perhaps 30–40% of children with SLI have problems on frequency discrimination tasks (G. McArthur, personal communication). Moreover, amongst children with SLI, those with poor frequency discrimination tend to show poor nonword reading in relation to those with normal thresholds (who have more specific difficulty reading irregular words; McArthur & Bishop, 2004a,b).

One of the first studies to look at several indices of central auditory processing in the same individuals was reported by Bishop, Carlyon, Deeks, and Bishop (1999), who estimated thresholds for detecting backward masked tones, frequency modulation, and frequency discrimination using temporal cues, and compared these with performance on the ART measured 2 years earlier. There were marked individual differences on the backward masking and frequency modulation tasks and performance on these tasks correlated with each other and with the ART measure taken 2 years earlier, suggesting that these different auditory tasks were tapping into a common process that remained stable over time. However, none of the auditory tasks showed reliable differences between the SLI and control children, and performance on the auditory tasks tended to correlate better with measures of nonverbal ability than measures of language skill. Overall, the small differences in performance between the SLI and control children, coupled with high degrees of variability within groups, led these authors to conclude that auditory deficits were neither necessary nor sufficient as causes of language impairments.

To date, relatively few studies have investigated the acoustic cues that signal prosodic features of language in SLI, such as duration and amplitude. Sensitivity to such cues may be an important precursor to the extraction of segmental information required for word learning. To explore this issue, Corriveau, Pasquini, and Goswami (2007) assembled a group of 21 children with SLI aged 7–11 years and compared them with two comparison groups on a series of auditory and phonological processing tasks. The first was a group of age-matched controls (CA controls) and the second a younger comparison group of children matched for receptive and expressive

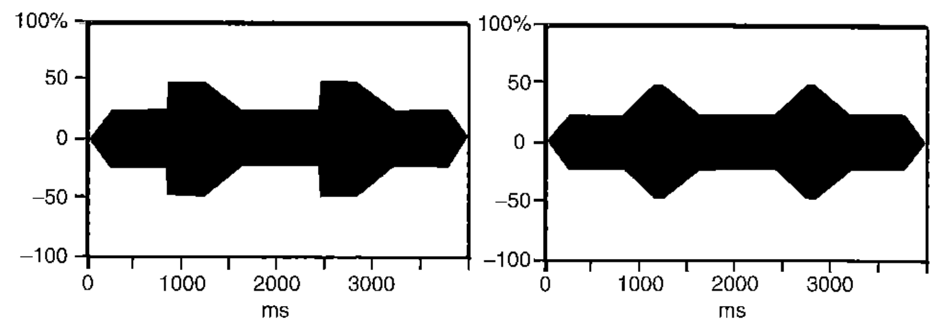


Figure 4.6 Schematic illustration of the stimuli used to assess amplitude envelope onset rise time. (Reprinted with permission from Basic auditory processing skills and specific language impairment: A new look at an old hypothesis by K. Corriveau, E. Pasquini, and U. Goswami. *Journal of Speech, Language and Hearing Research*, 50(3), 652. Copyright 2007 by American Speech-Language-Hearing Association. All rights reserved.)

vocabulary knowledge (LA controls). The key auditory tasks were tests of amplitude envelope onset rise time and duration discrimination, assumed to be important for the perception of stressed and unstressed syllables in words. There were two tasks assessing amplitude envelope rise time, each requiring the child to judge between a standard and a target tone. In each case, the child was told to indicate the "sharper" stimulus in terms of its onset (see Figure 4.6). In two tasks assessing duration discrimination, pairs of tones were presented and the child had to indicate the longer tone. In addition, each child completed a temporal order judgment task, an intensity discrimination task, and tests of phoneme deletion and rime oddity.

The authors report that between 70 and 80% of the children with SLI performed below the 5th centile for their age on one of the tests of amplitude envelope onset rise time and in the duration discrimination tasks, despite showing normal performance on the temporal order judgment and intensity discrimination tasks. However, the effect sizes for the difference between the children with SLI and the CA controls are much lower in terms of Cohen's *d* on the critical amplitude rise time tasks (one-ramp threshold: 0.49; two-ramp threshold: 0.18) than are group differences in phoneme deletion (2.58) and rime oddity (2.12), and they are similar in magnitude to the effect size for group differences in nonverbal IQ (0.47). Moreover, the SLI group scored more poorly than controls on tests of working memory and nonword repetition tasks. Thus the interesting conclusion of this study, that sensitivity to duration and amplitude envelope cues is impaired in SLI and predictive of language and literacy outcomes, must remain tentative pending further studies in which groups are better equated for general cognitive resources.

In a similar vein, the literature using electrophysiological measures to examine the neural correlates of auditory processing in SLI is mixed. Here some groups have reported group differences in components of the ERP (event-related potential) that correspond to detection of an auditory stimulus (e.g., Tonnquist-Uhlen, 1996), while others have failed to find reliable differences (e.g., Marler, Champlin, & Gillan, 2002). A different component of the ERP, the mismatch negativity (MMN), indexes the ability to distinguish between two different sounds, rather than just detecting them. Here too the results have been inconsistent, with some groups reporting a diminished MMN in SLI and others not (see Bishop, 2007a, for a review).

The inconsistencies observed in the literature on auditory processing in SLI might be explained by heterogeneity within the disorder (e.g., in the Corriveau et al. study described above, reading standard scores ranged from 63 to 116). In this light, there is both behavioral (Heath, Hogben, & Clark, 1999) and ERP evidence (McArthur & Bishop, 2004a, b) to suggest that auditory deficits may be most apparent in children who have difficulties in both oral language and literacy, and this suggests that auditory processing deficits may be particularly associated with language difficulties that include phonological problems. Second, the profile of auditory deficit may depend on the age at which children are tested and, following findings that the brain waveforms of many children with SLI resemble those of younger children, Bishop and McArthur (2005) have suggested that there may be a maturational delay in cortical processing of auditory stimuli. A third possibility is that the problems seen in some children with SLI on auditory perceptual tasks reflect more general problems of sustaining attention in difficult and often lengthy tasks. In relation to this hypothesis it would be interesting for more studies to combine measures of auditory processing in children with SLI with a broader range of measures tapping nonauditory speed of processing. Finally, it clearly remains possible that auditory processing deficits may be a "synergistic risk factor" for language impairment (Bishop, Carlyon, Deeks, & Bishop, 1999) that, in the context of other risk factors, contributes to language learning problems.

Phonological memory deficits in SLI

Another causal hypothesis of SLI places the proximal deficit in the phonological memory system. This theory was first proposed by Gathercole and Baddeley (1990), who examined verbal working memory processes in a group of six children with SLI, comparing them to age- and verbal-age-matched controls. Although the children with SLI performed typically on tests of speech discrimination and articulation rate, and showed the normal effect of word length in memory, they had significant difficulty on a test of nonword repetition relative to CA (but not verbal-age) control children. The authors argued from this finding that SLI could be traced to a deficit in the ability to represent material in phonological form in working memory. In subsequent work, Gathercole and colleagues have argued that children need the capacity to store phonological material in short-term memory in order to learn new words (Baddeley, Gathercole, & Papagno, 1998). Thus, individual differences in phonological memory are predictors of the ability to learn new vocabulary in the native language and in foreign language learning (Service, 1992).

In the last decade, other studies have confirmed the presence of nonword repetition deficits in many children with SLI (Dollaghan & Campbell, 1998) and, along with past tense elicitation, nonword repetition has been found to be an excellent behavioral marker of SLI, discriminating children diagnosed with SLI from control children with a high degree of accuracy (Conti-Ramsden, Botting, & Farragher, 2001) even when their language difficulties have resolved (Bishop, North, & Donlan, 1996). Nonword repetition also appears to be a more effective marker of language impairments than standardized language tests in ethnic minority populations and those who speak nonstandard dialects (Dollaghan & Campbell, 1998). Finally, nonword repetition ability has been shown to be highly heritable in twin studies (Bishop et al., 1996; Kovas, Hayiou-Thomas et al., 2005). In an important study investigating the heritability of temporal order processing and phonological memory, Bishop, Bishop et al. (1999) tested 37 same-sex twins aged 7–13 years, one of whom in each pair had a language impairment, and 104 same-sex twin pairs of the same age from the normal population on Tallal's auditory repetition task (see above) and on Gathercole and Baddeley's nonword repetition test. In line with previous research, this study showed that children with SLI were impaired on both the ART and the nonword repetition test. Moreover, nonword repetition was a more robust predictor of language performance on tests of receptive grammar, comprehension, memory for sentences, and word finding than was ART, which only predicted receptive grammar when nonword repetition, age, and IQ were controlled. Importantly, whereas nonword repetition was highly heritable in this sample, ART was not.

The evidence that children with SLI show impaired performance on tests of nonword repetition is strong, though perhaps this is not surprising given that this is a measure of one aspect of language function (phonology). The best interpretation of the nonword repetition problems seen in children with SLI is far from clear. In one view nonword repetition is a complex phonological task that involves segmenting an unfamiliar spoken form, generating an appropriate speech output representation, and articulating the response (Snowling, Chiat, & Hulme, 1991). In this view problems of nonword repetition may simply be a relatively pure measure of the phonological processing difficulties that are one symptom of SLI. An alternative view is that nonword repetition indexes a deficit in holding temporary phonological representations in memory, which in turn are causally related to the impairments of vocabulary development observed in this population (Gathercole, Tiffany, Briscoe, Thorn, & ALSPAC team, 2005). Evidence refuting the strong version of this hypothesis comes from dissociations between nonword repetition and vocabulary knowledge in language impaired samples (Snowling, 2006) and from the finding that nonword repetition deficits are not universal in children with SLI (Catts, Adlof, Hogan, & Ellis Weismer, 2005). In short, although phonological memory resources are one component of new word learning, semantic factors and factors influencing the mapping of phonological onto semantic representations must also play a role. Whether nonword repetition deficits are best seen as a symptom or a cause of SLI remains open to debate.

Word learning deficits in SLI

Young children show a remarkable facility for learning new words, with estimates of vocabulary growth of around 10 words per day in the preschool years. In contrast, as we have seen, children with SLI show slow acquisition of the lexical and grammatical components of language. It is possible that, although these difficulties affect different domains of language, they may be related. To the extent that children use sentence frames to infer the meanings of new words (syntactic bootstrapping), their word learning will be limited. The corollary is that these children will have limited resources for using the meaning of words to infer their grammatical relations (semantic bootstrapping). Notwithstanding this, the language learning difficulties of children with SLI could be attributable to a deficit in verbal association learning or in the storage of new word forms in memory.

Rice and her colleagues have conducted a series of elegant experiments examining a process described as Quick Incidental Learning (QUIL) in children with SLI. QUIL refers to a child's ability to discover the meanings of new words in naturalistic settings. The paradigm that this group has developed to assess QUIL is one in which children are exposed to new words, embedded in narrative, voiced over a short video film. Children are assigned randomly to experimental or control groups. The children in the experimental groups hear novel words in the place of familiar words during the video (e.g., viola for violin; aviate for fly), whereas the children in the control groups hear the familiar items. Before the film starts, children's knowledge of the control and novel words is assessed (pretest). At the end of the film, the children are tested for their understanding of the novel words that have been introduced using a four-choice vocabulary test in which the child has to point to the correct picture depicting the new word they have heard (post-test). Distracter items typically include another picture depicting a new word from the film and two other pictures from the film depicting items that were not named.

Rice, Oetting, Marquis, Bode, and Pae (1994) used this paradigm to investigate the effect of the frequency with which novel nouns and verbs were included in the film on children's ability to learn their meanings. In one condition they heard the novel words 10 times each (F10), in another 3 times (F3), and in the control condition not at all. Thirty children with SLI, aged 4–6 years, took part in the experiment, randomly assigned to frequency-10, frequency-3, and control conditions. Their performance was compared to that of individually age-matched controls as well as to younger children matched for mean length of utterance (MLU). As well as examining the performance of the children at pre- and post-test, this experiment included a test to see how well the children remembered the words 3 days later (retention test).

The results of study were complex, with different groups performing differently at the three different test points. However, the main findings are shown in Figure 4.7. Basically in the 10 condition both the SLI and CA control groups made significant gains in their word knowledge between pre- and post-test, while the younger controls did not. Strikingly however, whereas the control group knew even more words at a delayed retention test, the SLI group did not improve any further. In the 3 condition, the SLI and the younger MLU group made similar gains and losses, both of which were minimal, whereas again the CA controls gained in word knowledge throughout and after the experiment. The SLI group learned more verbs than nouns at post-test but made correspondingly greater losses from this word category.

Overall the results indicated that children with SLI learned on average 2.5 new words between pre-and post-test, a gain that was comparable to that seen among

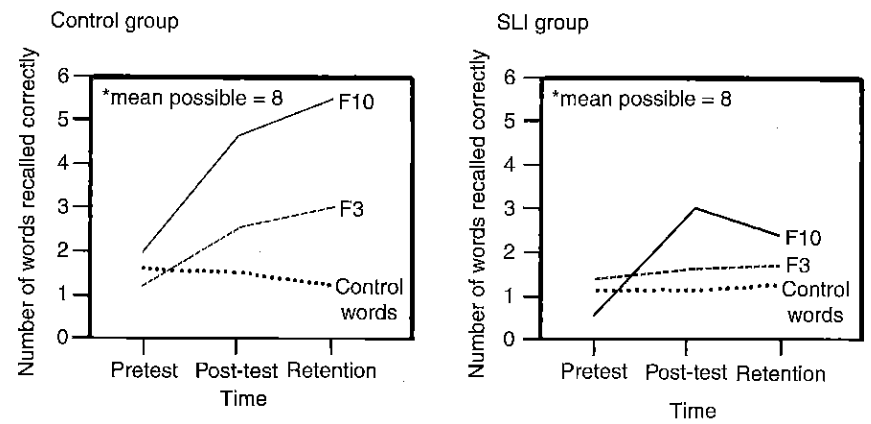


Figure 4.7 New word learning by children with SLI and controls: F10 (bold line) shows learning after 10 exposures; F3 (dashed line) shows learning after 3 exposures; control words (dotted) were untaught. (Reprinted with permission from Frequency of input effects on word comprehension of children with specific language impairment, by M. L. Rice, J. B. Oetting, J. Marquiz, J. Bode, and S. Pae. *Journal of Speech and Hearing Research*, 37(10), 106–122. Copyright 1994 by American Speech-Language-Hearing Association. All rights reserved.)

controls of the same age, although their absolute scores were lower. Thus, children with SLI seem to be able to form new associations between words and their referents, given a few instances of the new words. However this new word learning is not stable, such that 3 days later they suffer losses particularly of words from the verb category.

Oetting, Rice, and Swank (1995) extended this work to investigate the ability of older children with SLI, aged 6–8 years, to learn words from four categories: objects, actions, attributes, and affective states. There were five words in each category and each appeared five times. Once again, the SLI group showed specific difficulty in learning new action words (verbs) although they showed gains in their knowledge of the words from the object and affective state categories. The investigators did not test retention in this experiment, nor did they include a younger control group. Nonetheless, the findings add to the evidence that children with SLI have particular difficulty acquiring verbs. This difficulty may be because verb learning requires the abstraction of grammatical relations, whereas the semantic knowledge that underlies object names is relatively transparent. The data show that the view that vocabulary learning in SLI is constrained by phonological memory is too narrow since word learning depends upon the grammatical as well as the phonological attributes of the words to be learned.

Hybrid cognitive–linguistic accounts of SLI

The pattern of findings associated with the linguistic and cognitive theories of SLI that we have considered is quite disparate: children with SLI have difficulty with grammatical rules, with new word learning, and with auditory perceptual and phonological tasks. An obvious question is the extent to which these different deficits are related and which (if any) of the deficits play a causal role in the language learning difficulties of children with SLI. There have been two important attempts to produce integrative theories of SLI that take account not only of the basic cognitive deficits observed in the disorder but also its linguistic manifestations. The first is the surface hypothesis proposed by L. Leonard (1989) and the second is the connectionist hypothesis associated with Joanisse and Seidenberg (1998).

Surface hypothesis

L. Leonard (1989) proposed the surface hypothesis of SLI, which builds on three main sources of evidence: findings from typical language acquisition regarding the perceptual salience of grammatical features; data showing that children with SLI have processing limitations; and evidence from cross-linguistic research suggesting that factors such as perceptual salience, redundancy, relative frequency, pronounceability, and regularity are important in determining which aspects of a particular language will be hardest for children with SLI to learn.

To take one example, in English many grammatical morphemes that appear late in the speech of typically-developing children are low in phonetic substance and the same grammatical distinctions are acquired earlier in some other languages where the phonetic substance of the markers of these distinctions is higher. It seems plausible therefore that these morphemes will be vulnerable in English because of their surface properties (rather than their grammatical identity), particularly when there are resource limitations. Even within grammatical morphology some morphemes are more vulnerable than others; English-speaking children with SLI have particular problems with the past tense *-ed* and third person singular *-s* inflections, with the possessives, the infinitival *to*, as well as articles (Leonard, 1989). These are all morphemes with short duration relative to the words surrounding them. In contrast, the progressive inflection *-ing* does not seem to pose particular difficulty because this is of much longer duration than the morphemes noted above, especially when it is in final position in a sentence.

The characteristics of the language and the consequent predictions of which elements are likely to be most vulnerable are only half of the equation; the other half is the presumed processing limitation in the child with SLI (be it processing speed or poor sensitivity to auditory cues). The surface hypothesis suggests that limitations of processing will compromise the processing of morphemes, particularly those of brief duration.

Support for the surface hypothesis has come from a range of studies in English and other languages (Leonard, 1998). The illustration from English given above contrasts the relative difficulty posed by morphemes of low phonetic substance (past tense *-ed* and third person singular *-s*) and the relative ease of processing those of high phonetic substance (present progressive *-ing*). The comparison of SLI in English and in Italian is also of note. In English, production of the articles *the* and *a* poses difficulty for children with SLI, with about 55% of these retained in language samples. In Italian, difficulties with articles depend highly upon their phonological form. Hence, articles are retained 74% of the time in feminine form when they end with vowels (*la, una, I*) but only 7% of the time when they end in consonants (*il, un*). Thus the surface

hypothesis demonstrates how cognitive impairments in SLI, coupled with details of the surface form of the language, could in principle account for the manifestations of SLI and how these vary according to the language that is being learned.

Connectionism

A second attempt to integrate cognitive and linguistic accounts of SLI comes from connectionist computational modeling. The connectionist perspective of SLI explains the high-level syntactic deficits seen in children with SLI in terms of lower-level deficits in phonological encoding and representation, which in turn are attributable to auditory perceptual deficits. In some ways this approach could be seen as an attempt to produce a computationally explicit version of the surface hypothesis (Leonard, 1989) and is also compatible with the phonological hypothesis of SLI (Chiat, 2001). In a computational model, one can directly manipulate the quality of the phonological representation and quantify the effect on the learning of particular syntactic structures, thereby allowing a rigorous test of the hypothesized causal relationship.

Joanisse and colleagues have applied this approach to examine two structures of particular interest in SLI: pronouns, which have been central to the RDDR hypothesis (Joanisse & Seidenberg, 2003); and the English past tense, which has formed the focus of the influential Extended Optional Infinitive hypothesis (Joanisse & Seidenberg, 1998). In the pronoun study, a sentence processing model learned to associate a pronoun or reflexive to the correct antecedent (in *Baloo Bear says Mowgli is tickling him*, the *him* refers to Baloo Bear; in *Baloo Bear says Mowgli is tickling himself*, the *himself* refers to Mowgli). When a perceptual deficit was simulated by distorting the phonological input to the model, correct performance on pronouns and reflexives decreased significantly. Importantly, the model could still resolve pronouns when additional semantic information (such as gender) was available, thus simulating the pattern of performance in SLI. In the past tense study, the model learned to associate the phonological and semantic representations of verbs; a perceptual deficit was simulated by adding random noise to the phonological representations during the training phase. The result again corresponded to the pattern of performance in SLI: Regular, irregular, and nonword past tense generation were all impaired, but – critically for demonstrating that rule-like behavior can emerge in the absence of explicit rules – the decrement was most marked for nonwords (Joanisse, 2004).

One of the advantages of the connectionist perspective, not yet fully exploited, is that it may be able account for how variations in different resource pools (say in the perceptual and cognitive domains) might be reflected in heterogeneity of language profiles. Increasingly it is becoming clear that there is no single cause of SLI. Rather, as we shall see, it may be the behavioral outcome of a number of different risk factors (Bishop, 2006).

Summary of linguistic and cognitive theories of SLI

It will be clear by now that understanding the cognitive basis of SLI is much more complex than understanding reading disorders. A number of the proposed explanations for SLI are explanations that are "internal" to the language system; this would include theories that see SLI depending upon deficits in one or more components of an adult grammar. It would also include theories positing that SLI represents a deficit in word learning either as a result of problems relating phonological and semantic representations or as a result of problems in maintaining a phonological code in memory for long enough to support longer-term learning. Accepting explanations for SLI in terms of deficits in language processing modules aligns with accepting nativist explanations of typical language development. As we noted earlier such explanations seem less than totally satisfactory but clearly, given evidence for the heritability of language skills that we will discuss below, it remains possible that there will prove to be deficits in the development of language-specific mechanisms in children with SLI.

There have been two attempts to identify more basic cognitive impairments that might explain the language learning problems of SLI. The first sees the problem in SLI as a speed of processing deficit. The evidence for speed of processing deficits in children with SLI is good, but the problem with this as an explanation of SLI is that it is too general a deficit. Speed of processing tends to increase in the course of typical development (Kail, 1993) and shows deficits in children with general learning difficulties (low IQ; Kail 1992). Therefore, it is not at all clear why the speed of information processing deficit in SLI does not just result in general learning difficulties rather than problems that are specific to language learning. One response to this criticism would be to point out that many children who satisfy current diagnostic criteria for SLI show a pattern of deficits that is far from "specific" (e.g., Hill, 2001). In this view speed of processing impairments may be one cause of SLI (that may quite possibly interact with other causes). The second basic deficit that has attracted a lot of attention as a possible cause of SLI is a deficit in auditory information processing. This seems in many ways an eminently plausible theory of SLI since learning spoken language clearly must depend upon adequate auditory input. The evidence we have reviewed suggests that this deficit is at most a weak contributor to the language learning problems seen in children in SLI, though the possibility that an early deficit in auditory processing has downstream effects on language development (e.g., Benasich & Tallal, 2002) has not been well tested. Overall, it seems we so far lack a clear and well-supported cognitive level of explanation for the language learning problems seen in children with SLI. Given the complexity of language, and the heterogeneity of language difficulties seen in children with SLI, it seems likely that explanations of SLI may require multiple deficits that may have differing effects on the development of partially separable language subsystems (Bishop, 2006).

The Etiology of SLI

Genetic risk factors and SLI

Quantitative genetics

A growing number of twin studies now show that SLI is a highly heritable disorder. Considering SLI categorically, more MZ twin pairs are concordant for the disorder than DZ twins, consistent with genetic influence on SLI (Tomblin & Buckwalter, 1998). Interestingly, concordance rates are increased for MZ pairs and decreased for DZ pairs if definitional criteria are broadened to include children with nonspecific language impairment (i.e., they may have low nonverbal skills in addition to the language deficit; Bishop, 1994; Hayiou-Thomas, Oliver, & Plomin, 2005) or children who may have had speech and language therapy but do not fulfill formal diagnostic criteria (Bishop, North, & Donlan, 1996). There is also recent evidence that the heritability of SLI is greater for children with speech difficulties (who are primarily those ascertained in referred samples) than for those with language difficulties of the same level of severity in the absence of speech problems (Bishop & Hayiou-Thomas, 2008). Interestingly, this latter group is also less likely to be referred for speech and language therapy.

Twin studies have also shown significant genetic influence on quantitatively assessed language skills, both in the normal range and at the low extreme (Bishop, Kovas et al., 2005, Spinath, Price, Dale, & Plomin, 2004; Stromswold, 2001; North, & Donlan, 1995). In two recent studies that included a wide range of language measures in large samples of preschool children, there was consistent evidence of moderate genetic effects on diverse areas of language skill, from syntax to phonology (Byrne et al., 2002; Kovas, Hayiou-Thomas, et al., 2005). However, these studies also provide some evidence that genetic effects may be weaker, and environmental effects stronger, for vocabulary, and that some of the strongest genetic effects are apparent for deficits in expressive rather than receptive language skills.

Molecular genetics

Quantitative genetics has confirmed a genetic influence on SLI, and pointed to the components of language that are most likely to be influenced by this genetic effect. Molecular genetic studies in this area were fueled by the discovery of the FOXP2 mutation in a UK family with many of its members affected by speech and language impairment (the KE family; Lai, Fisher, Hurst, Vargha-Khadem, & Monaco, 2001). The FOXP2 mutation on chromosome 7 was present in all 15 family members with the speech and language impairment, and not present in the unaffected family members, thus making it both a necessary and sufficient cause of the language impairment in the KE family. However, the KE family, although initially described in terms of specific grammatical deficits, has an unusual type of speech and language impairment that includes deficits in orofacial motor control. Such orofacial dyspraxia is not typical in SLI, and indeed the FOXP2 mutation was not found in samples of more typical children with SLI (SLI Consortium, 2002).

Genome screens in linkage studies of SLI have so far identified four potential QTLs (chromosomal regions linked to a disorder): SLI1 on chromosome 16q, SLI2 on chromosome 19q, SLI3 on chromosome 13q, and SSD on chromosome 3p (SLI Consortium, 2002, 2004; Stein et al., 2004). Although it is still early days, this work supports the idea that SLI is a multifactorial disorder, and that some of the heterogeneity seen at the behavioral level may be reflected in the genetic etiology. It also suggests that at least one of the component processes likely to be involved in SLI, phonological short-term memory, may be a promising place to begin unpicking the complex pathways from genotype to phenotype (Newbury, Bishop, & Monaco, 2005).

Environmental factors

It is likely that, as with most common disorders, SLI will be associated with interactions between multiple genes and multiple environmental factors (Rutter, 2005a). Much of the research on the environmental factors that influence language development has focused on the normal range of variation, rather than addressing SLI directly. Nonetheless, it is likely that at least some of the same variables will contribute to risk status for SLI. One plausible candidate is the quality of the linguistic environment provided in the home: Speaking directly to children, encouraging them to talk, and parents' use of decontextualized language and a diverse and complex vocabulary are all linked to larger vocabularies in children.

Another frequently cited environmental variable that may affect language development is otitis media with effusion (OME), an infection of the middle ear that is very prevalent among young children (commonly referred to as glue ear). Recurrent bouts of OME could plausibly affect speech perception and thereby general language acquisition; however, there is no evidence that it is an important risk factor for SLI, particularly when it occurs in isolation (see Bishop, 1997b).

Neurobiology of SLI

Children with SLI do not typically show any detectable brain abnormality but findings suggest that subtle neurodevelopmental abnormalities appear to be implicated. Unfortunately, progress in this field has been hampered by a lack of agreement surrounding diagnostic criteria and the inclusion of individuals with comorbid disorders in study samples. In addition, it needs to be borne in mind that few studies have conducted comprehensive analyses: frontal and temporal regions have attracted the most scrutiny and the majority of studies have relied on single methods of investigation (C. Leonard, Eckert, & Bishop, 2005).

A small number of studies have used brain imaging or electrophysiological techniques to reveal converging evidence of abnormalities in brain structure and function in individuals with SLI. Abnormalities of structure have primarily been reported in frontal and perisylvian language regions of the cortex, most often on the left but sometimes bilaterally distributed. Studies that have investigated the basal ganglia have also found damage or reduction in volume, as well as changes bilaterally in the structure of the cerebellum. The small number of functional imaging studies confirm patterns of under- or overactivation of these same areas during language processing tasks (Ullman & Pierpont, 2006).

Two sets of recent investigations deserve discussion because they have used more comprehensive methods of analysis. Studies of the KE family in which many members are affected by severe speech and language difficulties have compared affected and nonaffected family members. In initial studies, Vargha-Khadem and colleagues (Belton, Salmond Watkins, Vargha-Khadem, & Gadian, 2002; Vargha-Khadem et al., 1998; Watkins et al., 2002) revealed reduced gray matter in Broca's area with increased gray matter in left anterior insular and right sensorimotor cortex, changes in volume in regions of the basal ganglia and thalamus, and bilaterally increased gray matter in posterior temporal cortex and angular gyrus. Subsequent studies have broadly replicated this pattern of abnormalities although detailed analyses reveal variability in the quantities of gray matter in different regions. One problem in generalising from studies of the KE family, as noted above, is that it may not be representative of the SLI population.

C. Leonard et al. (2002) examined brain structure in children with SLI, contrasting them with children with dyslexia. This research strategy is useful because it controls for the comorbidity of language and reading impairments. Leonard et al. (2002) reported that the two groups were differentiated in that those with SLI had a smaller surface area of Heschl's gyrus on the left than those with dyslexia, and the planum temporale tended to be symmetric. Drawing together this and previous work, Leonard and colleagues proposed an anatomical risk index ranging from a positive risk associated with phonological difficulties (larger cerebral and auditory cortex and more marked asymmetries than the population norm) to a negative risk associated with comprehension deficits (for brains showing smaller cerebral and auditory cortex and less marked asymmetries).

To assess the validity of this risk index, C. Leonard et al. (2006) obtained structural MRI scans from 22 children with language learning impairments aged 11–16 years who were also assessed across three domains: phonological processing, literacy skills, and receptive and expressive language. The MRI scans were evaluated by raters blind to subject identity and hemisphere of origin. Overall, measurements of cerebral volume were smaller than expected for age for the group and there was an expected trend for cerebral volume to be greater in boys. For all children, better language performance was associated with slightly positive risk indices (indicative of normal anatomy). Importantly, children with negative risk indices had more severe deficits and deficits in more domains than children with positive risk indices who had fewer deficits (primarily affecting phonology) with relative sparing of receptive language and reading comprehension. The findings of this study are intriguing but they are in need of replicating on larger samples of children with specific and more general language processing impairments.

The neuroscientific study of language impairment is still in its infancy but together findings suggest that brain development is atypical in SLI (though it should be noted that anatomical risk is sometimes seen in the brains of those who do not show language impairments). Ullman and Pierpont (2005) propose a conceptual framework, "the procedural deficit hypothesis" (PDH), that holds promise for integrating research on the neural, cognitive, and linguistic bases of SLI and also explains heterogeneity in the linguistic and nonlinguistic deficits found in the disorder. According to the PDH, a substantial number of individuals with SLI have abnormalities of brain structures that constitute the procedural memory system, and these individuals may compensate to varying degrees by relying on the declarative memory system.

The PDH draws on dual-route views of language processing (e.g., Pinker, 1994). According to Ullman and Pierpont (2005), rule-governed components of language fall under the remit of the procedural memory system, while associative lexical learning is handled by the declarative memory system. In SLI, the PDH proposes that a disordered procedural memory system should impair the development of grammar across domains (syntax, morphology, and phonology) whilst allowing specific instances of rule-like behavior to be acquired by rote learning, enabled by the intact declarative memory system. Examples would include the ability of some children to rote-learn past tense forms (e.g., *walked*) without being able to generate novel forms, or the ability to repeat words but not nonwords that require the abstraction of phonological structure. Such compensation would be more likely for high-frequency or particularly salient forms.

Part of the appeal of the PDH as an explanatory framework, however, is that it also addresses the nonlinguistic deficits often observed in SLI. Procedural and declarative memory are not language specific, but rather two domain-general systems that are appropriate for different types of information processing. Therefore, nonlinguistic processes that are mediated by the procedural system – such as the learning and execution of complex sequences and hierarchies across cognitive and motor domains – should also be impaired in SLI. Conversely, functions that rely on declarative memory, such as the acquisition and representation of semantic and declarative knowledge, should be spared. The neural corollary of this approach is that the frequently observed comorbidity between SLI and other developmental disorders, such as ADHD and dyspraxia, may be accounted for by the overlapping brain structures and cognitive processes involved.

In its present form, the PDH is highly productive but it has limitations. In particular, as pointed out by Thomas (2005), the ability of the language system to compensate (for a procedural learning deficit) must be constrained in some way in the light of the relatively poor outcome for many children with SLI. Furthermore, more specific predictions are needed with regard to *which* children with SLI have a deficit of the procedural memory system, and what the theory predicts their comorbid conditions should be. The PDH is an intriguing hypothesis; it remains to be seen how well it can account for the complex etiology of SLI and its manifestations across development.

Treatment of SLI

There is a sizeable literature on interventions for children with speech and language impairments. However many studies are informal and a recent systematic review identified only 25 studies with adequate methodology to examine the progress of children and adolescents with primary language impairments in response to interventions (Law, Garret, & Nye, 2004). The interventions varied in duration and included focused therapies to promote specific linguistic skills as well as approaches that aimed to foster language skills in natural environments. Interventions that focused on expressive phonology and vocabulary development were found effective, with less evidence of effectiveness for interventions tackling expressive syntax or receptive language skills. There was little evidence that therapist-delivered interventions were any more effective than those delivered by parents, or of group therapy being more effective than individual approaches, although one study suggested that the involvement of peers was helpful. When interpreting these findings it needs to be borne in mind that the evidence base is limited, and within each study there was considerable variation in response to the intervention.

One specific form of intervention that has generated considerable research interest as an intervention for SLI because of its theoretical underpinnings is training in rapid auditory processing. According to Tallal and her colleagues (Merzenich et al., 1996; Tallal et al., 1996), the causal connection between auditory processing and language comprehension skills provides a clear rationale for capitalizing on the brain's plasticity for change and training children with SLI in rapid auditory processing skills. In two companion papers, Merzenich et al. (1996) and Tallal et al. (1996) reported positive results from a training program for children with language learning impairments that incorporated computerized games and activities to promote rapid auditory processing skills (*Fast ForWord*; Scientific Learning Corporation, 1997). However, this program is intensive and multifaceted, making it very hard to be sure which components produce such training effects. Furthermore, subsequent studies have not found the program to be more effective than intervention programs that do not manipulate the input processing rate (e.g., Cohen et al., 2005; Gillam, Loeb and Friel-Patti, 2001; Gillam et al., 2008). Finally, Bishop, Adams, and Rosen (2006) reported a training study that compared a computerized grammatical training program where in one condition the speech was acoustically modified to lengthen and amplify dynamic (changing) portions of the signal. The participants were children with SLI who had significant receptive language difficulties and were attending specialist schools. There were no reliable effects of training overall and no evidence that the acoustically modified speech was more effective.

Perhaps even more problematic for the approach advocated by Tallal et al. (1996) are findings that although it is possible to train auditory processing skills to within normal limits, transfer to language tasks is often minimal (McArthur, Ellis, Atkinson, & Coltheart, 2008), and receptive language skills may be particularly resistant to treatment. These findings also clearly pose serious problems for the theory discussed above, that deficits in rapid auditory temporal processing are a cause of the problems seen in children with SLI. Bishop et al. (2006) make the important point that children with SLI can comprehend grammatical constructions, often to about 90% accuracy, but they persist in making occasional errors – these findings imply that it is not grammatical competence per se that should be targeted by interventions. Arguably, the use of language in natural settings may be a more effective approach than the use of computer-based training regimes for children with such difficulties (Fey, Long, & Finestack, 2003). Furthermore, the accepted clinical view that interventions play an important role in improving aspects of socio-emotional and behavioral adjustment, and may also reduce parental stress, should not be underestimated.

Summary and Conclusions

The causal chain from the putative genetic risk factors for SLI to its educational and psychosocial outcomes is complex and varied. There appear to be several different developmental trajectories and, at the present time, the causal mechanisms are only

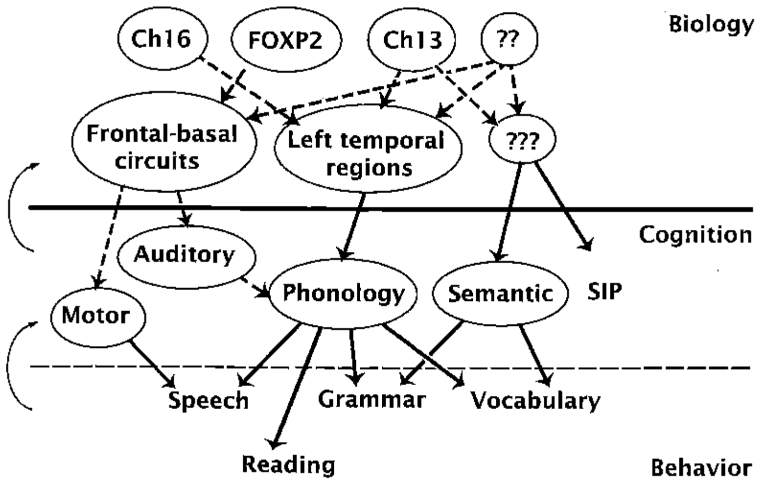


Figure 4.8 A path model for specific language impairment. (SIP = speed of information processing.)

partly understood. Importantly, genes have their action on brain structures through environments (Rutter, 2005b), and these aspects of the etiology of SLI are under-researched. However, advances in knowledge of the cognitive and behavioral phenotype of SLI are beginning to bear fruit, both in terms of refining neurobiological research questions and in providing a framework for clinical practice.

Figure 4.8 shows a path diagram with separate biological, cognitive, and behavioral levels of explanation (Morton & Frith, 1995) that summarizes some of the research we have reviewed in this chapter. At the biological level, a number of genetic markers have been associated with SLI and these, in interaction with environmental influences, presumably result in atypical patterns of brain development in SLI. Although the links between neurobiological correlates and cognitive-level deficits are not fully understood, associations with multiple deficits in phonology and semantics are hypothesized, moderated by speed of processing deficits. Sensory impairments are also shown at this level but the causal association between these and the cognitive deficits remain highly controversial.

The mappings between cognitive deficits and behavioral outcomes are predicted based on what is known from studies of typical development. The heterogeneity within SLI is captured by the complex array of causal arrows that are shown. However, single deficits are also permitted within this model and single deficits will likely lead to different developmental trajectories than those associated with multiple deficits. For example, a child with a single deficit in phonology may present with speech sound disorder and, depending on severity, with concomitant literacy problems. More typically, in children diagnosed with SLI, multiple deficits are observed leading to complex patterns of language delay and disorder.

Importantly within this putative model there are interactions with environmental input and experience at the biological and behavioral levels, and in turn behaviour may affect cognition through feedback loops. There is as yet limited evidence on

how environmental experience can modify the behavioral manifestations of SLI, but key factors such as linguistic environment and the possible effects of intervention are represented in this model. We would emphasize that the model presented here is both complex and tenuous, and this we believe presents a realistic view of our current understanding of SLI. The reality is that SLI is a highly complex and probably heterogeneous disorder (or set of disorders) and at the moment we are far from having a complete or unifying theory of how best to explain the disorder. It is striking that the model shown here is considerably more complicated than the models of causal influences we considered in Chapters 2 and 3 for reading disorders.