CHAPTER

4

Do Heterogeneous Deficits Require Heterogeneous Theories? SLI Subgroups and the RDDR Hypothesis

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The heterogeneity of specific language impairment (SLI) in children is a major issue in current research on the etiology of the disorder. Are these studies looking at one or many disorders? And, what are the relations between co-occurring deficits found in some children with SLI? Determining whether differences between various forms of SLI are qualitative or quantitative would considerably advance understanding of the disorder and could have direct clinical implications. For instance, if there are definable subgroups, with different etiologies, then distinctive theories as well as therapeutic approaches may be called for. Furthermore, such knowledge would provide valuable insight into the development of cognitive function and structure—a focal area of ongoing debate in cognitive science. This chapter first discusses the theoretical and methodological issues raised by the heterogeneity of SLI. Second, it argues for the detailed study of SLI subgroups to complement those of nondifferentiated SLI groups. Third, to illustrate the subgroup approach, consideration is given to the characteristics of the grammatical-SLI (G-SLI) subgroup and the representational deficit for dependent relations (RDDR) hypothesis, which has been advanced to account for the grammatical deficits found in G-SLI.

THE HETEROGENEITY ISSUE

An ongoing controversy surrounds the heterogeneity of the linguistic and cognitive characteristics found in children with SLI and the significance of

this for any single account of the cause and nature of the disorder. Although there is a general consensus that a genetic deficit causes SLI (Bishop, 1997b; Bishop, North, & Donlan, 1995; Fisher, Vargha-Khadem, Watkins, Monaco, & Marcus, 1998; Leonard, 1998; van der Lely & Stollwerck, 1996; see also Wexler, chap. 1 in this volume), researchers are far from understanding how genes affect the development of neural pathways to result in an impaired grammatical system or in an impairment in language abilities generally. A further issue in this controversy is whether aspects of language, such as parts of grammar, are under specific genetic control. Some scholars reject the notion that a genetic impairment can lead to specific higher order cognitive deficits (Elman et al., 1996; Karmiloff-Smith, 1998; Tomblin & Pandich, 1999), whereas others contend that this is a viable possibility (Marcus, 1999; Pinker, 1999; van der Lely, Rosen, & McClelland, 1998). This controversy revolves around the domain-general versus domain-specific view of the development of specialized cognitive systems.

The *domain-general*, or *domain-relevant*, perspective puts forward that mechanisms underlying specialized functions are not unique to any one function, but become specialized with the development process and specific environmental interactions (Elman et al., 1996; Karmiloff-Smith, 1998). Moreover, Karmiloff-Smith (1998) contended that any genetic deficit affecting cognitive functioning is likely to result in a cascade of subtle deficits rather than a single higher level one. Furthermore, Karmiloff-Smith (1998) considered that different cognitive disorders lie on a continuum, rather than are truly specific. According to the domain-general perspective, this is because genes cannot target specific mechanisms, because mechanisms are not developmentally specific to any one function (Elman et al., 1996; Karmiloff-Smith, 1998). Thus, the domain-general perspective predicts that developmental domain-specific deficits should not exist. Therefore, the finding of a domain-specific deficit in the absence of any other cognitive impairment would be evidence against this theoretical perspective.

Alternatively, the domain-specific perspective contends that genetically determined cognitive mechanisms could uniquely subserve specialized cognitive functions such as grammar (Coltheart, 1999; Marcus, 1999; Pinker, 1994, 1999; van der Lely et al., 1998). Marcus (1999) argued that by acting as switches, specific "master control genes" could trigger complex hierarchical cascades of genes that elicit widely varying arrangements of cells. Moreover, aspects of language could be under specific genetic control and, for instance, a specific grammatical impairment could reflect the absence of some gene that ordinarily triggers a cascade of events that leads to the construction of machinery that uniquely subserves grammar (Marcus, 1999). Thus, the finding of a consistent co-occurring deficit or deficits alongside a grammatical deficit would provide evidence against this domain-specific perspective.

The issue of the nature of SLI is relevant to basic research as well as to clinical assessment and remediation of children with SLI, because definable

subgroups, with different etiologies, may require distinctive therapeutic approaches. Thus, does SLI constitute multiple disorders, which vary subtly in genetic and behavioral characteristics? Does it constitute different and specific deficits, which occur heterogeneously across populations of SLI children? Or, is it a single deficit, which variably manifests itself in cognitive and linguistic deficits?

One approach to address these controversial issues is to study selected, homogeneous subgroups and compare their performance across behavioral measures of grammar, nongrammatical language abilities, and nonverbal abilities. Comparisons within and between subgroups, and between subgroups and groups who are not homogeneous selected SLI subgroups, could yield invaluable insight into whether these are truly qualitatively different forms of SLI, as well as into the developmental relations between aspects of language and cognitive function. Toward this end, the next three sections review data from nonlinguistic cognitive abilities, nongrammatical abilities, and grammatical abilities of an SLI subgroup of children with G-SLI and compare their pattern of performance with those of other groups of SLI children reported in the literature, in order to consider possible interpretations of these data with respect to the nature and cause of SLI.

The G-SLI subgroup is a homogeneous subgroup of children with SLI, who are selected for exhibiting persistent grammatical impairment. These children do not display pragmatic language impairments or any consistent nonverbal cognitive deficits (van der Lely et al., 1998). All the children were age 9 or older (up to age 18) when selected. They exhibit grammatical deficits in syntax and morphology, which affect performance on comprehension, expression, grammaticality judgments, and sentence-picture judgment tasks. G-SLI subjects' speech is clear and intelligible and they do not evince speech (dyspraxic) impairment, although subtle phonological deficits are evident upon detailed testing (Peiris, 2000; van der Lely & Harris, unpublished data, 1999). As with many children with SLI, vocabulary development lags behind normal, but is generally less impaired than their grammatical abilities. In contrast, language abilities that rely on pragmatic skills, such as theory of mind, inferential abilities, or pragmatic-social abilities (understanding what the listener knows and can infer, e.g., in story-telling) are age appropriate (van der Lely, 1997; van der Lely et al., 1998).

SLI IN CHILDREN WITH AND WITHOUT CO-OCCURRING NONVERBAL COGNITIVE DEFICITS

Low IQ scores (less than 85 IQ) alongside language impairment are reported in studies of SLI twins (D. Bishop, Bright, James, S. Bishop, & van der Lely, 2000), in the "KE" family (a large family spanning three generations of

which half suffer from SLI; Vargha-Khadem, Watkins, Fletcher, & Passingham, 1995), as well as in longitudinal studies of SLI children (Aram, Ekelman, & Nation, 1984; Leonard, 1998). Some researchers have interpreted this finding as a general measure of cognitive impairment in children with SLI, and as providing support for the domain-general, nonmodular view of cognitive development (Bishop, 1997b; Elman et al., 1996; Karmiloff-Smith, 1998). Thus, it might be expected that those children with co-occurring cognitive deficits would have more severe language impairment. However, this does not appear to be the case.

When similar language assessments have been administered to subjects with and without nonverbal cognitive impairments alongside SLI, they show little difference in their language performance. For example, the same test of past tense morphology was administered to the KE family and the G-SLI subgroup (Ullman & Gopnik, 1999; van der Lely & Ullman, 2001). Both subjects from the KE family and the G-SLI subgroup were impaired in producing regular and irregular past tense forms, were more impaired relative to control subjects in producing regular forms, and, in contrast to control subjects, showed frequency effects for regular past tense production (Ullman & Gopnik, 1999; van der Lely & Ullman, 2001). The affected members of the KE family had a mean performance IQ of 86 (range 71–111), whereas the unaffected members had a mean IQ of 104 (range 84–119) (Vargha-Khadem et al., 1995). These data are taken by some scholars to indicate that SLI is a multifaceted cognitive deficit affecting many cognitive functions (Elman et al., 1996; Karmiloff-Smith, 1998). However, this conclusion seems premature. First, it is noteworthy that there is considerable overlap in IQ in the affected and unaffected members of the KE family, yet no direct relation is found between severity of language deficit and cognitive abilities. Furthermore, despite strong similarities between the KE family and the G-SLI children in the test of past tense morphology, the G-SLI subjects' mean performance IQ is 99.09 (range 86–119) (van der Lely & Stollwerck, 1997; van der Lely & Ullman, 2001). Moreover, within the G-SLI subgroup, severity of grammatical impairment does not appear to be related in any way to performance IQ; the brightest subjects in the subgroup continue to have severe grammatical difficulties (van der Lely, 1997; van der Lely et al., 1998). Thus, without a theory of how a particular genetic deficit can cause multiple cognitive impairments—including grammar in some individuals, but selected primary grammatical deficits in other individuals—there appears to be little reason to pursue this line of inquiry in its broadest form, as the evidence directly conflicts with the predictions of a broad version of the domain-general perspective.

A narrower version of the domain-general perspective is the long-standing hypothesis that SLI is caused by capacity limitations for processing rapidly successive auditory verbal and nonverbal stimuli (Tallal, 2000). Indeed,

Tallal et al. (1996), Wright et al. (1996), and colleagues claimed that performance on nonverbal auditory tasks distinguishes normal children from those with language impairment. Moreover, remediation of the nonverbal auditory processing deficit is claimed to improve general language abilities (Tallal, 2000). Evidence showing a consistent deficit in auditory processing in all SLI children would provide convincing evidence for a strong relation between mechanisms involved in nonverbal cognitive abilities and language abilities.

This chapter examines 1 of the 28 studies that Tallal (2000) claimed demonstrates that SLI subjects have deficits with speed of nonverbal auditory processing, and compares their findings with those of auditory investigations of the G-SLI subgroup. Neville, Coffey, Holcomb, and Tallal's (1993) study is particularly interesting to the issues central to this discussion. First, it provides neurophysiological (event-related potentials) evidence alongside behavioral measures. Second, it provides data on nonverbal auditory processing and grammatical sentence processing. And third, it explores individual profiles alongside group data.

Neville et al. (1993) studied 34, 9-year-old children with SLI and reading disabilities who were part of the longitudinal cohort studied by Tallal and colleagues since they were 4 years old and an age matched group of control children. The subjects were administered tests, including the Tallal Auditory Repetition Tests, in which tones of different frequencies were presented at different rates (i.e., by varying the interstimuli intervals, ISI), and the Curtiss and Yamada Comprehensive Language Evaluation–Full, including the syntactic subtests (see Curtiss et al., 1992). ERP recordings of open and closed class words during online sentence processing were also made while the subjects read sentences that ended in a semantically appropriate or anomalous word.

The results revealed that, as a group, the children showed abnormalities in behavioral and neurophysiological measures of these auditory and grammatical abilities—thus, concurring with much previous research (Tallal & Piercy, 1973). However, finer grained analyses revealed that within the group multiple aspects of processing were affected, but the effect was heterogeneous across the group (Neville et al., 1993). ERP components linked to auditory processing were abnormal only in a subset of the children who also displayed abnormal auditory temporal discrimination. Conversely, abnormal ERP components associated with syntactic processing were found for a subset of children who scored poorly on tests of grammar. Neville et al. (1993) pointed out that it is important to note that this second subset of children is not the same as that which displayed auditory sensory processing deficits. Indeed, grammatical impairment was not correlated with the sensory deficits in this study. In sum, Neville et al. (1993) concluded that their data clearly indicate that multiple factors contribute to language proc-

essing deficits and these deficits are heterogeneous across populations of SLI children.

Moreover, Bishop and colleagues' studies of monozygotic (MZ) and dizygotic (DZ) twins revealed that environmental factors rather than genetic factors account for auditory impairments in children with SLI, whereas the reverse is the case for phonological abilities and syntactic abilities, which were the same syntactic abilities on which subjects with G-SLI children fail (Bishop, 1997a; Bishop et al., 1999a). These data further indicate that the underlying causes of auditory and grammatical impairments in children are not directly related.

However, it is still necessary to provide detailed analyses of auditory abilities of different subgroups in order to see if auditory abilities are affecting the language disorder in any way. The G-SLI subgroup could be similar to the subgroup in Tallal's cohort who exhibits grammatical deficits. The study tested 15 G-SLI subjects' auditory processing on two tasks, which have been claimed to distinguish normal children from those with impaired language development. First, Tallal and Piercy's (1973) same/different tasks presenting complex tones that vary in fundamental frequency, synthesized *ba–da*, and the second formant (F2) alone from the *ba–da* condition, with varying ISIs (0–400 ms), were used to compare the G-SLI subjects' auditory processing with that of age matched controls and younger children matched on vocabulary abilities or sentence understanding. The *ba–da* sounds are comprised of a number of formants, only one of which (the second formant, or F2) carries the phonemic distinction. Presentation of sounds with the second formant on its own, enabled presentation of sounds that contained the same dynamic spectral information, but were not heard as speech. Both the speech sounds and the nonspeech analogues have the same spectral transitions, but the speech sounds are acoustically more complex (in that they have other noninformative formants present). The nonspeech sounds were also presented on a monotone, to make them even less speechlike—they can be said to sound like quacks. The results revealed that the effect of ISI did not discriminate the groups from each other. Moreover, as a group, the G-SLI subjects' performance did not differ on any condition from that of the language matched controls but was significantly impaired in the tasks in comparison to the age controls. However, calculation of standardized residual (z scores) for each G-SLI subject based on the mean and standard deviation of the age matched controls, revealed that 66% (10/15) G-SLI subjects were normal (within 1.64 *SD*) (range $z = +1.03$ to -1.22) in their auditory processing of the F2 alone condition and 44% (6/15) were normal on the *ba–da* and tone condition (Rosen, van der Lely, & Dry, 1997; van der Lely, Rosen, & Adlard, MS., 2002).

The second set of auditory tests examining absolute thresholds, backward and simultaneous masking in a band-pass noise (Rosen, van der Lely,

& Adlard, 1999) revealed a broadly similar pattern of performance for the groups. The G-SLI subjects performed significantly better than the language matched control groups, but as a group performed worse than the age matched controls. However, once again, individual analysis revealed that a substantial number of the G-SLI subjects (57% 8/14, for backward masking, and 71% 10/14 for simultaneous masking) were within 1.64 *SD* (range: backward masking, $z = -1.59$ to + 1.48; simultaneous $z = -1.59$ to + .14) of the age controls' mean score with 5/14 G-SLI subjects being within 1 *SD* of the age controls' mean score on both tasks. Finally, there was no correlation between performance on auditory tasks and grammatical tasks. The grammatical impairment in G-SLI children did not differ as a function of performance on auditory tasks (van der Lely et al., 1998).

In sum, the findings from investigations of nonverbal cognitive abilities in nondifferentiated populations of SLI children and auditory abilities in the G-SLI subgroup, and those in the Tallal longitudinal cohort of SLI children investigated by Neville and colleagues (Neville et al., 1993) largely concur and, moreover, prove inconsistent with the domain-general predictions.

GRAMMATICAL IMPAIRMENT IN CHILDREN WITH AND WITHOUT NONGRAMMATICAL LANGUAGE DEFICITS

Language impairments in nongrammatical aspects of language, such as pragmatic-social abilities are also variably reported for children with SLI (Bishop, 1997b). Pragmatic-social knowledge, needed for example in storytelling, involves anticipating the knowledge and needs of your listener (intuitive psychology), rather than grammatical rules of a language. Therefore, pragmatic ability is likely to tap memory capacity, inferential abilities (including Theory of Mind), previous world knowledge, as well more general processing and integration of information for online monitoring of the listeners needs (see also Schaeffer, chap. 5 in this volume). Thus, many cognitive capacities are involved in normal pragmatic ability. Therefore, the cooccurrence of grammatical and pragmatic language deficits is unlikely to reflect a domain-specific language deficit of a language system that underlies both abilities, but nothing else.

There appear to be (at least) two subgroups of children with SLI with different linguistic characteristics, who are pragmatically impaired. The first of these is the subgroup, identified by Rapin and Alan (1983) as semantic-pragmatic deficit syndrome. This subgroup is characterized by normal or relatively intact grammar and phonology, but with inadequate conversational skills, selecting inappropriate words, poor maintenance of topic, and so on (Bishop & Rosenbloom, 1987; Conti-Ramsden, Crutchley, & Botting, 1997; Rapin & Allen, 1983). These children exhibit similar pragmatic-lan-

guage deficits as those of subjects with autism, but without all of the concomitant social-cognitive and behaviors disorders associated with autism. Although it has been suggested that children with semantic-pragmatic disorder have a mild form of autism, the evidence is inconclusive (Bishop, 2000). However, pragmatic-SLI is clearly distinct from G-SLI. G-SLI subjects have normal pragmatic abilities as measured by, for example, their use of pronouns in story-telling and their ability to make conversational inferences (van der Lely, 1997; van der Lely et al., 1998). Conversely, some children with grammatical (syntactic and phonological) impairments also have pragmatic impairments as shown by tests of referential communication skills and story comprehension (Bishop & Adams, 1991, 1992). The dissociation between impairments of pragmatics and grammar, albeit that these disorders can co-occur, indicates the independence of developmental pragmatic and grammatical impairments, and it may be concluded, their underlying cognitive systems (see also Schaeffer, chap. 5 in this volume). This is not to say that when pragmatic and grammatical impairments co-occur in a child, they will not interact and cause a complex, language disorder—clearly they will. However, the manifestation of such a complex language disorder does not necessarily mean that the subcomponents of the disorder are fundamentally related.

Further deficits in nongrammatical language abilities (i.e., in vocabulary development) have also been taken to suggest that more general purpose cognitive systems are important for language but are not restricted to language acquisition (Bates & Goodman, 1997; Tomblin & Pandich, 1999). In particular, Tomblin and Pandich (1999) and other researchers (e.g., Bates & Goodman, 1997) interpret a high correlation between vocabulary and morphology scores as evidence to support the theory that the same mechanism underlies syntactic acquisition and vocabulary development.

Although G-SLI subjects, like many children with language impairment, evince vocabulary impairment (van der Lely & Stollwerck, 1997), an alternative interpretation is that there are (at least) two or three mechanisms involved in word learning (Bloom, 1999, 2000) and G-SLI subject's vocabulary impairment results from their grammatical deficit (van der Lely, 1994). Because many factors contribute to word learning and some of the abilities that contribute to it are specific to language and some are not (Bloom, 2000; Bloom & Markson, 1998), vocabulary impairment can co-occur with many cognitive impairments. Among the abilities needed for word learning, Bloom and Markson (1998) argued that children succeed at word learning because they possess certain conceptual biases about the external world, they have the ability to infer the referential intentions of others, and they develop an appreciation of syntactic cues to word meaning. Thus, children with pragmatic-SLI or autism could fail to learn word meaning due to impaired mechanisms underlying inferential abilities, whereas G-SLI children

and other children with grammatical impairment fail to learn word meaning because of their grammatical deficit, which affects the use of syntactic cues to word meaning (van der Lely, 1994). Moreover, subjects with G-SLI are normal with respect to logical reasoning and social-pragmatic inference (van der Lely et al., 1998)—the abilities likely to underlie the second mechanisms for word learning listed earlier. Consistent with this alternative, children with G-SLI are impaired in using grammatical cues to learn the meaning of novel verbs (O'Hara & Johnston, 1997; van der Lely 1994), novel collective nouns (Froud & van der Lely, 2002), and are particularly impaired in learning the semantic scope of quantifiers (*every, all*) (van der Lely & Drozd, unpublished data, 1999), and abstract words and relational terms (Leonard, 1998)—exactly those words and aspects of meaning for which grammatical cues are relevant.

In conclusion, the previous data showing language impairments outside the grammatical system do not necessarily provide evidence against a specific and dedicated mechanism underlying grammar. There is evidence from children with SLI and with other cognitive disorders that pragmatic and grammatical impairments dissociate. Further, vocabulary deficits might be predicted in children with grammatical deficit because grammatical cues play an important role in word learning. "Vocabulary" should not be thought of as a core unitary language system per se; and grammatical impairment could cause the vocabulary deficits found in children with SLI.

GRAMMATICAL IMPAIRMENTS IN CHILDREN: VARIATION IN PHONOLOGICAL, MORPHOLOGICAL, AND SYNTACTIC IMPAIRMENT

The distinction between different forms of SLI within the grammatical system is less clear than those between the grammatical system and non-grammatical language systems and nonverbal systems. Caron and Rutter (1991) pointed out that in developmental disorders, the probability of two disorders co-occurring is greater than expected from the population incidence of either disorder alone. Consequently, when impairments within the grammatical system co-occur, as they frequently do, it is less clear whether researchers are looking at comorbidity of two or more different conditions that frequently occur together in the same individual, or variations in the manifestation of the same underlying disorder. Bearing this in mind, first consider phonological impairments and their relation to syntactic impairments.

Primary, specific phonological impairment can be found in children and adults with dyslexia, and it is accepted by many researchers that this reading and writing disorder as well as other related cognitive deficits (e.g., im-

paired verbal short-term memory) is a consequence of a phonological representational deficit (Snowling, 2000; Snowling & Hulme, 1994). Thus, it seems that developmental phonological impairment can occur without syntactic impairment. However, there is some evidence from longitudinal prospective and cross-sectional studies that expressive or receptive vocabulary may be impaired in children with dyslexia (Gallagher, Frith, & Snowling, 2000; Gathercole & Baddeley, 1989, 1990). Once again, researchers make reasoned arguments that the vocabulary deficits are a consequence later in development of a primary phonological processing impairment (Frith & Happé, 1998; Snowling, 2000).

In contrast to the scant evidence of syntactic or morphological problems in children with primary phonological deficits, many children with SLI, including those classified as G-SLI, have phonological impairment (Bishop, North, & Donlan, 1996; Peiris, 2000; van der Lely & Harris, 1999, unpublished data). One interpretation of this variable co-occurrence of syntactic and phonological impairment is that the phonological deficits are caused by different etiologies in dyslexia and SLI. Consistent with the domain-specific deficit view of G-SLI is that a common grammar-specific proto-mechanism underlies structural relations in syntax and phonology. G-SLI subjects' syntactic abilities reveal particular problems with dependent structural relations (van der Lely, 1998). Further, initial analysis of G-SLI subject's phonological deficits indicates that their expressive phonological abilities break down only with increasing structural phonological complexity (Peiris, 2000). Thus, the evidence so far is consistent with an impairment of domain-specific grammatical mechanism(s) or representation(s) underlying structural relations. However, it is not clear whether a similar deficit could only affect the phonological system in children, as in dyslexia, or whether the origins of phonological impairment in dyslexia is different from that of SLI.

Although the theoretical framework adopted here concurs with specialized mechanisms (e.g., those in syntax, phonology, or morphology) underlying grammar—and as such proto-mechanisms could underlie grammatical structural relations generally—normal phonological (or morphological) development may also rely on mechanisms that are not unique to the grammatical system or to humans. For example, babies appear to be "pre-wired" to attend to and use phonotactic information, prosody, and stress patterns from the speech stream to enable them by 10 months or so to identify "words" in connected speech, although they have no knowledge of word meaning (Jusczyk, 1999). However, these abilities might not be specific to humans but might be shared by other primates (Houser, 1996). Therefore, although these early language detection abilities lay the foundation for later phonological development (Jusczyk, 1999), a deficit with such abilities may not be indicative of a language-specific deficit. In contrast, only humans are capable of forming complex structural syntactic and phonological

relations. Thus, as with vocabulary development (phonological deficits may occur for a variety of reasons), only one of them is directly related to a deficit in a specialized dedicated mechanism for grammar in its broader sense, and thus, general mechanisms may also contribute to normal phonological functioning. Further research comparing detailed linguistic analysis of subjects with dyslexia and SLI, if possible, alongside genetic analysis, could lead to a better understanding of the relation between these deficits.

Consider the reported differences in morphological impairments in children with SLI. Although it is widely agreed that morphology is impaired in children with SLI (Bishop, 1994; Clahsen, 1989; Dalalakis, 1994, 1996; Gopnik, 1990; Leonard, 1998; Rice & Wexler, 1996; van der Lely, 1998), the characterization of the deficit varies in different studies of SLI subjects. Some differences may be due to an investigative strategy that focuses on certain aspects of morphology. For instance, most scholars agree that inflectional morphology is impaired—although not uniformly—in SLI, but that derivational morphology is unimpaired (Clahsen, 1989; Leonard, 1998; Rice & Wexler, 1996). However, Dalalakis, (1994, 1996) revealed that when derivational morphology is directly investigated, deficits are evident in English- and Greek-speaking subjects with SLI. It is unclear how extensive deficits in derivational morphology are in the SLI population, because this aspect of language has not received the attention of other aspects of language such as tense or agreement marking (cf. Clahsen, Bartke, & Goellner, 1997; Rice, Wexler, & Cleave, 1995). Thus, until derivational morphology is subjected to more general, detailed investigation, it can only be concluded that the "heterogeneity" in the morphological characteristics of children with SLI is attributable to researchers' investigative strategy, rather than true differences between subjects.

Conversely, using similar investigatory techniques to assess different populations of subjects with SLI, qualitative differences have been revealed in the SLI children's underlying deficits. A clear example of this is two investigations of word formation in noun compounding, both based on Gordon's (1985) study (see also Clahsen & Temple, chap. 13 in this volume, for a similar experiment with children with Williams syndrome). Oetting and Rice's (1993) study of 14, 5-year-old children with SLI found that the majority (11/14) produced irregular plural nouns inside compounds, (e.g., *mice-eater*) but not regular plural nouns (**rats-eater*). Thus, they showed a similar pattern of performance as normally developing children and adults (Gordon, 1985; Oetting & Rice, 1993; van der Lely & Christian, 2000). In contrast, van der Lely and Christian's (2000) study of 16, 10- to 18-year-old G-SLI subjects revealed that the majority of their subjects (14/16) produced regular nouns (*rats-eater*) as well as irregular nouns inside compounds. This indicates that the majority of G-SLI subjects are preferentially storing regular plural forms in their lexicon, rather than computing such forms on the basis of a gram-

matical rule. It is interesting that, in Oetting and Rice's (1993) study, three subjects with SLI performed in a similar way to the G-SLI subjects, producing regular plural nouns inside compounds. Thus, differences in the subjects' ages cannot account for the differences between the children's performance. These studies suggest qualitative differences between SLI children's morphological representation of words and thus heterogeneity (even) within the grammatical system in the nature of SLI. Replication and substantiation of such findings have implications for the understanding of the disorder and suggest fractionation of impairments within the grammatical system that are revealed in development.

Finally, this section comments on the implications of the finding that syntactic errors made by children with SLI are also found in much younger children who are developing normally. Recent research, particularly that of Wexler and colleagues (Wexler, Schütze, & Rice, 1998), highlights the similarities between SLI grammar and that of much younger children (see also Rice, chap. 2 in this volume; Wexler, chap. 1 in this volume). For example, the use of infinitival verb forms (*jump*) in a matrix clause context when a tensed form would be expected (*jumps, jumped*) is used by both children with SLI and young normally developing children (Rice et al., 1995). More recently, Bishop and colleagues (Bishop et al., 2000; Norbury, Bishop, & Briscoe, 2000), replicating the findings of impaired understanding on passive sentences and assigning reference to pronouns and reflexives previously found for G-SLI subjects (van der Lely, 1996; van der Lely & Stollwerck, 1997), found that young normally developing children (if they make any errors) make errors that show a similar pattern to those of children with SLI. Norbury et al. (2000) interpreted this finding as evidence for general processing limitations and against a modular domain-specific deficit underlying the syntactic errors in SLI grammar.

Although general processing limitations remain a possibility, an alternative is that maturational factors and development within the (domain-specific) grammatical system causes such syntactic errors in young children (cf. Wexler, 1998; chap. 1 in this volume). The difference between children with SLI and those developing normally is that (genetically controlled?) grammatical maturation occurs in children developing normally but not in children with SLI who remain at an early stage in particular areas of syntactic acquisition and thus continue to produce grammatical errors found in young children.[1] Moreover, as a general processing deficit account

[1]An alternative explanation within the "Continuity framework" (Radford, 1990) would be that a genetic deficit affects the underlying representations or mechanisms underlying these representations for the parameters within UG, causing later difficulties in determining appropriate parameter setting—hence the deficits in SLI do not show up until later. However, the distinction between the maturational and continuity approaches are not central to the line of reasoning pursued here.

is inconsistent with the selective deficits within syntax found in many children with SLI (see later), a deficit with a genetically determined specialized mechanism, necessary for the normal development of grammar, provides a more parsimonious explanation for the deficits found.

IMPLICATIONS OF HETEROGENEITY IN SLI

The previous sections have provided a snap shot of the available evidence to evaluate whether there is support for consistent co-occurring deficits in nonverbal abilities or nongrammatical language abilities with grammatical deficits. In addition, within the grammatical system in its broader sense (syntax, phonology, morphology), they considered the autonomy versus the association between these grammatical systems in different developmental disorders, as well as illustrated qualitative differences within one grammatical system (morphology) found in different groups of children with SLI.

The data were striking for the fact that despite extensive investigation, no consistent deficit in nonverbal abilities or nongrammatical abilities has been found to occur in all children with grammatical-syntactic deficits. However, many children with SLI show one or more deficits in nonverbal or nongrammatical language abilities that appear unrelated to their syntactic deficits. The occurrence of auditory and cognitive deficits or nongrammatical language deficits in the absence of language impairment, and, conversely, the absence of such deficits in children with G-SLI, strongly indicate the autonomy of these cognitive systems. Thus, these data are inconsistent with the domain-general perspective underlying specialized grammatical abilities. The simplest explanation for the association between disorders is the propensity for comorbidity of disorders in development (Caron & Rutter, 1991).

The autonomy of deficits within the grammatical system is less clear. The evidence for phonological disorder in subjects with dyslexia, in the absence of syntactic disorder, clearly indicates the independence of these grammatical systems. This finding alongside the evidence of underlying phonological deficits in many, if not all, children who evince syntactic deficits attest to qualitatively different causes underlying phonological impairment. The co-occurrence of phonological and syntactic impairments in children with SLI speaks to the extent of the deficit within the grammatical system. Contrary to some scholars' view (e.g., Bishop et al., 2000; Norbury et al., 2000), there appears to be no convincing reason to reject the domain-specific deficit hypothesis on the basis of these data. As already mentioned, phonological structure, like syntactic structure, is hierarchical in nature and involves structural complexity (Chomsky, 1986; Harris, 1994) and is part

of the language faculty unique to humans (Pinker, 1994). Thus, it is feasible that a genetically determined specialized mechanism, unique to grammatical systems, is adopted and developed to independently serve both phonology and syntax and thereby can be selectively impaired in children with SLI.

Finally, the apparent fractionation of deficits in SLI, illustrated by differences in the lexical representation of morphologically regular words, further emphasizes the heterogeneous nature of SLI and the need for detailed investigation of a broad range of language abilities in different SLI subgroups, if this disorder is to be fully understood. However, it should be noted that performance on any experimental tests of grammar (syntax, morphology, phonology) measured by behavioral scales (i.e., performance measures rather than neurological measures such as event-related potential) might be subject to postgrammatical, cognitive knowledge and information processes.[2] Thus, a deficit, with a particular syntactic structure could result in different children using different strategies or cognitive abilities to cope with the task. Thus, although the RDDR hypothesis can predict where the problems may or may not occur within the grammar, it does not predict the child's use of nongrammatical cognitive resources.

In sum, the evidence supports the view that genetically determined cognitive mechanisms underlie specialized cognitive functions and can be developmentally selectively impaired. However, the underlying autonomy of deficits within the grammatical system and within each subsystem (e.g., morphology or syntax) requires further research before conclusions can be drawn with any confidence.

The final sections describe, first, the syntactic characteristics of the subgroup of children with G-SLI, and second, the representational deficit for dependent relations (RDDR) hypothesis, which specifies where the breakdown in the syntactic system is occurring, which could lead to G-SLI grammar. These sections aim to illustrate how using a complementary approach to the study of SLI (i.e., studying highly selected homogeneous SLI subgroups) can contribute and advance knowledge of the cause of the disorder.

SYNTACTIC CHARACTERISTICS OF THE G-SLI SUBGROUP

This section aims to provide a description of the syntactic abilities and disabilities of children with G-SLI. This aim may be contrasted with those who seek to highlight prototypical characteristics or clinical markers of SLI,

[2]Although measurements of grammar from experimental procedures are potentially subject to extra grammatical processing, they have the advantage over spontaneous speech analysis where the target utterance is unknown and/or the child simply avoids problematic structures.

such as the incorrect use of optional infinitives (Rice & Wexler, 1996; Rice, chap. 2 in this volume; Wexler, chap. 1 in this volume) or impaired nonword repetition (Bishop et al., 1996).

Subjects with G-SLI evince a broad deficit in aspects of syntax that are normally taken to be core to the human language faculty (Smith, 1999). First, G-SLI subjects show the deficits in tense and agreement marking that are reported in many studies of children with SLI (e.g., Clahsen, 1997; Rice & Wexler, 1996). As with all their grammatical errors, these are found regardless of processing factors. For instance, past tense marking errors, where the infinitival form is used in a past tense context, are found in spontaneous speech, expressive story-telling tasks, elicitation tasks, as well as grammaticality judgments (Gollner, 1995; van der Lely, 1997; van de Lely & Ullman, 1996, 2001). However, G-SLI is not a deficit restricted to inflectional morphology. One of the most reliable findings in G-SLI subjects is problems with assigning theta roles in reversible passive sentences or sentences with complex argument structure, such as dative sentences (van der Lely, 1994, 1996; van der Lely & Dewart, 1986; van der Lely & Harris, 1990). Thus, subjects with G-SLI may interpret *The man is eaten by the fish* or *The man is being eaten*, as either an active sentence (*The man is eating the fish*) or as an adjectival passive (*The eaten man*). Recent research reveals that similar deficits are evinced in other English-speaking and Greek-speaking children with SLI, although some of the children studied do not show such discrete deficits in grammar as the G-SLI subgroup (Bishop et al., 2000; Norbury et al., 2000; Precious & Conti-Ramsden, 1988; Stavrakaki, 2001a, 2001b). G-SLI subject's problems with structural syntactic relations are also revealed when assigning co-reference to pronouns and anaphors in sentences when only syntactic cues are available (e.g., *Mowgli says Baloo is tickling him/himself*), as well as understanding and producing embedded phrases and clauses (*The frog with the blanket . . .*) (van der Lely & Hennesey, 1999; van der Lely & Stollwerck, 1997). Thus, in a story-telling task, subjects with G-SLI produced few, if any, spontaneous embedded or subordinate clauses (van der Lely, 1997). Similar deficits with general structural relations affecting verb structure, noun phrases, as well as clauses and embedded structures are slowly emerging in the literature for other groups of children with SLI (Bishop et al., 2000; Hamann, Penner, & Lindner, 1998; Ingham, Fletcher, Schelletter, & Sinka, 1998; Jakubowicz, Nash, Rigaut, & Gérard, 1998; Norbury et al., 2001; Stavrakaki, 2001a, 2001b). Thus, although deficits in syntactic structural relations are not typically reported, this may well be due to an artifact of an investigative focus on inflectional morphology. As recent research indicates, the SLI deficit is much broader in the general SLI population as well as in subjects with G-SLI.

Finally, G-SLI subjects, like many children with SLI, show both correct and incorrect performance for the same syntactic structure. Thus, it is rare

for any structure to be "missing" per se from G-SLI grammar, although many structures are certainly problematic. In sum, the G-SLI subgroup inconsistently manipulates core aspects of syntax. The RDDR hypothesis provides a precise account of the deficit within the syntactic system.

THE REPRESENTATIONAL DEFICIT FOR DEPENDENT RELATIONS HYPOTHESIS

The representational deficit for dependent relations hypothesis (RDDR) hypothesis, developed over a number of years, aims to account for the broad range of deficits found in G-SLI subjects that are at the core of the syntactic system. The RDDR account identifies the underlying deficit in the computational syntactic system—that is, in the syntax proper (van der Lely, 1994, 1998; van der Lely & Stollwerck, 1997). As a working hypothesis, the RDDR hypothesis assumes that although much of language might arise from general cognitive capacities, certain aspects of grammar have an autonomous psychological and neural basis. Investigations into G-SLI children aim to provide a further step toward identifying which aspects of the grammatical system are autonomous. The RDDR account is not tied to the linguistic minimalist program (Chomsky, 1995, 1998, 1999), but uses it to provide a precise definition of G-SLI grammar. The RDDR account contends that the core deficit responsible for G-SLI grammar involves "movement" (Chomsky, 1995). And, more specifically, whereas the basic grammatical operation/rule "move" in normal grammar is (by definition) obligatory, in G-SLI grammar it is optional. Thus, G-SLI children's grammar may be characterized by "optional movement" (van der Lely, 1998). Within the minimalist perspective (Chomsky, 1998, 1999), long distance dependencies necessitate movement, where movement is construed as attraction by a noninterpretable feature (e.g., tense, case) for the purposes of feature checking.

In other words, a dependent structural (syntactic) relation is formed in a sentence for the purpose of linking and checking (matching, copying, or moving) grammatical features associated with lexical items (or constituents). For instance, the inflectional (Infl) functional category with tense features "attracts" the verb in order that the verb's tense features can be checked (i.e., V to I movement). Thus, in more theory neutral terms, this syntactic dependency occurs when one sentence constituent "looks for" a "sister constituent" for feature checking/matching/copying. Although Chomsky (1995, 1998, 1999) defined this syntactic dependency operation as "movement," the terminology to describe this operation may change with developing linguistic theories. However, it is this basic operation of syntactic dependency and the resulting grammatical operations/processes (feature checking/matching/copying) that is central to the RDDR account of G-SLI and, indeed, central to syntax.

The optionality, rather than the absence, of movement characterizing G-SLI subjects' grammar indicates that the operation or rule "Move F" (a feature) is available to them. Thus, the underlying deficit is not in the operation move itself, but the implementation of the operation (van der Lely, 1998). R. Manzini (personal communication, 10th February, 1998) suggested that the locus of the deficit is with the economy principles (Chomsky, 1998). Van der Lely (1998) explored this suggestion and concluded that of the various principles or properties of economy (e.g., minimal link condition, last resort) that a deficit within last resort provided a parsimonious explanation of the data. Formally, Chomsky (1995) defined last resort as "Move F raises F (a feature) to target K only if F enters into a checking relation with a sublabel of K." Last resort may be thought of as comprising two principles (R. Manzini, personal communication, 10th February, 1998). The first principle, economy 1, ensures that the operation move is permitted only if it satisfies a feature-checking relation. Thus, move F occurs only if there are features to be checked. The second principle, economy 2, forces movement (and thus checking) if the target has not had its features checked. Thus, economy 2 principle of last resort insures that movement operations are obligatory (van der Lely, 1998). Van der Lely (1998) contended that the economy 2 ("Must-Move") principle of last resort is missing in G-SLI grammar and this accounts for the optionality of movement. From a computational, mechanistic viewpoint, this could be interpreted as an impaired (specialized) algorithm, underlying movement representations or operations in G-SLI, such that movement can occur, but, in contrast to normal grammar, is not "automatic" (whereby a 'steady state' has occurred) and thus, compulsory. Conversely, features that can be checked via "merge" (Chomsky, 1999) may be realized correctly—merge being the basic operation whereby a category is inserted into the derivation and unlike move does not form further structural relations with other categories that are in nonlocal relations.

Problems with head-to-head movement (e.g., V to I) can account for G-SLI subjects' deficit with tense and agreement marking. Further, problems with A(argument)-movement can account for G-SLI subjects' difficulties in assigning thematic roles to noun phrases, particularly in passive sentences (van der Lely, 1994, 1996; van der Lely & Dewart, 1986; van der Lely & Harris, 1990). Thus, the RDDR can account for the range of deficits found in G-SLI subject, whereas other accounts of the linguistic deficits in children with SLI, such as the extended optional infinitive account (Rice & Wexler, 1996; Wexler et al., 1998), or the agreement deficit account (Clahsen et al., 1997) can only account for their tense and agreement errors (see van der Lely, 1998). Note that it falls outside of the scope of the focus of here to further discuss alternative accounts of these data (see van der Lely, 1998, for discussion of this issue).

The RDDR hypothesis makes clear predictions with respect to weaknesses and strengths in G-SLI grammar. For example, it predicts that G-SLI

subjects would have problems with Wh-operator movement, and Q-feature (do-support) movement in question formation. Conversely, based on the RDDR hypothesis, Davies (2001) predicted that insertion of negative particles (***not*** do***n't***) would not be problematic, because no movement occurs in the syntax, although I-C movement problems may cause auxiliary and copular forms to be omitted (e.g., *They ___ not running*). Van der Lely and Battell (1998, 2001) investigated 16, 11- to 18-year-old G-SLI subjects' production of 36 subject and object questions balanced for *who, what,* and *which* words and compared their performance with that of 5- to 9-year-old, language matched control children. The G-SLI subjects were significantly impaired in producing subject and object questions, and in contrast to the language controls, produced fewer correct object questions. An error analysis revealed that all the G-SLI children produced both wh-operator, such as gap filling or no movement of the wh-phrase (e.g., **What something in Mrs Brown's desk? *Which Mrs Peacock liked jewellery?*) and Q-feature movement errors (e.g., **What cat Mrs White stroked? *What did they drank?*).

In contrast, Davies' investigations of the same subgroup of G-SLI subjects, using an elicitation task revealed that the noncontracted or contracted negative particle was never omitted in 288 sentences (e.g., *They are not running, He's not on the skateboard, He isn't skipping, They aren't on the skateboards*), although the predicted omissions of auxiliary and copular verbs were found (**They not wearing hats. *He not on the skateboard*) (Davies, 2001; Davies & van der Lely, 2000).

CONCLUSIONS

The extensive and detailed exploration of G-SLI subjects' grammatical abilities, in the context of knowledge of their nongrammatical and nonverbal cognitive abilities, has revealed a domain specific but broad deficit with structural relations within the grammatical system. Preliminary research indicates that the structural deficit in G-SLI grammar extends to phonology and morphology. However, further investigations are required to fully explore and define the phonological and morphological characteristics of G-SLI. The RDDR hypothesis provides a characterization of the syntactic deficit in G-SLI, and in so doing enables strengths and weaknesses of G-SLI grammar to be predicted. Moreover, it lays the foundation for further research to evaluate whether core deficits within the grammatical system are directly related or whether they reflect comorbidity of disorders. Such research will elucidate whether there truly are qualitative differences in the nature of SLI in different children, who may or may not manifest deficits in other cognitive abilities. Thus, the significance of the heterogeneity of SLI may be revealed, and thereby, further understanding of SLI in all its manifestations.

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